M.R. KARIMOV, O.M. ALIMNAZAROV

MEXANIKA

FANIDAN HISOB–GRAFIK ISHLARI VA KURS LOYIHALARINI BA JARISH BO‘YICHA

(o‘quv qo‘llanma)

TOSHKENT -2024

O‘ZBEKISTON RESPUBLIKASI OLIY TA’LIM, FAN VA INNOVATSIYALAR VAZIRLIGI

TERMIZ MUHANDISLIK-TEXNOLOGIYA INSTITUTI

M.R. KARIMOV, O.M.ALIMNAZAROV

MEXANIKA

(Nazariy mexanika, Materiallar qarshiligi, Mashina mexanizmlar nazariyasi va Mashina detallari)

fanlaridan hisob – grafika ishlari va kurs loyihalarini bajarish bo‘yicha

O‘zbekiston Respublikasi Oliy ta’lim, fan va innovatsiyalar vazirligi tomonidan o‘quv qo‘llanma sifatida tavsiya etilgan

TERMIZ - 2024

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t.f.f.d., M.R.Karimov, O.M.Alimnazarov, "Mexanika (Nazariy mexanika, materiallar qarshiligi, mashina mexanizmlar nazariyasi va mashina detallari) fanlaridan hisob-grafik ishlari va kurs loyihalari"ni bajarish: O'quv qo'llanma. – Termiz: 2024, 192 b.

O'quv qo'llanmada "Mexanika (Nazariy mexanika, materiallar qarshiligi, mashina mexanizmlar nazariyasi va mashina detallari)" fanlaridan quyidagi 60712500-Transport vositalari muhandisligi ta'lim yo'nalishi va unga turdosh ta'lim yo'nalishlarida tahsil oluvchi talabalarga hisob-grafik ishlari va kurs loyihalarini bajarish bo'yicha asosiy usullar matematik formulalar yordamida hisoblash bo'yicha zarur bo'lgan tavsiyalar, ko'rsatmalar keltirilgan bo'lib, unda kurs loyihasini hisoblash usullarini o'z ichiga olgan bo'lib, yurutmaning kinematik tahlili, yurutma uchun elektrodvigatelni tanlash, bir pog'onali to'g'ri tishli va qiya tishli silindrik uzatmalarni loyihalash, bir pog'onali konussimon va chervyakli uzatmalarni loyihalash, yurutmaning eskiz va ishchi chizmasini tayyorlash, podshipniklarni tanlash, muftalarni tanlash shartlarini aniqlashga doir ko'nikmalarini talabalarda shakllantirish nazarda tutilgan.

Taqrizchilar: A.U.Qo'ziyev – TerDU "Transport tizimlari va inshootlari" kafedrasi dotsenti, t.f.n.

R.Q.Qalandarov – TMTI "Muhandislik va kompyuter grafikasi" kafedrasi professori, t.f.n.

O'zbekiston Respublikasi Oliy ta'lim, fan va innovatsiyalar vazirliigining 2023-yil 6-noyabrdagi 491-sonli buyrug'iga asosan o'quv qo'llanma sifatida tavsiya etilgan.

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KIRISH

Mamlakatimizda ishlab chiqarish sohalarini rivojlantirish uchun yuqori malaka va bilimga ega bo'lgan kadrlarni tayyorlash va ularga ishlab chiqarish tarmoqlari va inshootlarini loyihalash, qurish va ekspluatatsiya qilish uchun keng talablar qo'yilmoqda. Buning uchun esa bo'lajak bakalavrlardan zamonaviy talablarga javob bera olishi hamda sohaga doir ma'lumotlardan xabardor bo'lishlari va ularning muqobil yo'llarini tanlay bilishlari zaruriyati talab etiladi.

O'quv qo'llanma 60712500-Transport vositalari muhandisligi ta'lim yo'nalishida tahsil oluvchi talabalar uchun mo'ljallangan bo'lib, o'quv qo'llanmada "Nazariy mexanika" bo'limining statika, kinematika va dinamika bo'limlariga oid hisoblash ishlarini olib borish usullari ko'rsatilgan.

Mazkur o'quv qo'llanmada hisoblash ishlari uchun muhim ahamiyat kasb etadigan zaruriy ko'rsatmalar berilgan.

O'quv qo'llanmaning "Materiallar qarshiligi" bo'limida cho'zilish – siqilishda statik aniq va noaniq masalalar, sterjenning buralishi va tekis shakllarning geometrik xarakteristikasi hamda eguvchi moment epyuralarini qurish bo 'yicha talabalar mustaqil topshiriqlarni bajarish uchun vazifalar berilgan.

O'quv qo'llanmaning "Mashina va mexanizmlar nazariyasi" bo'limida mexanizmlarni loyihalash va ularni tekshirishning nazariy hamda amaliy usullari hamda zaruriy tushuncha va ko'rsatmalar taqdim etilgan. Mexanizmning kinematik sxemasini to'g'ri tanlash, uni kinematikasini va dinamikasini hisoblash hisoblanadi.

Hozirgi texnika taraqqiyotining barcha sohalaridagi texnologik jarayonlar va ishlab chiqarishni yuqori malakali mutaxassislar boshqarishini talab qiladi. O'z navbatida har bir muhandis mashina va mexanizmlarni loyihalash, ularni tekshirish, takomillashtirish usullarini yaxshi bilishi talab etiladi.

Avval richagli mexanizmlarini strukturaviy, kinematik va kinetostatikaviy tekshirishlar yuzasidan kurs loyiha (ishi), keyin tishli va kulachokli mexanizmlar yuzasidan kurs loyiha (ishi) lari bajariladi.

Mexanizmning tarkibidagi zveno, kinematik juft va guruhning geometrik va kinematik, dinamik parametrlarini hisoblash usullarining asoslarini yaxshi o'rganib chiqan talabalar murakkab tuzilishga ega bo'lgan mexanizmlarni be'malol loyihalashi va tadqiq etishi mumkin bo'ladi.

O'quv qo'llanmada "Mashina detallari" bo'limi bo'yicha amaliy mashg'ulotning mavzulari, ularning qisqacha mazmunlari va masalalarni bajarish tartiblari bo'yicha tavsiyalar va masalalar yechish bo'yicha namunalar berilgan.

Shuningdek, talabalarga topshiriqlarni mustaqil bajarish uchun vazifalar berilgan.

Bu vazifalarni talabaning qanday darajada bajarganligiga qarab baholanadi.

Baholash tizimining asosiy vazifalari quyidagilardan iborat:

a) talabalarda Davlat ta'lim standartlariga muvofiq tegishli bilim, ko'nikma va malakalar shakllanganligi darajasi va uni tahlil qilaolishiga qarab;

b) talabalarda mustaqil ishlash ko'nikmalarini shakllanganligi hamda axborot resurslari manbalaridan samarali foydalanganligiga qarab;

d) fanning talabalar tomonidan tizimli tarzda va belgilangan muddatlarda o'zlashtirilganligi va uni tahlil qilaolishiga qarab.

I – BOB. NAZARIY MEXANIKA

Hisob – grafik ishining mazmuni va hajmi

Hisob – grafik ishining maqsadi talabalarning o'qish davrida olgan bilimlarini aniq muhandislik yechimini aniqlashni o'rgatishdan iborat bo'lib, shu bilan birgalikda masalalarni yechishning ilg'or texnologik jarayonlarini ishlab chiqishni o'rganish, talabalarni konstruktorlik g'oyalarini amalga joriy etishga tayyorlash va ularning amaliy faoliyatlarini olib borishlari uchun yo'naltirishdir.

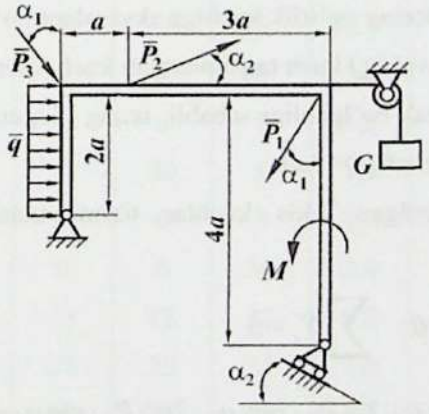
Hisob – grafik ishi A4 (210x297 mm) bichimdagi 20...25 sahifadan iborat hisob tushintiruv yozuvidan iborat bo'ladi.

Hisob tushintiruv yozuvi quyidagi bo'limlardan iborat bo'lishi kerak:

- Titul varag'i (muqova);
- Kirish;
- Mavzularga oid nazariy ma'lumotlar;
- Berilgan topshiriqlarni bajarish tartibi;
- Xulosa;
- Foydalanilgan adabiyotlar.

1-Topshiriq. Ramkaga nisbatan bog'lanish reaksiya kuchlarini aniqlash

Ramkaga ta'sir etuvchi kuch vektorlari ta'siridagi tayanch reaksiya kuchlarini qiymatini toping. Topshiriq namunalari 1.2-jadvalda keltirilgan. Topshiriqni bajarish uchun qiymatlar 1.1-jadvalda ko'rsatilgan.

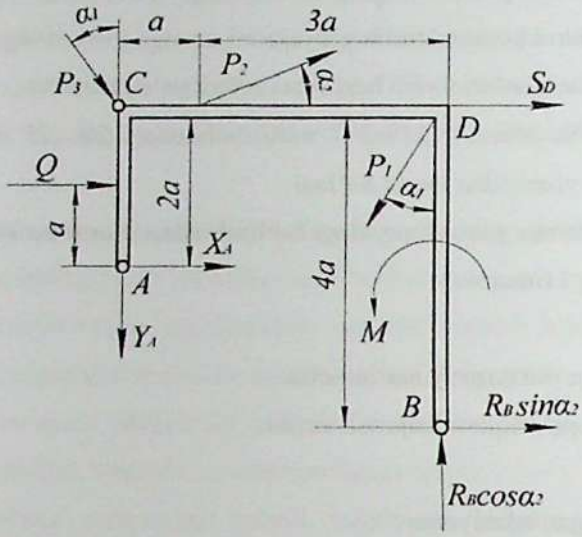


Topshiriqni bajarish uchun namuna

Berilgan: Rasmda ramka namunasi keltirilgan.

G=3kN; P_1=2kN; P_2=0; P_3=5kN; q=8kN/m; M=4kN·m; $\alpha_1=30^0$; $\alpha_2=60^0$; a=1m.

Ramkaga ta'sir etuvchi kuch vektorlari va ularning reaksiyalarini aniqlaymiz.



Hisoblash: X_A va Y_A A sharnirning tekislikdagi noma'lum reaksiyalari, biz ularning qiyamatlarini koordinata o'qlaridagi proeksiyalari bo'yicha aniqlaymiz. R_B B tayanch reaksiyasi va ularni $R_B\cos\alpha_2$ va $R_B\sin\alpha_2$ tayanch tekisligiga perpendikulyar ravishda yo'naltirmaiz. Arqonning taranglik kuchi ramkadan S_D bo'ylab yo'naladi va yukning og'irlik kuchiga ekvivalent bo'ladi. S_D=G=3kN.

Gorizantal ta'sir etuvchi Q kuch taqsimlangan kuch intensivligi q uchastkaning shakli to'g'ri to'rtburchak bo'lganligi sababli, uning dioganallari kesishgan nuqta ya'ni o'rtasiga to'g'ri keladi. $Q=2a\cdot q$

Ramkaga tatbiq etilgan tekis kuchlar tizimi uchun uchta muvozanat tenglamasini tuzamiz.

$$\sum M_A=0; \quad \sum X_i=0; \quad \sum Y_i=0.$$

$$\sum M_A=-Q\cdot a-P_3\cdot \sin\alpha_1\cdot 2a-P_2\cdot \cos\alpha_2\cdot 2a+P_2\cdot \sin\alpha_2\cdot a-S_D\cdot 2a+P_1\cdot \sin\alpha_1\cdot 2a-$$

$-P_1 \cdot \cos\alpha_1 \cdot 4a + M + R_B \cdot \sin\alpha_2 \cdot 2a + R_B \cdot \cos\alpha_2 \cdot 4a = 0;$

$\sum X_i = X_A + Q + P_3 \cdot \sin\alpha_1 + P_2 \cdot \cos\alpha_2 + S_D - P_1 \cdot \sin\alpha_1 + R_B \cdot \sin\alpha_2 = 0;$

$\sum Y_i = -Y_A - P_3 \cdot \cos\alpha_1 + P_2 \cdot \sin\alpha_2 - P_1 \cdot \cos\alpha_1 + R_B \cdot \cos\alpha_2 = 0.$

$R_B = 7,483\ kN$

$X_A - 26,98\ kN$

$Y_A = 0,4185\ kN$

Hisoblashlarning to'g'riligini tekshirish uchun ixtiyoriy tanlangan nuqta uchun muvozanat tenglamasini tuzamiz.

$\sum M_C = Q \cdot a + X_A \cdot 2a + P_2 \cdot \sin\alpha_2 \cdot a - P_1 \cdot \cos\alpha_1 \cdot 4a + M + R_B \cdot \sin\alpha_2 \cdot 4a + R_B \cdot \cos\alpha_2 \cdot 4a = 0;$

$\sum M_C = 0$

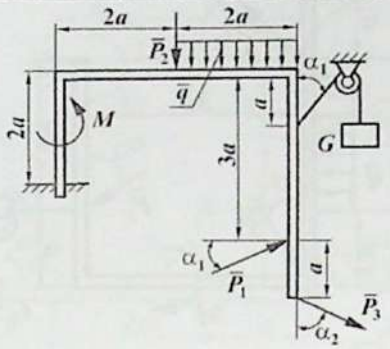
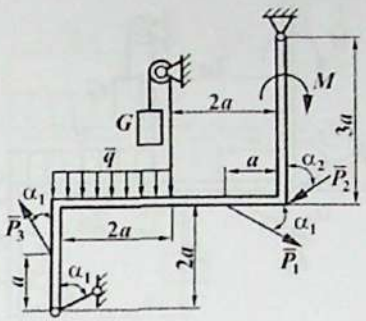
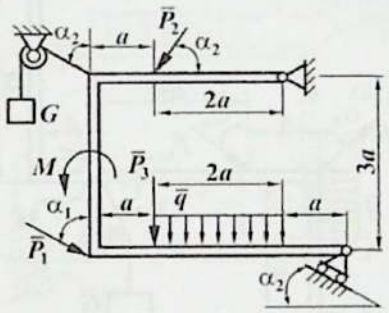
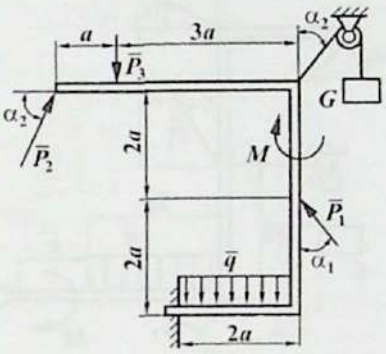
Mustaqil bajarish uchun topshiriqlar

1.1 – jadval

№	M	P_1	P_2	P_3	G	q	α_1	α_2	a
	kN·m	*kN*	*kN*	*kN*	*kN*	*kN/m*	*gradus*	*gradus*	*m*
1	4	0	5	9	10	0,5	45	60	0,5
2	2	6	0	10	12	1,2	30	45	1,0
3	3	4	12	0	14	2,0	60	30	1,2
4	6	0	8	15	6	2,2	45	45	0,8
5	10	16	0	20	8	3,0	30	60	1,0
6	12	8	20	0	1	1,6	60	45	1,2
7	16	0	0	20	5	1,8	45	45	1,4
8	8	20	6	6	9	1,5	30	30	1,4
9	4	0	0	0	30	2,4	60	30	1,2
10	6	20	23	12	22	0,8	30	45	1,8
11	2	6	24	25	25	1,0	45	60	3,0
12	3	0	21	23	24	1,3	60	60	3,4

13	5	25	22	12	23	1,8	45	45	3,0
14	6	24	24	16	18	2,0	30	45	2,0
15	8	0	21	18	5	2,5	45	30	2,4
16	12	23	12	20	7	3,0	45	60	0,8
17	13	22	14	21	12	1,7	30	60	0,5
18	14	12	17	26	16	1,9	60	30	1,2
19	2	16	19	23	18	1,7	60	45	3,1
20	15	18	20	15	20	0,8	45	45	2,5
21	17	25	0	16	22	0,6	30	45	3,0
22	18	27	23	0	14	1,4	45	30	2,3
23	21	22	24	12	18	1,8	60	30	2,0
24	12	24	25	17	12	1,4	45	45	3,0
25	14	18	28	18	29	0,8	45	60	0,7
26	16	15	29	25	25	1,6	30	60	0,9
27	18	12	25	20	23	1,5	30	60	1,4
28	14	14	23	22	18	3,0	60	45	1,8
29	12	16	15	0	8	2,7	60	45	1,6
30	18	17	16	12	10	3,0	45	30	2,0

1.2 – jadval

1 – topshiriq	2 – topshiriq
	
3 – topshiriq	**4 – topshiriq**
	
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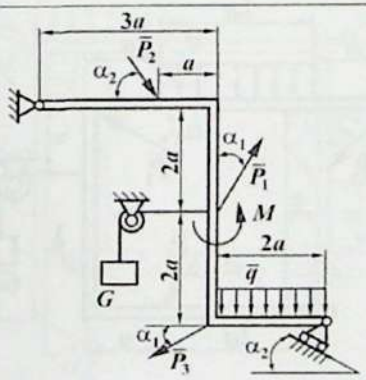	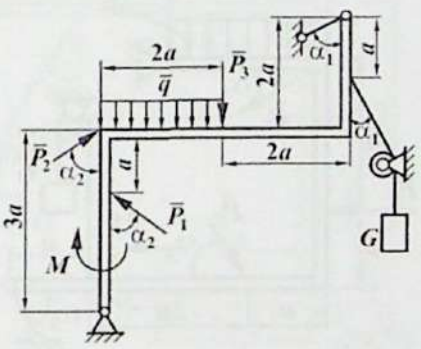

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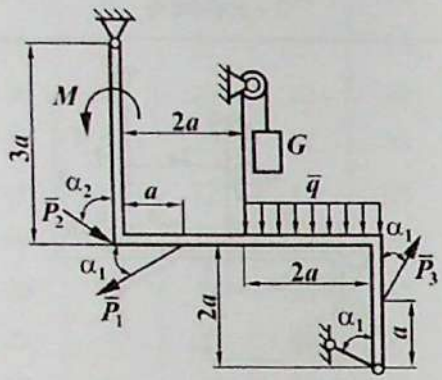	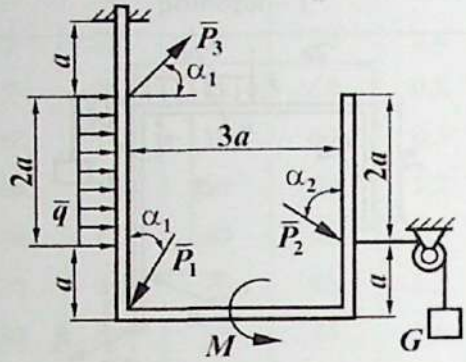
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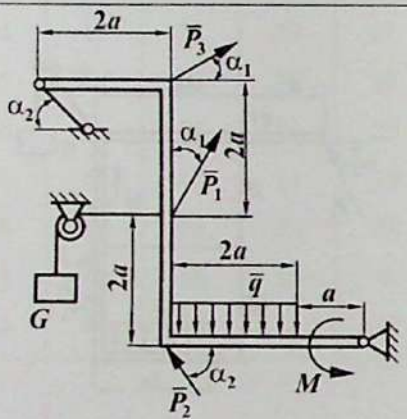	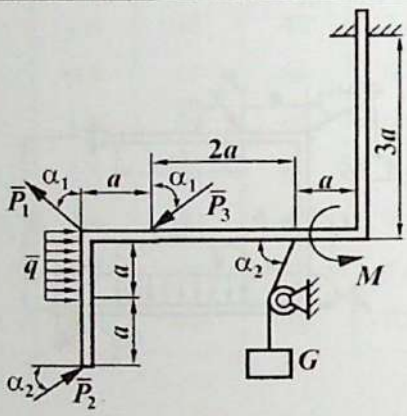
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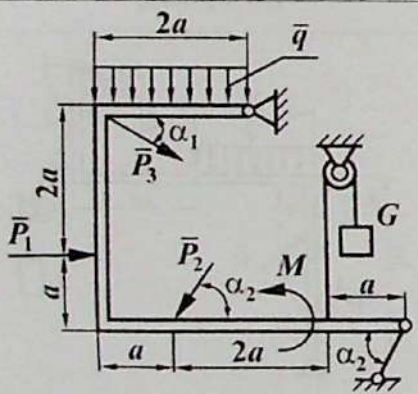	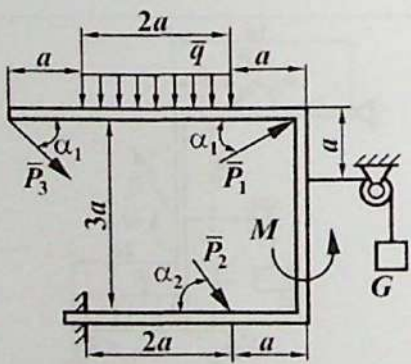

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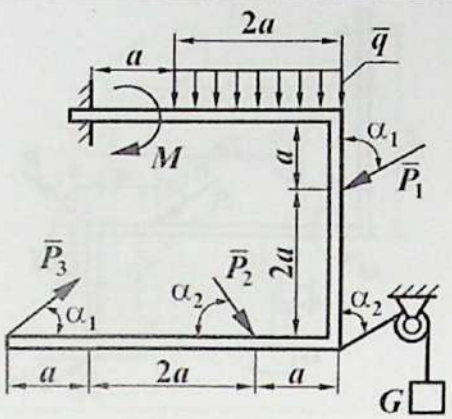	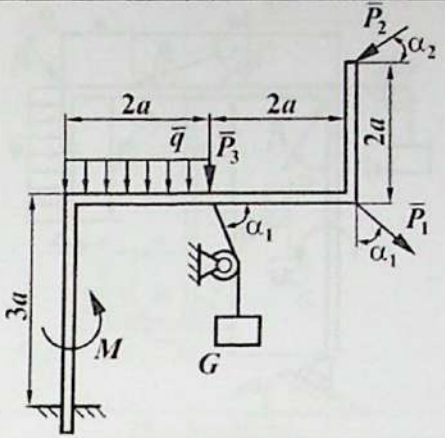
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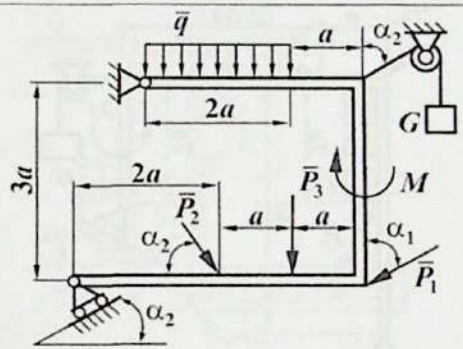	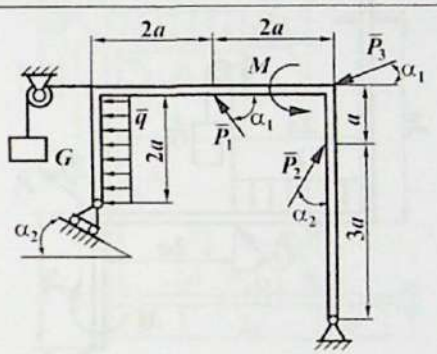
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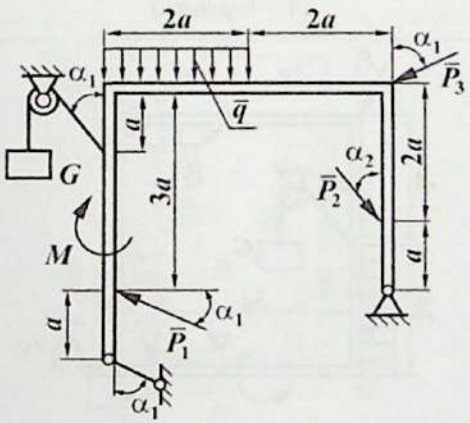	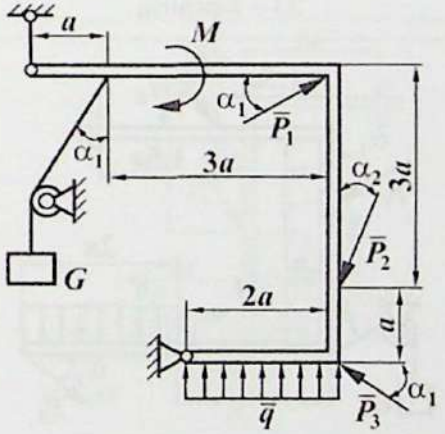

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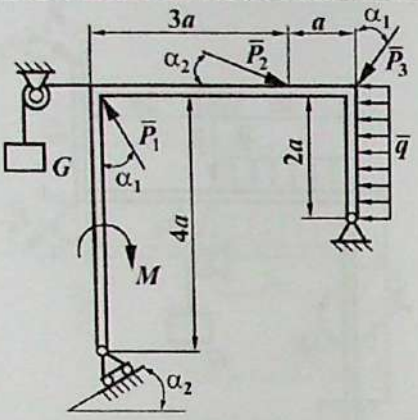	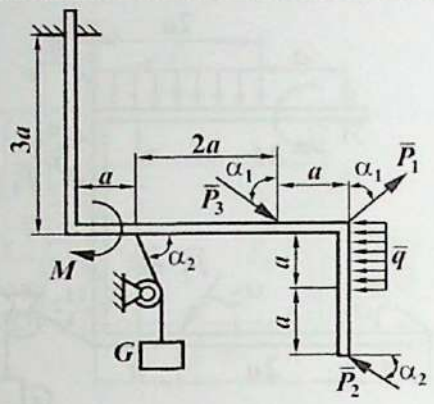
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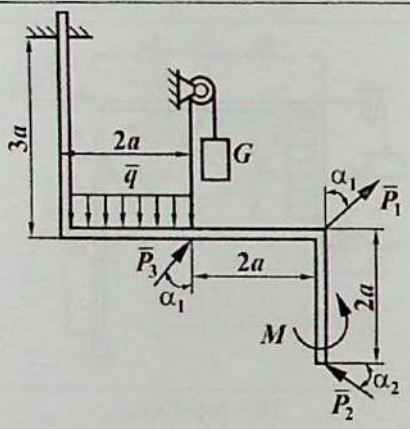	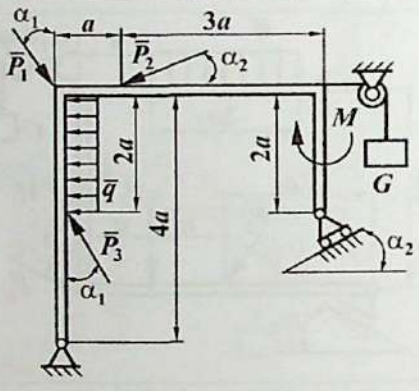
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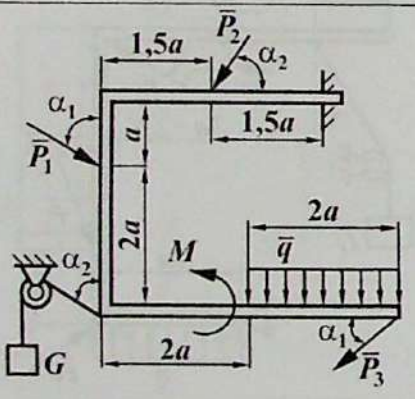
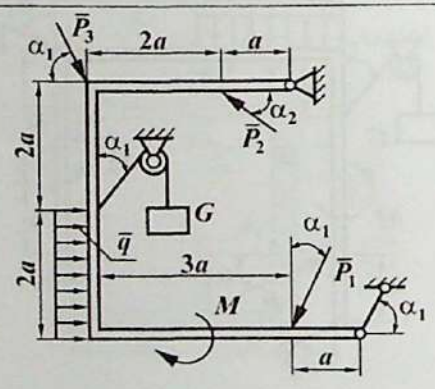
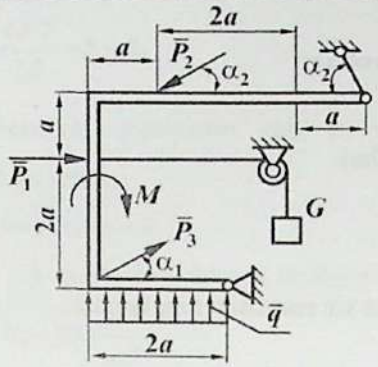
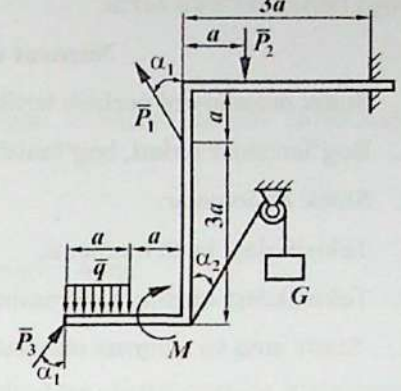
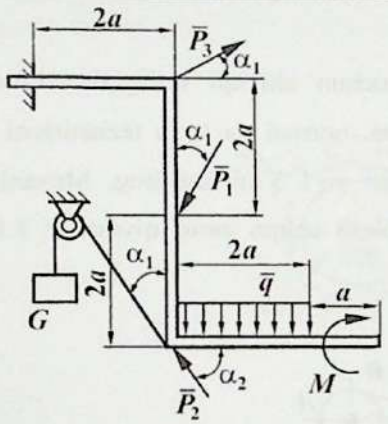
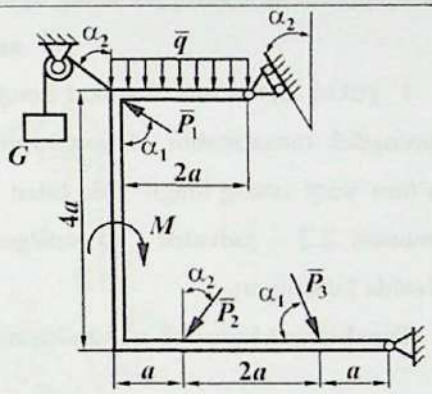
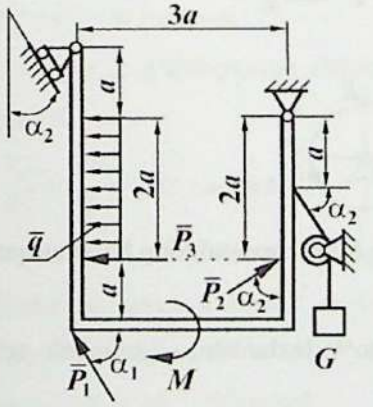
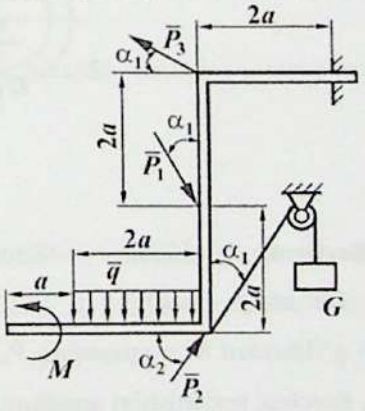
	

25 – topshiriq	26 – topshiriq
	
27 – topshiriq	28 – topshiriq
	
29 – topshiriq	30 – topshiriq
	

Bajarilgan ishni himoya qilish bilan, talaba nazorat savollariga javob berishga tayyor bo'lishi kerak.

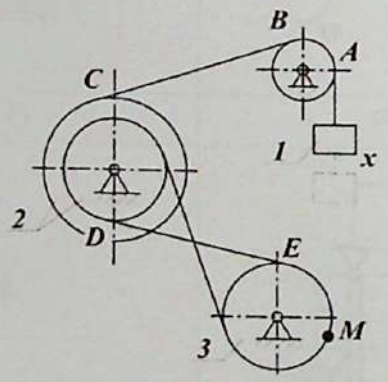
Nazorat uchun savollar:

1. Statik masalalarni yechish tartibi.
2. Bog'lanishlar turlari, bog'lanish reaksiyalari.
3. Statik aksiomalar.
4. Tekislikdagi kuch momenti.
5. Tekislikdagi kuchlar sistemasining teng ta'sir etuvchisi tenglamasi.
6. Statik aniq va aniqmas masalalar.

2 – Topshiriq. Qattiq jismning aylanma harakatidagi tezlik va tezlanishini aniqlash

1 yukni noma'lum harakat tenglamasi uchun chiziqli tezligini aniqlang, shuningdek mexanizmni M nuqtasining urinma, normal va to'la tezlanishini va ma'lum vaqt oralig'idagii yuk bilan yuradigan yo'l S ni aniqlang. Mexanizm namunasi 2.2 – jadvalda ko'rsatilgan. Hisoblash uchun zarur qiymatlar 2.1 – jadvalda keltirilgan.

Topshiriqni bajarish uchun namuna.



Berilgan: $R_2=50\ sm;\ r_2=40\ sm;\ R_3=20\ sm;\ S=45\ sm;$ yukning harakat qonuni $x=5+10t^2$ sm (t – vaqt).

3 g'ildirakni M nuqtasining V_M tezligi, a_M to'la tezlanishi, ω_3 burchak tezligi va ε_3 burchak tezlanishini aniqlang.

Hisoblash. $x=x(t)=5+10t^2=45$ sm,

$$t=\sqrt{\frac{45-5}{10}}=2\ sek.$$

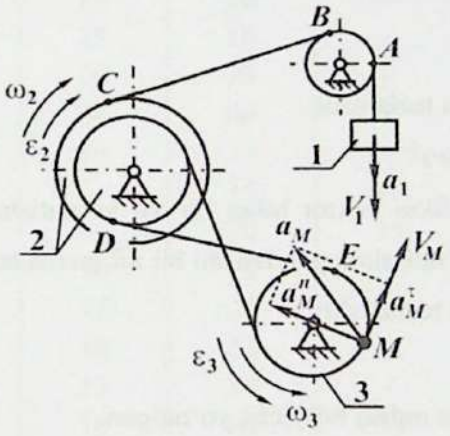
Harakat qonunidan vaqt bo'yicha olingan birinchi darajali differensiyali tezlikka teng.

$V_1=\dot{x}=20t\ sm/sek$

A nuqtaning chiziqli tezligi yukning tezligiga teng.

$$V_A=V_1=20\ t\frac{sm}{sek}.$$

C nuqtada bog'lanishda bo'lgan 2 g'ildiraklar chetki qismida joylashgan A va B nuqta yordamchi birlikka ulanadi, uning chiziqli tezligi B nuqta tezligiga teng.



$V_A=V_C=V_B=20\ t\ sm/sek$

C nuqta 2 g'ildirakning chiziqli tezligi va burchak tezligi ω_2 quyidagicha aniqlanadi:

$$\omega_2=\frac{V_C}{R_2}=\frac{20t}{50}=0,4t\cdot\ rad/sek$$

D nuqtasi 2 g'ildirakka tegishli va kichikroq radiusda joylashgan. 2 g'ildirakning burchak tezligi ω_2 berilgan bo'yicha D nuqtaning chiziqli tezligi quyidagicha aniqlanadi:

$V_D=\omega_2\cdot r_2=0,4t\cdot 40=16t\cdot sm/sek$

Moslanuvchan bog‘lanish yordamida 3 g‘ildiraklarda joylashgan E nuqta 2 g‘ildirakka ulanadi, shuning uchun uning chiziqli tezligi D nuqtasi tezligiga teng.

$V_E=V_D=16t\cdot sm/sek$

Shuning uchun M va E nuqtalarning joylashuvi bir xil aylanada yotadi.

$V_E=V_D=16t\cdot sm/sek$

Tezlik vektori 3 g‘ildirakning aylanish yo‘nalishi bo‘yicha radiusga perpendikulyar ravishda yo‘nalgan.

M nuqta 3 g‘ildirakning chiziqli tezligi va burchak tezligi ω_3 quyidagicha aniqlanadi:

$$\omega_3=\frac{V_M}{R_3}=\frac{16t}{20}=0,8\ t\ rad/sek$$

3 g‘ildirakning burchak tezligi ω_3, bilan burchak tezlanishi ε_3 quyidagicha aniqlanadi:

$\varepsilon_3=\dot{\omega}_3=0,8\ rad/sek$

M nuqtaning urunma tezlanishi:

$a_M^\tau=\varepsilon_3\cdot R_3=0,8\cdot 20=16\ sm/s^2$

Urunma vektori tezlikni vektor bilan bir xil yo‘nalishga ega, chunki ko‘rib chiqilayotgan misolda g‘ildirakning aylanishi bir xil tarzda tezlashadi.

M nuqtaning normal tezlanishi:

$a_M^n=\omega_3^2\cdot R_3=20\ \omega_3^2\ sm/s^2$

3 g‘ildirak markaziga radius bo‘yicha yo‘nalgan.

M nuqtaning to‘la tezlanishi quyidagicha aniqlanadi:

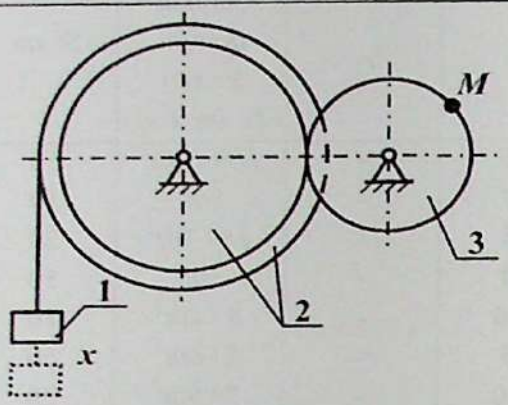
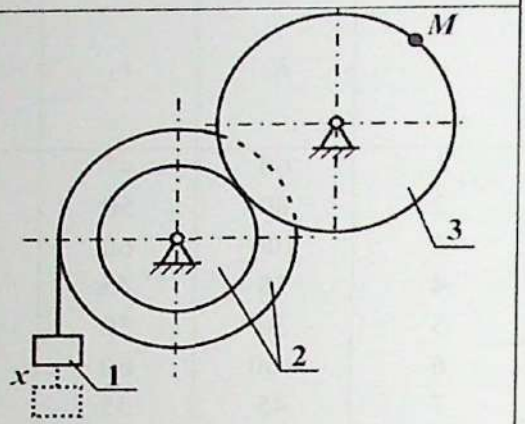
$$a_M=\sqrt{(a_M^n)^2+(a_M^\tau)^2}$$

V_M	Tezlanish sm/s^2			ω_3	ε_3
	a_M^n	a_M^τ	a_M		
32	51,2	16	53,64	1,6	0,8

2.1 – jadval

	Radius, *sm*				Yukning harakat qonuni $x=x(t)$ *(x-sm, t-s)*	S, *sm*
	R_2	r_2	R_3	r_3		
1	60	45	36	-	$10+100t^2$	50
2	80	50	60	-	$80t^2$	10
3	100	60	75	-	$18+70t^2$	20
4	58	45	60	-	$50t^2$	50
5	30	20	100	-	$8+40t^2$	10
6	100	60	15	-	$5+60t^2$	50
7	45	35	110	-	$7+90t^2$	20
8	90	20	10	-	$4+30t^2$	50
9	120	100	30	-	$3+80t^2$	20
10	100	80	20	-	$70t^2$	40
11	40	25	10	-	$5+40t^2$	30
12	50	30	20	-	$2+50t^2$	10
13	30	20	60	-	$60t^2$	40
14	25	10	15	-	$6+20t^2$	10
15	15	-	15	10	$8+40t^2$	30
16	30	-	20	15	$3+40^2$	40
17	40	30	70	-	$80t^2$	60
18	30	15	20	-	$4+20t^2$	30
19	15	10	50	-	$5+80t^2$	20
20	25	15	30	-	$50t^2$	30
21	20	10	50	30	$4+90t^2$	50
22	40	20	30	15	$10+40t^2$	50
23	30	20	15	10	$7+40t$	60
24	10	30	40	-	$90t^2$	20
25	50	20	32	-	$20+50t$	50
26	32	16	40	16	$5+60t^2$	10
27	40	18	30	10	$6+30t^2$	30
28	50	25	60	15	$50t^2$	40
29	25	20	30	60	$33+30t^2$	60
30	30	15	22	-	$5+60t^2$	20

2.2 – jadval

1 – topshiriq	2 – topshiriq
	
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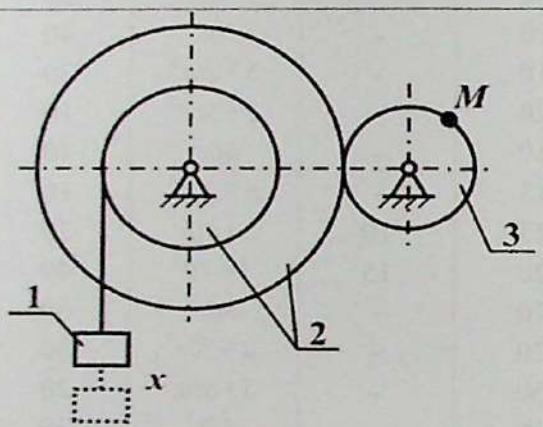	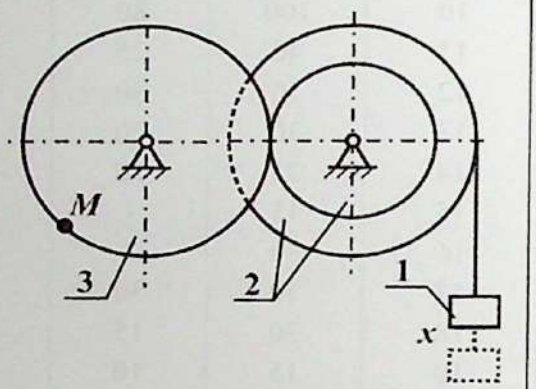
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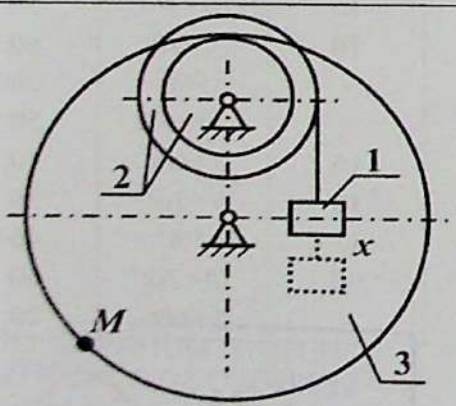	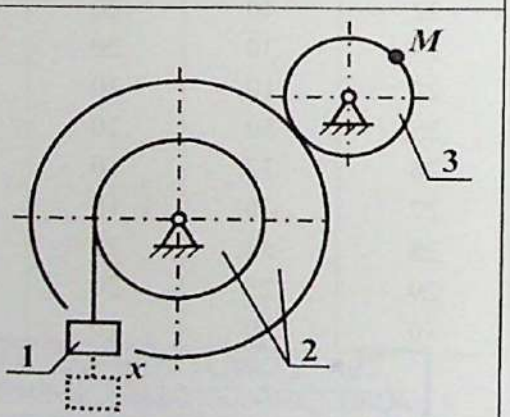

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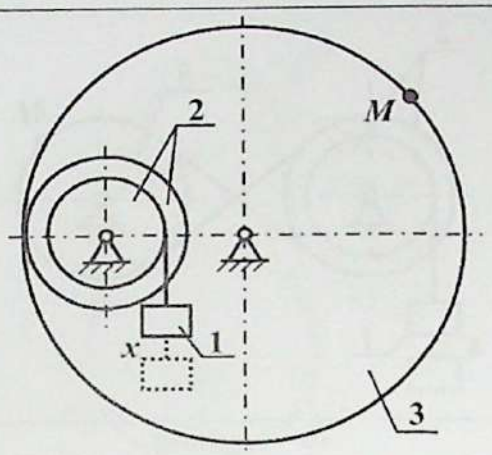	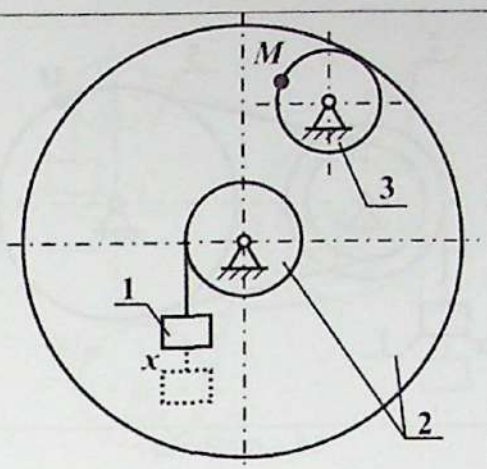
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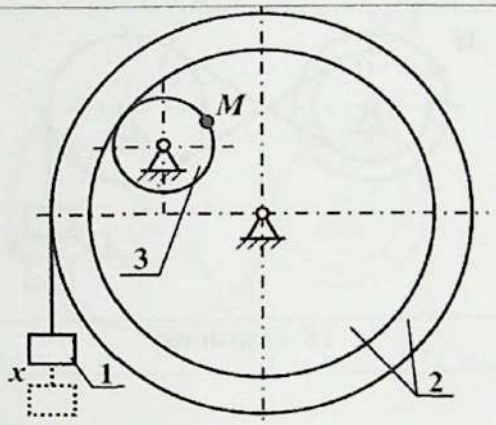	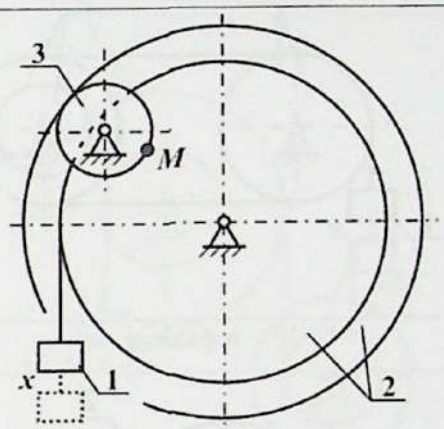
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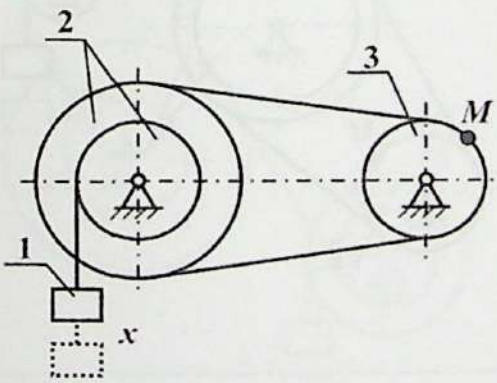	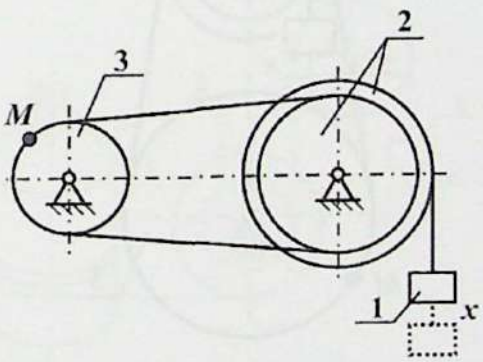

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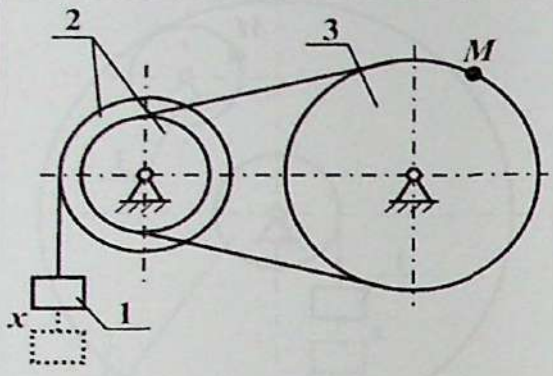	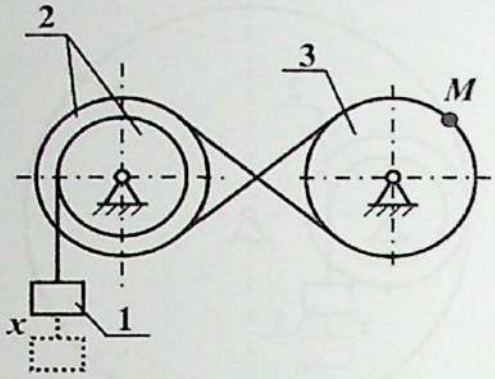
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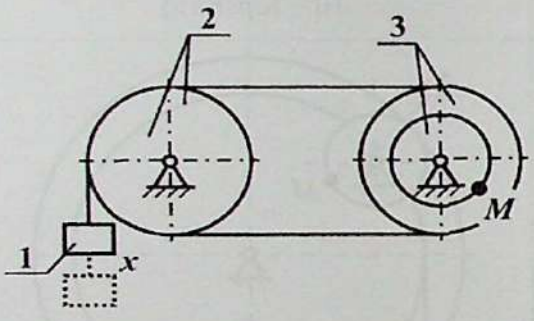	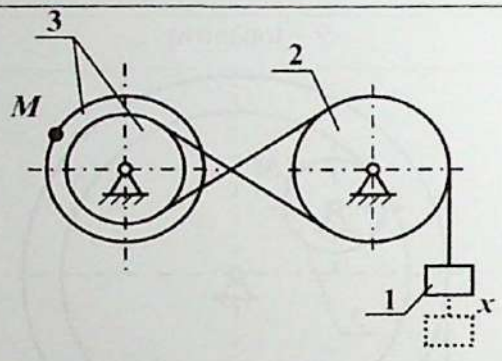
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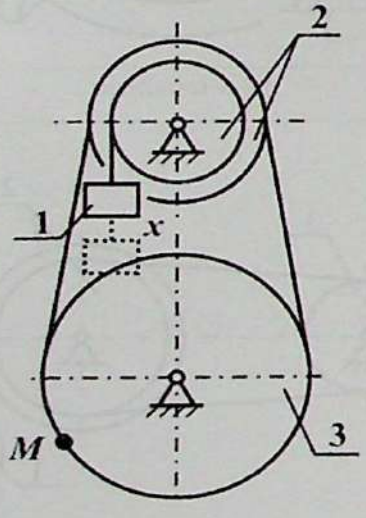	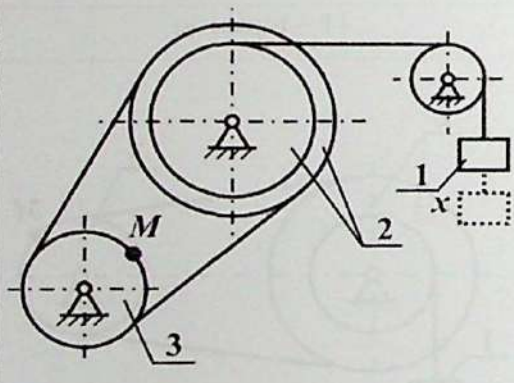

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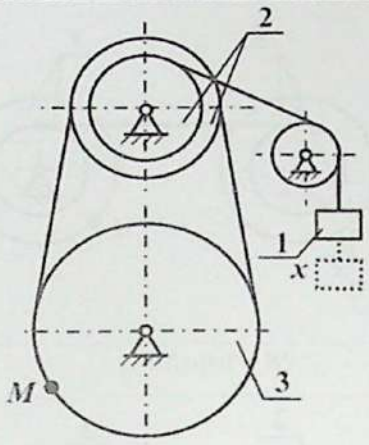	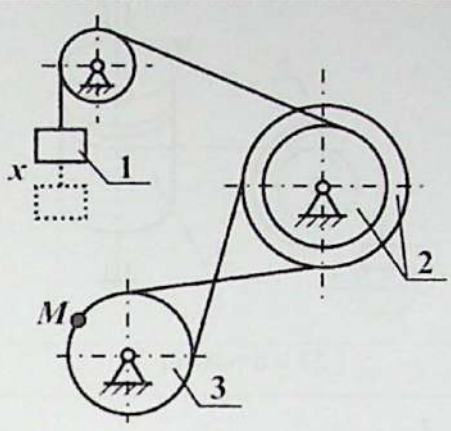
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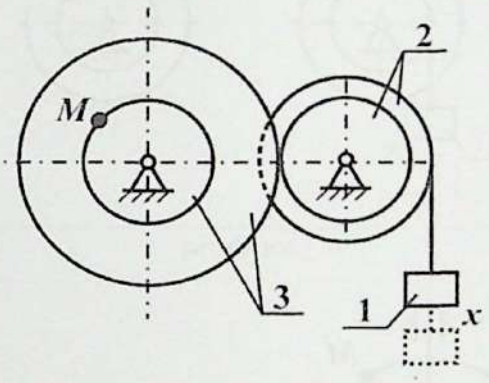	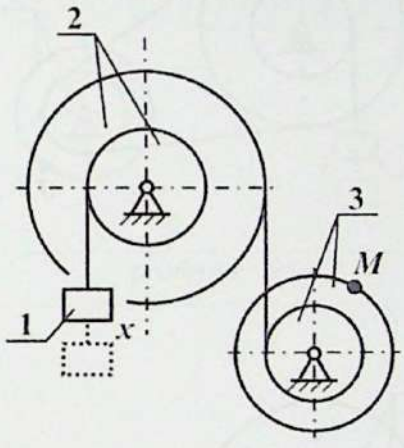
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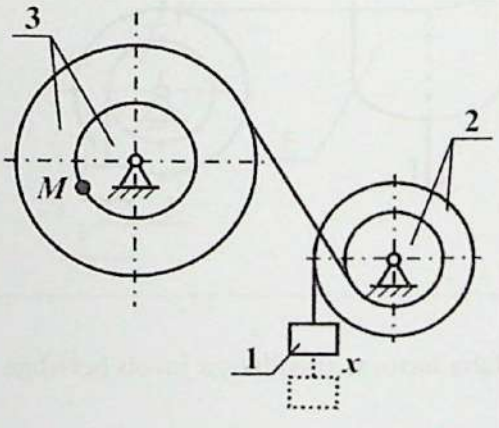	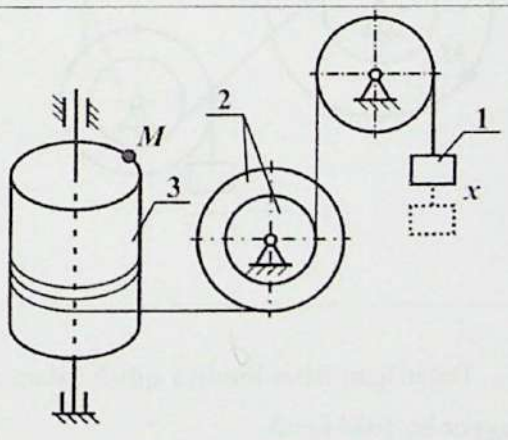

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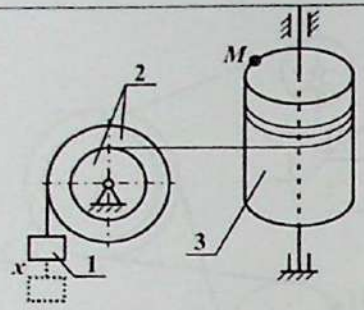
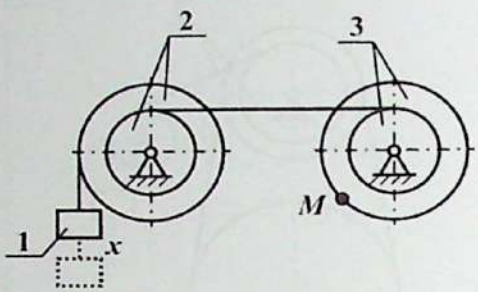
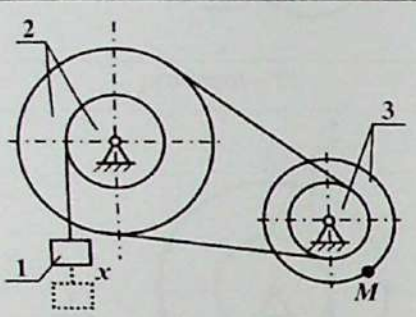
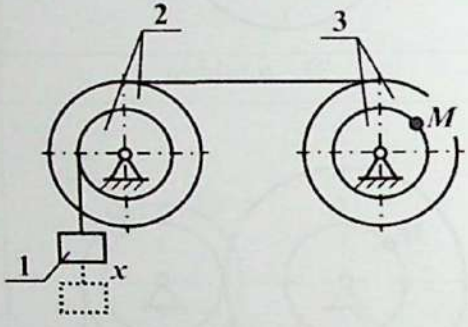
	
27 – topshiriq	28 – topshiriq
	
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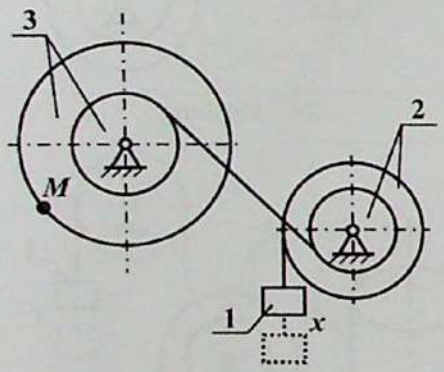
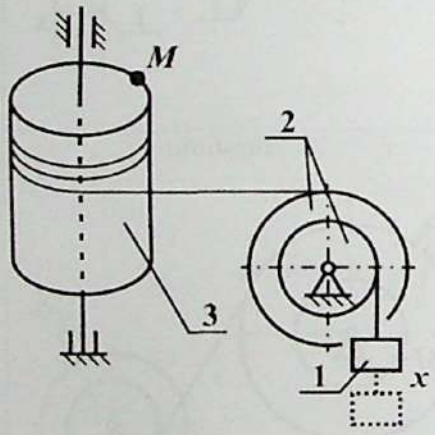
	

Bajarilgan ishni himoya qilish bilan, talaba nazorat savollariga javob berishga tayyor bo‘lishi kerak.

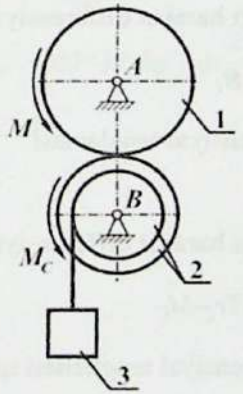
Nazorat uchun savollar:

1. Nuqta harakatining berilish usullari.
2. Qattiq jismning qo'zg'almas o'q atrofidagi aylanma harakati.
3. Qattiq jismning parallel harakati.
4. Qattiq jismning murakkab harakati.
5. Qattiq jismning qo'zg'almas o'q atrofidagi aylanma harakatida burchak tezligi va burchak tezlanishi.

3 – Topshiriq. Kuch ta'siridagi qattiq jismning aylanma va ilgarilanma harakatini aniqlash

G'ildiraklarning massalari m_1 va m_2 ga teng. Yuk massasi esa m_3=400 kg bo'lsa, katta va kichik g'ildiraklarning radiuslari R_1, r_1, R_2, r_2 ga teng. Ipning taranglik kuchini aniqlang. Mexanizm namunasi 4.2 – jadvalda ko'rsatilgan. Hisoblash uchun zarur qiymatlar 4.1 – jadvalda keltirilgan.

Ishni bajarish uchun namuna: 1 va 2 g'ildirak va 3 yuk mexanik tizimni tashkil etadi. 1 g'ildirakka $M=M(t)$ juft kuch momenti bilan $P=P(t)$ kuch ta'sir etadi. $t_o=0$ dan t vaqtda 1 g'ildirakning burchak tezligi ω_{10} ga teng. Mc moment 2 g'ildirakning aylanishiga qarshilik qiladi.



Berilgan:

m_1=100 kg; m_2=150 kg; m_3=400 kg; M=4200+200t N·m; Mc=2000 N·m; R_1=60 sm; R_2=40 sm; r_2=20 sm; $\rho_1=20\sqrt{2}$ sm; ρ_2=30 sm; t=1 sek

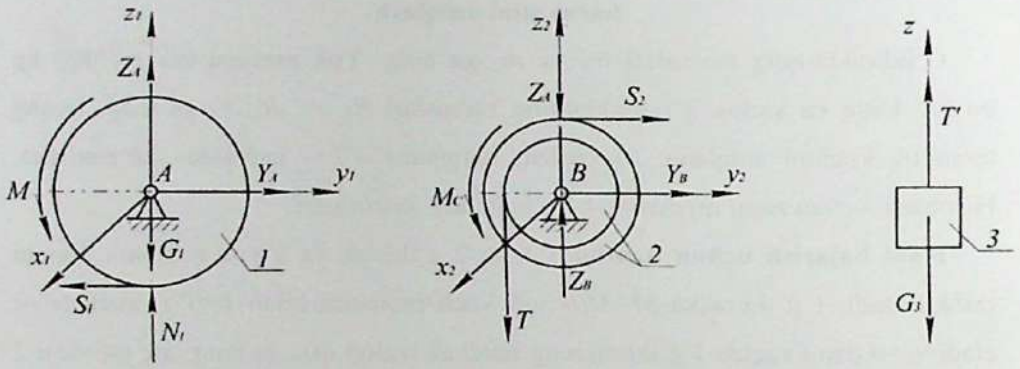
1 g'ildirakning aylanma harakat tenglamasi $\varphi_2=f(t)$ ga teng.

Yechish:

Mexanizmni alohida qismlarga ajratamiz. 1 g'ildirakning og'irlik kuchi G_1, momenti M, tayanch reaksiya kuchlari Y_A, Z_A, harakatlantiruvchi kuch S_1 va 2 g'ildirakning ta'sir normal reaksiya kuchi N_1 ga teng.

Mexanizmni alohida qismlarga ajratamiz. 2 g'ildirakning og'irlik kuchi G_2, momenti M, tayanch reaksiya kuchlari Y_A, Z_A, harakatlantiruvchi kuch S_2 va 1 g'ildirakning ta'sir normal reaksiya kuchi N_2 ga teng.

Ipning taranglik kuchi T va 3 yukning og'irlik markazi G ga teng.



$S_2=S_1$, $N_2=N_1$, $T'=T$

G'ildirak 1 ning x_1 o'q atrofidagi harakat differensiyal tenglamasini tuzamiz:

$$J_1\ddot{\varphi}_1=\sum M^e_{kx},\quad \sum M^e_{kx}=M-S_1R_1$$

G'ildirak 1 ning aylanma differensiyal tenglamasi

$$J_1\ddot{\varphi}_1=M-S_1R_1$$

G'ildirak 1 ning x_2 o'q atrofidagi harakat differensiyal tenglamasini tuzamiz:

$$J_2\ddot{\varphi}_2=\sum M^e_{kx},\quad \sum M^e_{kx}=S_2R_2-Tr_2-M_C$$

G'ildirak 1 ning aylanma differensiyal tenglamasi quyidagicha ifodalaniladi:

$$J_2\ddot{\varphi}_2=S_2R_2-Tr_2-M_C$$

Yukning harakat differensiyal tenglamasini tuzamiz:

$$m_3\ddot{z}=\sum F^e_{kz},\quad \sum F^e_{kz}=T'-G_3$$

Yukning ilgarilanma harakat differensiyal tenglamasi

$m_3\ddot{z}=T'-G_3$

$\ddot{\varphi}_1/\ddot{\varphi}_2=R_2/R_1$

$\ddot{z}=\ddot{\varphi}_2 \cdot r_2$

$m_3 \cdot \ddot{\varphi}_2 \cdot r_2=T-m_3 g$

$m_3 \cdot \ddot{\varphi}_2 \cdot r_2+m_3 g=T$

$SR_1=M-J_1\ddot{\varphi}_1$

$SR_2=J_2\ddot{\varphi}_2+Tr_2+M_C$

$J_1=m_1\rho_1^2$

$J_2=m_2\rho_2^2$

$J_1=8kg \cdot m^2$

$J_2=13,5\ kg \cdot m^2$

$M-J_1 \cdot \ddot{\varphi}_1=J_2 \cdot \ddot{\varphi}_2+Tr_2+M_C$

$J_2 \cdot \ddot{\varphi}_2+J_1 \cdot \ddot{\varphi}_1=M-Tr_2-M_C$

$\ddot{\varphi}_1/\ddot{\varphi}_2=R_2/R_1$

$J_2 \cdot (R_2/R_1 \cdot \ddot{\varphi}_2)+J_1 \cdot \ddot{\varphi}_1=M-Tr_2-M_C$

$J_2 \cdot (R_2/R_1 \cdot \ddot{\varphi}_2)+J_1 \cdot \ddot{\varphi}_1=M-(m_3 \cdot \ddot{\varphi}_2 \cdot r_2+m_3 g)r_2-M_C$

$4400-(400 \cdot 0,2 \cdot \ddot{\varphi}_2+400 \cdot 9,81)0,2-2000=13,5\ddot{\varphi}_2+8(\frac{2}{3} \cdot \ddot{\varphi}_2)$

$4400-8\ddot{\varphi}_2-785-2000=13,5\ddot{\varphi}_2+5,5\ddot{\varphi}_2$

$4400-785-2000=27\ddot{\varphi}_2$

$1615=27\ddot{\varphi}_2$

$\ddot{\varphi}_2=60\ rad/s^2$

$m_3 \cdot \ddot{\varphi}_2 \cdot r_2+m_3 g=T$

$400 \cdot 60 \cdot 0,2+400 \cdot 9,81=T$

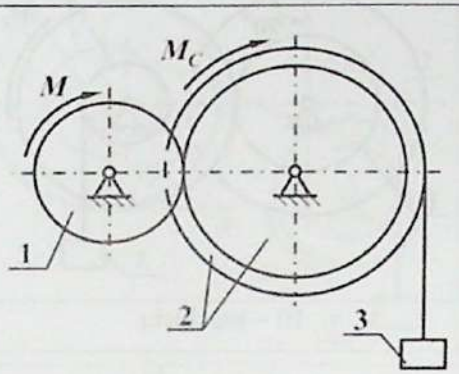
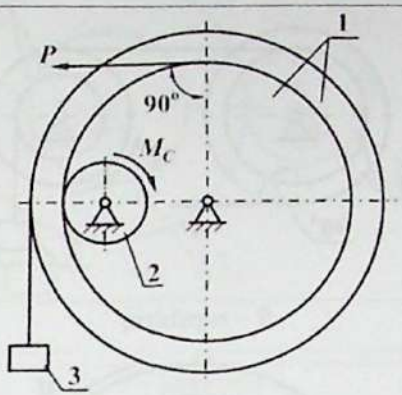
$T=8724\ N$

Mustaqil bajarish uchun topshiriqlar

4.1 – jadval

№	m_1	m_2	R_1	R_2	ρ_1	ρ_2	*M, P*	*Mc*	*t*	Jism
1.	100	300	20	60	-	50	*2100+20t*	1000	2	1
2.	300	80	70	20	60	-	*9800+100t*	600	0,5	2
3.	200	100	60	30	-	25	*6100+20t*	800	2,5	1
4.	100	250	20	50	-	40	*1000+40t*	1400	2	1
5.	150	300	30	50	-	30	*5500+200t*	1500	1	3
6.	400	250	70	30	-	25	*4800+10t*	800	4	1
7.	300	200	60	30	50	20	*3000+10t*	500	3	3
8.	300	250	50	40	40	30	*9700+50t*	500	2	1
9.	200	100	80	20	65	-	*5900+30t*	600	3	2
10.	250	100	40	30	30	-	*2500+50t*	1200	1,5	2
11.	150	300	40	60	30	40	*3900+50t*	1500	2	1
12.	180	100	50	30	40	20	*2700+200t*	400	1	2
13.	150	100	50	60	65	-	*2100+20t*	1000	2	1
14.	300	80	40	20	30	-	*9800+100t*	600	0,5	2
15.	300	180	20	30	30	65	*6100+20t*	800	2,5	1
16.	250	250	60	50	40	30	*1000+40t*	1400	2	1
17.	200	100	50	50	65	30	*5500+200t*	1500	1	3
18.	250	100	20	30	-	-	*4800+10t*	800	4	1
19.	400	150	50	30	65	20	*3000+10t*	500	3	3
20.	200	100	50	40	30	-	*9700+50t*	500	2	1
21.	250	150	50	20	30	30	*5900+30t*	600	3	2
22.	200	100	60	30	40	-	*2500+50t*	1200	1,5	2
23.	100	80	40	60	65	-	*3900+50t*	1500	2	1
24.	150	200	30	30	-	40	*2700+200t*	400	2	1
25.	250	80	60	60	-	-	*2100+20t*	1000	0,5	2
26.	250	200	50	20	65	65	*9800+100t*	600	2,5	1
27.	60	150	50	30	30	30	*6100+20t*	800	2	1
28.	50	200	20	50	-	30	*1000+40t*	1400	1	3

4.2 – jadval

1 – topshiriq	2 – topshiriq
	
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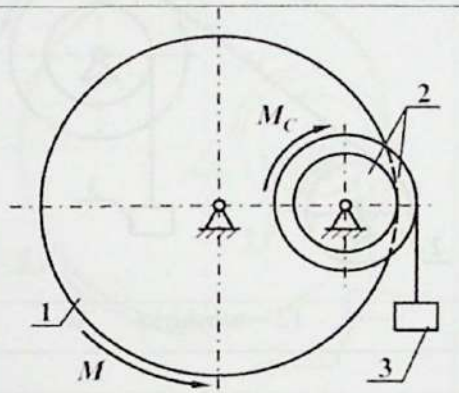	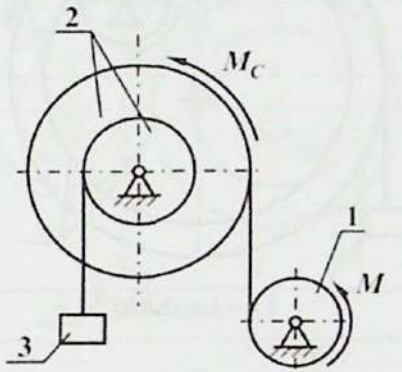
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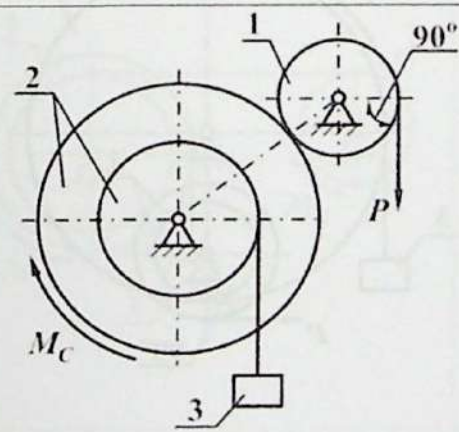	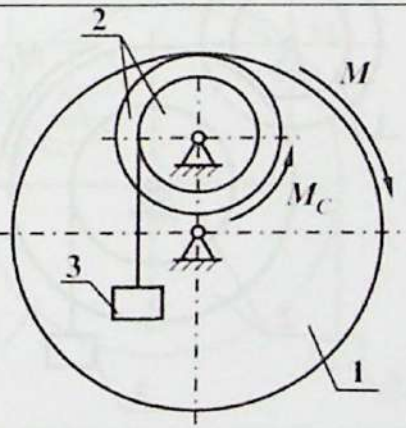

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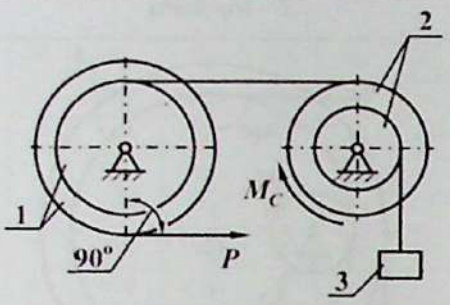	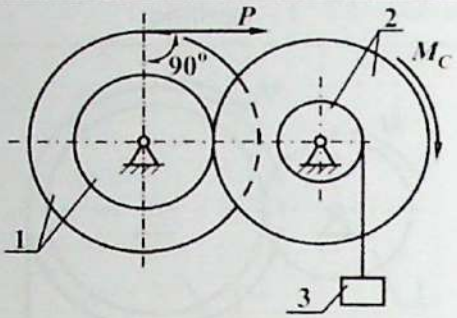
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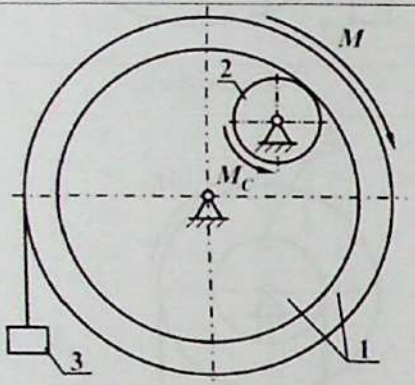	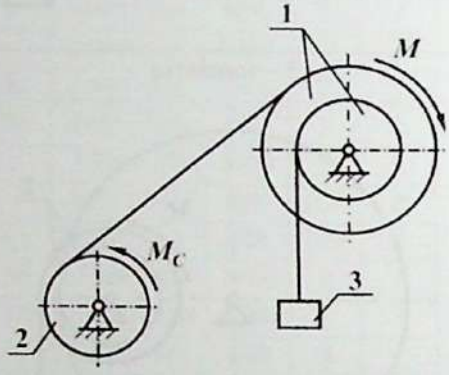
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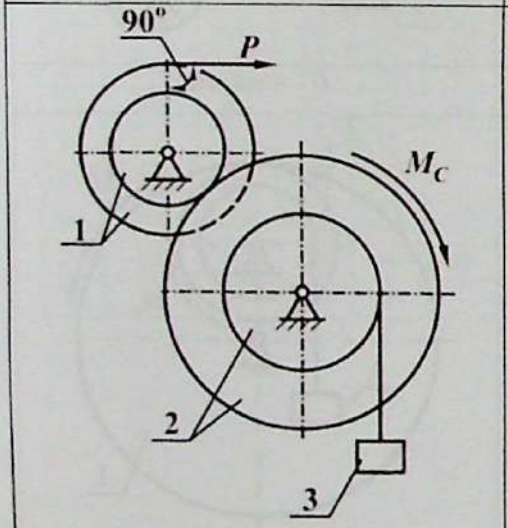	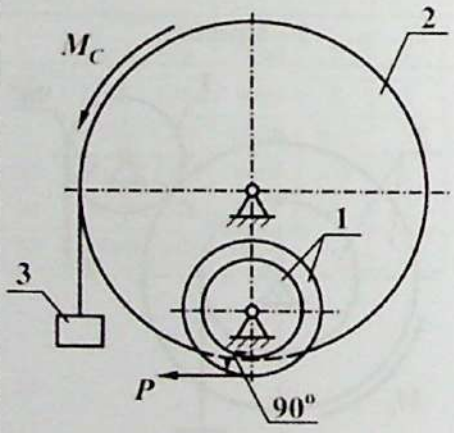

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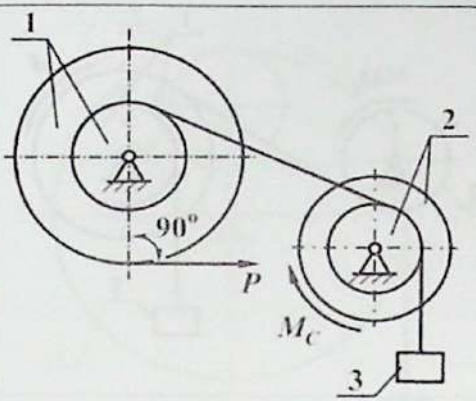
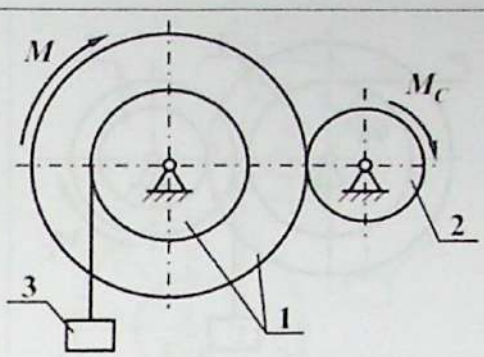


14 – topshiriq



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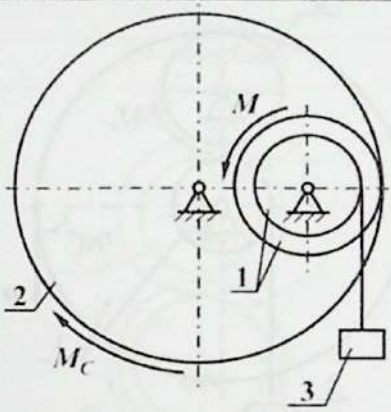
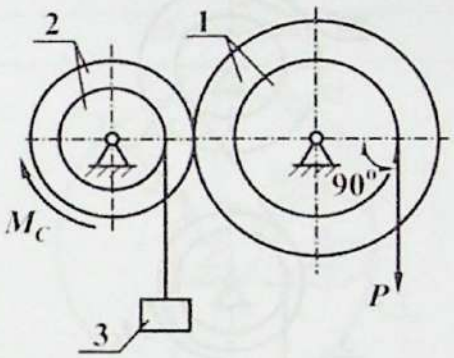


16 – topshiriq



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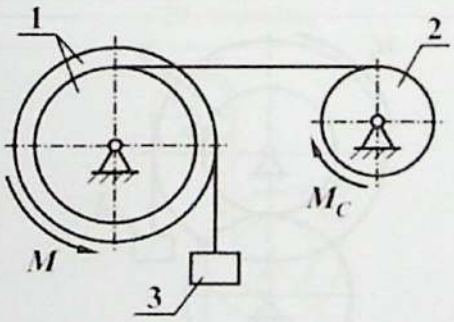

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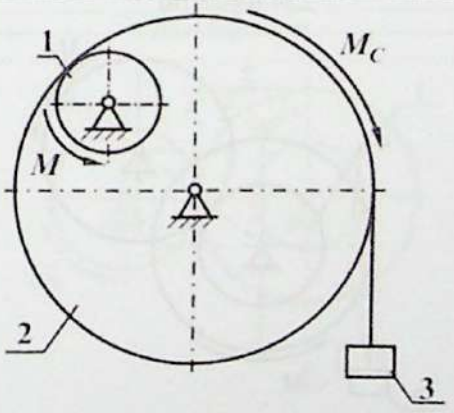

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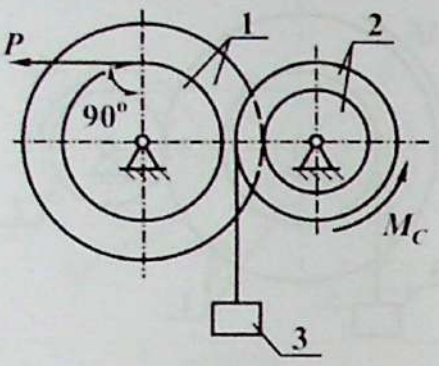	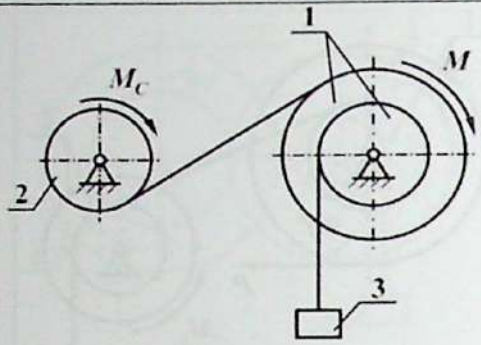
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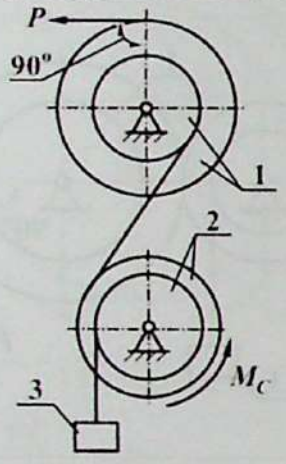	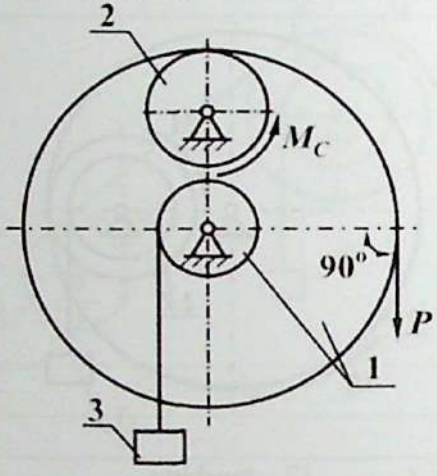
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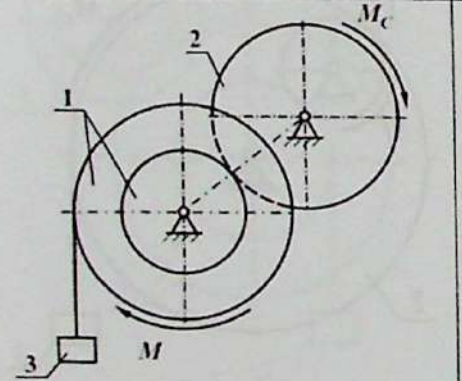	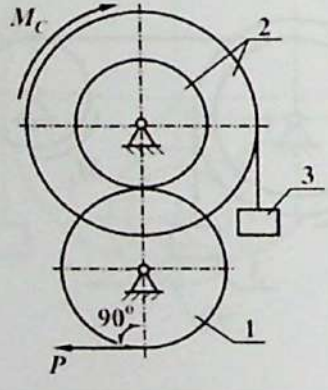

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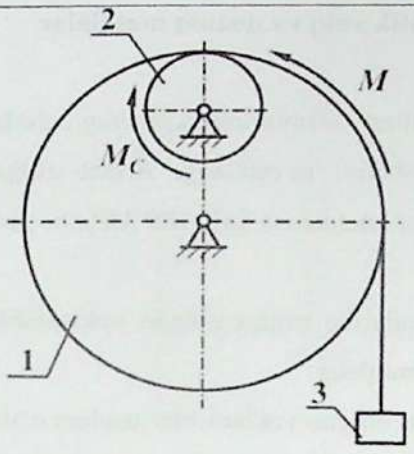	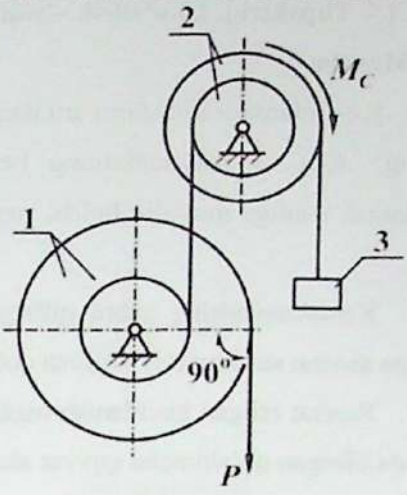
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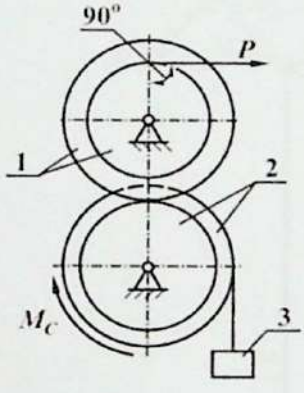	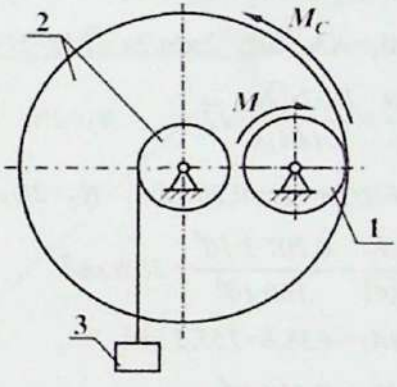
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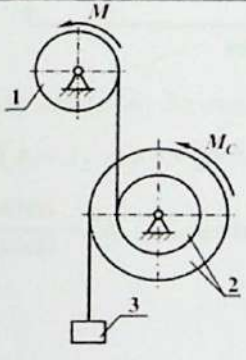
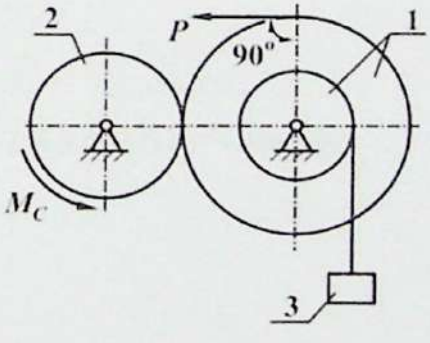
	

II – BOB. MATERIALLAR QARSHILIGI

1 – Topshiriq. Cho'zilish – siqilishda statik aniq va noaniq masalalar

Masala.

1. Kesimlardagi kuchlarni aniqlang va ularning kesimlarini ikkita teng uchidan tanlang, $A_1/A_2=4$ maydonlarning berilgan nisbatini ta'minlang, ruxsat etilgan kuchlanish usuliga muvofiq holda, ruxsat etilgan kuchlanish $[\sigma]=160\ MPa$ bo'lishi kerak.

2. Kesishmalarning qabul qilingan o'lchamlarida ruxsat etilgan yuklanishlar usuliga asosan strukturaviy siljitish qobiliyatini aniqlang.

3. Ruxsat etilgan kuchlanish usulidan ruxsat etilgan yuklanishlar usuliga o'tish vaqtida olingan qo'shimcha quvvat zaxira foizini hisoblang. $F=3000\ kN$ deb olinsin.

Statik tenglamasi: $\sum m_0=0$

$$N_1\cdot 2a+N_2\cdot \cos 45^0\cdot 2a=F\cdot a, \qquad 2N_1+\sqrt{2}N_2=F$$

$$\Delta l_2/\Delta l_1=AA_1/BB_1=2ad\alpha/2a\sqrt{2}d\alpha=1/\sqrt{2}$$

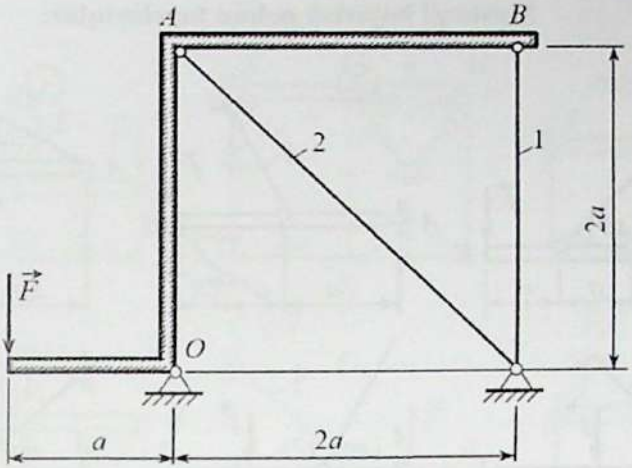
$$\frac{N_1\cdot 2a}{E\cdot A_1}=\frac{N_2\cdot 2\sqrt{2}a}{E\cdot(4A_1)}\cdot\sqrt{2}, \qquad N_2=2N_1$$

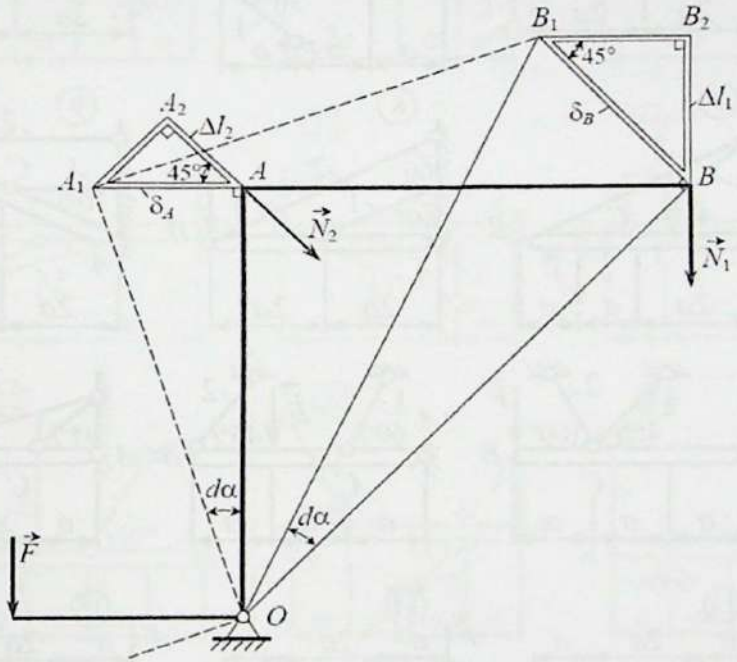
$$N_1=F/2(1+\sqrt{2})=0{,}207\ F; \qquad N_2=2N_1=0{,}414\ F$$

$$A_1=\frac{N_1}{[\sigma]}=\frac{0{,}207\cdot 3\cdot 10^6}{160\cdot 10^6}=38{,}8\ sm^2$$

$$A_2=4A_1=4\cdot 38{,}8=155{,}2\ sm^2$$

$$A_2=\frac{N_1}{[\sigma]}=\frac{0{,}414\cdot 10^6}{16\cdot 10^6}=77{,}6\ sm^2; \qquad A_1=\frac{A_2}{4}=19{,}3\ sm^2$$



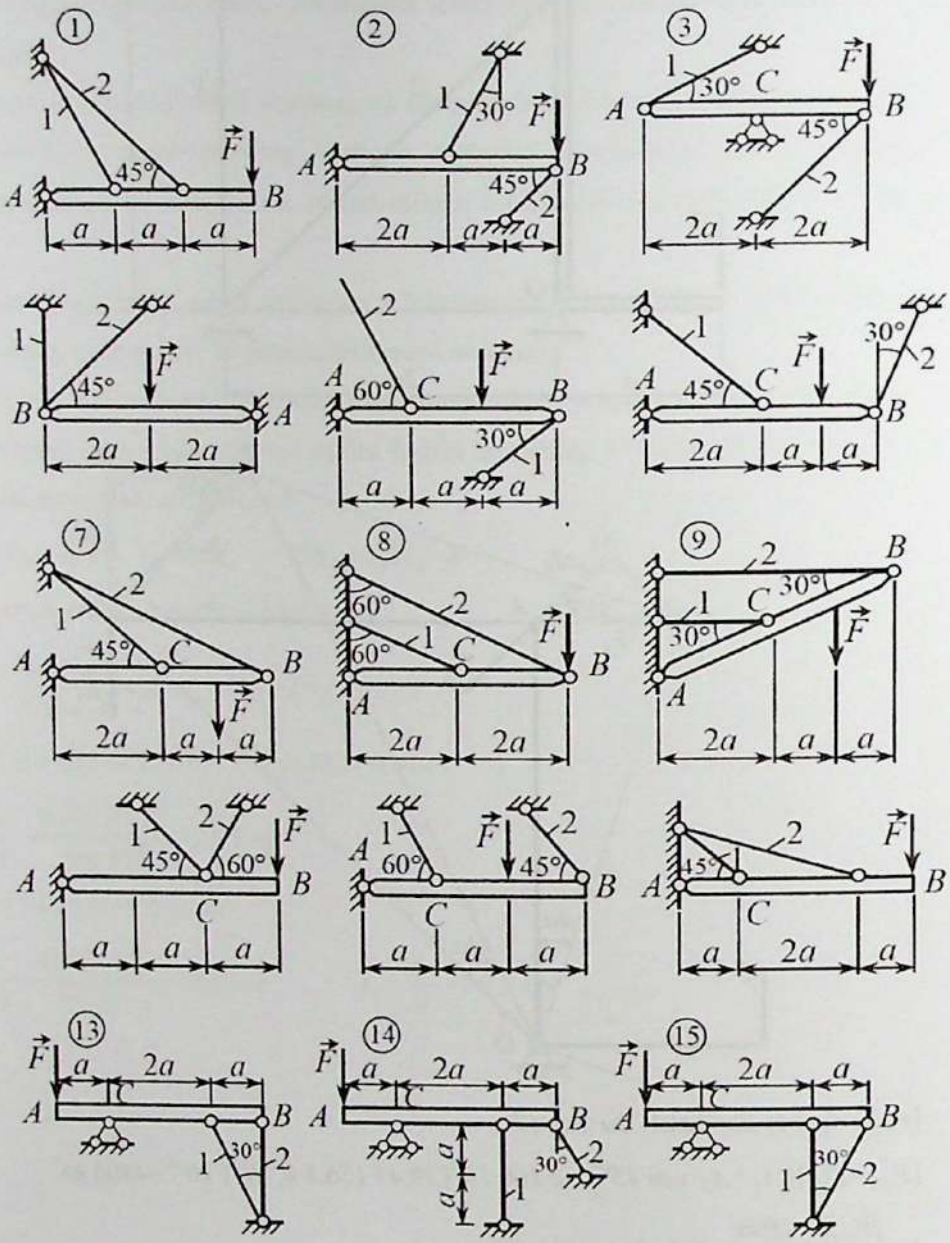


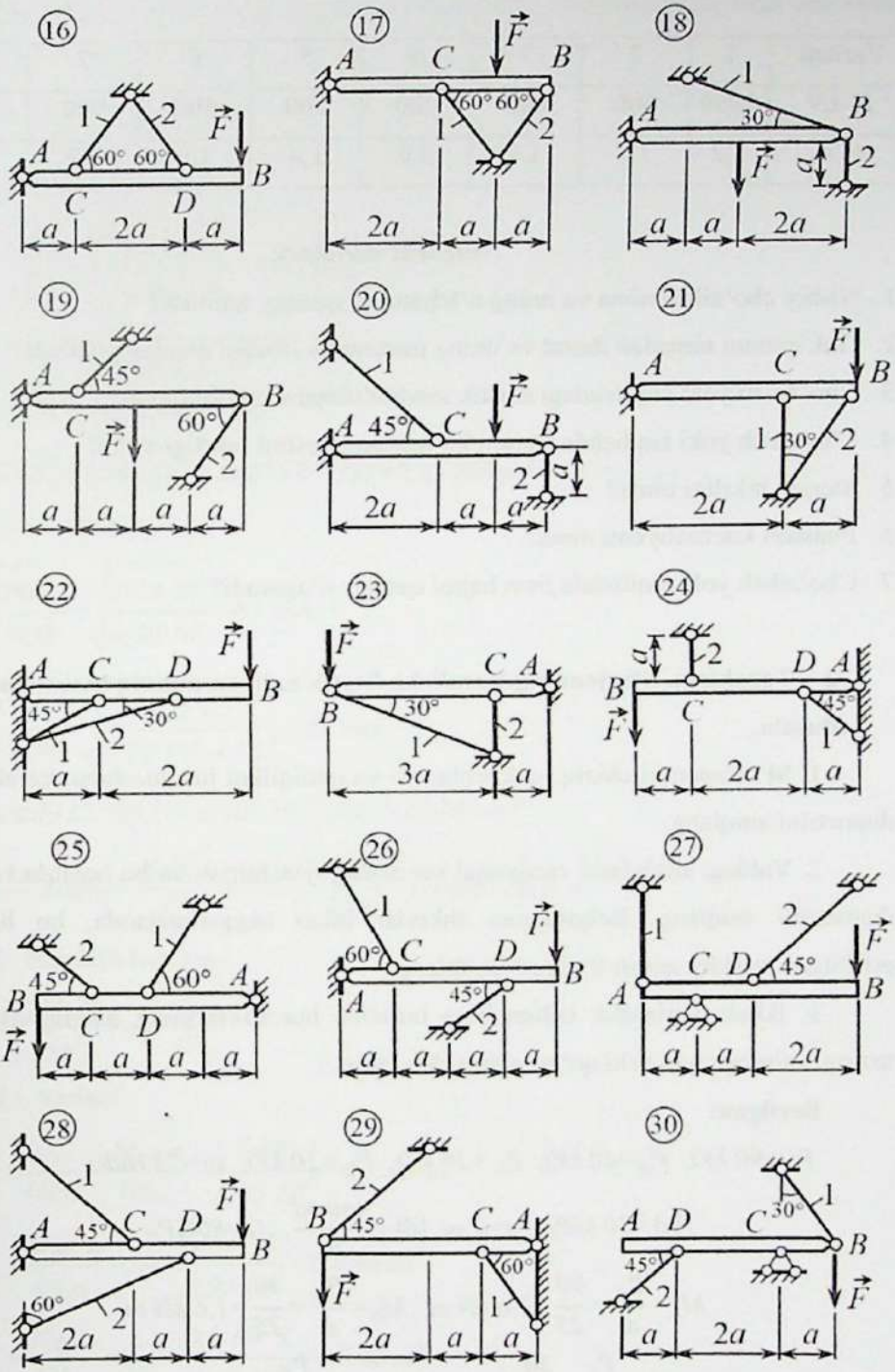
$[F_F]a=[\sigma]A_1\cdot 2a+[\sigma]A_2\cdot 2a\cdot\cos 45^0$,

$[F_F]=2[\sigma]\left(A_1+A_2\cdot\cos 45^0\right)=2\cdot 160\cdot 10^6(39{,}4+156{,}8\cdot 0{,}707)\cdot 10^{-4}=4808\ kN$

$k=\dfrac{[F_F]}{F}=\dfrac{4808}{3000}=1{,}6$ bu yerda 60%

Mustaqil bajarish uchun topshiriqlar:

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1.1 – jadval

Variant	1	2	3	4	5	6	7	8
F, kN	1000	600	800	400	700	500	900	600
A_2/A_1	1,2	1,8	1,5	2,0	1,4	1,6	2,2	1,3

Nazorat savollari:

1. Nisbiy cho'zilish nima va uning o'lchamlari qanday topiladi?
2. Guk qonuni nimadan iborat va uning matematik ifodasi qanday yoziladi?
3. Cho'zilish yoki siqilishdagi elastik moduli nimani xarakterlaydi?
4. Cho'zilish yoki siqilishda sterjen ko'ndalang kesimi bikrligi nima?
5. Sterjen bikrligi nima?
6. Puasson koeffitsiyenti nima?
7. Cho'zilish yoki siqilishda jism hajmi qanday o'zgaradi?

2 – Topshiriq. Sterjenning buralishi. Statik aniq va noaniq masalalar

Masala.

1. M momentni chiziq va kuchlanish va qattiqlikni hisoblashdan kerakli val diametrini aniqlang.

2. Valdagi shkivlarni ratsiyonal ravishda joylashtirish va bu holatda valning diametrini aniqlang. Belgilangan shkivlar bilan taqqoslanganda, bu holatda erishilgan moddiy tejash foyizini hisoblang.

3. Ikkala variantlar uchun ham buralish burchaklarining diagrammalarini tuzing, valning chap uchi qo'zg'almas deb oling.

Berilgan:

$P_A=90\ kVt,\ P_B=40\ kVt,\ P_C=30\ kVt,\ P_D=20\ kVt,\ \omega=25\ rad/s,$

$$[\tau]=30\ MPa,\ a=1\ m,\ [\theta]=\frac{4mrad}{m},\ G=80GPa$$

$$M_A=\frac{P_A}{\omega}=\frac{90}{25}=3,6\ kN\cdot m,\ M_B=\frac{P_B}{\omega}=\frac{40}{25}=1,6\ kN\cdot m,$$

$$M_C=\frac{P_C}{\omega}=\frac{30}{25}=1,2\ kN\cdot m,\ M_D=\frac{P_D}{\omega}=0,8\ kN\cdot m$$

Valning sxemasi va M_k momentini hisoblash. Shkivning eng katta burovchi momenti

$$M_K=\frac{P_A}{\omega}=\frac{90}{25}=3,6\ kN\cdot m$$

1 – variant

$$d_{pr}=\sqrt[3]{\frac{16M_k}{\pi[\tau]}}=\sqrt[3]{\frac{16\cdot 3,6\cdot 10^3}{\pi\cdot 80\cdot 10^6}}=100\ mm,$$

$$d_j=\sqrt[4]{\frac{32M_k}{\pi G[\theta]}}=\sqrt[4]{\frac{32\cdot 3,6\cdot 10^3}{\pi\cdot 80\cdot 10^9\cdot 4\cdot 10^{-3}}}=104\ mm$$

$$GI_{p1}=G\pi d_1^4/32=80\cdot 10^9\cdot\pi\cdot 105^4\cdot 10^{-12}/32=0,95\ MH\cdot m^2$$

2 – variant

$$d_{pr}=\sqrt[3]{\frac{16M_k}{\pi[\tau]}}=\sqrt[3]{\frac{16\cdot 2\cdot 10^3}{\pi\cdot 30\cdot 10^6}}=67\ mm,$$

$$d_j=\sqrt[4]{\frac{32M_k}{\pi G[\theta]}}=\sqrt[4]{\frac{32\cdot 2\cdot 10^3}{\pi\cdot 80\cdot 10^9\cdot 4\cdot 10^{-3}}}=89\ mm$$

$$GI_{p2}=G\pi d_2^4/32=80\cdot 10^9\cdot\pi\cdot 90^4\cdot 10^{-12}/32=0,52\ MN\cdot m^2$$

$$\mu=\frac{A_1-A_2}{A_1}\cdot 100\%=\frac{d_1^2-d_2^2}{d_1^2}\cdot 100\%=\frac{105^2-90^2}{105^2}\cdot 100\%=26,5\ \%$$

3. Buralish burchagi

$$\varphi=\varphi_0+\int_0^z\frac{M_k dz}{GI_p}=\varphi_0+\frac{\omega_M}{GI_p}$$

1 – variant

$$\varphi_B=\varphi_A+\frac{\omega_M}{GI_{P1}}=\frac{M_{AB}\cdot a}{GI_{P1}}=\frac{3,6\cdot 10^3\cdot 1}{0,95\cdot 10^6}=3,8\ mrad$$

$$\varphi_C=\varphi_B+\frac{M_{BC}\cdot a}{GI_{P1}}=3,8+\frac{2\cdot 10^3\cdot 1}{0,95\cdot 10^6}=5,9\ mrad$$

$$\varphi_D=\varphi_A+\frac{M_{AC}\cdot a}{GI_{P1}}=5,9+\frac{0,8\cdot 10^3\cdot 1}{0,95\cdot 10^6}=6,7\ mrad$$

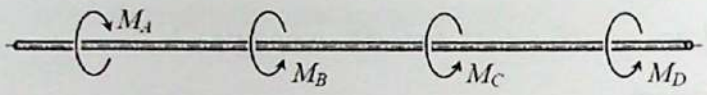
2 – variant

$$\varphi_A=\varphi_B+\frac{M_{BA}\cdot a}{GI_{P2}}=-\frac{1,6\cdot10^3\cdot1}{0,52\cdot10^6}=-3,1\ mrad$$

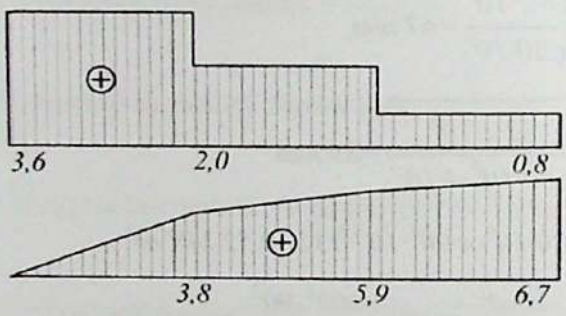
$$\varphi_C=\varphi_A+\frac{M_{AC}\cdot a}{GI_{P2}}=-3,1+\frac{2\cdot10^3\cdot1}{0,52\cdot10^6}=0,8\ mrad$$

$$\varphi_D=\varphi_C+\frac{M_{CD}\cdot a}{GI_{P2}}=0,8+\frac{0,8\cdot10^3\cdot1}{0,52\cdot10^6}=2,3\ mrad$$

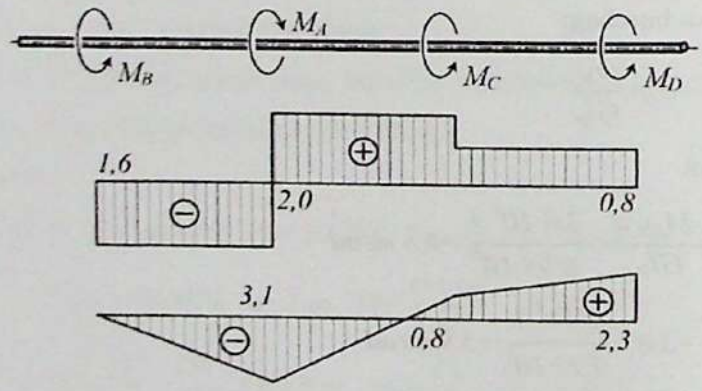
$P_A=90\ kVt,\ P_B=40\ kVt,\ P_C=30\ kVt,\ P_D=20\ kVt$



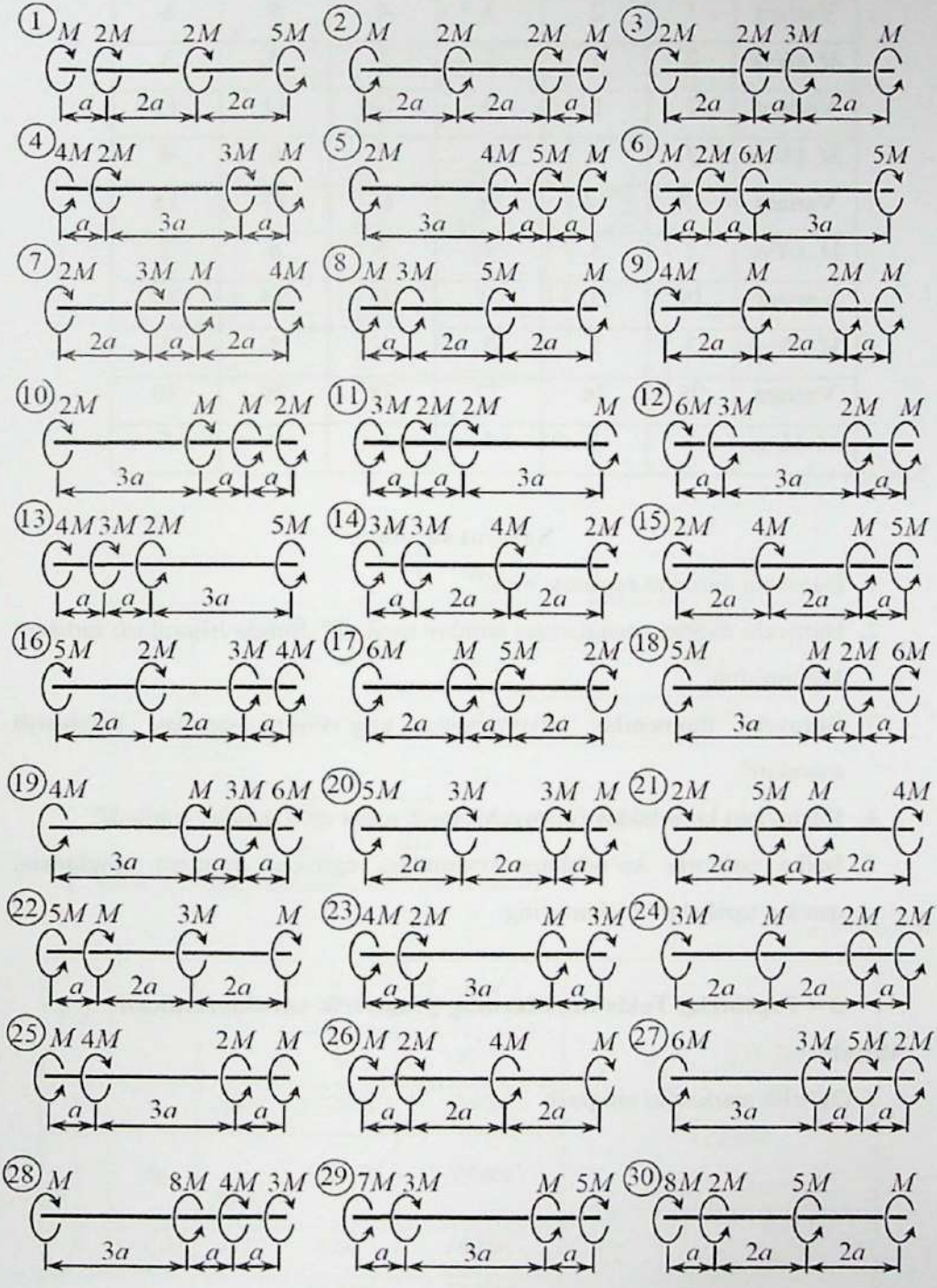
1 – variant



2 – variant



Mustaqil bajarish uchun topshiriqlar:



4.3–jadval

Variant	1	2	3	4	5	6
M, kN·m	2	1	3	5	4	3
Variant	7	8	9	10	11	12
M, kN·m	3	4	2	4	6	4
Variant	13	14	15	16	17	18
M, kN·m	3	5	7	5	6	2
Variant	19	20	21	22	23	24
M, kN·m	3	5	6	8	5	3
Variant	25	26	27	28	29	30
M, kN·m	1	3	4	6	3	5

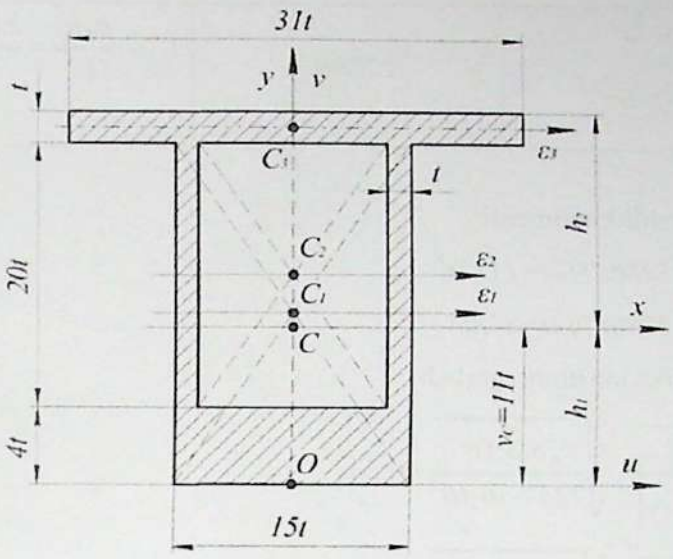
Nazorat savollar:

1. Burovchi moment epyurasi nima?
2. Burovchi moment tenglamasi qanday tuziladi? Bunda ishoralash tartibini tushuntiring.
3. Burovchi momentlar epyurasining to‘g‘riligini qanday tekshirish mumkin?
4. Kesimdagi ko‘ndalang (kesuvchi) kuch nima va u qanday topiladi?
5. Balka ixtiyoriy ko‘ndalang kesimidagi eguvchi moment tenglamasi qanday tuzilishini tushuntiring.

3 – Topshiriq. Tekis shakllarning geometrik xarakteristikasi

Masala.

1. Og‘irlik markazini aniqlash



3.1 - jadval

№	v_i	A_i	v_iA_i
1	12t	$360t^2$	$4320t^3$
2	14t	$-260t^2$	$-3640t^3$
3	24,5t	$31t^2$	$760t^3$
$\sum$		$131t^2$	$1440t^3$

$$v_C=\sum v_iA_i/\sum A_i=1440t^3/131t^2=11t$$

2. Asosiy o'qqa nisbatan inersiya momenti

3.2 - jadval

T/R	y_i	A_i	$I_x=\sum(I_\varepsilon+y_i^2A_i)$	
			I_x	$y_i^2A_i$
1	t	$360t^2$	$17280t^4$	$360t^4$
2	3t	$-260t^2$	$-866,7t^4$	$-2340t^4$
3	13,5t	$31t^2$	$2,6t^4$	$5650t^4$
			$8616t^4$	$3670t^4$

$y_i=v_i-v_c$

$$I_{\varepsilon 1}=\frac{b_1h_1^3}{12}=\frac{15t(24t)^3}{12}=$$

$$=17280t^4$$

$$I_{\varepsilon 2}=-\frac{b_2h_2^3}{12}=\frac{13t(20t)^3}{12}=$$

$$=-8666,7t^4$$

Σ	$12286t^4$	$I_{c3}=-\frac{b_3h_3^3}{12}=\frac{31t(t)^3}{12}=2,6t^4$

3. Qarshilik momenti

$W_1=I_x/h_1=12286t^4/11t=1117t^3$

$W_2=I_x/h_2=12286t^4/14t=878t^3$

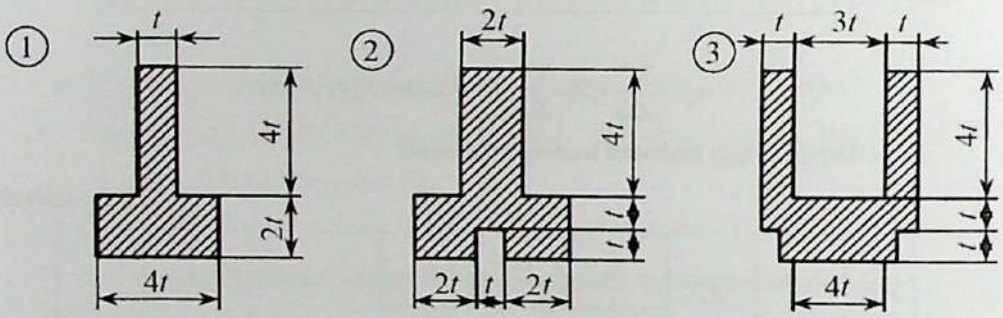
4. Balka kesimini ajratish

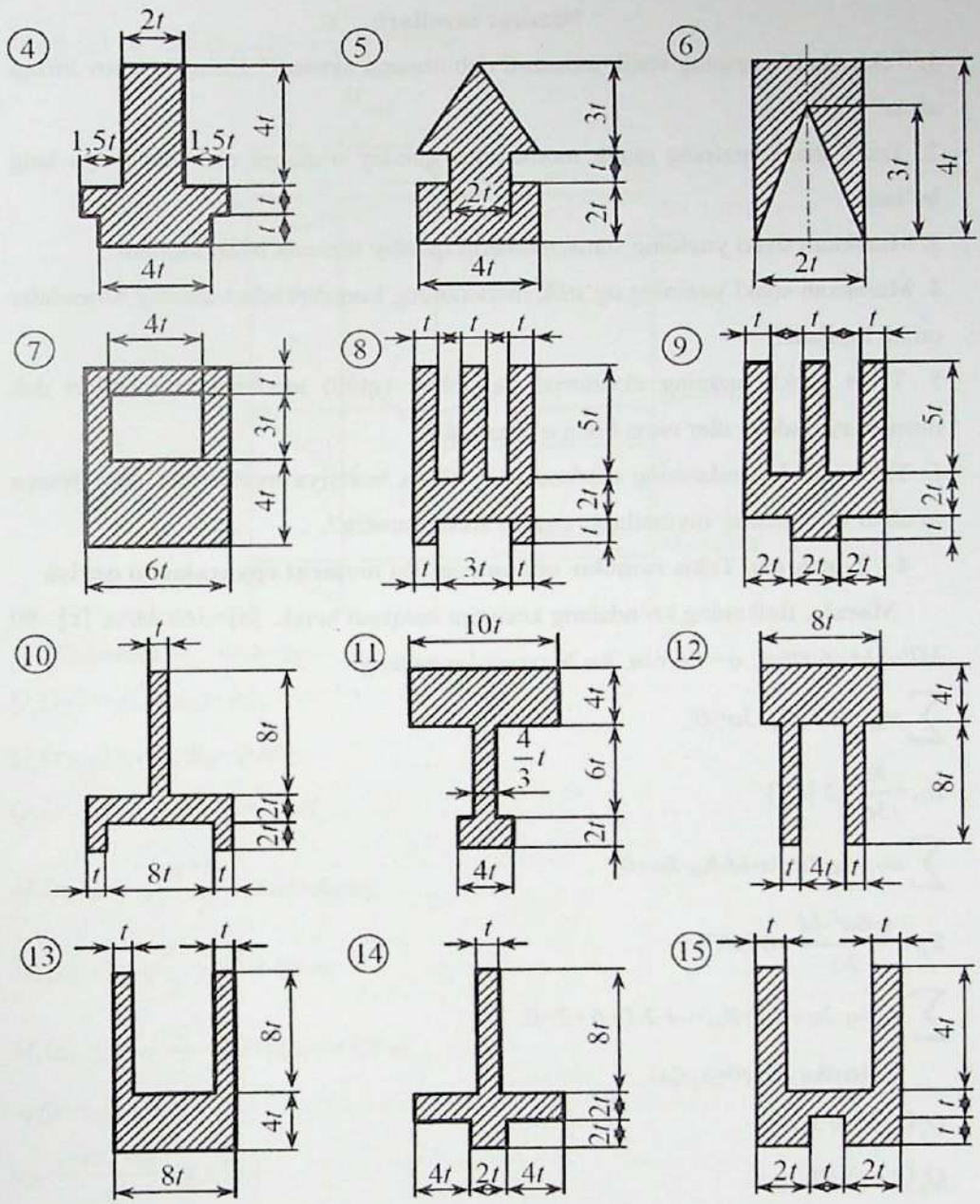
$$t_{siq}\geq\sqrt[3]{\frac{M_{siq}}{117[\sigma_{siq}]}}=\sqrt[3]{\frac{28,8\cdot10^3}{1117\cdot50\cdot10^6}}=8\ mm$$

$$t_{siq}\geq\sqrt[3]{\frac{M_{siq}}{878[\sigma_{siq}]}}=\sqrt[3]{\frac{28,8\cdot10^3}{878\cdot120\cdot10^6}}=6,5\ mm$$

$$\sigma_{max}=\frac{M_B}{W_2}=\frac{2qa^2}{W_2}=\frac{2\cdot18\cdot0,8^2\cdot10^3}{878\cdot8^3\cdot10^{-9}}=51,3\ MPa$$

Mustaqil bajarish uchun topshiriqlar:

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Nazorat savollari:

1. Tekis shakl yuzining statik momenti deb nimaga aytiladi? Uning o'lchov birligi nima?
2. Tekis shakl yuzining statik momentlari qanday o'qlarga nisbatan nolga teng bo'ladi?
3. Murakkab shakl yuzining statik momenti qanday formula bilan topiladi?
4. Murakkab shakl yuzining og'irlik markazining koordinatalari qanday formulalar orqali topiladi?
5. Tekis shakl yuzining ekvatorial va polyar (qutb) inertsiya momentlari deb nimaga aytiladi va ular nima bilan o'lchanadi?
6. Tekis shakl yuzalarining markazdan qochma inertsiya momentlari deb nimaga aytiladi va u qanday qiymatlarga ega bo'lishi mumkin?

4 – Topshiriq. Tekis ramalar uchun eguvchi moment epyuralarini qurish

Masala. Balkaning ko'ndalang kesimini aniqlash kerak. $[\sigma]=160\ MPa$, $[\tau]=80\ MPa$, $M=6\ kN\cdot m$, $q=4\ kN/m$, $h=2b$ va $a=1m$ ga teng.

$$\sum m_B = -M+R_D\cdot 3a=0;$$

$$R_D=\frac{M}{3a}=2\ [kN].$$

$$\sum m_D = q\cdot 2a\cdot 3a-M-R_B\cdot 3a=0;$$

$$R_B=\frac{q\cdot 6a^2-M}{3a}=6\ [kN].$$

$$\sum Y = -q\cdot 2a+R_B+R_D=-4\cdot 2\cdot 1+6+2=0.$$

Uchastka AB $(0\le x_1\le a)$:

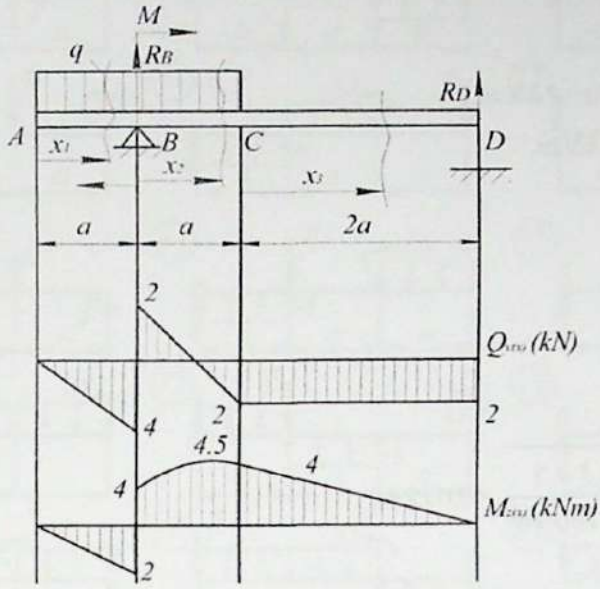
$$Q_y(x_1)=-q\cdot x_1;$$

$$Q_y(x_{1\ 0})=0;$$

$$Q_y(x_{1\ 0})=-qa=-4\ kN;$$

$$M_z(x_1)=-q\cdot\frac{x_1^2}{2};$$

$M_z(x_{1-0})=0;\quad M_z(x_{1-0})=-q\frac{a^2}{2}=-2\ kN\cdot m.$



Uchastka *BC* $(0\le x_2\le a)$:

$Q_y(x_2)=-q(a+x_2)+R_B;$

$Q_y(x_{2-0})=-qa+R_B=2\ kN;$

$Q_y(x_{2-0})=-q\cdot 2a+R_B=-2\ kN;$

$M_z(x_{2-0})=-q\frac{(a+x_2)^2}{2}+M+R_B\cdot x_2;$

$M_z(x_{2-0})=-q\frac{a^2}{2}+M=4\ kN\cdot m;$

$M_z(x_{2-a})=-q\frac{4a^2}{2}+M+R_Ba=4\ kN\cdot m.$

$-q(a+x_{20})+R_B=0$

$x_{20}=\frac{-qa+R_B}{q}=0,5\ [m].$

$M_z(x_2=x_{20})=-q\frac{(a+x_{20})^2}{2}+M+R_B\cdot x_{20}=4,5\ kN\cdot m.$

Uchastka *DC* $(0\le x_3\le 2a)$:

$Q_y(x_3)=-R_D=-2\ kN;$

$M_z(x_3)=R_D\cdot x_3;$

$M_z(x_3)=0;$

$M_z(x_{3=2a})=R_D\cdot 2a=4\ kN\cdot m.$

$M_{his}=M_{max}=4,5\ kN\cdot m.$

$$W_z=\frac{bh^2}{6}$$

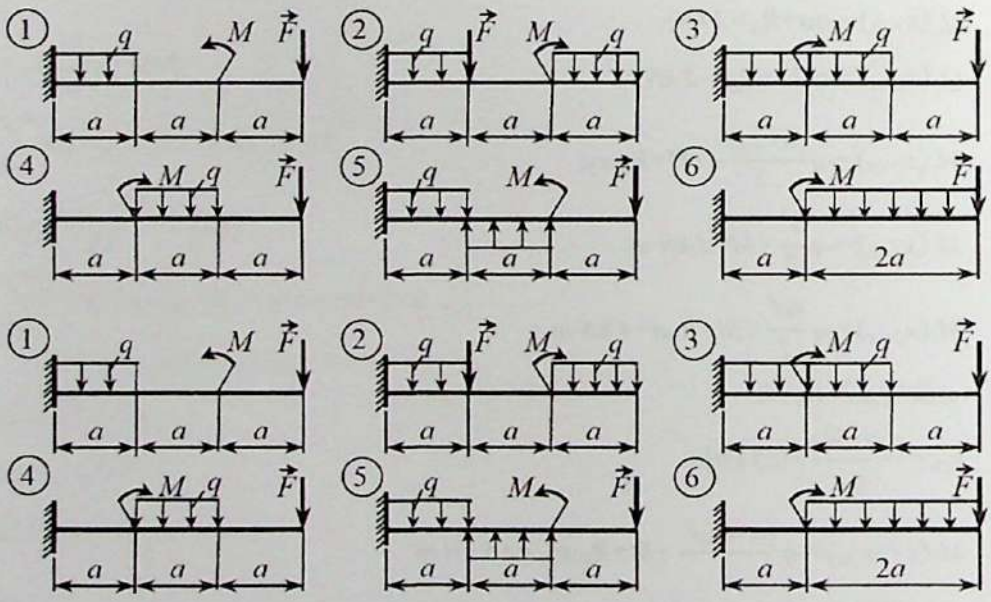
$$W_z=\frac{2}{3}b^3$$

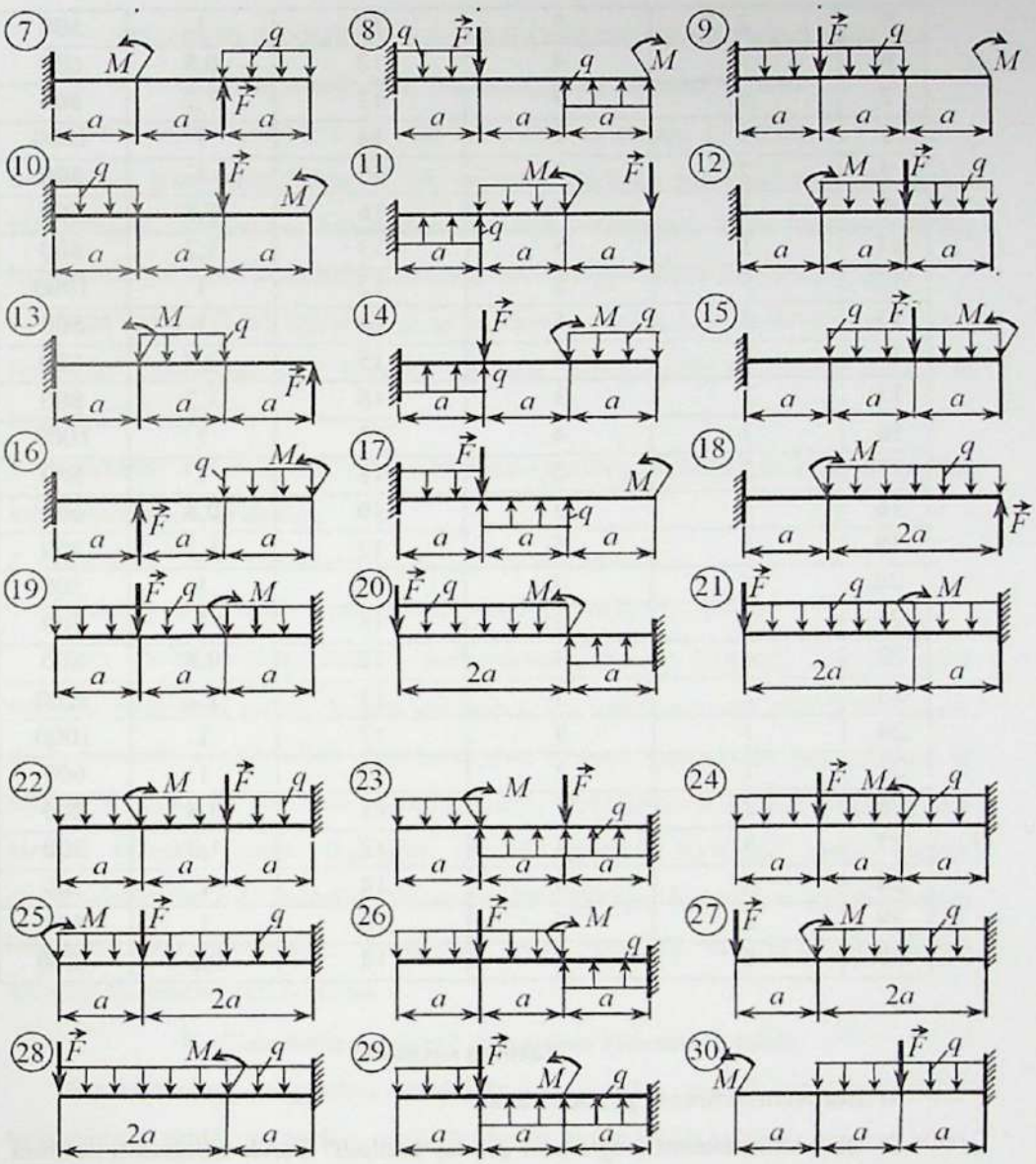
$$W_z\geq\frac{M_{his}}{[\sigma]}$$

$$b\geq\sqrt[3]{\frac{3M_{his}}{2[\sigma]}}=\sqrt[3]{\frac{3\cdot 4,5}{2\cdot 160\cdot 10^3}}\approx 0,035\ m.$$

$$\tau_{max}=\frac{3}{2}\cdot\frac{Q_y}{bh}=2,45\ MPa<[\tau]$$

Mustaqil bajarish uchun vazifalar:





4.1– jadval

№	$F=Kqa$	$M=Kqa^2$	q, kN/m	a, m	$l/[f]$
1.	3	1	12	1	500
2.	2	3	20	0,8	600
3.	1	4	16	1,2	800
4.	3	2	18	1	1000

5.	2	3	12	1	500
6.	3	4	12	0,8	600
7.	5	3	13	1,2	800
8.	6	2	14	1	1000
9.	7	3	15	1	500
10.	1	4	16	0,8	600
11.	3	5	13	1,2	800
12.	5	3	12	1	1000
13.	4	6	14	1	500
14.	1	5	15	0,8	600
15.	2	3	16	1,2	800
16.	3	4	17	1	1000
17.	2	2	18	1	500
18.	1	3	19	0,8	600
19.	6	5	12	1,2	200
20.	4	4	13	1	300
21.	3	3	15	1	700
22.	4	4	12	0,8	800
23.	2	3	15	1,2	1200
24.	1	4	17	1	1000
25.	1	2	16	1	600
26.	2	1	17	0,8	200
27.	3	4	12	1,2	300
28.	4	5	14	1	700
29.	5	6	16	1	800
30.	6	4	18	0,8	1200

Nazorat savollar:

1. Burovchi moment epyurasi nima?
2. Burovchi moment tenglamasi qanday tuziladi? Bunda ishoralash tartibini tushuntiring.
3. Burovchi momentlar epyurasining to‘g‘riligini qanday tekshirish mumkin?
4. Kesimdagi ko‘ndalang (kesuvchi) kuch nima va u qanday topiladi?

III – BOB. MASHINA VA MEXANIZMLAR NAZARIYASI

Kurs loyihasi (ishi) topshiriqlarini bajarish tartibi

Kurs loyiha (ishi) 3 ta A2 formatli qog'ozdagi chizmalar va hisob – tushintiruv yozuvidan iborat bo'lib, talaba topshiriqni mustaqil bajarishi uchun biriktirilgan o'qituvchi tomonidan beriladi. Talabalar kurs loyihasi (ishi) topshiriqlarini o'zlarining guruh jurnaliga mos kelgan raqam bo'yicha oladilar.

Kurs loyiha (ishi) quyidagi 3 ta topshiriq asosida bajarilishi kerak: Loyiha (ish)ning chizmalari A2 format (594x420 mm) bo'lgan varaq (vatman) da bajariladi. Bunda:

1 – topshiriq: Tekis richag – sharnirli mexanizmning strukturasi, kinematikasi va kinetostatikasini tekshirish;

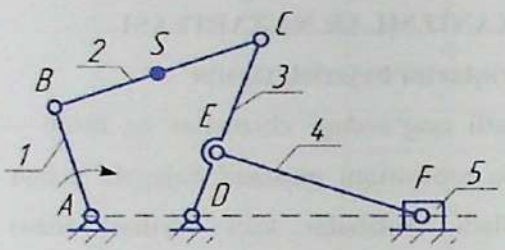
2 – topshiriq: Tishli reduktorni loyihalash va uni tekshirish,

3 – topshiriq: Kulachokli mexanizmni loyihalash ishlari bajariladi.

Kurs loyihasi (ishi)ni hisob – tushuntiruv qismi A4 formatli (210x297 mm) varaqda bajarilishi lozim. Yozuv varaqning 1 – tomoniga chiroyli va tushunarli qilib yoziladi. Tikish uchun chap tomondan 30 mm, tepadan 20 mm, pastdan 20 mm va o'ngdan 15 mm dan joy qoldiriladi. Tushintiruv yozuviga qisqartirishlar kiritish mumkin emas, faqatgina Davlat standarti bo'yicha ruxsat etilgan qisqartirishlar bo'lishi mumkin. Yozuvda qabul qilingan formulalar, qabul qilingan kattaliklar, koeffitsiyentlar, standartlar qaysi adabiyot va ma'lumotnomadan olingani ko'rsatib o'tilishi kerak.

1 – Topshiriq. Richagli mexanizm kinematik tahili

Mexanizmning bo'g'inlari nuqtalarining siljishi, tezligi va tezlanishini aniqlashning grafik va grafo – analitik (tezlik va tezlanish rejalari) usullari bilan tanishamiz. Mexanizmning turi, bo'g'inlarining uzunligi va aylangichni aylanish chastotasi berilgan.



$l_{AB}=20$ *mm*, $l_{DE}=60$ *mm*, $l_{BC}=100$ *mm*, $l_{EF}=200$*mm*, $l_{BS}=50$ *mm*, $\Pi_1=300$ *ayl/min*, $l_{CD}=120$ *mm*.

Vazifa quyidagi tartibda bajariladi

1.1. Mexanizmning tuzulishini tahlil qilish

Mexanizm tarkibidagi bo'g'inlarni va turli sinfli kinematik juftlar sonlariga qarab uning erkinlik darajasi hisoblanadi: $W=3n-2P_5=3\cdot5-2\cdot7=1$

Bo'g'inlar: 1 – aylangich, 2 – shatun, 3 – chayqalgich, 4 – shatun, 5 – sudralgich ($n=5$).

Kinematik juftlar soni: $P_5(A, B, C, E, D, F,F,)=7$ n va P_5 qiymatlari.

1.2. Nuqtaning traektoriyalarini aniqlash

Mexanizmning masshtablari aniqlanadi:

$$\mu_l=\frac{l_{AB}}{AB}=\frac{20}{40}=0,5\ \frac{mm}{mm}$$

Bu yerda: l_{AB} – aylangichni berilgan uzunligi, *mm*

AB – aylangichni chizmadagi uzunligi, *mm*

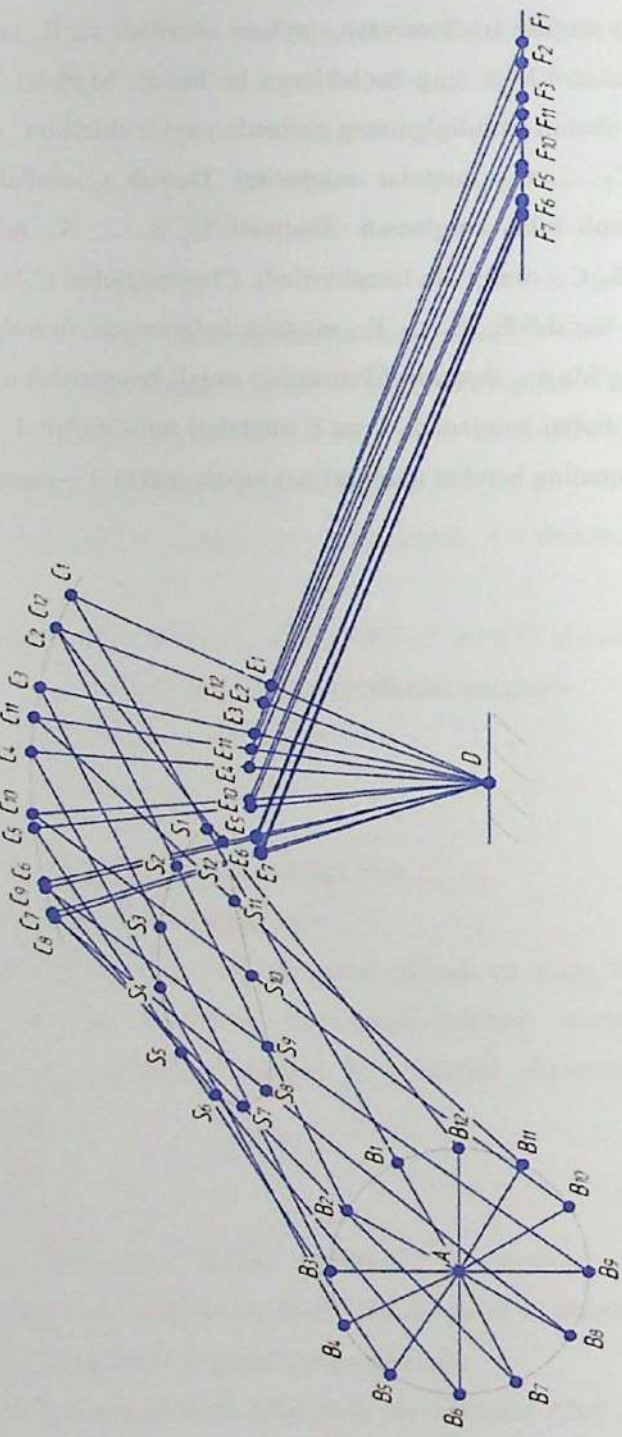
AB aylangichni chizmadagi uzunligi qabul qilinadi va uning miqdoriga qarab chizmani kattaroq yoki kichikroq masshtabda chizish mumkin. Masshtab tanlangandan so'ng mexanizmni qolgan bo'g'inlarini chizmadagi uzunliklari aniqlanadi. Masalan:

$$BC=\frac{l_{BC}}{\mu_e},\ CD=\frac{l_{CD}}{\mu_e}$$

Bu uning "Harakatsiz" holati chiziladi. "Harakatsiz" holat deganda chayqalgichni tebranma harakatidagi chetki holati, ya'ni C nuqtani tezligi nolga teng bo'lgan holat tushuniladi. U quyidagicha quriladi:

a) A va D tayanch nuqtalari bilan tutashtirib mexanizmni AB_0C_0D "Harakatsiz" holati chiziladi.

b) aylangichni B nuqtasi traektoriyasi – aylana chiziladi va B_0 nuqtadan boshlab bir nechta, masalan 12 ga teng bo'laklarga bo'linadi. Markazi B_1, B_2, ..., B_{12} nuqtalarda B_0C_0 shatun uzunligiga teng radiusda yoylar chizilib C nuqta yoyi bilan kesishgan C_1, C_2, ..., C_{12} nuqtalar aniqlanadi. Demak C nuqtalarning holatlari "Kesishtirish" usuli bilan aniqlanadi. Shatunni S_0, S_1, ..., S_{12} nuqtalari holatlari B_0C_0, B_1C_1, ..., $B_{12}C_{12}$ oralig'ida tutashtiriladi. Chayqalgichni C_1D, C_2D, ..., C12D holatlari chizilib tegishli E_0, E_1, ..., E_{12} nuqtalar belgilanadi. Sudralgich F nuqtasini traektoriya chizig'ida 4 – shatunni EF uzunligi orqali kesishtirish usulida F_0, F_1, ..., F_{12} nuqtalarning holati aniqlanadi. F va E nuqtalari tutashtirilib 4 – shatunning 12 ta holati va F nuqtaning harakat traektoriyasi aniqlanadi (1.1 – rasm).



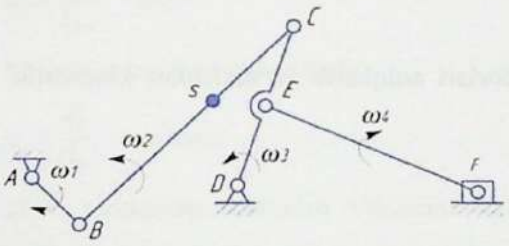
1.1 – rasm. Nuqtaning 12 ta holatidagi kinematik sxemasi

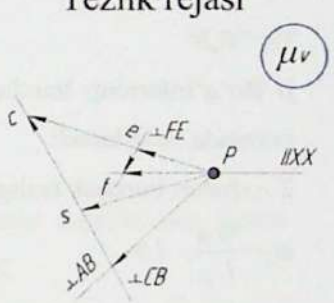
1.3. Nuqtalarning yo'l yoki masofa grafiklarini qurish va ularning grafik differensiyal tezlik va tezlanishlarini aniqlash

Mexanizmda aylangich bir marta aylanganda bo'g'inlarning nuqtalari ilgarilanma – qaytma (E va C nuqtalar) va ilgarilanma (S nuqta) harakatlanadi. Bunda C va E nuqtalarning masofalari oshib borib, so'ngra nuqta orqali harakatlanib masofasi kamaya boshlaydi. C nuqtani $S - t$ masofa grafigidan differensiyallashni vatarlar sulini qo'llab, S nuqtani yo'l grafigidan esa ordinata ortirmalarini o'lchash yo'li bilan tezlik $(v - t)$ va tezlanishlar $(a - t)$ diagrammalari quriladi.

1.4. Tezlik rejalarini qurish

Mexanizmni 12 ta holatidan biri tanlanib kinematik sxemasi alohida chiziladi (1.2 – rasm).





1.2 – rasm. Tezlik rejasini qurish.

Tezlik rejasi quyidagi tartibda bajariladi:

a) B nuqtaning tezlik miqdori hisoblanadi: $v_B=\omega_1 l_{AB}=\pi n/30 \cdot l_{AB}$, *m/sek*

l_{AB} – aylangich uzunligi, metrda qabul qilinadi. v_B – tezlik vektori aylangichni AB holatiga tik yo'naladi. Ixtiyoriy P – qutb nuqtasi tanlanib AB bo'g'inga tik chiziq o'tkaziladi. P_B kesma uzunligi ixtiyoriy qabul qilinadi.

b) Tezlik rejasi masshtabi hisoblanadi:

$$\mu_v=\frac{v_B}{P_B} \quad m/s \cdot mm$$

c) C nuqtaning tezlik vektorini aniqlash uchun vektor tenglamalar tizimi tuzuladi va rejada yechiladi: $\bar{v}_C=\bar{v}_B+\bar{v}_{CB}$

d) S nuqtaning tezlik vektori o'xshashlik teoremasidan quyidagicha aniqlanadi:

$$\frac{BC}{BS}=\frac{BC}{BS}, \quad BS=\frac{BS\cdot BC}{BC}\ mm$$

e) E nuqtaning tezlik vektori o'xshashlik teoremasidan quyidagicha aniqlanadi:

$$\frac{DC}{DE}=\frac{Pc}{Pe}, \quad Pe=\frac{DE\cdot Pc}{DC}\ mm$$

f) F nuqtaning tezlik vektorini aniqlash uchun vektor tenglamalar tizimi tuzuladi va rejada yechiladi: $\overline{v}_F=\overline{v}_E+\overline{v}_{FE}$

g) Reja masshtabidan foydalanib absolyut va nisbiy tezliklar hisoblanadi:

$v_C=\mu_v Pc$

$v_E=\mu_v Pe$

$v_F=\mu_v Pe$

$v_{CB}=\mu_v 6c$

$v_{FE}=\mu_v fe$

j) Bo'g'inlarning burchak tezliklari miqdorlari aniqlanib yo'nalishlari kinematik sxemada belgilanadi.

2 – shatun burchak tezligi:

$$\omega_2=\frac{v_{CB}}{l_{CB}},\ 1/s$$

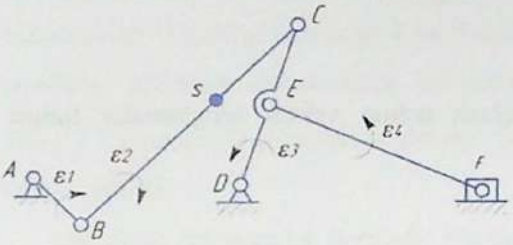
3 – shatun burchak tezligi:

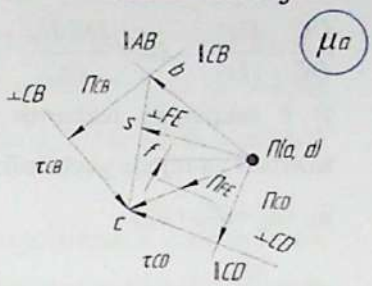
$$\omega_3=\frac{v_{CD}}{l_{CD}}=\frac{v_C}{l_{CD}},\ 1/s$$

4 – shatun burchak tezligi:

$$\omega_4=\frac{v_{FE}}{l_{FE}},\ 1/s$$

1.5. Tezlanish rejasini qurish





1.3 – rasm. Tezlanish rejasini qurish.

Vazifani bajarish tartibi

a) B nuqtani normal tezlanishini hisoblanadi (E_1=0 bo'lgani uchun, $a_B^\tau=0$)

$$a_B^n=\frac{v_B^2}{l_{AB}},\quad m/s^2$$

b) Reja masshtabi aniqlanadi:

$$\mu_a=\frac{\overline{a}_B^n}{\Pi_a},\quad m/s^2\cdot mm$$

c) C nuqtaning tezlanish vektorini aniqlash uchun vektor tenglamalar tizimi tuziladi va rejada C nuqta absolyut tezlanish vektori quriladi.

$$\overline{a}_C=\overline{a}_B+\overline{a}_{CB}^n+\overline{a}_{CB}^\tau$$

$$\overline{a}_C=\overline{a}_D+\overline{a}_{CD}^n+\overline{a}_{CD}^\tau$$

$$a_{CB}=\frac{v_{CB}^2}{l_{CB}},\ m/s^2$$

$$a_{CD}=\frac{v_{CD}^2}{l_{CD}},\ m/s^2$$

$$\Pi_{CB}=\frac{a_{CB}^n}{\mu_a},\quad mm$$

$$\Pi_{CD}=\frac{a_{CD}^n}{\mu_a},\quad mm$$

d) S nuqtani absolyut tezlanish vektori o'xshashlik teoremasidan aniqlanadi:

$$\frac{BC}{BS}=\frac{\text{вс}}{\text{вs}},\qquad \text{вs}=\frac{BS\cdot\text{вс}}{BC},\quad mm$$

Bu yerda *вс* – tezlanish rejasidagi kesma uzunligi.

e) E nuqtani absolyut tezlanish vektori o'xshashlik teoremasidan aniqlanadi:

$$\frac{DC}{DE}=\frac{\Pi c}{\Pi e},\qquad \Pi e=\frac{DE\cdot\Pi c}{DC},\quad mm$$

f) F nuqtaning tezlanish vektorini aniqlash uchun vektor tenglamalar tizimi tuzuladi va rejada yechiladi:

$$\bar{a}_F=\bar{a}_E+\bar{a}^n_{FE}+\bar{a}^\tau_{FE}$$

$$a^n_{FE}=\frac{v^2_{FE}}{l_{FE}},\quad m/s^2$$

$$\Pi_{FE}=\frac{a^n_{FE}}{\mu_a},\quad mm$$

j) Nuqtalarning absolyut va nisbiy tezlanishlari hisoblanadi:

$$a_C=\mu_a\Pi c,\quad m/s^2$$

$$a_E=\mu_a\Pi e,\quad m/s^2$$

$$a_F=\mu_a\Pi f,\quad m/s^2$$

$$a^\tau_{CB}=\mu_a\tau_{CB},\quad m/s^2$$

$$a^\tau_{CD}=\mu_a\tau_{CD},\quad m/s^2$$

$$a^\tau_{FE}=\mu_a\tau_{FE},\quad m/s^2$$

Πe, Πc, Πf, τ_{CB}, τ_{CD}, τ_{FE} kesmalar rejadan o'lchanadi.

k) Bo'g'inlarning burchak tezlanishlari miqdorlari aniqlanib yo'nalishlari kinematik sxemada belgilanadi.

2 – shatun burchak tezligi:

$$\bar{\varepsilon}_2=\frac{\bar{a}_{CB}}{l_{CB}}\quad 1/s^2$$

3 – shatun burchak tezligi:

$$\bar{\varepsilon}_3=\frac{\bar{a}_{CD}}{l_{CD}}\quad 1/s^2$$

4 – shatun burchak tezligi:

$$\bar{\varepsilon}_4=\frac{\bar{a}_{FE}}{l_{FE}}\quad 1/s^2$$

2 – Topshiriq. Tishli reduktorni loyihalash va uni tekshirish

Berilgan oddiy va planetar pog'analardan iborat reduktorlarning kinematikasi hisoblanadi. Tishli g'ildiraklar 4 va 5 dan tuzilgan oddiy uzatmaning evolventaviy profillari chiziladi. Sxemalarda ko'rsatilgan markaziy g'ildirak 1, 3 lar satillit *2(2-2')* va vodilo *N* planetar uzatmani, tishli g'ildiraklar 4, 5 esa oddiy uzatmani tashkil qiladi.

Quyidagi parametrlar beriladi: Yetaklanuvchi zveno g'ildirak 5 ning aylanish soni n_5; planetar uzatma g'ildiraklari Z_1, Z_2, $Z_{2'}$, Z_3 tishlarining soni; oddiy uzatma g'ildiraklari orasidagi masofa a_w va uning uzatish soni U_{45}. Barcha g'ildiraklarning ilashish moduli m bir–biriga teng qilib olingan.

Talab qilinadi:

1) Planetar uzatma va reduktorning uzatish sonlari U_r va U_l ni aniqlash;

2) Elektr dvigatelning (yetaklovchi g'ildirakning) aylanish chastotasi n_1 ni aniqlash;

3) Oddiy uzatma g'ildiraklarining tishlari sonini hisoblash;

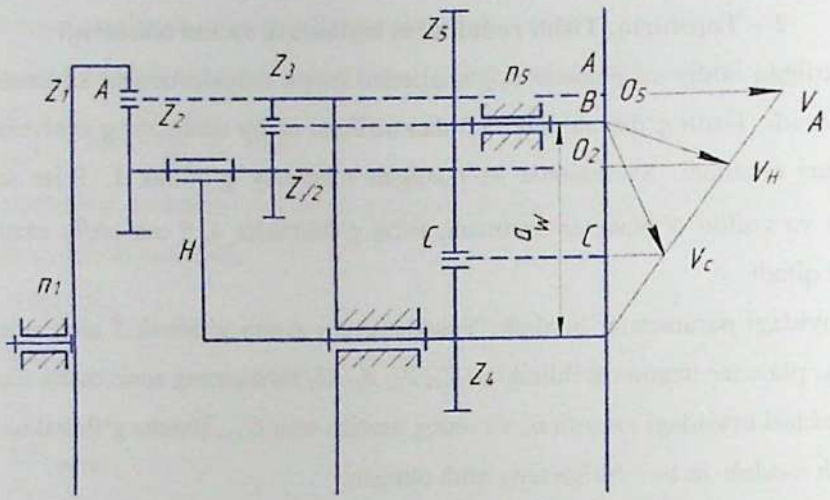
4) Reduktor g'ildiraklarining boshlang'ich aylanasi va vadilo radiuslarini hisoblab topish, uning sxemasini μ_l masshtabda chizish;

5) Reduktorning μ_v masshtabda tezliklar rejasini qurib, g'ildiraklarning tezliklarini topish;

6) G'ildiraklar 4 va 5 ning asosiy geometrik parametrlari ilashish qadami R, bo'lish aylanasi bo'ylab tishning qalinligi s, boshlang'ich r_a va r_b aylanalar radiusi, tish kallagi r_a hamda tish oyog'i r_f bo'ylab o'tkazilgan aylanalarning radiuslarini hisoblash;

7) Bir juft g'ildirak tishlari ilashmasini chizish, bunda uzunlik masshtabini shunday tanlanadiki, tishning h balandligi *30 mm* dan kam bo'lmasin, har bir g'ildirak uchun kamida 3 ta tishning profili chizib ko'rsatiladi.

Misol. Berilgan: $Z_1=20$; $Z_2=21$; $Z_{2'}=20$; $Z_3=62$; $U_{45}=2$; $a_w=150$ *mm*; $m=5$; $n_5=122$ *ayl/min*.



$U_{loy}=U_r+U_{yu}$

$U_{yu}=U_{45}$

$U_r=U^3_{1H}=1-\frac{z_1 z_2}{z_1 z_2'}$

$V_A=\omega_1 \cdot r_1$

$\omega_1=\frac{\pi n_1}{30}$

Tishli planetar mexanizmning uzatish soni quyidagi formuladan aniqlanadi:

$$U^1_{H3}=1-\frac{z_2 \cdot z_3}{z_1 \cdot z_2'}=1-\frac{21 \cdot 62}{20 \cdot 20}=-2,25$$

Reduktorning umumiy uzatish soni planetar va oddiy uzatmalar uzatish sonlarining ko'paytmasiga teng:

$$U_{loy}=U_r \cdot U_{yu}=U^3_{1H} \cdot U_{45}=-2,25 \cdot 2=4,5$$

Elektrik dvigatel valining aylanish soni quyidagicha aniqlanadi:

$$n_1=U_{loy} \cdot n_5=4,5 \cdot 122=549 \ ayl/min$$

Oddiy uzatma g'ildiraklarining tishlari sonini aniqlaymiz:

$$z_4=\frac{2 \cdot a_w}{m(1+U_{45})}=\frac{2 \cdot 150}{5(1+2)}=20$$

$$z_5=U_{45} \cdot z_4=2 \cdot 20=40$$

Reduktor sxemasini chizamiz (2.1 – shakl). Buning uchun tishli g'ildiraklarning bo'lish aylanasi hamda vodilo radiuslarini aniqlaymiz. z_1 g'ildirakning bo'lish aylanasi radiusi:

$$r_1=\frac{mz_1}{2}=\frac{5\cdot 20}{2}=50\ mm$$

z_2 g'ildirakning bo'lish aylanasi radiusi:

$$r_2=\frac{mz_2}{2}=\frac{5\cdot 21}{2}=52,5\ mm$$

z_2' g'ildirakning bo'lish aylanasi radiusi:

$$r_2'=\frac{mz_2}{2}=\frac{5\cdot 20}{2}=50\ mm$$

z_3 g'ildirakning bo'lish aylanasi radiusi:

$$r_3=\frac{mz_3}{2}=\frac{5\cdot 62}{2}=155\ mm$$

vodila N ning radiusi:

$$R_H=r_1+r_2=50+52,5=102,5\ mm$$

z_4 g'ildirakning bo'lish aylanasi radiusi:

$$r_4=\frac{mz_4}{2}=\frac{5\cdot 20}{2}=50\ mm$$

z_5 g'ildirakning bo'lish aylanasi radiusi:

$$r_5=\frac{mz_5}{2}=\frac{5\cdot 40}{2}=100\ mm$$

Reduktor sxemasining uzunlik masshtabi koeffitsiyenti μ_l ni tanlaymiz:

$$\mu_l=\frac{r_1}{r_1}=\frac{0,05\ m}{50\ mm}=0,001\ m/mm$$

Ikki pog'onali ichki ilashmali planetar va bir pog'onali oddiy tishli ilashmadan iborat reduktorning g'ildiraklari tezliklarini L.Smirnov usuli bilan topish.

Buning uchun berilgan n_1 orqali ω_1 va birinchi g'ildirakning A nuqtasi tezligi V_A ni ixtiyoriy vektor kattalikda, μ_v mashtabda qo'yamiz. v_A nyqtani O_1 markaz bilan birlashtirib 1 – g'ildirakni tezliklar planini quramiz. O_2 ikkinchi g'ildirakni va 4 - g'ildirakni S nuqtasini tezlik vektorlarini $v_A - O_1$ chiziq bilan uchrashtirib v_H

va v_C tezliklarni topamiz. v_C tezlik vektorini O_5 markaz bilan birlashtirib 5 – g'ildirak tezlik planini quramiz. v_C tezlik vektorini V nuqta bilan birlashtirib z_2' g'ildirakni tezliklar plani topiladi. Tezliklarni skolyar miqdorini topish uchun, istalgan nuqtani vektor kattaligini o'lchab olib μ_v masshtabga ko'paytiramiz.

2.1. Oddiy uzatma 4 va 5 g'ildiraklarining asosiy geometrik parametrlarini hisoblaymiz

Asosiy aylanalarning radiuslari:

$r_{B_4}=r_4 \cdot cos\alpha=50 \cdot cos20^0=47\ mm$

$r_{B_5}=r_5 \cdot cos\alpha=100 \cdot cos20^0=94\ mm$

G'ildirak tishlarining balandligi:

$h_4=h_5=2,25 \cdot m=2,25 \cdot 5=11,25\ mm$

Tish kallagi balandligi:

$h_{a4}=h_{a5}=h_a \cdot m=1 \cdot 5=5\ mm$

Tish oyog'i balandligi:

$h_{f4}=h_{f5}=1,25 \cdot m=1,25 \cdot 5=6,25\ mm$

Ilashmaning boshlang'ich aylana yoyi bo'yicha qadami:

$p=\pi \cdot m=3,14 \cdot 5=15,7\ mm$

Tishning boshlang'ich aylana yoyi bo'yicha qalinligi:

$S_4=S_5=0,5 \cdot p=0,5 \cdot 15,7=7,85\ mm$

Ikki tishning boshlang'ich aylana yoyi bo'yicha oralig'i:

$e_4=e_5=0,5 \cdot p=0,5 \cdot 15,7=7,85\ mm$

G'ildirak tishlarining chiqiqlari aylanasi radiuslari:

$r_{a_4}=r_4+h_{a_4}=50+5=55\ mm$

$r_{a_5}=r_5+h_{a_5}=100+5=105\ mm$

G'ildirak tishlarining botiqligi aylanasi radiuslari:

$r_{f_4}=r_4-h_{f_4}=50-6,25=43,75\ mm$

$r_{f_5}=r_5-h_{f_5}=100-6,25=93,75\ mm$

Galtelning yumaloqlanish radiusi:

$\rho_f=0,3\cdot m=0,3\cdot 5=1,5\ mm$

2.2. Tashqi ilashmali evolventa profilli g'ildirak tishini yasash

1. Chizmaning uzunlik masshtabi μ ni tanlaymiz. Bunda tishning chizmadagi balandligi $h>30\ mm$ bo'lishi kerak:

$$\mu_l=\frac{h}{\overline{h}}=\frac{0,01125}{30}=0,000375\ m/mm$$

Siz chizmangizda h=30 mm qilib olasiz.

2. G'ildiraklarning O_4 va O_5 markazlari oralig'ini (2.2 – shakl) topamiz:

$$\overline{a_w}=\frac{a_w}{\mu_l}=\frac{0,150}{0,000375}=400\ mm$$

3. O_4 va O_5 markazlar to'g'ri chiziq bilan tutashtiriladi, bu markazlardan

$$\overline{r_4}=\frac{r_4}{\mu_l}=\frac{0,050}{0,000375}=133,3\ mm$$

$$\overline{r_5}=\frac{r_5}{\mu_l}=\frac{0,100}{0,000375}=266,6\ mm$$

radiuslar bilan bo'lish aylanalari chiziladi.

4. Ikki aylananing urinish nuqtasi R dan (ilashish qutbidan) bo'lish aylanalariga urinma $\tau\tau$ chiziq o'tkaziladi. U O_4 va O_6 markazlarni tutashtiruvchi chiziqqa tik bo'ladi.

5. O_4 va O_5 markazlardan

$$\overline{r_{b_4}}=\frac{r_{b_4}}{\mu_l}=\frac{0,047}{0,000375}=125,3\ mm$$

$$\overline{r_{b_5}}=\frac{r_{b_5}}{\mu_l}=\frac{0,094}{0,000375}=250,6\ mm$$

radiuslar bilan asosiy aylanalar chiziladi.

6. Qutb nuqtasi R dan τ-τ urinmaga $\alpha=20^o a$ burchak ostida asosiy aylanalarga umumiy bo'lgan urinma chiziq $N-N$ o'tkaziladi. Bu urinma chiziq asosiy aylanala $\overline{r_{b_4}}$, $\overline{r_{b_5}}$ da urinish nuqtalari A va B ni beradi. Bunda AB kesma nazariy ilashish chiziq bo'ladi.

7. G'ildirakning O_4 va O_5 markazlaridan

$$\overline{r_{a_4}} = \frac{r_{a_4}}{\mu_l} = \frac{0,055}{0,000375} = 146,6\ mm$$

$$\overline{r_{a_5}} = \frac{r_{a_5}}{\mu_l} = \frac{0,105}{0,000375} = 280\ mm$$

radiuslar bilan g'ildirak tishlarining chiqiqlik aylanasi radiuslari,

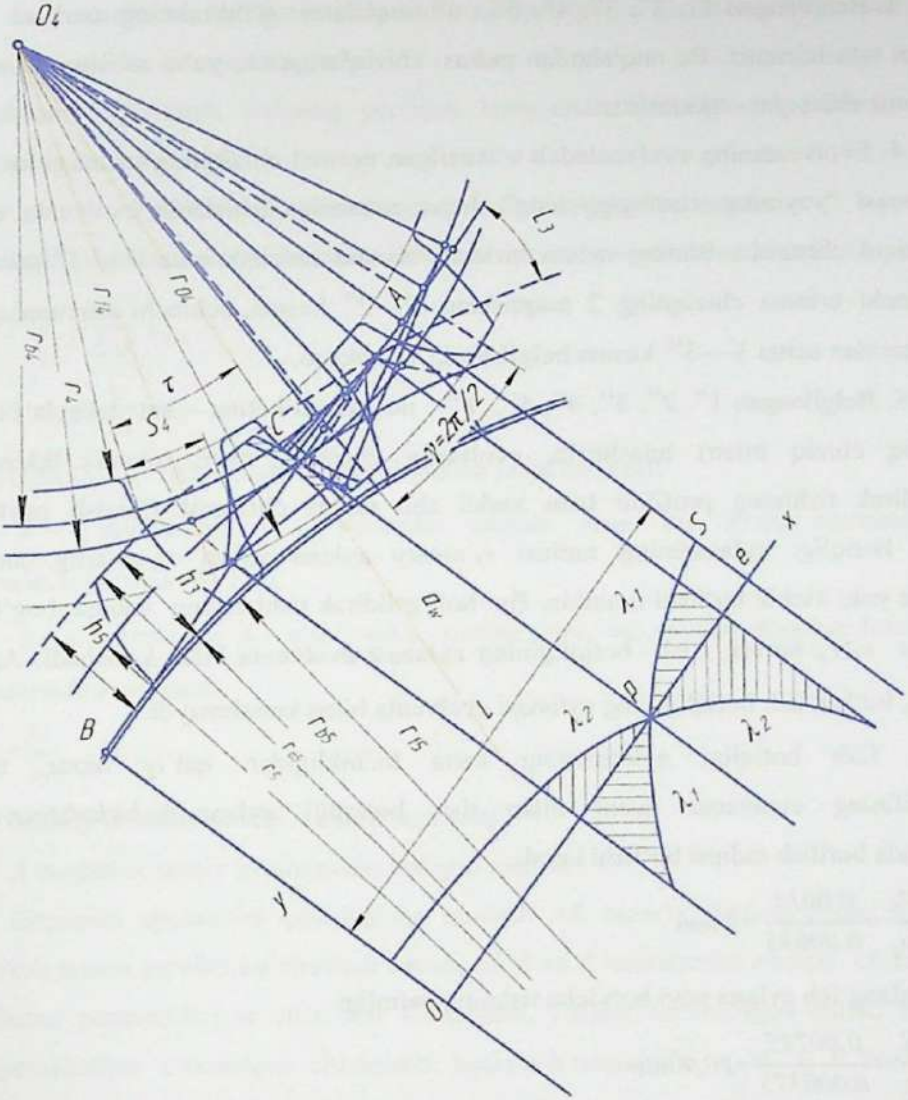
$$\overline{r_{f_4}} = \frac{r_{f_4}}{\mu_l} = \frac{0,04375}{0,000375} = 116,6\ mm$$

$$\overline{r_{f_5}} = \frac{r_{f_5}}{\mu_l} = \frac{0,09375}{0,000375} = 250\ mm$$

radiuslar bilan esa g'ildirak tishlarining botiqlari aylanasi chiziladi.

8. Ilashish chiziqi $N - N$ ni ikki g'ildirakning asosiy aylanalarida dumalatib, qutb nuqtasi R dan o'tuvchi evolventa profili chiziladi.

Tish profili chizishning grafikaviy usulini ko'rib chiqamiz.



2.2 – rasm

2.3. Tishning profilini grafikaviy usulda chizish

1. Chizmadagi $\overline{AP}$ kesmani teng qismlarga bo'lamiz. Masalan, $\overline{AP}$ kesmani to'rtta teng qismga bo'lib, $\overline{P3}$, $\overline{32}$, $\overline{21}$, $\overline{1A}$ kesmalarni olamiz. Ilashish chizig'ining davomida $\overline{A5}$, $\overline{56}$ teng kesmalarni ham belgilaymiz

2. A nuqtadan boshlab, asosiy aylanada bu kesmalarga teng $\overline{A1}=\overline{A1'}$, $\overline{A2}=\overline{A2'}$, $\overline{A3}=\overline{A3'}$ shuningdek, yoylarni belgilaymiz.

3. Belgilangan $1''$, $2''$, $3''$, $4''$, $5''$, $6''$ nuqtalarni g'ildirakning markazi O_4 bilan tutashtiramiz. Bu nuqtalardan radius chiziqlariga tik, ya'ni asosiy aylanaga urinma chiziqlar o'tkazamiz.

4. Evolventaning evolventadan o'tkazilgan normal chiziqning uzunligi asosiy aylanasi "yoyining uzunligiga teng" degan xossasiga asoslanib, evolventa egri chizig'ini chizamiz. Buning uchun birinchi urinma chiziqda bitta $1'$— $1''$ kesma, ikkinchi urinma chiziqning 2 nuqtasidan $2'$—$2''$ kesma, uchinchi urinmaning 3 nuqtasidan uchta $3'$—$3''$ kesma belgilaymiz va hokazo.

5. Belgilangan $1''$, $2''$, $3''$, $4''$, $5''$, $6''$ nuqtalarni ketma – ket lekayla bilan (silliq chiziq bilan) tutashtirib, evolventa chiziqini hosil qilamiz. Ikkinchi g'ildirak tishining profilini ham xuddi shu tarzda chizamiz. Chizish paytida tish botiqligi aylanasining radiusi r_f asosiy aylana radiusi r_b ga teng, undan katta yoki kichik bo'lishi mumkin. Bu hol g'ildirak tishlarining soniga bog'liq. Agar $r_f \geq r_b$ bo'lsa, tish botiqligining aylanasi evolventa bilan kesishadi. Agar $r_f \leq r_b$ bo'lsa, tish botiqligining aylanasi evolventa bilan kesishmaydi.

Tish botiqligi aylanasining katta kichikligidan qat'iy nazar, tish profilining evolventa qismi bilan tish botiqligi aylanasini birlashtiruvchi qismda burilish radiusi bo'lishi kerak.

$$\rho_f = \frac{P_f}{\mu_1} = \frac{0,0015}{0,00035} = 4\ mm$$

Boshlang'ich aylana yoyi bo'yicha tishning qalinligi

$$\bar{S} = \frac{S}{\mu_1} = \frac{0,00785}{0,000375} = 20,9\ mm$$

ni belgilaymiz va uni teng ikki qismga bo'lamiz. Uni g'ildirak markazi O_4 bilan tutashtirib, tishning simmetriya o'qini hosil qilamiz. Simmetrik proeksiyalash usulida tishning ikkinchi evolventa profilini chizamiz.

7. Tishning boshlang'ich aylana yoyi bo'yicha qadami

$$\bar{P} = \frac{P}{\mu_1} = \frac{0,0157}{0,000375} = 41,8\ mm$$

ga teng oraliqda qo‘shni tishlarnint simmetriya o‘qlarini belgilaymiz va tishning profillarini chizamiz.

8. Ikkinchi g‘ildirak tishning profilini ham chizamiz. Har bir g‘ildirakning uchtadan tishi chiziladi.

2.4. Tishli ilashmaning sirpanish epyurasini qurish

Tishli ilashmalarni sirpanish koeffitsenti quyidagi formula orqali aniqlanadi.

$$\lambda_1 = 1 + y_{4.5} - \frac{L}{L-x} \cdot y_{4.5}$$

$$\lambda_2 = 1 + y_{5.4} - \frac{L}{L-x} \cdot y_{5.4}$$

bu yerda: λ_1, λ_2- tishli ilashmaning sirpanish koeffitsiyenti;

$y_{4.5}$- 4 – g‘ildirakning 5 – g‘ildirakka uzatish soni, bu qiymat hammaning variantida berilgan bo‘ladi.

$y_{5.4}$- 5 – g‘ildirakning 4 – g‘ildirakka uzatish soni, bu qiymat quyidagi formula yordamida aniqlanadi.

$$y_{5.4} = \frac{z_4}{z_5}$$

L – nazariy ilashish chiziqi $\overline{AB}$ kesmaga teng

$X - A$ nuqtadan asosiy aylanagacha bo‘lgan masofa

Sirpanish epyurasini quyidagicha quriladi AB nazariy ilashish chizig‘ini O_5 markaz tamon parallel ko‘chiriladi hamda A, B va R nuqtalardan nazariy chiziqga nisbatan perpendikulyar chizi qlar o‘tkaziladi. Parallel ko‘chirilgan chiziq bilan perpendikulyar o‘tkazilgan chiziqlarni kesishish nuqtalarini A, B va R hariflari bilan belgilanadi. A nuqtadan R uqtagacha bo‘lgan masofani teng ixtiyoriy bo‘laklarga va R nuqtadan B nuqtagacha bo‘lgan masofani ham teng ixtiyoriy bo‘laklarga bo‘lib uqtalar qo‘yiladi. Bu nuqtalardan AB kesmaga nisbatan perpendikulyar chizi qlar o‘tkaziladi. Yuqoridagi formuladan foydalanib sirpanish koeffitsiyenti aniqlanadi va mos ravishda qiymatlarni qo‘yiladi. Agarda qiymat musbat bo‘lsa chap tomonga manfiy bo‘lsa o‘ng tomonga qo‘yiladi.

3 – Topshiriq. Kulachokli mexanizmni loyihalash

Kulachokli mexanizmlar yetaklanuvchi zvenoni (turtkichni) bir vaziyatdan ikkinchi vaziyatga siljitish yoki burish uchun xizmat kiladi. Ular universal bo'lib, turtkichning oldindan belgilangan harakat qonunini bajara oladi.

Ular texnikaning ko'pgina tarmoqlarida: metall kesish stanoklarida, avtomatlarda, o'lchash va hisoblash priborlarida, bug' mashinalarida va ichki yonuv dvigatellarida keng ko'lamda ishlatiladi.

Kulachokli mexanizm loyihalashda ko'zda tutilgan asosiy maqsad etaklanuvchi zvenoning istalgan, oldindan berilgan harakat qonuni bajaruvchi kulachok profilini yasash, foydali ish koeffitsiyenti yuqori va gabariti kichik mexanizm sxemasi tavsiya etiladi (3.1 – shakl).

A sxema – to'g'ri chiziq bo'ylab ilgarilanma – qaytarilanma harakat qiluvchi rolikli turtkichi bo'lgan kulachokli mexanizm.

V sxema – to'g'ri chiziq bo'ylab ilgarilanma – qaytarilanma harakat qiluvchi tekis tarelkali turtkichi bo'lgan kulachokli mexanizm.

S sxema – tebranma (burilma) harakatlanuvchi, rolikli koromisloli turtkichi bo'lgan kulachokli mexanizm.

Kulachokli mexanizm loyihalash uchun quyidagi parametrlar ma'lum bo'lishi kerak.

1. Turtkichning xarakat qonuni (3.2 – shakl):

$$\frac{d^2S}{d\varphi^2}=\frac{d^2S}{d\varphi^2}(\varphi) \quad \text{yoki} \quad \frac{d^2\beta}{d\varphi^2}=\frac{d^2\beta}{d\varphi^2}(\varphi)$$

Bu turtkichning harakat qonuni to'g'ri burchakli diagramma bo'yicha o'zgaradi deb qabul qilamiz.

2. Kulachokning burilish burchaklari: turtkichning ko'tarilish burchagi $\varphi_k=60^o$ turtkichning uzoqlashgan vaziyatda turish burchagi $\varphi_y=20^o$ turtkichning qaytish burchagi $\varphi_k=60^o$ turtkichning yaqinlashgan vaziyatda turish burchagi $\varphi_e=220^o$

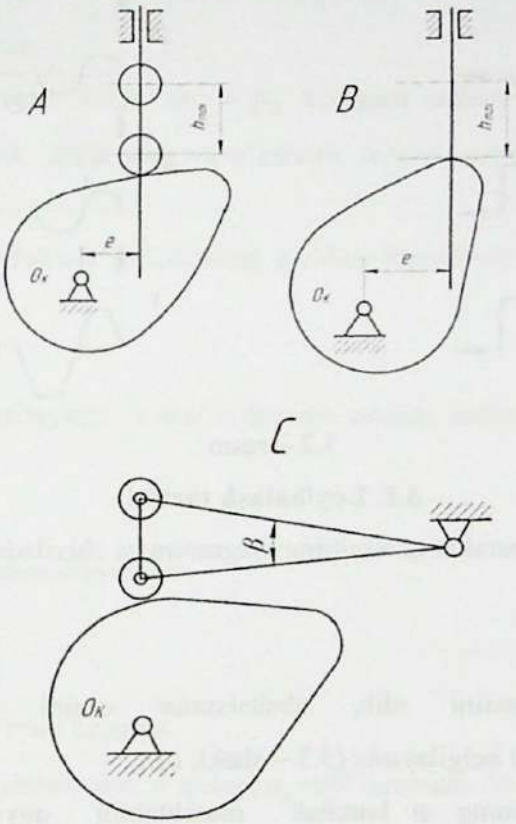
3. Kulachokning aylanishlar soni: $n_k=100\ ayl/min$

4. Tutkichning maksimal siljishi: $h_{max} = 0,035\ m$

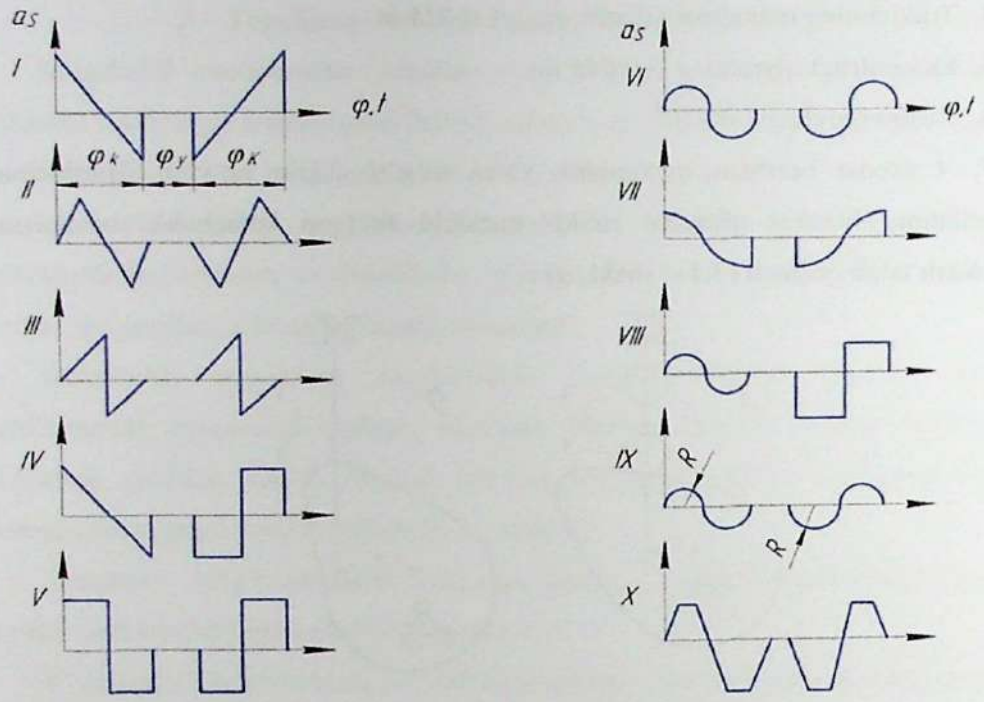
5. Ekssentritet qiymati: $e = 0,015\ m$

6. Bosim burchagi: $\alpha = 30^{o}$

7. *A* sxema berilgan mexanizm, ya'ni to'g'ri chiziq bo'ylab ilgarilanma qaytarilanma–harakat qiluvchi rolikli turtkichi bo'lgan kulachokli mexanizm loyixalash talab qilinadi (3.1 – shakl, *a*).



3.1– rasm



3.2 – rasm

3.1. Loyihalash tartibi

Berilgan turtkich harakat qonunining diagrammasi chiziladi. Buning uchun

$$\frac{d^2S}{d\varphi^2}=\frac{d^2S}{d\varphi^2}(\varphi)$$

koordinatalar sistemasini olib, absitsissalar o‘qini chizamiz va unga $\overline{OM}=140\ mm$ kesmani belgilaymiz (3.3 – shakl, *a*).

Abssissalar o‘qining φ burchak masshtabini quyidagi formuladan aniqlaymiz:

$$\mu\varphi=\frac{\varphi_p^o}{\overline{OM}}=\frac{\frac{\pi}{180^o}(\varphi_k^o+\varphi_y^o+\varphi_k^o)}{\overline{OM}}=\frac{3,14(60^o+20^o+60^o)}{180^o\cdot 140}=0,001745\ rad/mm$$

bu yerda φ_p^o kulachokning burilish burchagi

Ordinatalar o‘qiga turtkichning ixtiyoriy

$$\mu\frac{d^2S}{d\varphi^2}$$

masshtabda berilgan harakat qonuni diagrammasini chizamiz, bunda kulachokning burilish burchagi φ_k qismdagi ordinata balandligini ixtiyoriy $\alpha=60^o$ kesma bilan belgilaymiz. $\varphi_k=60^o$ li abssissalar o'qini teng to'rt burchakli bir xil shakllar chizamiz (3.3 – shakl, *a*), bunda turtkichning ko'tarilish vaziyatiga taaluqli diagramma hosil bo'ladi.

So'ngra absitsissalar o'qining davomida μ_φ masshtabda $\varphi_y^o=20^o$ ning kesma uzunligini belgilaymiz.

Berilgan shartga ko'ra $\varphi_k = \varphi_k$ bo'lgani uchun $\varphi_k=60^o$ kesimni φ_k burchakka simmetrik qilib, teng va o'xshash to'g'ri to'rtburchaklik shakllarni chizamiz.

Grafikaviy integrallash usullarining biridan foydalanib chizilgan

$$\frac{d^2S}{d\varphi^2}=\frac{d^2S}{d\varphi^2}(\varphi)$$

diagrammani integrallaymiz. Vatar o'tkazish usulini tadbiq etib,

$$\frac{d^2S}{d\varphi^2}=\frac{d^2S}{d\varphi^2}(\varphi)$$

grafikni bir marta integrallaymizda,

$$\frac{d^2S}{d\varphi^2}=\frac{d^2S}{d\varphi^2}(\varphi)$$

ning diagrammasini hosil qilamiz.

Buning uchun abssissalar o'qidagi $\varphi_k=60^o$ kesmani $10'=10\ mm$ deb olib, bir – biriga teng oltita kesmaga bo'lamiz. Bo'lingan kesmalarning abssissalar o'qidagi 0, 1, 2, 3 ... nuqtalaridan vertikal chiziqlar o'tkazamizda, berilgan grafikda bo'lish nuqtalari $0'''$, $1'''$, $2'''$, $3'''$,... ni hosil qilamiz.

$$\frac{d^2S}{d\varphi^2}=\frac{d^2S}{d\varphi^2}(\varphi)$$

yuqori qismida

$$\frac{dS}{d\varphi}=\frac{dS}{d\varphi}(\varphi)$$

grafigi uchun yangi koordinatalar sistemasini chizamiz.

$$\frac{d^2S}{d\varphi^2}=\frac{d^2S}{d\varphi^2}(\varphi)$$

diagrammasidagi vertikal chiziqlarni yuqori tomonga davom ettirib, 0_φ abssissalar o'qini 0–1, 1–2, 2–3, ga teng kesmalarga bo'lamiz (3.2 – shakl, *b*).

$$\frac{d^2S}{d\varphi^2}=\frac{d^2S}{d\varphi^2}(\varphi) \quad va \quad \frac{dS}{d\varphi}=\frac{dS}{d\varphi}(\varphi)$$

diagrammalarining ordinata o'qlarini bir xil va teng masshtabda chizish uchun

$$\frac{d^2S}{d\varphi^2}=\frac{d^2S}{d\varphi^2}(\varphi)$$

diagrammasining chap tomonidagi qutb oralig'i quyidagicha bo'lishi kerak:

$$H_2=\frac{1}{\mu\varphi}=\frac{1}{\pi/180^o}=57,2\ mm$$

Abssissalar o'qining chap tomonida $\overline{OA_2}=H_2=57,2\ mm$ kesmani chizib, A_2 nuqtani belgilaymiz. 0‴, 1‴, 2‴, 3‴,... ni hokazo chiziqlarn[ing har biri o'rtasidagi I‴, II‴, III‴, ... nuqtalarni

$$\frac{d^2S}{d\varphi^2}$$

ordinatalar o'qiga ko'chiramiz.

Ordinatalar o'qidagi I‴, II‴, III‴, ... nuqtalarni A_2 qutb bilan tutashtirib A_2–I‴, A_2–II‴, A_2–III‴, ... nurlarni o'tkazamiz. So'ngra

$$\frac{dS}{d\varphi}=\frac{dS}{d\varphi}(\varphi)$$

diagrammasining 0 nuqtasidan A_2–I‴ nurga parallel qilib 0–1 qismning birinchi vertikal chizig'i bilan uchrashguncha chiziq o'tkazib, I″ nuqtani belgilaymiz (3.3 – shakl, *b*).

Ordinatadagi vertikal chiziqning I″ nuqtasidan A_2–II‴, nur chizig'iga parallel chiziq o'tkazib, ikkinchi vertikal chiziqda 2″ nuqtani olamiz. Diagrammaning qolgan qismlari ham xuddi shu tarzda chiziladi. Belgilangan 0‴, 1‴, 2‴, 3‴,... nuqtalarni birlashtirib grafikaviy integrallangan

$\frac{dS}{d\varphi}=\frac{dS}{d\varphi}(\varphi)$

diagrammasini hosil qilamiz.

Shuningdek,

$\frac{dS}{d\varphi}=\frac{dS}{d\varphi}(\varphi)$

diagrammani yana bir marta grafikaviy integrallab, $S=S(\varphi)$ siljish diagrammasini chizamiz (3.3 – shakl, *c*). Shunda S va

$\frac{dS}{d\varphi}$

ordinata masshtablari teng bo'lishi uchun $\overline{H_1}=\overline{OA_1}=57,2\ mm$ qilib olish kerak.

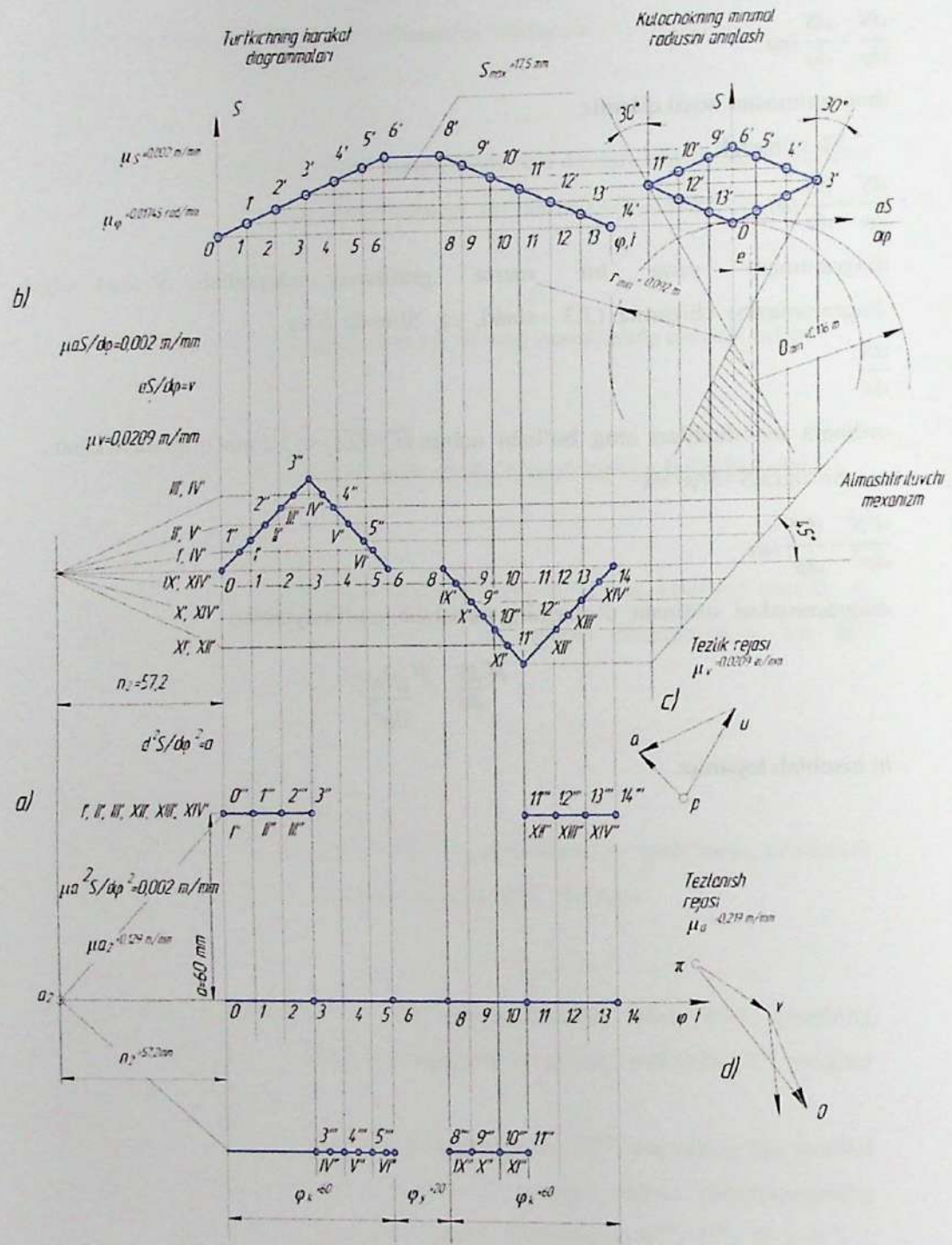
So'ngra $S=S(\varphi)$ va

$\frac{d^2S}{d\varphi^2}=\frac{d^2S}{d\varphi^2}(\varphi)$

diagrammalari ordinata o'qlarining masshtab koeffitsiyentlari

$$\mu_{\frac{dS}{d\varphi}},\ \mu_{\frac{d^2S}{d\varphi^2}}$$

ni hisoblab topamiz.


Turtkichning harakat diagrammalari
Kulachokning minimal radiusini aniqlash
S
S_{max} =175 mm
μ_S =0,002 m/mm
μ_φ =0,01745 rad/mm
0 1 2 3 4 5 6 8 9 10 11 12 13 φ, i
30°
$\frac{dS}{d\varphi}$
e
r_{min} = 0,092 m
0_{min} =0,116 m
b)
$\mu_{dS/d\varphi}$=0,002 m/mm
$eS/d\varphi=v$
μ_v=0,0209 m/mm
Almashtiruvchi mexanizm
51°
Tezlik rejasi
μ_v =0,0209 m/mm
c)
a
u
p
a)
$d^2S/d\varphi^2=a$
μ_{a^2}=0,002 m/mm²
μ_{a_2} =0,294 m/mm
a=60 mm
a_2
n_2 =57,2mm
Tezlanish rejasi
μ_a =0,294 m/mm
π
v
d)
0
φ_1 =60
φ_2 =30
φ_3 =60

3.2. Diagramma masshtablarini aniqlash

Turtkich siljish diagrammasi ordinata o'qining masshtabi quyidagi formuladan aniqlanadi:

$$\mu_S = \frac{h_{max}}{S_{max}} = \frac{0,035}{17,5} = 0,002\ m/mm$$

bu yerda S_{max}- siljish diagrammasi ordinatasining maksimal analogining qiymati, mm.

Tezlik analogining ordinata masshtabi:

$$\mu_{\frac{dS}{d\varphi}} = \frac{\mu_S}{H_1 \cdot \mu_\varphi} = \frac{\mu_S}{\frac{1}{\mu_\varphi} \cdot \mu_\varphi} = \mu_S = 0,002\ m/mm$$

Tezlanish analogining ordinata masshtabi:

$$\mu_{\frac{d^2S}{d\varphi^2}} = \frac{\mu_{\frac{dS}{d\varphi}}}{H_2 \cdot \mu_\varphi} = \frac{\mu_{\frac{dS}{d\varphi}}}{\frac{1}{\mu_\varphi} \cdot \mu_\varphi} = \mu_{\frac{dS}{d\varphi}} = 0,002\ m/mm$$

Shundan keyin ordinatalar o'qining chiziqli tezligi μ_V masshtabi va urinma tezlanishi masshtabi μ_a ni aniqlaymiz. Nazariy mexanika kursidan ma'lumki, yo'lning burilish burchagi bo'yicha birinchi hosilasi chiziqiy tezlik ordinatasiga proporsional bo'ladi, ya'ni:

$$V_2 = \frac{dS}{dt} = \frac{dS \cdot d\varphi}{dt \cdot d\varphi} = \omega_k \cdot \frac{dS}{d\varphi}$$

Bunda

$$\frac{dS}{dk} = \frac{V_2}{\omega_k}$$

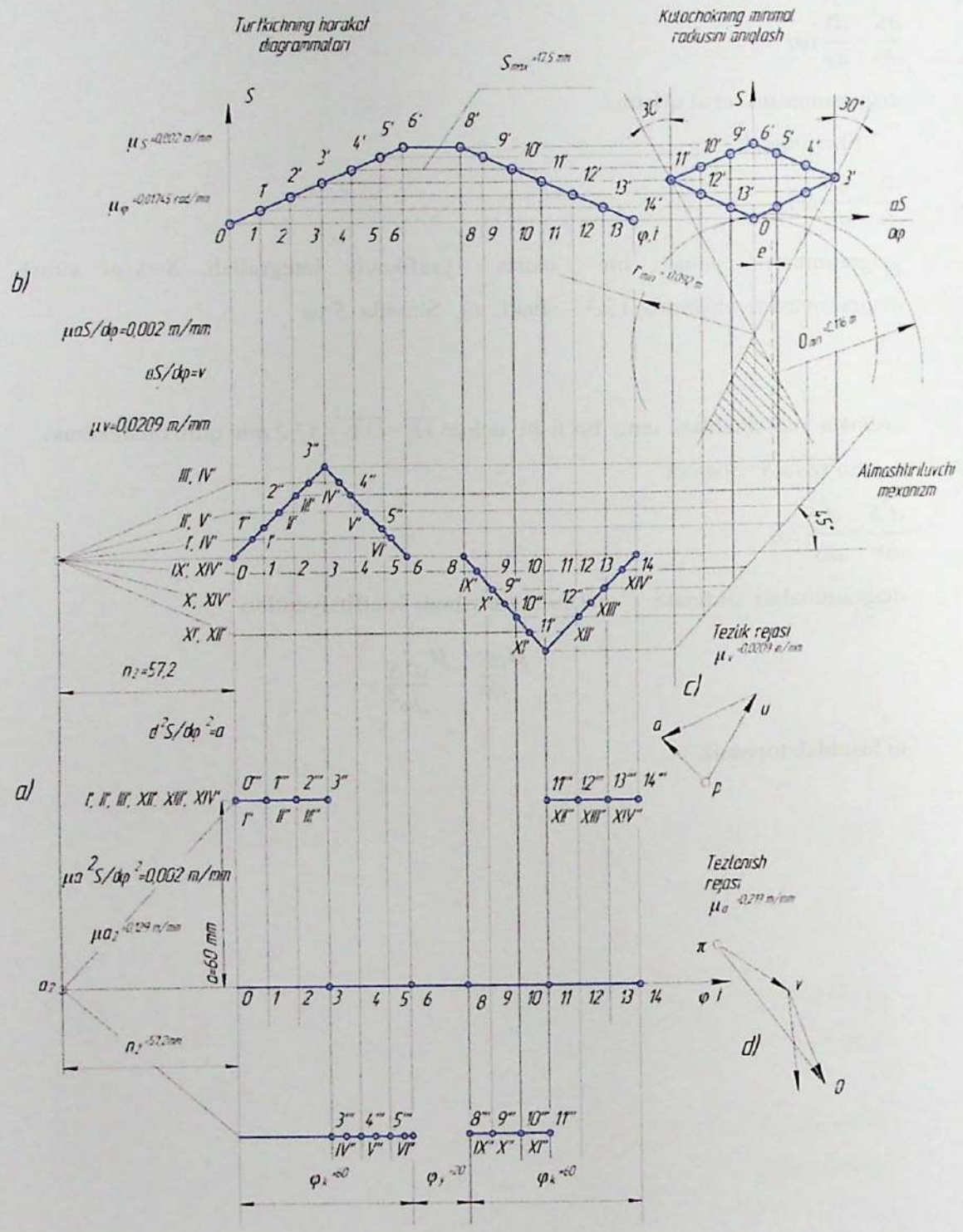
kelib chiqadi. Demak, chiziqli tezlikning ordinata masshtabi

$$\mu_{V_2} = \omega_k \cdot \mu_{\frac{dS}{d\varphi}} = 10,46 \cdot 0,002 = 0,209 \frac{m}{sek}/mm$$

bo'ladi, bu yerda

$$\omega_k = \frac{\pi n_k}{30} = \frac{3,14 \cdot 100}{30} = 10,46\ rad/sek$$

kulochokning burchak tezligi. Chiziqli tezlanishining ordinata masshtabi quyidagicha aniqlanadi.


Turtkichning harakat diagrammalari
Kulochokning minimal radiusini aniqlash
b)
a)
c)
d)
Tezlik rejasi
Tezlanish rejasi
Almashtiriluvchi mexanizm

3.2. Diagramma masshtablarini aniqlash

Turtkich siljish diagrammasi ordinata o'qining masshtabi quyidagi formuladan aniqlanadi:

$$\mu_S = \frac{h_{max}}{S_{max}} = \frac{0,035}{17,5} = 0,002\ m/mm$$

bu yerda S_{max}- siljish diagrammasi ordinatasining maksimal analogining qiymati, mm.

Tezlik analogining ordinata masshtabi:

$$\mu_{\frac{dS}{d\varphi}} = \frac{\mu_S}{H_1 \cdot \mu_\varphi} = \frac{\mu_S}{\frac{1}{\mu_\varphi} \cdot \mu_\varphi} = \mu_S = 0,002\ m/mm$$

Tezlanish analogining ordinata masshtabi:

$$\mu_{\frac{d^2S}{d\varphi^2}} = \frac{\mu_{\frac{dS}{d\varphi}}}{H_2 \cdot \mu_\varphi} = \frac{\mu_{\frac{dS}{d\varphi}}}{\frac{1}{\mu_\varphi} \cdot \mu_\varphi} = \mu_{\frac{dS}{d\varphi}} = 0,002\ m/mm$$

Shundan keyin ordinatalar o'qining chiziqli tezligi μ_V masshtabi va urinma tezlanishi masshtabi μ_a ni aniqlaymiz. Nazariy mexanika kursidan ma'lumki, yo'lning burilish burchagi bo'yicha birinchi hosilasi chiziqiy tezlik ordinatasiga proporsional bo'ladi, ya'ni:

$$V_2 = \frac{dS}{dt} = \frac{dS \cdot d\varphi}{dt \cdot d\varphi} = \omega_k \cdot \frac{dS}{d\varphi}$$

Bunda

$$\frac{dS}{dk} = \frac{V_2}{\omega_k}$$

kelib chiqadi. Demak, chiziqli tezlikning ordinata masshtabi

$$\mu_{V_2} = \omega_k \cdot \mu_{\frac{dS}{d\varphi}} = 10,46 \cdot 0,002 = 0,209 \frac{m}{sek}/mm$$

bo'ladi, bu yerda

$$\omega_k = \frac{\pi n_k}{30} = \frac{3,14 \cdot 100}{30} = 10,46\ rad/sek$$

kulochokning burchak tezligi. Chiziqli tezlanishining ordinata masshtabi quyidagicha aniqlanadi.

$$\mu_a=\omega_k^2\cdot\mu_{\frac{d^2S}{d\varphi^2}}=10,46^2\cdot 0,002=0,219\ \frac{m/sek^2}{mm}$$

3.3. Kulachokning minimal radiusini aniqlash

Grafikaviy usulda

$$S=S(\varphi)\qquad \frac{ds}{d\varphi}=\frac{ds}{d\varphi}(\varphi)$$

larning diagrammalarida o‘zgaruvchi φ burchakni yo‘qotib,

$$S=S(\varphi)\left(\frac{ds}{d\varphi}\right)$$

diagrammasini chizamiz (9-shakl,g). buning uchun

$$S=S(\varphi)\left(\frac{ds}{d\varphi}\right)$$

ning to‘g‘ri burchakli koordinatalar sistemasini chizib, uning ordinatalar o‘qiga turtkichning siljishi S ni va abssissalar o‘qiga tezlik analogi

$$\frac{ds}{d\varphi}$$

ni qo‘yamiz. Bunda

$$\frac{ds}{d\varphi}=\frac{ds}{d\varphi}(\varphi)$$

diagrammasining qutbiy oralig‘i H_1 ni hisoblashda tezlik masshtabi $\mu_{\frac{ds}{d\varphi}}$ ni siljish masshtabi μ_S ga teng qilib olish kerak. Kulachokning aylanish markazi O_k ni olamiz. O_k nuqtani

$$S=S(\varphi)\left(\frac{ds}{d\varphi}\right)$$

diagrammasining koordinatalar boshi O bilan birlashtirilib, aksial kulachokning minimal radiusini ko‘rsatuvchi kesmani olamiz. U holda,

$$r_{O\,min}=\overline{O_kO}\cdot\mu_S=46\cdot 0,002=0,092\ m$$

bo‘ladi. Agar turtkichning siljish chizig‘i yo‘nalishi kulachokning aylanish markazi O_k dan e oraliqqa o‘tsa, kulachokning minimal radiusi quyidagicha aniqlanadi:

$$\overline{e}=\frac{e}{\mu_S}=\frac{0,015}{0,002}=7,5\ mm$$

Bu kesmani kulachokning aylanishi bo'yicha OS to'g'ri chiziqning o'ng tomonida punktir to'g'ri chiziq bilan belgilaymiz. Uni urinma chiziq bilan kesishguncha davom ettirib, dezaksial kulachokning markazi O_k' ni aniqlaymiz.

Kulachokning minimal radiusi

$$r_{O\ min}=\overline{O_k'O}\cdot\mu_S=58\cdot 0,002=0,0116\ m$$

3.4. Ilgarilanma – qaytarilanma harakatlanuvchi rolikli turtkichi bo'lgan markaziy kulachokli mexanizm loyihalash

Agar $e=0$ bo'lsa, markaziy (aksial) kulachok profili chiziladi. Mexanizmni "qaytarish" usulini tatbiq etib, kulachok profilini chizamiz.

1. Chizmada ixtiyoriy nuqtada kulachokning aylanish markazi O_k ni tanlaymiz.
2. Uzunlik masshtabi $\mu_l=0,001\ m/mm$ bo'yicha kulachok radiusini xisoblaymiz:

$$r_{O\ min}=\frac{r_{O\ min}}{\mu_e}=\frac{0,092}{0,001}=92\ mm$$

Bu radius bilan aylana chizamiz (3.3 – shakl, *d*). Bu yerda kulachok profilining uzunlik masshtabi μ_l siljish grafigining masshtabi μ_S ga teng emas. Shuning uchun proporsionallik koeffitsiyenti K hisobga olinadi:

$$\mu_l=K\cdot\mu_S=\frac{1}{2}\cdot 0,002=0,001\ m/mm$$

3. Kulachokning markazi O_k dan vertikal $y-y$ chiziq o'tkazamiz. Kulachok markaziga rolikning yaqin turish paytida turtkichning vaziyatini belgilaymiz. Shunda rolikning markazi A kulachokning nazariy minimal radiusi $r_{O\ min}$ bilan o'tkazilgan aylanasida yetadi. Bu vaziyat turtkichning ko'tarilish payti bo'ladi.

3.5. Turtkich roliklarining radiusini aniqlash

Kulachok profilining yeyilishini va oliy kinematikaviy juftning shqalanishi kamaytirish uchun yetaklanuvchi zvenoga rolik o'rnatiladi. Rolikning o'lchamlari kulachok yasashda, uning profil chiziqlarining o'zaro kesishmaslik sharti va boshqa shartlarga binoan

$r_p \le (0,7...0,8)\rho_{min}$

$r_p \le (0,4...0,5)r_{O\,min}$

qilib olinadi (bu yerda ρ_{min} – kulachok markaziy profilining minimal egrilik radiusi). Bu ikki ifoda yordamida rolikning radiusini hisoblab topamiz. Uning kichik qiymati qabul qilinadi. Kulachok profilining minimal egrilik radiusini eng kichik bo'lgan qismi tanlanadi. Shu qism minimal radiusining markazi topiladi.

Buning uchun egrilik radiusi qidirilaètgan profil nuqtasi profilning shu nuqtaga yaqin o'ng va chap nuqtalari bilan tutashtirib, yoyning vatari o'tkaziladi. So'ngra vatarlar o'rtasidan tik chiziqlar o'tkazilib, ularning kesishuv nuqtasi belgilanadi. (3.3 – shakl, *d*). Ana shu nuqta egrilik radiusining markazi bo'ladi. Aksial kulachokli mexanizmlar roliklarining radiusini quyidagicha hisoblab topiladi:

$$r_p = 0,8 \cdot \overline{\rho_{min}} \cdot \mu_l = 0,8 \cdot 50 \cdot 0,001 = 0,040\ m$$

$$r_p = 0,4 \cdot r_{O\,min} = 0,4 \cdot 0,092 = 0,037\ m$$

hisoblab topilgan bu radiuslarning eng kichigi, ya'ni $r_p = 0,037\ m$ qabul qilinadi.

3.6. Haqiqiy kulachok profilini chizish

Kulachokning markaziy profili bo'yicha rolikning markazini aniqlab,

$$r_p = \frac{r_p}{\mu_l} = \frac{0,037}{1,001} = 37\ mm$$

radiusli bir necha aylanma chiziladi va bu aylanalarning chekka nuqtalari tutashtirilib, kulachokning haqiqiy profili hosil qilinadi.

3.7. Almashtirilgan mexanizm chizish va turtkichning tezlik va tezlanishini aniqlash

Oliy kinematikaviy juftli mexanizmlarni kinematikaviy analiz qilishda hisoblash usulini soddalashtirish maqsadida, ko'pincha, ularning oniy vaziyati shartli mexanizmga almashtiriladi. Kulachok profilida turtkichning vaziyatiga qarab, almashtirilgan mexanizmning uzunlik o'lchamlari o'zgaradi.

Buning uchun kulachokli mexanizmning berilgan vaziyati uchun uning oliy kinematikaviy jufti quyi kinematikaviy juftga almashtirilib, faqat quyi kinematikaviy juftli richagli mexanizm chiziladi.

Oliy kinematikaviy juft quyi kinematikaviy juftga almashtirilganda yangi mexanizmning qo'zg'aluvchanlik darajasi o'zgarmasligi kerak. Bunda oliy kinematikaviy juft ikkita aylanma yoki aylanma va ilgarilanma quyi kinematikaviy juftli bitta shartli zvenoga almashtiriladi.

Almashtirish tartibi quyidagicha bo'ladi:

Zvenolarning oliy kinematikaviy juftlarining urinish nuqtasidan ularning profiliga normal chiziqlar o'tkaziladi. Bu chiziqlarda har bir zveno egrilik radiusining markazi topiladi. Profilning egrilik radiusi markaziga aylanma kinematikaviy juft (sharnir) joylashtiriladi. Agar egrilik radiusining markazi cheksizlikda yotsa, ya'ni zveno profili to'g'ri chiziq bo'lsa, u holda profilning urinish nuqtasiga ilgarilanma kinematikaviy juft o'rnatiladi. So'ngra aniqlangan kinematikaviy juftlar chiziq bilan birlashtirilib, qo'shimcha zveno olinadida, u oldingi zvenolar bilan birlashtiriladi.

Almashtirilgan mexanizm kulachokli mexanizmning chizmasida shtrix chiziqlar bilan ko'rsatilgan (3.3 – shakl, *e*).

Kulachok va rolikdan iborat mexanizmning oliy kinematikaviy juftini unga ekvivalent bo'lgan quyi kinematikaviy juftli mexanizm bilan almashtiramiz.

Kulachok profillarining urinish nuqtalarining egrilik markazlarini aniqlaymiz. Rolikning profili aylana bo'lishi uchun uning egrilik markazi aylanish o'qi *A* da joylashgan bo'ladi. Kulachokning profili egri chiziq bo'lgani uchun urinish nuqtalarining egrilik markazlarini aniqlaymiz. Rolikning profili aylana

bo'lgani uchun, uning egrilik marakazi aylanish o'qida yotadi. Kulachokning profili egri chiziq bo'lgani uchun uning urinish nuqtasi A_4 dan profilga normal $n-n$ chiziq o'tkazamiz va unda egrilik markazi M nuqtani belgilaymiz. A_4 va M nuqtalarni shtrix to'g'ri chiziq bilan birlashtirib, yangi qo'shimcha zvenoni hosil qilamiz. Almashtirilgan mexanizm krivoship – polzunli mexanizmdir. Almashtirilgan mexanizm uchun tezliklar planini chizamiz (3.3 – shakl, *j*). Kulachokdagi M nuqtaning tezligi quyidagicha bo'ladi:

$$V_M=O_kM\cdot\omega_k=\overline{O_kM}\cdot\mu_l\cdot\omega_k=74\cdot0,001\cdot10,46=0,774\ m/sek$$

$$\mu_V=\mu_{V_2}=0,0209\ \frac{m/sek}{mm}$$

U holda, A nuqta tezligi vektorning kesma uzunligi

$$\overline{pM}=\frac{V_M}{\mu_V}=\frac{0,774}{0,0209}=37\ mm$$

Turtkichning A nuqtasi tezligini aniqlash uchun uning vektoriyal tenglamasini tuzamiz:

$$\overline{V_A}=\overline{V_M}+\overline{V_{AM}}$$

$$\overline{V_A}=\overline{V_y}+\overline{V_{Ay}}$$

Tezliklarning kutbiy rejasini chizib, turtkichning A nuqtasi tezligini aniqlaymiz (3.3 – shakl, *j*).

$$V_A=\overline{P_1a}\cdot\mu_V=21\cdot0,0209=0,44\ m/sek$$

$$\frac{ds}{d\varphi}=\frac{ds}{d\varphi}(\varphi)$$

diagrammasidan turtkichning shu vaziyatdagi tezligini aniqlaymiz:

$$V_A^l=\overline{44'}\cdot\mu_{V_2}=20\cdot0,0209=0,42\ m/sek$$

Tezliklar farqini hisoblab topamiz:

$$\Delta V=\frac{V_A-V_A^l}{V_A}\cdot100\%=\frac{0,44-0,42}{0,44}\cdot100\%=4,55\%$$

3.8. Almashtirilgan mexanizmning tezlanishlarini aniqlash

Kulachok o'zgarmas tezlik $\omega_k=const$ bilan aylangani uchun, uning burchagiy tezlanishi ε ham, urinma chiziqiy tezlanishi a^τ ham nolga teng. U holda kulachokdagi M nuqtaning tezlanishi quyidagicha bo'ladi:

$$a_M=a^n_{MO}=O_kM\cdot\omega_k^2=\overline{O_kM}\cdot\mu_l\cdot\omega_k^2=74\cdot0,001\cdot10,46^2=8,1\ m/sek^2$$

tezlanishlar rejasini chizish uchun tezlanish masshtabi μ_a tezlanishlar

$$\frac{d^2s}{d\varphi^2}=\frac{d^2s}{d\varphi^2}(\varphi)$$

diagrammasining masshtabi μ_{α_2} ga teng qilib olamiz:

$$\mu_a=\mu_{a_2}=0,219\ \frac{m}{mm\cdot sek^2}$$

Kulachokdagi M nuqtaning tezlanishi vektori kesmaning uzunligini aniqlaymiz:

$$\overline{\pi M}=\frac{a_M}{\mu_a}=\frac{8,1}{0,219}=37\ mm$$

Tezlanishlar rejasi chizish uchun tezlanishlarning vektoriyal tenglamasini tuzamiz:

$$\overline{a_a}=\overline{a_M}+\overline{a^n_{AM}}+\overline{a^\tau_{AM}}$$

$$\overline{a_A}=\overline{a_y}+\overline{a^n_{AM}}+\overline{a^\tau_{Ay}}$$

Yo'naltirilgan qo'zg'almas bo'lgani uchun $a_y=0$, $a^k_{Ay}=0$ bo'ladi. yuqoridagi tenglamada normal tezlanish

$$a^n_{AM}=\frac{V^2_{AM}}{MA}=\frac{\left(\overline{Ma}\cdot\mu_V\right)^2}{\overline{MA}\mu_l}=\frac{(39\cdot0,0209)^2}{52\cdot0,001}=12,78\ m/sek^2$$

Tezlanishlar planini chizib (3.3 – shakl, z), turtkichning A nuqtasi tezlanishi qiymatini aniqlaymiz.

$$a_A=\overline{\pi a}\cdot\mu_a=61\cdot0,219=13,36\ m/sek^2$$

turtkichning turish vaziyati

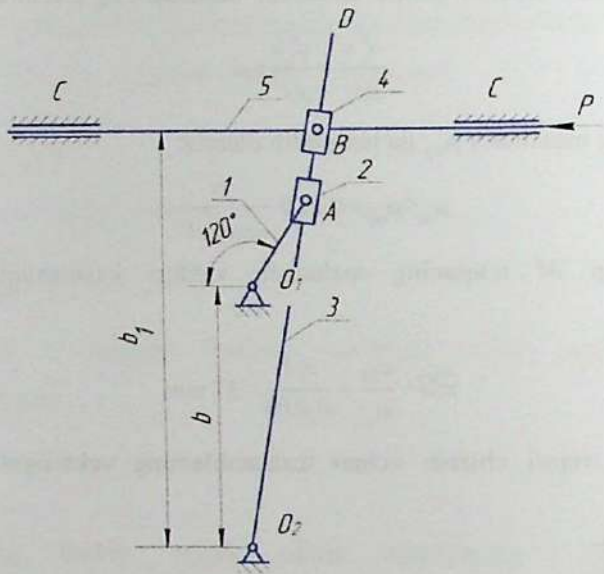
$$a^d_A=\overline{4\text{-}4'''}\cdot\mu_{a_2}=60\cdot0,219=13,14\ m/sek^2$$

Turtkichning tezlanishlari farqi quyidagicha bo'ladi:

$$\Delta a=\frac{a_A-a_A^d}{a_A}\cdot 100\%=\frac{13,36-13,14}{13,36}\cdot 100\%=1,6\%$$

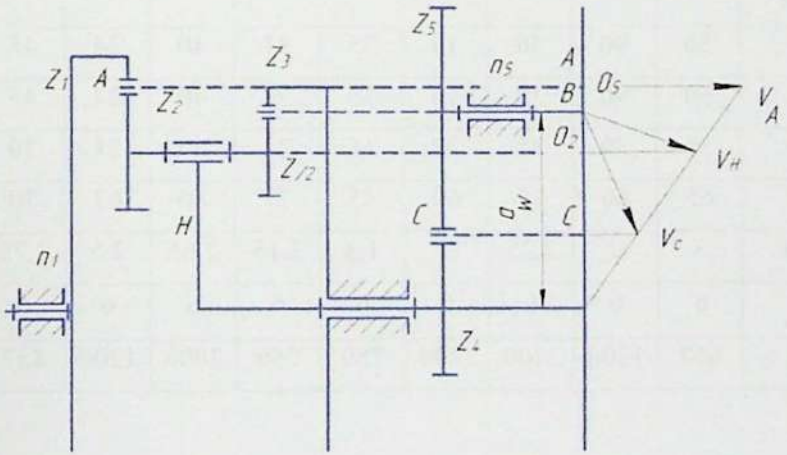
Demak, turtkichning tezlik va tezlanishlari qiymatini ikki usul bilan aniqlaganimizda, ularning qiymatlari bir – biridan katta farq qilmadi, ya`ni 5% dan oshmadi.

Mustaqil bajarish uchun topshiriqlar

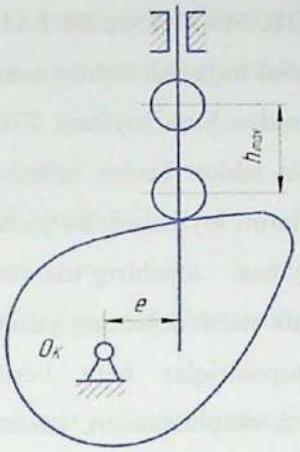


I – topshiriq bo'yicha variantlar						
Zvenolarning uzunligi	Berilgan kattaliklar	Variantlar				
		1	**2**	**3**	**4**	**5**
$b=2,5\cdot O_1A$	O_1A, m	0,04	0,05	0,06	0,08	0,10
	φ, rad	330	30	60	270	90
	n, $\frac{ayl}{min}$	60	70	80	50	40
$b_1=4\cdot O_1A$	P, N	200	300	400	350	250
	Berilgan kattaliklar	Variantlar				
		6	**7**	**8**	**9**	**10**
	O_1A, m	0,12	0,14	0,16	0,18	0,20
	φ, rad	240	120	210	180	0

$O_2D=5\cdot O_1A$	$n, \frac{ayl}{min}$	30	90	100	80	60
	P, N	220	320	360	340	260
Zvenolarning uzunligi	Berilgan kattaliklar	Variantlar				
		11	**12**	**13**	**14**	**15**
$b=2,5\cdot O_1A$	O_1A, m	0,06	0,07	0,08	0,09	0,11
	φ, rad	340	40	70	280	90
	$n, \frac{ayl}{min}$	70	80	90	60	50
$b_1=4\cdot O_1A$	P, N	200	300	400	350	250
	Berilgan kattaliklar	Variantlar				
		16	**17**	**18**	**19**	**20**
	O_1A, m	0,13	0,15	0,17	0,19	0,20
$O_2D=5\cdot O_1A$	φ, rad	250	130	230	190	0
	$n, \frac{ayl}{min}$	30	90	110	90	60
	P, N	230	330	370	350	270



II – topshiriq bo'yicha variantlar										
Kattaliklar	Variantlar									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
n_5, $\frac{ayl}{min}$	667	1200	2400	1200	750	750	2000	1200	857	750
Z_1	80	60	70	64	65	84	85	56	75	72
Z_2	40	80	30	16	35	21	30	14	35	18
Z'_2	40	80	30	16	35	21	30	14	35	18
Z_3	25	20	25	12	15	14	25	21	20	12
a_w, *mm*	65	50	65	60	45	77	80	63	60	66
y_{45}	3	2	2,23	2	1,29	2,13	2,65	2,5	1,75	2,13
m, *mm*	6	6	6	6	6	6	6	6	6	6
Kattaliklar	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
	660	1200	2400	1200	750	750	2000	1200	860	750
n_5, $\frac{ayl}{min}$	90	70	80	74	75	84	85	66	85	82
Z_1	50	90	30	16	35	31	40	24	45	28
Z_2	50	90	30	16	35	31	40	24	45	28
Z'_2	35	30	35	22	15	24	35	21	30	22
Z_3	65	60	75	60	45	77	80	63	70	66
a_w, *mm*	3	2	2,25	2	1,3	2,15	2,65	2,5	1,75	2,15
y_{45}	6	6	6	6	6	6	6	6	6	6
m, *mm*	667	1200	2400	1200	750	750	2000	1200	857	750



III – topshiriqlar bo'yicha variantlar										
Diagramm anig turi	Asosiy hisoblash parametrlari	Variantlar								
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
IX	$\varphi_k=\varphi_k$, *grad*	110	75	85	95	105	100	90	110	120	130
	φ_y, *grad*	20	25	15	35	15	10	20	0	10	0
	h_{max}, *m*	0,03	0,035	0,02	0,015	0,05	0,025	0,02	0,015	0,03	0,02
	n_k, *ayl/min*	400	450	500	550	600	625	650	475	600	425
	e, m	0,012	0,01	0,02	0,025	0,015	0,025	0,02	0	0,01	0,02
		11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
IX	$\varphi_k=\varphi_k$, *grad*	120	85	85	95	110	110	90	120	130	140
	φ_y, *grad*	25	25	25	35	25	20	25	0	20	0
	h_{max}, *m*	0,03	0,035	0,02	0,015	0,05	0,025	0,02	0,015	0,03	0,02
	n_k, *ayl/min*	400	450	500	550	600	625	650	475	600	425
	e, m	0,012	0,01	0,02	0,025	0,015	0,025	0,02	0	0,01	0,02

IV – BOB. MASHINA DETALLARI

1.1. Kurs loyihasini bajarish uchun umumiy ma'lumot

"Mashina detallari" fanidan kurs loyihasi 710000 – Muhandislik ishi va 720000 – Ishlab chiqarish va ishlov berish ta'lim sohalarida tahsil olayotgan talabalar uchun mashina detallarini loyihalash bo'yicha ilk amaliy – konstruktorlik tajribasi bo'ladi. Kurs loyihasi topshirig'ida talabalarga ularning ta'lim yo'nalishidagi ishchi texnologik mashinalarning yuritmalarini loyihalash bo'yicha mustaqil bajarish uchun topshiriqlar ham beriladi. Topshiriqda, odatda, yuritmaning kinematik sxemasi, ekspluatatsion, yuklama va energetik parametrlari beriladi.

Talabalar berilgan vazifa bo'yicha yuritmaning hamma elementlari hisobini bajarishi va silindrik, konussimon, chervyakli va boshqa turdagi reduktor ko'rinishidagi yopiq va ochiq uzatmani hamda yuritmani loyihalashlari zarur bo'ladi.

Kurs loyihasi asosan talabalarning mustaqil ishga ajratilgan vaqti hisobiga bajariladi. Lekin talabalardan bu loyihani o'z vaqtida sifatli bajarish ancha jiddiy mehnat va malakani talab etadi. Shu sababli, kurs loyihasiga rahbar va maslahatchi o'qituvchilar o'tiladigan maslahat darslarida talabalarning aksariyat qismida qiyinchilik tug'diradigan masalalarni tushuntirib, talabalar to'g'ri anglashiga va adabiyotlardan to'g'ri foydalanishiga yo'nalish, ko'rsatma va tavsiyalar berishi kerak bo'ladi. Bunda kurs loyihalari topshiriqlarining ayrim qismlarini dars vaqtida hamma talabalar bilan misol ishlab ko'rilsa maqsadga muvofiq sanaladi. Shu bilan birga, talabalarning kurs loyihasini to'g'ri va o'z vaqtida bajarishga yordam beradigan boshqa choralarni, jumladan, loyihaning ma'lum qismi hisoblari yoki chizmani kompyuter dasturlari yoki grafik dasturlar yordamida bajarishga imkon berish mumkin. Lekin, bu dastur va vositalardan foydalanganda talabaga ko'chirish yoki dasturdan shablon – andoza sifatida foydalanishga yo'l qo'yib bo'lmaydi.

Kurs loyihasi vazifasini bajarishda talabaga tarqatiladigan topshiriq ochiq bir yoki ikki pog'onali reduktor ko'rinishidagi uzatmalardan iborat bo'ladi.

Kurs loyihasi hajmi 30 – 35 varaq A4 formatidagi izoh (hisobiy – tushutirish yozuvi) va 3 ta A1 formatidagi chizmalardan iborat bo'ladi.

Izoh matni mazmuni:

1. Loyihalash uchun topshiriq.
2. Yuritmaning kinematik hisobi.
3. Ochiq uzatmaning hisobi.
4. Yopiq uzatma (reduktor)ning loyiha va tekshiruv hisoblari.
5. Vallarning hisobi.
6. Reduktor detallarini eskizda joylashtirishning birinchi bosqichi.
7. Podshipniklar tanlash va ularning xizmat muddati – umrboqiyligini aniqlash.
8. Shponka tanlash va shponkali birikma mustahkamligini hisoblash.
9. Reduktor detallarining eskizda joylashtirishning ikkinchi bosqichi.
10. Muftalarni tanlash.
11. Moylash tizimini ishlab chiqish va moy tanlash.

Kurs loyihasi chizmasi tarkibi va mazmuni:

1. Reduktorning umumiy ko'rinishi.
2. Reduktorning 3 – 4 detali ishchi chizmalari.
3. Yuritmaning eskiz chizmasi.

Bundan tashqari kurs loyihasini iqtisodiy baholash ham bajarilsa, maqsadga muvofiq bo'ladi.

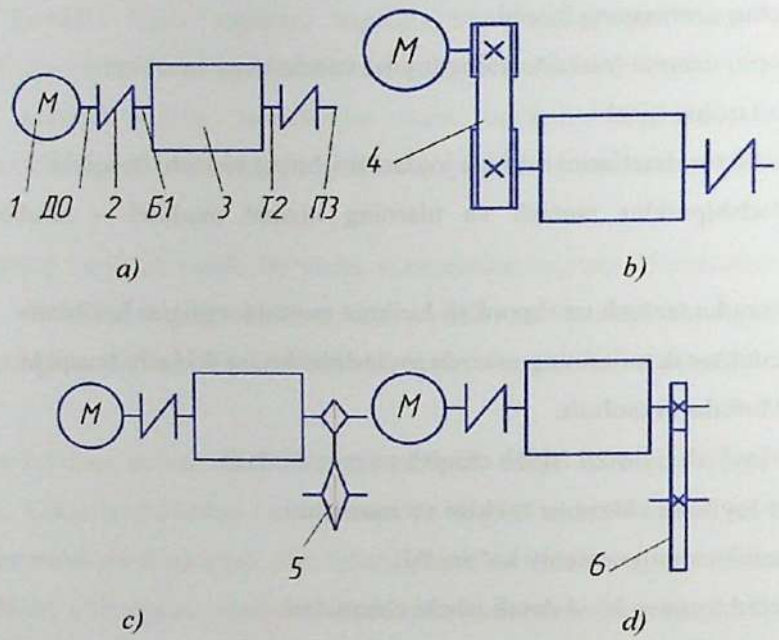
Kurs loyihasining taxminiy ro'yxati

- Bir pog'onali, silindrik g'ildirakli reduktorli lentali konveyer yuritmasini loyihalash.
- Bir pog'onali, silindrik g'ildirakli reduktorli zanjirli konveyer yuritmasini loyihalash.
- Bir pog'onali, konussimon reduktorli lentali konveyer yuritmasini loyihalash.
- Bir pog'onali, konussimon reduktorli zanjirli konveyer yuritmasini loyihalash.

- Bir pog‘onali, chervyakli reduktorli lentali konveyer yuritmasini loyihalash.
- Bir pog‘onali, chervyakli reduktorli zanjirli konveyer yuritmasini loyihalash.

Kurs loyihasi bo‘yicha texnik topshiriqlar

Texnik topshiriqda umumiy maqsadli yurutma loyihalashtirish taklif etiladi. Tavsiya etilgan yurutmanig kinematik sxemalari quyidagicha ifodalash mumkin:



Yuritmani sxemalari:

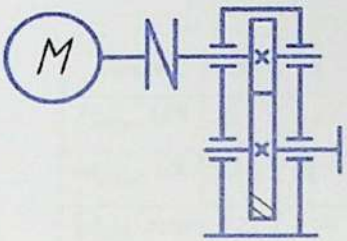
1 – elektr motor; 2 – elastik birikma; 3 – bir pog‘onalili reduktor; 4 – tasma; 5 – zanjirli uzatish; 6 – silindrsimon ochiq uzatmalar qutisi;

ДО – dvigatel vali; *Б1* – yuqori tezlikli uzatmalar qutisi vali; *Т2* – past tezlikli reduktor vali; *П3* – ishchi mashinaning uzatuvchi vali.

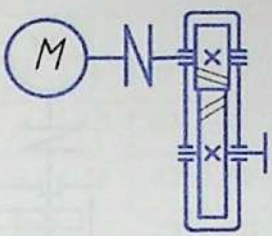
1.2. Kurs loyihasini mustaqil bajarish uchun topshiriqlar

I – topshiriq

Bir pog‘onali, silindrik g‘ildirakli reduktorli lentali konveyer yuritmasi loyihalansin. Mustaqil bajarish uchun topshiriqlar 1.1 – jadvalda ko‘rsatilgan.



1.1.1– rasm



1.1.2– rasm

Xizmat muddati – 10 yil;

Yillik koeffitsiyenti – $K_y = 0,8$

Kunlik foydalanish koeffitsiyenti – $K_C = 0,3$

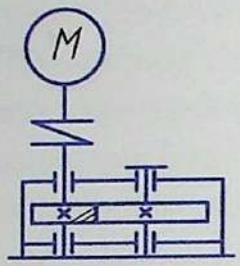
1.1– jadval

Variant	1	2	3	4	5	6	7	8	9	10	11	12
P_{chiq}, *kVt*	3,5	5	10	17	19	23	26	28	34	27,5	9	8
ω_{chiq}, *1/s*	16	16	18	20	18	16	14	13	11	9,5	28,5	20
$[a_\omega]$, *mm*	125	140	160	180	200	225	250	280	315	315	125	140
n_c, *1/min*	1000								750		1000	
Sxema	1.1.2									1.1.1		

13	14	15	16	17	18	19	20	21	22	23	24
8,5	10	14	15,5	20,5	2,5	3,5	5	1,5	2,5	3,5	5
12	11	11	9,5	9,5	37,5	37,5	37,5	28,5	30	30	25
180	200	225	250	280	80	90	100	80	90	100	112
750					1500	1500	1500	1500	1500	1500	1000
1.1.1					1.1.1	1.1.1	1.1.1	1.1.2	1.1.2	1.1.2	1.1.1

II – topshiriq

Bir pog'onali, silindrik g'ildirakli reduktorli zanjirli konveyer yuritmasi loyihalansin. Mustaqil bajarish uchun topshiriqlar 1.2 – jadvalda ko'rsatilgan.



1.2.1 – rasm

Xizmat muddati – 10 yil;

Yillik koeffitsiyenti – K_y= 0,8

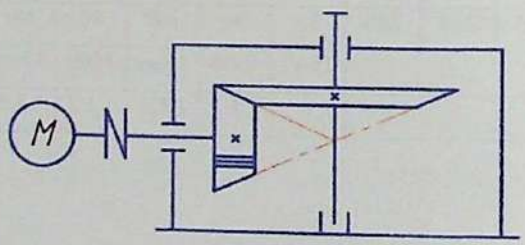
Kunlik foydalanish koeffitsiyenti – K_C=0,3

1.2 – jadval

Variant	1	2	3	4	5	6	7	8	9	10
P_{chiq}, *kVt*	10,5	12	22	12	13,5	16	19	17	19,5	27,5
ω_{chiq}, *1/s*	85	76,5	69	28	25	19,5	20	13,5	12	12
$[a_\omega]$, *mm*	80	100	125	140	160	180	200	225	250	280
n_c, *1/min*	1500	1500	1500	1000	1000	750	1000	750	750	750

III – topshiriq

Bir pog‘onali, konussimon reduktorli lentali konveyer yuritmasi loyihalansin. Mustaqil bajarish uchun topshiriqlar 1.3 – jadvalda ko‘rsatilgan.



1.3.1 – rasm

Xizmat muddati – 10 yil;

Yillik koeffitsiyenti – K_y= 0,8

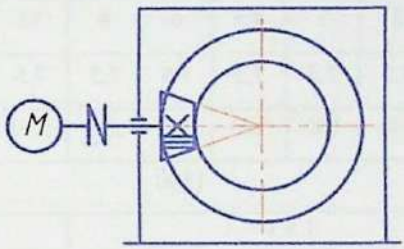
Kunlik foydalanish koeffitsiyenti – K_C=0,3

1.3 – jadval

Variant	1	2	3	4	5	6	7	8	9	10
P_{chiq}, *kVt*	0,5	1	1,5	2	3	4,5	6,5	9	13	18,5
ω_{chiq}, *1/s*	30,5	31	31	31,5	31,5	32	32	32	32,5	32
$[d_{e2}]$, *mm*	125	140	160	180	200	225	250	280	315	355
n_c, *1/min*	1000									

IV – topshiriq

Bir pog'onali, konussimon reduktorli zanjirli konveyer yuritmasi loyihalansin. Mustaqil bajarish uchun topshiriqlar 1.4 – jadvalda ko'rsatilgan.



1.4.1 – rasm

Xizmat muddati – 10 yil;

Yillik koeffitsiyenti – $K_y = 0,8$

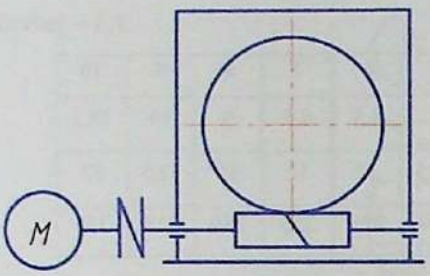
Kunlik foydalanish koeffitsiyenti – $K_C = 0,3$

1.4 – jadval

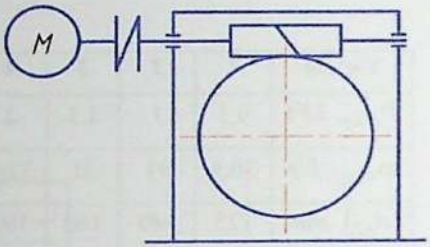
Variant	1	2	3	4	5	6	7	8	9	10
P_{chiq}, *kVt*	3,5	5	7	10	14	19,5	28	25,5	0,5	1
ω_{chiq}, *1/s*	60	60,5	61	61	61,5	61,5	61,5	49	65	66
$[d_{e2}]$, *mm*	160	180	200	225	250	280	315	355	80	90
n_c, *1/min*	1500									

V – topshiriq

Bir pog'onali, chervyakli reduktorli lentali konveyer yuritmasi loyihalansin. Mustaqil bajarish uchun topshiriqlar 1.5 – jadvalda ko'rsatilgan.



1.5.1 – rasm



1.5.2 – rasm

Xizmat muddati – 2000 soat

1.5 – jadval

Variant	1	2	3	4	5	6	7	8	9	10	11
P_{chiq}, *kVt*	1,5	2	3	4,5	6	8	12	17	24	1,5	2
ω_{chiq}, *1/s*	7,5	7,5	7,5	7,5	7,5	7,5	7,5	7,5	7,5	5,5	5,5
$[a_\omega]$, *mm*	125	140	160	180	200	225	250	280	315	125	140
n_c, *1/min*	1500									1000	
	1.5.1						1.5.2				1.5.2

2. Elektr dvigatelini tanlash

2.1. Uzatmani kinematikasi va kuchga hisoblash

1) Uzatmaning umumiy samaradorligini aniqlash (2.1 – jadval)

$$\eta_{um}=\eta_m \cdot \eta_{red}$$

Bu yerda: η_{red} - reduktorning foydali ish koeffitsiyenti;

η_m - muftaning foydali ish koeffitsiyenti;

$\eta_{red}=\eta_z$

$\eta_z=$

$\eta_m=$

$\eta_{um}=$

2.1 – jadval

Uzatmaning turi	Yopiq uzatma	Ochiq uzatma
Silindrsimon	0,96 ÷ 0,98	0,93 ÷ 0,95
Konussimon	0,95 ÷ 0,97	0,92 ÷ 0,94
Chervyakli		
kirimlar soni Z_1=1	0,65 ÷ 0,7	0,5 ÷ 0,6
Z_1=2	0,7 ÷ 0,6	0,6 ÷ 0,7
Z_1=4	0,8 ÷ 0,9	–
Zanjirli	0,95 ÷ 0,97	0,9 ÷ 0,93
Tasmali		
yassi	–	0,96 ÷ 0,98
ponasimon	–	0,95 ÷ 0,97
Bir juft dumalash podshipniklari	η= 0,99 ÷ 0,95	
Bir juft sirpanish podshipniklari	η= 0,98 ÷ 0,99	

2) Dvigatel quvvatini qabul qilish

$$P_d = \frac{P_{chiq}}{P_{um}} = \qquad kVt$$

3) Dvigatel kuchining ma'lum qiymatiga asoslanib, elektr motorni 2.1 – rasmdan (2.2 – jadval) tanlaymiz

2.2 – jadval

Quvvati P, kVt	n_c aylanishlar soni, 1/min			
	3000	1500	1000	750
0,25	–	–	–	71B8/680
0,37	–	–	71A6/910	80A8/675
0,55	–	71A4/1390	71B6/900	80B8/700
0,75	71A2/2840	71B4/1390	80A6/915	90LA8/700
1,1	71B2/2810	80A4/1420	80B6/920	90LB8/700

1,5	80A2/2850	80B4/1415	90L6/935	100L8/700
2,2	80B2/2850	90L4/1425	100L6/950	112MA8/700
3,0	90L2/2840	100S4/1435	112MA6/955	112MB8/700
4,0	100S2/2880	100L4/1430	112MB6/955	132S8/720
5,5	100L2/2880	112V4/1445	132S6/965	132M8/720
7,5	112V2/2900	132S4/1455	132V6/970	160S8/730
11	132M2/2900	132M4/1460	160S6/975	160M8/730
15	160S2/2940	160S4/1465	160M6/975	180M8/730
18,5	160M2/2940	160M4/1465	180M6/975	–

4A seriali elektrodvigatellar

2.3 – jadval

Elektrodvigatel markalari	Polyuslar soni	Gabarit o'lchamlari,mm				O'lchamlari, mm								
		L_1	L_2	H	D	d_1	d_2	l_1	l_2	l_3	b	d	h	h_o
4A71	2:4:6:8	285	330	201	170	19	19	40	45	90	112	7	71	9
4A80A		300	355	218	186	22	22	50	50	100	125	10	80	10
4A80B		320	375											
4A90L		350	405	243	208	24	24	50	56	125	140	10	90	11
4A100S	2:4:6:8	365	427	265	235	28	28	60	63	132	160	12	100	12
4A100L		395	457	230						140				
4A112M		452	534	310	260	32	32	80	70	140	190	12	112	12
4A132S		480	560	350	302	38	38	80	89	178	216	12	132	13
4A132M		530	610											
4A180S	2	624	737	430	358	42	42	110	108	178	254	15	160	18
	4:6:8					48								
4A160M	2	667	780	430	358	42	42	110	108	210	254	15	160	18
	4:6:8					48								
4A180S	2	662	778	470	410	48	48	110	121	203	279	15	180	20
	4:6:8					55				241				
4A180M	2	702	818	470	410	48	48	110	121	241	279	15	180	20

4) Uzatmaning uzatishlar sonini aniqlash:

$$u_{um}=\frac{n_d}{n_{u.ay}}=$$

n_d - dvigatel valining aylanishlar soni, 1/m;

$n_{u.ay}$ - uzatmadagi ishchi valining aylanishlar soni, 1/m.

5) Valning aylanishlar sonini aniqlash:

$n_o=n_d=n_1=$ *1/min;*

$n_2=\frac{n_1}{u_{um}}=$ *1/min.*

6) Boshlang'ich burchak tezligi, tezyurar valning burchak tezligini aniqlash:

$$\omega_o=\omega_1=\frac{\pi \cdot n_1}{30}=$$ *1/s*

7) Tinch holatdagi valning burchak tezligini aniqlash:

$$\omega_2=\frac{\pi \cdot n_2}{30}=$$ *1/s*

8) Uzatmaning vallaridagi quvvat, kVt:

$P_0=P_d=$ *kVt;*

$P_1=P_o \cdot \eta_m=$ *kVt;*

$P_1=P_o \cdot \eta_z=$ *kVt;*

9) Uzatma vallaridagi burovchi momentlar:

$$M_0=\frac{P_o}{\omega_o}=$$ *N·m;*

$$M_1=\frac{P_1}{\omega_1}=$$ *N·m;*

$$M_2=\frac{P_2}{\omega_2}=$$ *N·m;*

Materiallarni tanlash

Uzatmaning ishlash sharoiti hamda g'ildirak o'lchamlarini hisobga olgan holda yetaklovchi va yetaklanuvchi tishli g'ildiraklar uchun materiallar 2.4 – jadvalda keltirilgan.

Yetaklovchi va yetaklanuvchi tishli g'ildiraklar uchun 45,40X, 40XH, 35XM, 45XL markali po'lat materiallari tanlanadi.

Tishli g'ildiraklar uchun material hamda termiknqayta ishlashni tanlash $[\sigma_{FO}]$ va $[\sigma_{HO}]$ lari qiymatlari

2.4 – jadval

Tish yuzasining qattiqligi	269 ÷ 302 HB	235 ÷ 262 HB	45 ÷ 50 HRC 48 ÷ 53 HRC 50 ÷ 56 HRC	269 ÷ 302 HB	45 ÷ 50 HRC 48 ÷ 53 HRC 50 ÷ 56 HRC
Tishli g'ildiraklarning materiallarini tanlash	45,40X, 40XH, 35XM, 45XL				
$[\sigma_{FO}]$	1,03 HB o'r	m≥3 bo'lganda 370 m<3 bo'lganda 370	1,03 HB o'r	m≥3 bo'lganda 370 m<3 bo'lganda 370	480
$[\sigma_{HO}]$	1,8 HB o'r +67	14 HB o'r +170	1,8 HB o'r +67	14 HB o'r +170	19 HB o'r

Ruxsat etilgan $[\sigma_H]$ va $[\sigma_F]$ kuchlanishlar

Ruxsat etilgan kontakt $[\sigma_H]$ va egilishdagi $[\sigma_F]$ kuchlanishlarning qiymatlari yetaklanuvchi va yetaklovchi tishli g'ildiraklar uchun alohida aniqlanadi:

$$[\sigma_H]=K_{HL}\cdot[\sigma_{HO}]\ MPa,\ [\sigma_F]=K_{FL}\cdot[\sigma_{FO}]\ MPa$$

Bu yerda: $[\sigma_H]$ va $[\sigma_F]$ – kuchlanishlar siklining o'zgarishiga bog'liq ruxsat etilgan kuchlanishlar bo'lib, qiymati 2.5 – jadvaldan olinadi.

K_{HL}- uzatmaning ishlash muddatini hisobga oluvchi koeffitsiyent:

$$K_{HL}=m\sqrt{\frac{N_{HO}}{N_2}}$$

N_{HO} - yuklanish davrlarining asosiy soni 2.6 – jadvaldan olinadi; m=6 – daraja ko'rsatkichi (termik qayta ishlash yaxshi bo'lganda).

K_{FL} - uzatmaning ishlash muddatini hisobga oluvchi koeffitsiyent:

$$K_{FL}=m\sqrt{\frac{N_{FO}}{N}}$$

Bu yerda: $N_{FO}=4\cdot10^6$- o'zgaruvchan yuklanish sikli; m=9 – daraja ko'rsatkichi (termik qayta ishlash toblashda).

Po'lat materiallarining mexanik ta'riflari

2.5 – jadval

Po'lat materiallari	Diametr d, mm	Eni b, mm	Tishning markazida HB	Tishning yuzasida HRC	σ_M	σ_{oq}
					MPa	
45	125	80	235 ÷ 262		780	540
	80	50	269 ÷ 302		890	650
	200	125	235 ÷ 262		790	640
40 X	125	80	269 ÷ 301		900	750
	125	80	269 ÷ 302	45 ÷ 50	900	750
	315	200	235 ÷ 262		800	670
35 XM	200	125	269 ÷ 302		920	790
	200	125	269 ÷ 302	48 ÷ 53	920	790
40 XM	315	200	235 ÷ 262		800	630
	200	125	269 ÷ 302		920	750
	200	125	269 ÷ 302	48 ÷ 53	920	750
40 XЦ	315	200	235 ÷ 262			660
	200	125	269 ÷ 302			780
	200	125	269 ÷ 302	50 ÷ 56		780
20 X 20 XHM 18 XГM 25 XГHM	200	125	300 ÷ 400	56 ÷ 63		800

N_{HO} - qiymatlari

2.6 – jadval

G'ildirak tishlar yuzasining o'rtacha qattiqligi	HB o'r	200	250	300	350	400	450	500	550	600
	HRC o'r	–	25	32	38	43	47	52	56	60
$N_{HO} \cdot 10^6$ mln		10	16,5	25	35,4	50	68	87	114	143

2.2. Silindirsimon uzatmaning hisobi

Uzatmaning asosiy o'lchamlari o'qlararo masofa a_ω, uzatishlar soni u, tish eni b, koeffitsiyenti ψ_{ba}, modul m va tishning qiyalik burchagi β.

1. O'qlararo masofa a_ω

$$a_\omega = K_a(1+u)3\sqrt{\frac{K_{H\beta} \cdot T_2 \cdot 10^3}{\psi_{ba} \cdot u^2 \cdot [\sigma_H]^2}}$$

Bu yerda: K_a- o'qlararo masofa koeffitsiyenti bo'lib, qiya tishli uzatmalar uchun K_a=43, to'g'ri tishli uzatmalar uchun K_a=49,5 bo'ladi.

$K_{H\beta}$ – yuklanishning tish yuzasida notekis taqsimlanishini hisobga oluvchi koeffitsiyent bo'lib, natijalar 2.7 – jadvaldan olinadi.

ψ_{ba} va $K_{H\beta}$ koeffitsiyentlari

2.7 – jadval

Yetaklovchi tishli g'ildiraklarning tayanchga nisbatan joylashishi	ψ_{ba}	Tish yuzasining qattiqligi, HB	
		≤350	>350
Simmetrik	0,4 ÷ 0,5	1,00 ÷ 1,15	1,05 ÷ 1,25
Nosimmetrik	0,25 ÷ 0,4	1,10 ÷ 1,25	1,15 ÷ 1,35
Konsol	0,2 ÷ 0,25	1,20 ÷ 1,35	1,25 ÷ 1,45

2. Yetaklanuvchi tishli g'ildiraklar eni $b_2 = \psi_{ba} \cdot a_\omega$

3. Yetaklovchi tishli g'ildiraklar eni $b_1=1,12\cdot\psi_{ba}\cdot a_\omega$

4. Kontakt kuchlanishning hisobiy qiymati

$$\sigma_H=K\cdot\sqrt{\frac{F_t(u+1)\cdot K_H}{b_2\cdot d_2}}\le[\sigma_H]$$

Bu yerda: K- qo'shimcha koeffitsiyent, to'g'ri tishli silindrsimon g'ildiraklar uchun – 430, qiya tishli silindrsimon g'ildiraklar uchun – 376.

$F_t=2T_2/d_2$- aylanma kuch.

$K_H=K_{H\alpha}\cdot K_{H\beta}\cdot K_{HV}$- yuklanish koeffitsiyenti

$K_{H\alpha}$ – yuklanishni tishlararo notekis taqsimlanishni hisobga oluvchi koeffitsiyent, qiymati 2.8 – jadvaldan olinadi.

$K_{H\alpha}$- koeffitsiyent

2.8 – jadval

Aniqlik darajasi	Uzatma g'ildiraklarining aylanma tezligi, m/s				
	1 gacha	5 gacha	10 gacha	15 gacha	20 gacha
6	1	1,02	1,03	1,04	1,05
7	1,02	1,05	1,07	1,10	1,12
8	1,05	1,09	1,13	–	–
9	1,09	1,06	–	–	–

2.9 – jadval

Aniqlik darajasi	Uzatma g'ildiraklarining aylanma tezligi, m/s			
	To'g'ri tishli		Qiya tishli	
	silindrsimon	konussimon	silindrsimon	konussimon
6	15 gacha	12 gacha	30 gacha	20 gacha
7	10	8	15	10
8	6	4	10	7
9	2	1,5	4	8

$K_{H\nu}$- koeffitsiyenti

2.10 – jadval

Uzatmalar	Tish yuzasining qattiqligi HB	Aylanma tezligi, m/s			
		5 gacha	10	15	20
		Aniqlik darajasi			
		8		7	
To'g'ri tishli	≤350	1,05	–	–	
	>350	1,10	–	–	
Qiya va shevron tishli	≤350	1,0	1,01	1,02	1,05
	>350	1,0	1,05	1,07	1.10

5. Yetaklanuvchi tishli g'ildirak tish bo'luvchi aylanasining diametri aniqlanadi:

$$d_2 = \frac{2 \cdot a_\omega \cdot u}{(u+1)} \quad mm$$

6. Uzatma g'ildiraklarining ilashish moduli aniqlanadi

$$m_n \geq \frac{2 \cdot K_m \cdot T_2}{d_2 \cdot b_2 \cdot [\sigma_F]} \; mm$$

K_m – modul koeffitsiyenti; to'g'ri tishli silindrsimon g'ildiraklar uchun – 6,8; qiya tishli silindrsimon g'ildiraklar uchun – 5,8; ikki tomonlama qiya tishli silindrsimon g'ildiraklar uchun – 5,2.

$[\sigma_F]$ qiymati o'rniga $[\sigma_F]_1$, $[\sigma_F]_2$ lar qiymatining kichigi olinadi.

7. Uzatma g'ildirak tishlarining umumiy soni:

$$Z_y = \frac{2 \cdot a_\omega \cdot cos\beta_{min}}{m}$$

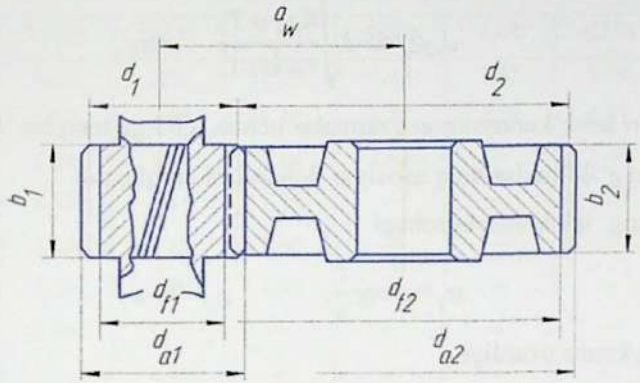
8. Yetaklovchi g'ildirak tishlari soni:

$$Z_1 = \frac{Z_y}{1+u} \geq Z_{1\,min}$$

To‘g‘ri tishli silindrsimon g‘ildiraklar uchun Z_1=17, qiya tishli silindrsimon g‘ildiraklar uchun $Z_{1\,min}= 17cos^3\beta$.

Yetaklanuvchi g‘ildirak tishlari soni $Z_2=Z_1 \cdot u$; $Z_2=Z_y-Z_1$

9. Uzatma g‘ildiraklarining geometrik o‘lchamlari 2.1 – rasm (2.11 – jadval)



2.1 – rasm. Silindirsimon g‘ildirakli uzatmalarning geometrik o‘lchamlari

2.11 – jadval

G‘ildirak diametrlari	To‘g‘ri tishli silindrsimon g‘ildiraklar	Qiya tishli silindrsimon g‘ildiraklar
Tish bo’luvchi aylanasining diametri a) Yetaklovchi g‘ildirak b) Yetaklanuvchi g‘ildirak	$d_1=mZ_1$ $d_2=mZ_2$	$d_1=mZ_1/cos\beta$ $d_2=mZ_2/cos\beta$
Tashqi diametr a) Yetaklovchi g‘ildirak b) Yetaklanuvchi g‘ildirak	$d_{a1}=d_1+2m$ $d_{a2}=d_2+2m$	$d_{a1}=d_1+2m_n$ $d_{a2}=d_2+2m_n$
Tish osti diametri a) Yetaklovchi g‘ildirak b) Yetaklanuvchi g‘ildirak	$d_{f1}=d_1-2,5m$ $d_{f2}=d_2-2,5m$	$d_{f1}=d_1-2,5m_n$ $d_{f2}=d_2-2,5m_n$

2.3. Yopiq konussimon uzatmaning hisobi

Uzatmaning asosiy o'lchamlari yetaklanuvchi g'ildirak tashqi diametri d_{e2}, uzatishlar soni u, tish eni b, modul m va tishning qiyalik burchagi β.

1. Yetaklanuvchi g'ildirak tashqi diametri

$$d_{e2} \geq 165 \cdot 3 \sqrt{\frac{K_{H\beta} \cdot u \cdot T_2}{\nu_H \cdot [\sigma_H]^2}} \quad mm,$$

ν_H - to'g'ri tishli konussimon uzatmalar uchun 0,85 ga teng bo 'ladi.

2. Uzatma g'ildiraklarining asosiy o 'lchamlari aniqlanadi

a) Boshlang 'ich konus burchagi

$$\varphi_1 = arctg\frac{1}{u}; \qquad \varphi_2 = 90 - \varphi_1$$

b) Tashqi konus uzunligi

$$R_e = \frac{d_{e2}}{2sin\varphi_2}$$

c) G'ildirak tishli qismining eni

$$b = 0,285 R_e$$

3. Kontakt kuchlanishva ruxsat etilgan kuchlanish solishtiriladi

$$\sigma_H = 2120 \sqrt{\frac{u \cdot T_2 \cdot K_{H\beta}}{V_H \cdot d_{e2}^3}} \leq [\sigma_H]$$

Aniqlangan kontakt $[\sigma_H]$ kuchlanish ruxsat etilgan kontakt kuchlanishdan 3% dan oshmasligi kerak. Agarda $\sigma_H / [\sigma_H]$ bo'lsa, d_{e2} ning qiymati kamaytiriladi.

4.

$$m_e (m_{te}) = \frac{14 \cdot K_{F\beta} \cdot T_2}{V_F \cdot d_{e2} \cdot b \cdot [\sigma_F]} \quad mm,$$

$K_{F\beta}$ – koeffitsiyenti qiymati 2.12 – jadvaldan olinadi.

2.12 – jadval

$\psi_{bd}=\frac{b}{a}$	Yetaklovchi g'ildirakning tayanchiga nisbatan joylashtirish							
	simmetrik		nosimmetrik		konsol			
					Zoldirli podshipnik		Rolikli podshipnik	
	Tish yuzasining qattiqligi							
	≤350	>350	≤350	>350	≤350	>350	≤350	>350
0,2	1,00	1,03	1,04	1,05	1,18	1,35	1.10	1,20
0,4	1,03	1,07	1,07	1,10	1,37	1,70	1,21	1,45
0,6	1,05	1,09	1,12	1,18	1,62	–	1,40	1,72
0,8	1,08	1,13	1,17	1,28	–	–	1,59	–
1,0	1,10	1,20	1,23	1,40	–	–	–	–
1,2	1,13	1,30	1,30	1,53	–	–	–	–
1,4	1,19	1,40	1,38	–	–	–	–	–
1,6	1,25	–	1,45	–	–	–	–	–
1,8	1,32	–	1,53	–	–	–	–	–

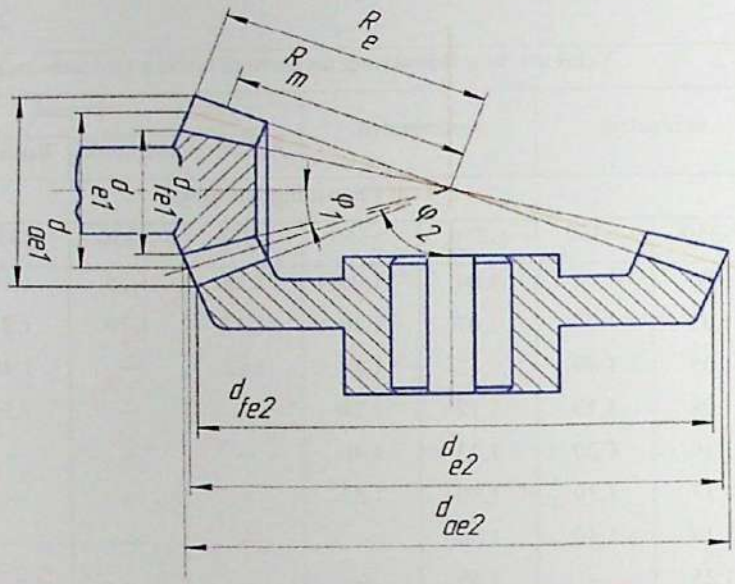
5. Uzatma g'ildirak tishlarining sonini aniqlash
   a) Yetaklovchi g'ildirak tishlar soni $Z_2=d_{e2}/m_e(m_{te})$
   b) Yetaklanuvchi g'ildirak $Z_1=Z_1/u$
6. Uzatish sonining hisobiy qiymati

$$u_x=\frac{Z_2}{Z_1}$$

Hisobiy qiymat berilgan qiymatdan 4% farq qilishi mumkin

$$\Delta u=\frac{(u_x-u)100}{u}\leq[4\%]$$

7. Uzatma g'ildiraklarining geometrik o'lchamlari 2.2 – rasm (2.13 – jadval)



2.2 – rasm. Konussimon g'ildirakli uzatmalarning geometrik o'lchamlari

2.13 – jadval

G'ildirak diametrlari	To'g'ri tishli uzatmalar uchun
Tish bo'luvchi aylanasi diametri a) Yetaklovchi g'ildirak b) Yetaklanuvchi g'ildirak	$d_{e1} = m_e \cdot Z_1$ $d_{e2} = m_e \cdot Z_2$
Tashqi diametr a) Yetaklovchi g'ildirak b) Yetaklanuvchi g'ildirak	$d_{ae1}=d_{e1}+2m_e\cos\varphi_1$ $d_{ae2}=d_{e2}+2m_e\cos\varphi_2$
Tish osti diametri a) Yetaklovchi g'ildirak b) Yetaklanuvchi g'ildirak	$d_{ae1}=d_{e1}-2,4m_e\cos\varphi_1$ $d_{ae2}=d_{e2}-2,4m_e\cos\varphi_2$

2.4. Chervyakli uzatmaning hisobi

Uzatmaning asosiy o'lchamlari o'qlararo masofa a_ω, uzatishlar soni u, chervyakning kirim soni Z_1 chervyakli g'ildirakning tishlar soni Z_2, modul m, chervyak diametri koeffitsiyenti q, chervyak o'ramining ko'tarilish burchagi γ, chervyak o'ramining uzunligi b_1 va chervyakli g'ildirakning eni b_2.

1. Chervyak va chervyakli g'ildiraklar uchun material 2.14 – jadvaldan tanlanadi.

2.14 – jadval

Tish yuzasining qattiqligi	269 ÷ 302 HB	235 ÷ 262 HB	45 ÷ 50 HRC 48 ÷ 53 HRC 50 ÷ 56 HRC	269 ÷ 302 HB	45 ÷ 50 HRC 48 ÷ 53 HRC 50 ÷ 56 HRC
Tishli g'ildiraklarning materiallarini tanlash	45,40X, 40XH, 35XM, 45XЦ				
$[\sigma_{FO}]$	1,03 HB o'r	m≥3 bo'lganda 370 m<3 bo'lganda 370	1,03 HB o'r	m≥3 bo'lganda 370 m<3 bo'lganda 370	480
$[\sigma_{HO}]$	1,8 HB o'r +67	14 HB o'r +170	1,8 HB o'r +67	14 HB o'r +170	19 HB o'r

Chervyakli g'ildirakning tishli gardishi antifiriksion xususiyatga ega materiallardan tayyorlanib 2.15 – jadvaldan uzatmaning sirpanish tezligiga nisbatan tanlanadi.

$$V_c \approx 0,0043\omega_1\sqrt{T_2} \quad l/s$$

2.15 – jadval

Materiallar gruppasi	Materiallar markalari	Quyish usuli	σ_{OK}	σ_M	σ_{B9}	V
I	Бр010Н1Ф1	Markazdan qochma usul	165	285	–	5

	Бр010Ф1		195	245	–	5
	Бр010Ф1	Qumda	132	215	–	5
II	БрА9Ж3Л	Markazdan qochma usul	200	500	–	2...5
	БрА9Ж3Л		195	490	–	2...5
	БрА9Ж3Л	Qumda	195	392	–	2...5
III	С4.15	Qumda			280	2

2. Ruxsat etilgan kuchlanish

I – gruppa uchun $[\sigma_H]=K_{HL}\cdot C_V\cdot[\sigma_{HO}]$ MPa

Bu yerda: K_{HL} - uzatmaning uzoq muddat ishlashini hisobga oluvchi koeffitsiyent

$$K_{HL}=\sqrt{\frac{10^7}{N}}$$

$N=573\omega_2 L_h$ - o'zgaruvchan yuklanishlar soni $N=25/10^7$ bo'lsa, $N=25\cdot10^7$

L_h - uzatmaning ishlash muddati, soat hisobida

C_V - chervyakli g'ildirakning yeyilishini hiobga oluvchi koeffitsiyenti bo'lib, qiymati sirpanish tezligiga nisbatan olinadi:

V_c	5	5	7	8
C_V	0.95	0.88	0,83	0,8

$[\sigma_H]$- o'zgaruvchan yuklanishlar soni 10^7 siklga to'g'ri kelgan ruxsat etilgan kontakt kuchlanish

$$[\sigma_H]=(0,75\div0,99)\sigma_M \ MPa$$

Bu yerda: ≤350 HB bo'lganda 0,75 olinadi, ≥45 HRC bo'lganda 0,9 olinadi

II – gruppa uchun

$$[\sigma_H]=[\sigma_{HO}]-25V_c \quad MPa$$

Bu yerda: ≤350 HB bo'lganda $[\sigma_{HO}]$=250 MPa olinadi, ≥45 HRC bo'lganda $[\sigma_{HO}]$ =300MPa olinadi.

III – gruppa uchun

$[\sigma_{HO}] = 175 - 35\ V_c \quad MPa$

Ruxsat etilgan egilishdagi kuchlanish:

Bu yerda:

$$K_{FL} = 3\sqrt{\frac{10^7}{N}}$$

$N = 573\omega L_h$- sikllar soni

I,II – gruppa uchun $[\sigma_{FO}] = 0,25\sigma_{OK} + 0,08\sigma_M$

III – gruppa uchun $[\sigma_{FO}] = 0,12\sigma_{B9}$

3. O'qlararo masofa

$$a_\omega \geq 61 \cdot 3\sqrt{\frac{T_2}{[\sigma_H]^2}} \quad mm$$

a_ω = 80, 100, 125, 140, 160, 180, 200, 225, 250, 280, 315, 356, 400, 450, 500, 560, 630, 710.

4. Chervyakning kirimlar soni Z_1

u.....8 dan 14 gacha	14 dan 30 gacha	30 dan yuqori
4	2	1

Yetaklanuvchi g'ildirak uchun tishlar soni:

$$Z_2 = Z_1 \cdot u \geq Z_{min} = 28$$

5. Uzatmaning moduli:

$$m = (1,5 \div 1,7)\frac{a_\omega}{Z_2}$$

Aniqlangan qiymatlar standart bo'yicha yaxlitlanadi, 2.16 – jadval

m	2,5; 3,5; 4,5	6; 3; 8; 10, 12,5;	6
q	8; 10; 12,5; 16; 20;	8; 10, 12,5; 14; 16, 20	8; 10; 12,5; 16

6. Chervyakning diametr koeffitsiyenti

$$q = \frac{2a_\omega}{m} + Z_z \geq q_{min}$$

q – ning eng kichik qiymati q_{min} =0,212 Z_2

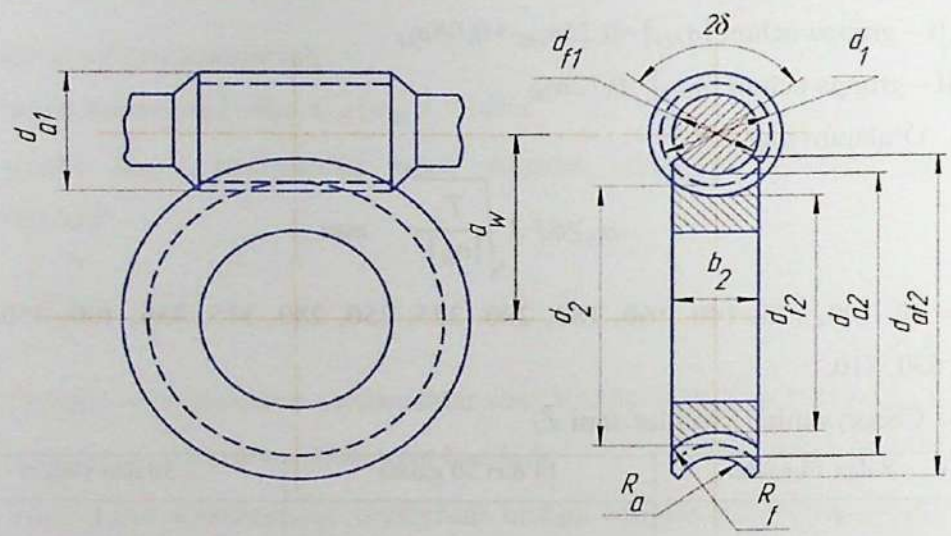
7. Siljish koeffitsiyenti

$$X=\left(\frac{a_\omega}{m}\right)-0,5(Z_2+q)$$

8. Uzatish sonining hisobiy qiymati

$$u_x=\frac{Z_2}{Z_1};\qquad \Delta u=\frac{(u_x-u)}{u}\cdot 100\%\le[4\%]$$

9. Uzatma g'ildiraklarining geometrik o'lchamlari 2.3 – rasm (2.17 – jadval)



2.3 – rasm. Chervyakli g'ildirak uzatmalarining geometrik o'lchamlari

2.17 – jadval

Chervyak va chervyakli g'ildirak geometrik o'lchamlari		Chervyak	Chervyakli g'ildirak
Tish bo'luvchi aylanasining diametri		$d_1=mq$	$d_2=mZ_2$
Tashqi diametr		$d_{a1}=d_1+2m$	$d_{a2}=d_2+2(1+x)m$
Tish osti diametr		$d_{f1}=d_1-2,4m$	$d_{f2}=d_2-2(1,2-x)m$
Chervyakli g'ildirakning eng katta tashqi diametri		–	$d_{aT2}\le d_{a2}+\frac{6m}{Z_1+Z}$
Chervyak	$Z_1=1,2$	$b_1\ge(11+0,06Z_2)m$	–

o'ramining uzunligi	$Z_1=4$	$b_1 \geq (12,5+0,09Z_2)m$	–
Chervyakli g'ildirakning tishli qismining eni	$Z_1=1,2$	–	$b_2 \leq 0,75d_{a1}$
	$Z_1=4$	–	$b_2 \leq 0,62d_{a1}$

10. Kontakt kuchlanishning hisobiy qiymati

$$\sigma_H = \frac{480}{d_2}\sqrt{\frac{K_H \cdot T_2}{d_1}} \leq [\sigma_H]$$

Bu yerda: K_H=1,0; V_c>3 m/s bo'lganda K_H=1,1 ÷ 1,3 bo'ladi.

Sirpanish tezligining hisobiy qiymati $V_c = V_1/cos\gamma$

Bu yerda: $V_1 = 0,5\omega_1 d_1$ - chervyakning aylanma tezligi

γ - chervyak o'ramining ko'tarilish burchagi, qiymati q va Z_1 nisbatan 2.18 – jadvaldan olinadi.

2.18 – jadval

Kirim soni	Chervyak diametr koeffitsiyenti					
	8	10	12,5	14	10	20
1	7°7′	5°43′	4°35′	4°05′	3°35′	2°52′
2	14°2′	11°19′	9°6′	8°3′	7°7′	5°43′
4	26°34′	21°48′	15°57′	14°2′	14°2′	11°19′

11. Uzatmaning foydali ish koeffitsiyenti

$$\eta = \frac{tg\gamma}{tg(\gamma+\rho')}$$

Bu yerda: ρ' – ishqalanish burchagi, qiymati sirpanish tezligiga nisbatan 2.19 – jadvaldan olinadi.

2.19 – jadval

V_c	0,5	1,0	1,5	2,0	2,5	3,0	4,0	7,0	10	15
ρ'	3°10′	2°30′	2°20′	2°00′	1°20′	1°30′	1°20′	1°00′	0°55′	0°50′
	3°40′	3°10′	2°50′	2°30′	2°20′	2°00′	1°40′	1°30′	1°20′	1°10′

12. Ilashishda hosil bo'lgan kuchlar.

Chervyakli g'ildirakka ta'sir qiluvchi aylanma kuch chervyakdagi bo'ylama kuchga teng:

$$F_{t2}=F_{a1}=\frac{2T_2}{d_2}$$

Chervyakdagi aylanma kuch chervyakli g'ildirakdagi bo'ylama kuchga teng:

$$F_{t1}=F_{a2}=\frac{F_{t2}Z_1}{q\cdot\eta}$$

Radial kuch $F_r=F_{t2}\cdot tg\alpha$ $\alpha=20^o$

13. Chervyakli g'ildirak tishlaridagi egilish kuchlarining hisobiy qiymati

$$\sigma_F=0,7\frac{Y_F\cdot K_F\cdot F_{t2}}{mb_2}\le[\sigma_F]$$

K_F - yuklanish koeffitsiyentining qiymati

Y_F- tish shaklining koeffitsiyenti qiymati 2.20 – jadvaldan olinadi.

2.20 – jadval

Z_{kel}	Y_{F2}	Z_{kel}	Y_{F2}	Z_{kel}	Y_{F2}	Z_{kel}	Y_{F2}
20	1,98	30	1,76	40	1,55	80	1,34
24	1,88	32	1,77	45	1,48	100	1,30
26	1,85	35	1,64	50	1,45	150	1,27
28	1,80	37	1,61	60	1,40	300	1,24

14.Uzatmaning qizishini tekshirish

a) Uzatma sun'iy ravishda sovitilmasa

$$t=\frac{(1-\eta)P_1}{(K_c\cdot A)}+20\le[t^o]=95^o$$

b) Uzatma sun'iy ravishda sovitilsa

$$t=\frac{(1-\eta)P_1}{[(0,7K_T+0,3K_{CB})\cdot A]}+20\le[t^o]=95^o$$

Bu yerda: K_c - sovitish koeffitsiyenti 12 – 18 Vt/m^2

K_{CB} - sovitish uchun vintilyator ishlatilsa

n_d=750	1000	1500	3000
K_e=17	21	19	40

$[t^o]=95^o$ C ruxsat etilgan qiymat.

A - uzatmada sovitiladigan yuza, qiymati 2.21 – jadvaldan olinadi.

P_1 - chervyak validagi quvvat.

2.21 – jadval

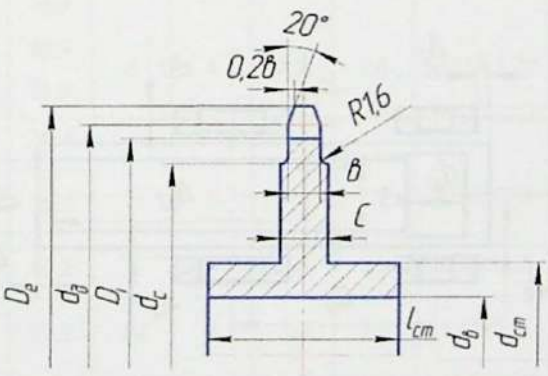
a_ω, mm	80	100	125	140	160	180	200	225	250	280
A, m^2	0,19	0,24	0,36	0,43	0,54	0,67	0,8	1,0	1,2	1,4

3. Vallar va o'qlar

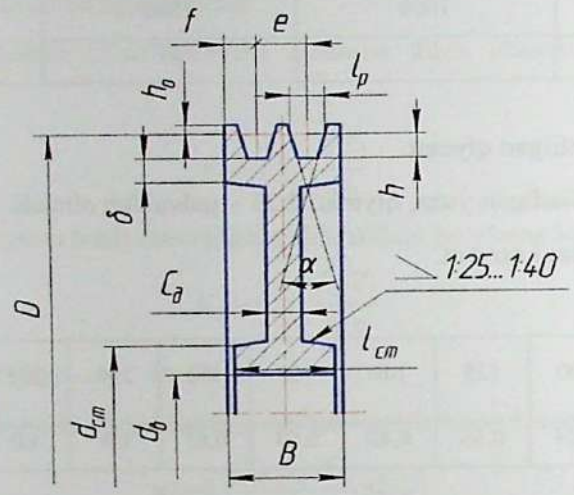
Vallar asosan uglerodli va legirlangan po'lat materiallaridan tayyorlanadi. Vallar termik qayta ishlanmagan Ст5 yoki qayta ishlangan 40, 45, 40X kabi po'lat materiallaridan tayyorlanadi. Og'ir yuklangan vallarni termik qayta ishlangan 40XH, 40XHMA, 30XГT po'lat materiallaridan tayyorlanadi.

3.1. Vallarning taxminiy hisobi va eskizi

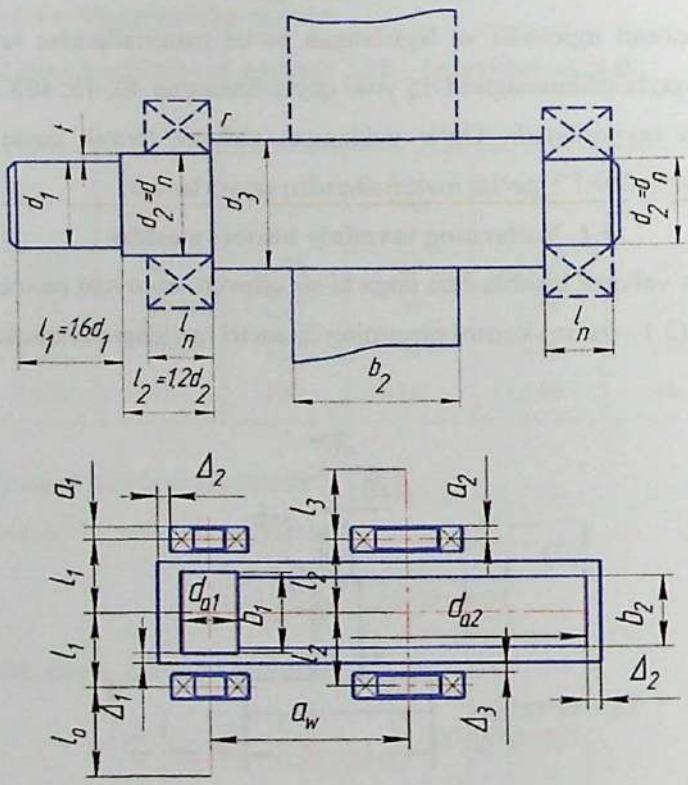
Mexanik vallarni hisoblashda unga ta'sir qiluvchi burovchi moment hisobga olinib, val uni (3.1 – rasm) konsol qismining diametri quyidagicha aniqlanadi:



Zanjirli uzatma yulduzchasi konstruksiyasi



Tasmali uzatma yulduzchasi konstruksiyasi



3.1 – rasm. Silindirsimon uzatma vallari

$$d_1=3\sqrt{\frac{T_1}{0,2[\tau]}} \quad mm$$

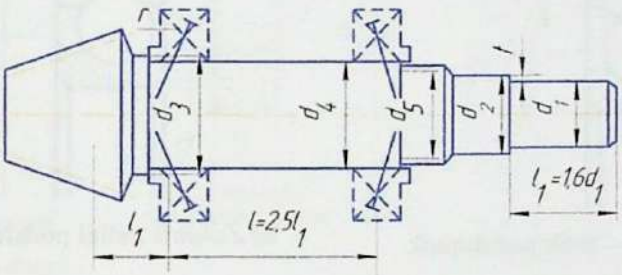
Bu yerda: T – burovchi moment, $N{\cdot}mm$

$[\tau]$ - buralishdagi ruxsat etilgan kuchlanish 40, 45, 40X po'lat materiallaridan tayyorlangan vallar uchun $[\tau]=15\div 25\ N$

Uzatma vallarini eskizini taxminiy chizib olish uchun quyidagicha hisoblash tavsiya etiladi:

$$d_2=d_1+2t, \qquad d_3=d_2+3,2r$$

Konussimon uzatmaning yetaklovchi validagi d_5 ning qiymatini (3.2 – rasm) d_2 ga nisbatan 3.1 – jadvaldan olinadi, $d_4=d_n=d_5+(2\text{-}5)mm$



3.2 – rasm. Konussimon uzatma yetaklovchi vali

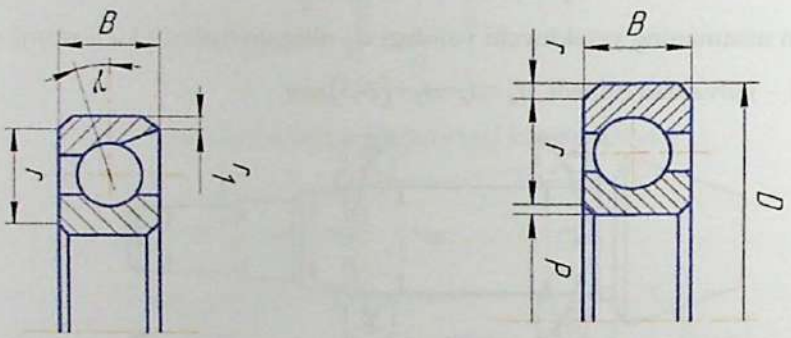
3.1 – jadval

d	l_1	l_2	$d_{o'r}$	b	h	t_1	t_2	d_1	d_2	l_3	l_4
20	36	22	18,9	4	4	2,5	1,8	M12X1,25	M6	6,5	8,8
22			20,9								
24			23,8								
28	42	24	26,8	5	5	3,0	2,3	M16X1,5	M8	9,0	10,7
32			30,2						M10	11,0	13,0
36	58	36	34,2	6	6	3,5	2,8	M20X1,5	M12	14,0	16,3
40	59		37,3	10	8	5,0	3,3	M24X2			
45	82	54	42,3	12	8	5,0	3,3	M30X2	M16	21,0	23,5
50			47,3	12	8	5,0	3,3	M36X2	M20	21,0	23,5

56			53,3	14	9	5,5	3,8			23,5	26,5
63			59,5	16	10	6,0	4,3	M42X3	M20	23,5	26,5
71	105	70	67,5	18	11	7,0	4,4	M48X3	M24	26,0	29,5
80			75,5	20	12	7,5	4,9	M56X4	M30	32,0	35,9
90	130	90	85,5	22	14	9,0	5,4	M64X4	M30	32,0	35,9

3.2. Podshipniklarni tanlash

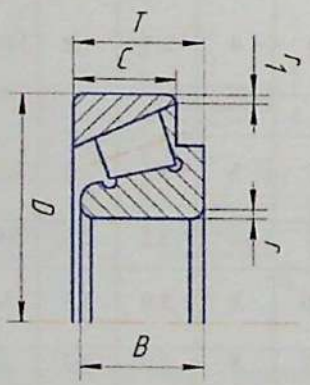
Silindrsimon uzatma vallari uchun asosan zoldirli radial podshipniklar ishlatiladi (3.3 – rasm).



a) Zoldirli radial – tirak podshipnik b) Zoldirli radial podshipnik

3.3 – rasm

Konussimon va chervyakli uzatmalarda bo'ylama kuch ta'sir etganligi sababli vallar uchun zoldirli yoki konussimon rolikli radial – tirak podshipniklar tanlash kerak (3.4 – rasm).



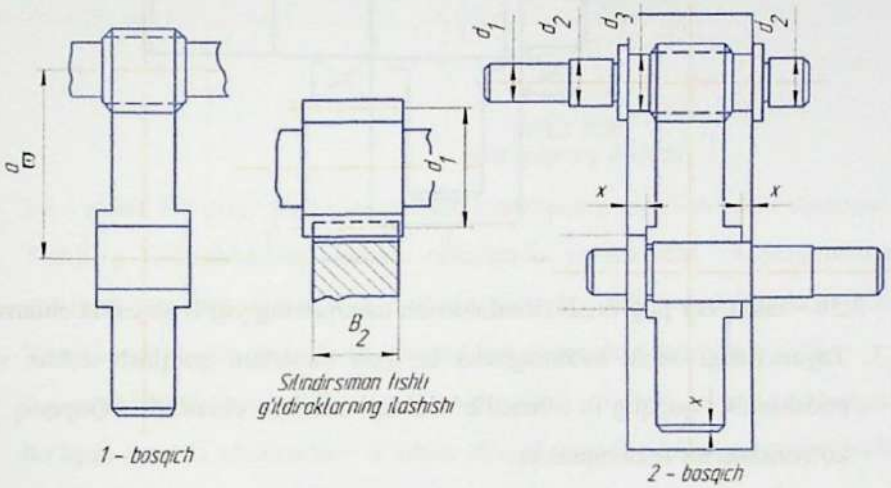
3.4 – rasm. Konussimon rolikli radial – tirak podshipnik

3.3. Tayanchlar o‘rtasidagi masofa

Vallarning diametrlarini aniqlanib, tanlangan podshipniklarni valga o‘rnatish sxemasi tanlangach valga o‘rnatiligan detallarning tayanchga nisbatan joylashishi hamda tayanchlar o‘rtasidagi masofa aniqlanadi.

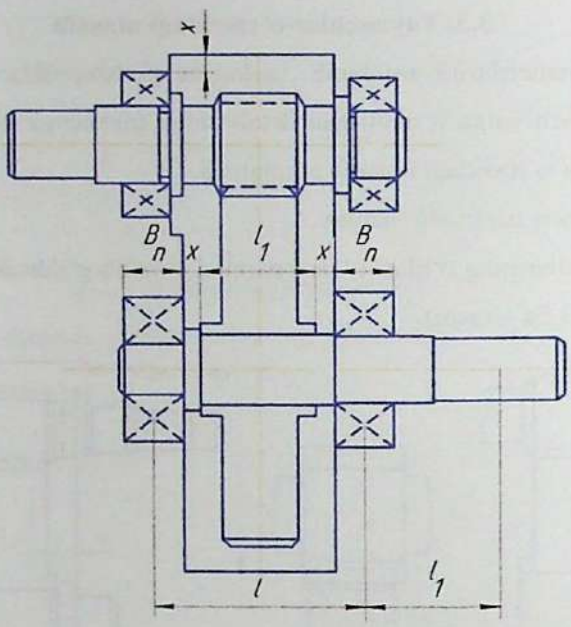
A. Silindirsimon uzatmalar uchun:

1. Uzatma vallarining o‘qlari o‘zaro parallel chizilib g‘ildiraklar ilashgan holda chiziladi (3.5a – rasm).



3.5a – rasm. Bir pog‘onali silindirsimon uzatmaning yig‘ilish eskiz chizmasi

2. Uzatma g‘ildirak vallari chizilib, yetaklanuvchi tishli g‘ildirak yon tomonlari X=5 – 8 mm masofa qoldirilib uzatma qolibga olinadi (3.5b – rasm).

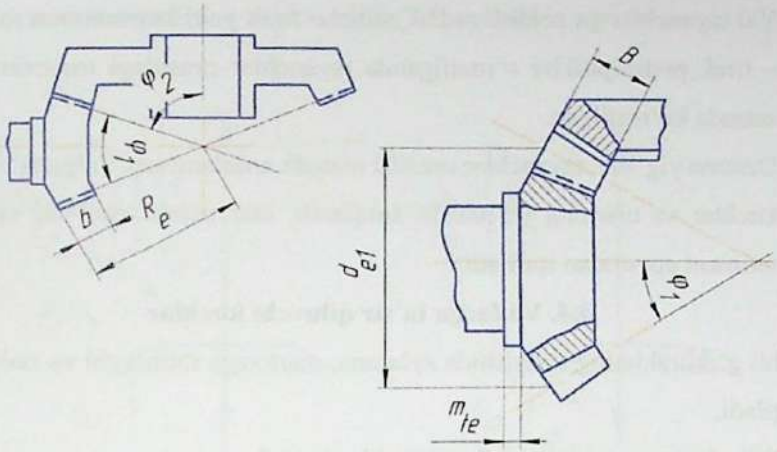


3.5b – rasm. Bir pog'onali silindirsimon uzatmaning yig'ilish eskiz chizmasi

3. Tayanchdagi ochiq uzatmagacha bo'lgan masofani aniqlash uchun valga podshipnik qopqog'i o'rnatilib ochiq uzatma chiziladi. Qopqoq ikki ko'rinishda bo'lishi mumkin.
   a) Podshipnik qopqog'i bolt yordamida qutiga mahkamlanadi (rasm).
   b) Podshipnik qopqog'i qutichaning asosi hamda qopqog'idagi maxsus ariqchaga o'rnatiladi (rasm).
4. Vallarga barcha detallar o'rnatilgach, tayanchlar o'rtasidagi masofa aniqlanadi (rasm).

B. Konussimon uzatma:

1. Uzatma vallari o'zaro $\varphi = 90^0$ burchak ostida chizilib, o'qlarning kesishgan nuqtasidan φ_1 burchak ostida R_e masofa chizilib, tishli g'ildiraklar ilashgan holda chiziladi (3.6 – rasm)



Konus tishli g'ildiraklarning ulashishi

3.6 – rasm. Bir pog'onali konussimon uzatmaning yig'ilish eskiz chizmasi

2. Tishli g 'ildiraklarning vallari chizilgach yetaklovchi va yetaklanuvchi g'ildirak yon tomonidan X=8 – 10 mm masofa qoldirib podshipnik chiziladi. Yetaklovchi valda podshipnik tayanchlari o'rtasidagi masofa l_2=2,5l_3.

   l_3 – podshipnik tayanchidan yetaklovchi tishli g'ildirak tish eni o'rtasigacha bo'lgan masofa chizmadan o'lchab olinadi hamda tanlangan podshipniklar chiziladi.

3. Valga hamma detallar o'rnatilgach tayanchlar o'rtasidagi masofa aniqlanadi.

C. Chervyakli uzatmalar uchun:

1. Uzatmaning ikki proeksiyasida, ya'ni uning oldidan hamda yonidan ko'rinishida vallarning o'qlari o'zaro ayqash holda chizilib, chervyak va chervyakli g'ildirak ilashgan holda chiziladi.
2. Uzatmada chervyak va chervyakli g'ildirak vallari chizilib, uning oldidan ko'rinishi chizilgan proeksiyada chervyakli g'ildirakning d_{aT2} diametridan va yonidan ko'rinishi chizilgan proeksiyasida X=5 – 8 mm masofa qoldirilib tanlangan podshipniklar chiziladi.
3. Uzatma vallariga hamma detallar o'rnatilgach, podshipnik tayanchlari o'rtasidagi masofa aniqlanadi.

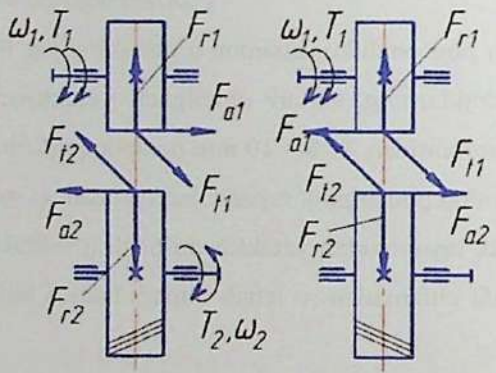
Val tayanchlariga zoldirli radial, radial – tirak yoki konussimon rolikli radial – tirak podshipniklar o'rnatilganda tayanchlar orasidagi masofani aniqlash rasmda ko'rsatilgan.

Uzatma yig'ilib, tayanchlar orasida masofa aniqlangach, valga ta'sir qiluvchi kuchlar va ularning yo'nalishi aniqlanib, ular uchun eguvchi va burovchi moment epyuralari quriladi.

3.4. Vallarga ta'sir qiluvchi kuchlar

Tishli g'ildiraklarnig ilashishida aylanma, markazga intiluvchi va radial kuchlar ta'sir qiladi.

a) Silindirsimon to'g'ri tishli g'ildiraklarda (3.7 – rasm)



3.7 – rasm

$F_t=\frac{2T_1}{d_1}$ - aylanma kuch

$F_r=F_t tg\alpha$ - markazga intiluvchi kuch

Bunda T – valdagi burovchi moment, N·mm

d_1 - tish buluvchi aylanasining diametri

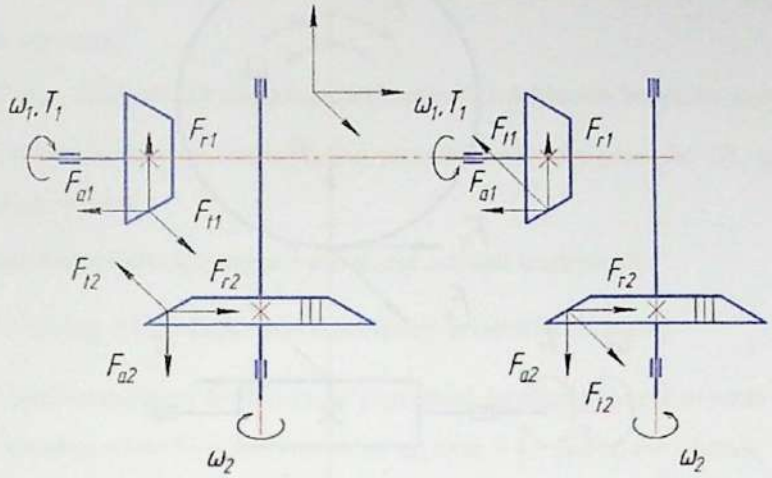
$\alpha= 20^\circ$ – g'ildirak tishlaring ilashish burchagi

Qiya tishli silindirsimon tishli uzatmalarda qo'shimcha bo'ylama F_a kuch hosil bo'ladi, qiymati quyidagicha aniqlanadi:

$$F_a=F_t \cdot tg\beta$$

β – g'ildirak tishlarining qiyalik burchagi $8^\circ \div 15^\circ$

b) To‘g‘ri tishli konussimon uzatmalarda (3.8 – rasm)



3.8 – rasm

$F_t = \frac{2T_1}{d_m}$ - aylanma kuch

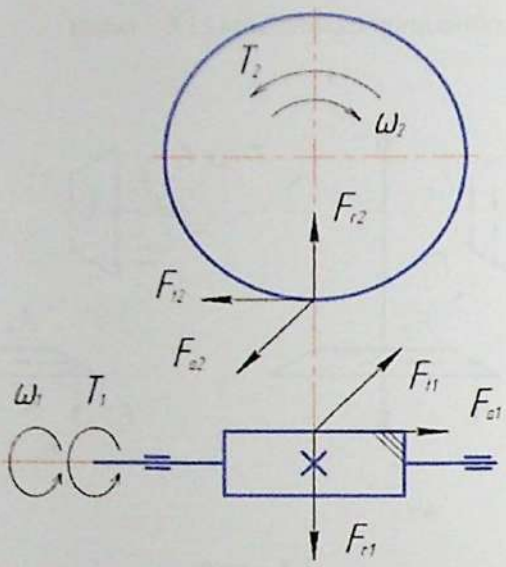
$F_r = F_{a2} = F_t \cdot tg\alpha \cdot cos\varphi_1$ - markazga intiluvchi kuch

$F_{a1} = F_{r2} = F_t \cdot tg\alpha \cdot sin\varphi_1$ - bo‘ylama kuch

d_m - o‘rtacha diametr – 0,857 d_{e1}

Bu yerda φ - konuslik burchagi

c) Chervyakli uzatmalarda (3.9 – rasm)



3.9 – rasm

$F_t=\frac{2T_1}{d_1}$ - aylanma kuch $F_{t1}=F_{a2}$

F_{a2} - bo'ylama kuch

$F_r=F_t \cdot tg\alpha$ - markazga intilma kuch

$\propto= 20^o$ – g'ildirak tishlaring ilashish burchagi

3.5. Vallarning xavfsizlik koeffitsiyenti S qiymatini aniqlash

Val kesimining xavfsizlik koeffitsiyenti quyidagicha aniqlanadi:

$$S=\frac{S_\sigma \cdot S_\tau}{\sqrt{S_\sigma^2+S_\tau^2}} \le [S]$$

Bu yerda: $[S]$-1,5 ÷ 2,5 xavfsizlik koeffitsiyentining ruxsat etilgan qiymati;

S_σ, S_τ- xavfsizlik koeffitsiyentining normal va urunma kuchlanishlar bo'yicha qiymati:

$$S_\sigma=\frac{\sigma_{-1}}{\frac{K_\sigma}{\varepsilon_\sigma}\sigma_a+\psi_\sigma\sigma_m}, \qquad S_\tau=\frac{\tau_{-1}}{\frac{K_\tau}{\varepsilon_\tau}\tau_a+\psi_\tau\tau_m}$$

Bu yerda: $\sigma_{-1}=0,43\ \sigma_M$ chidamlilik chegarasining egilishdagikuchlanish bo'yicha qiymati;

$\tau_{-1}=0,58\ \sigma_{-1}$- chidamlilik chegarasining urunma kuchlanish bo'yicha qiymati;

σ_M- val uchun tanlangan materialning mustahkamlik chegarasi bo'lib, qiymati 3.2 – jadvaldan olinadi.

$\sigma_a=\frac{M}{W}$ valning tekshirilayotgan kesimidagi normal kuchlanish;

$\tau_a=\frac{T}{W_p}$ - valning tekshirilayotgan kesimidagi urinma kuchlanish;

K_σ, K_τ - kuchlanishlarni bir joyga to'planishini xavfsizlik koeffitsiyenti qiymatiga ta'sirini hisobga oluvchi koeffitsiyentlar qiymati 3.4 – jadvaldan olinadi;

ε_σ, ε_τ - val materiali mustahkamligi va diametrining xavfsizlik koeffitsiyentiga ta'sirini hisobga oluvchi koeffitsiyent (3.5 – jadval).

Po'lat materiallarining mexanik ta'riflari

3.2 – jadval

Po'lat materiallari	Diametr d, mm	Eni b, mm	Tishning markazida HB	Tishning yuzasida HRC	σ_M	σ_{oq}
					MPa	
45	125	80	235 ÷ 262		780	540
	80	50	269 ÷ 302		890	650
	200	125	235 ÷ 262		790	640
40 X	125	80	269 ÷ 301		900	750
	125	80	269 ÷ 302	45 ÷ 50	900	750
	315	200	235 ÷ 262		800	670
35 XM	200	125	269 ÷ 302		920	790
	200	125	269 ÷ 302	48 ÷ 53	920	790
40 XM	315	200	235 ÷ 262		800	630
	200	125	269 ÷ 302		920	750
	200	125	269 ÷ 302	48 ÷ 53	920	750
	315	200	235 – 262			660

40 ХЦ	200 200	125 125	269 – 302 269 – 302	50 ÷ 56		780 780
20 Х 20 ХНМ 18 ХГМ 25 ХГНМ	200	125	300 – 400	56 ÷ 63		800

C – koeffitsiyent qiymatlari

3.3 – jadval

$\frac{d}{D}$	0,4	0,42	0,45	0,48	0,5	0,53	0,56	0,6	0,63	0,67	0,71
G	0,974	0,969	0,959	0,947	0,938	0,921	0,901	0,870	0,842	0,8	0,747

K_σ, K_τ – koeffitsiyentlar

3.4 – jadval

Po'lat materiallari uchun σ_M ning qiymatlari MPa bo'lgandagi K_σ ning qiymatlari				Po'lat materiallari uchun σ_M ning qiymatlari MPa bo'lgandagi K_τ ning qiymatlari			
600	700	800	900	600	700	800	900
Shponkali vallar uchun							
1,6	1,75	1,8	1,9	1,5	1,6	1,7	1,9
To'g'ri burchakli shlitsali vallar uchun							
1,55	1,6	1,65	1,7	2,35	2,45	2,55	1,65
Evolventli shlitsali vallar uchun							
1,55	1,6	1,65	1,7	1,46	1,49	1,52	1,55

ψ_σ, ψ_τ- kuchlanish sikli o'zgarmas qismining xavfsizlik koeffitsiyenti. Qiymati mustahkamligi $\sigma_M = 650 - 750$ MPa bo'lgan uglerodli po'latlar uchun ψ_σ=0,1, ψ_τ=0,1; legirlangan po'latlar uchun ψ_σ=0,25 – 0,30, ψ_τ=0,1.

ε_σ, ε_τ ning qiymatlari

3.5 – jadval

Po'lat		Valning diametri d,mm						
		20	30	40	50	70	100	200
Uglerodli	ε_σ	0,92	0,88	0,85	0,82	0,76	0,7	0,61
	ε_τ	0,83	0,77	0,73	0,7	0,65	0,59	0,52
Legirlangan	ε_σ	0,83	0,77	0,73	0,7	0,65	0,59	0,52
	ε_τ							

3.6. Vallarning tuzulishi

Silindirsimon, konussimon, chervyakli uzatma yetaklovchi va yetaklanuvchi vallarining egrilik radiusining o'lchamlari 3.6 – jadvalda ko'rsatilgan.

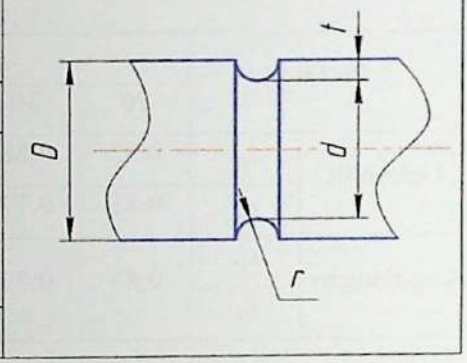
3.6 – jadval

t, z, f qiymatlari				
d	17....24	28....30	32.....40	42.....50
t	2	2,2	2,5	2,8
r	1,6	2	2,5	3,0
f	0	1,0	1,2	1,6

Podshipnik o'rnatiladigan yuza silliqlanadi. Silliqlagichning chiqishi uchun ariqchalar qilinadi. Ariqchalarning o'lchamlari 3.7 – jadvalda berilgan.

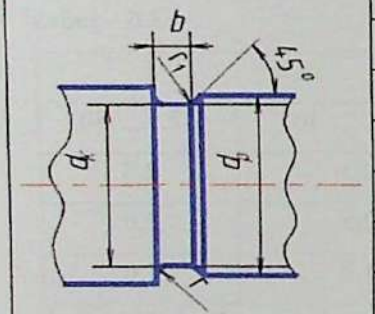
3.7 – jadval

	10 dan 50 gacha	50 dan 100 gacha	100 dan yuqori
b	3	5	8
h	0,25	0,5	
r	1,0	1,6	2,0



Silindirsimon uchli valning o'lchamlari, mm

3.8 – jadval



d	*l*	*t*	*r*	*f*	*d*	*l*	*t*	*r*	*f*
20	32	2,0	1,6	1,0	45	70	2,8	2	2,0
22	35				50	75		2,5	
25	40	2,2			55	82	3,0		
28	45				60	90			
32	50	2,5	2,0	1,6	70	105	3,5		
36	55				80	120			
40	30				90	130		3,0	2,5

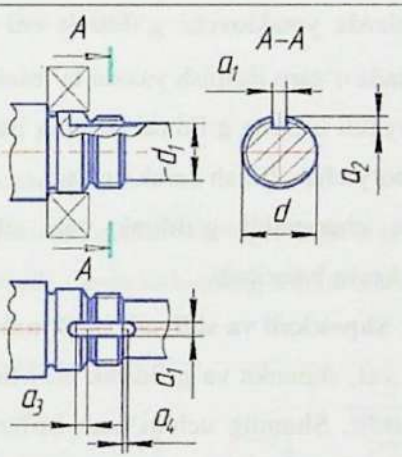
Bo'ylama kuchlarning qiymatlari kata bo'lsa, o'tkazilgan detalni gayka yordamida mahkamlanadi. Rezbaning o'lchamini valning diametriga nisbatan 3.9, 3.10 – jadvallardan olinadi. Yetaklanuvchi valda yetaklanuvchi g'ildirak o'tkazilgan qismining diametri $d_3=d_2+3,2r$

3.9 – jadval

d	l_1	l_2	$d_{o'r}$	*b*	*h*	t_1	t_2	d_1	d_2	l_3	l_4
20			18,9								
22	36	22	20,9	4	4	2,5	1,8	M12X1,25	M6	6,5	8,8
24			23,8								

28	42	24	26,8	5	5	3,0	2,3	M16X1,5	M8	9,0	10,7
32			30,2						M10	11,0	13,0
36	58	36	34,2	6	6	3,5	2,8	M20X1,5	M12	14,0	16,3
40	59		37,3	10	8	5,0	3,3	M24X2			
45	82	54	42,3	12	8	5,0	3,3	M30X2	M16	21,0	23,5
50			47,3	12	8	5,0	3,3	M36X2	M20	21,0	23,5
56			53,3	14	9	5,5	3,8			23,5	26,5
63	105	70	59,5	16	10	6,0	4,3	M42X3	M20	23,5	26,5
71			67,5	18	11	7,0	4,4	M48X3	M24	26,0	29,5
80			75,5	20	12	7,5	4,9	M56X4	M30	32,0	35,9
90	130	90	85,5	22	14	9,0	5,4	M64X4	M30	32,0	35,9

3.10 – jadval



d – rezba	a_1	a_2	a_3	a_4	d_1
M20×1,5	6	2	3,5	1,0	16,5
M22×1,5	6	2	3,5	1,0	18,5
M24×1,5	6	2	3,5	1,0	20,5
M27×1,5	6	3	4,0	1,5	23,5
M30×1,5	6	3	4,0	1,5	26,5
M33×1,5	6	3	4,0	1,5	29,5

M36×1,5	6	3	4,0	1,5	32,5
M39×1,5	6	3	4,0	1,5	35,5
M42×1,5	8	3	5,0	1,5	38,5
M45×1,5	8	3	5,0	1,5	41,5
M48×1,5	8	3	5,0	1,5	44,5
M52×1,5	8	3	5,0	1,5	48,0
M56×1,5	8	3	5,0	1,5	52,0
M60×1,5	8	3	6,0	1,5	56,0

3.7. Tishli g‘ildiraklar va podshipniklarni vallarga o‘tkazish

Yopiq uzatmada yetaklanuvchi tishli g‘ildirak *H7/p6* bo‘yicha, ochiq silindirsimon tishli g‘ildirak *H7/h6* bo‘yicha valga o‘tkaziladi. Qiya tishli silindirsimon va chervyakli g‘ildirak *H7/z6* bo‘yicha valga o‘tkaziladi.

Silindirsimon uzatmalarda yetaklovchi g‘ildirak eni nisbatan katta olinadi, ya’ni $b_1 \approx b_2 + 5\text{-}8$ *mm* natijada o‘zaro ilashish yaxshi ta’minlanadi.

Konussimon va chervyakli uzatma g‘ildiraklarining ilashishini normal holatga keltirish uchun valni o‘q bo‘yicha siljitish kerak bo‘ladi.

Chervyakli uzatmada chervyakli g‘ildirak vali siljitiladi. Bu sozlashlar podshipnik sozlangandan keyin bajariladi.

3.8. Shponkali va shlitsali birikmalar

Shponkali birikmalar val, shponka va g‘ildirak profilidagi (shkiv yoki boshqa detal profildagi)dan iboratdir. Shuning uchun ham birikmani tarkibiy qismlarga ajratish nisbatan oson. Ular asosan aylanuvchi detallarni (shkiv, g‘ildirak, mufta, yulduzcha kabi) val yoki o‘qga o‘rnatish uchun ishlatiladi. Ularning yana bir boshqa vazifasi, aylantiruvchi momentni val va detallar orasida uzatishdir. Shponkalarning asosiy turlari standartlashtirilgan.

Konstruksiyasi oddiy, yig‘ilishi va qismlarga ajratilishi nisbatan yengil va shuning uchun ham mashinasozliqsa keng tarqalgan. Shponkali birikmalar detallarni aylanma yo‘nalishda ishonchli o‘rnatish imkonini beradi.

Val sirtiga shponka uchun mo'ljallangan o'yiq qilinishi shponkali birikmalarning kamchiligi hisoblanadi. Chunki bunday o'yiqcha val ko'ndalang kesimini kamaytirib, uning mustahkamligini pasaytiradi.

Shponkali birikmalar zo'riqqan va zo'riqmagan bo'lishi mumkin. Zo'riqqan birikmalarda ponasimon shponkalar, zo'riqmagan birikmalarda esa prizmatik shponkalar ishlatiladi (3.11 – jadval).

Burovchi moment uzatilishda shponka yon yoqlari ezilishi mumkin. Bunda hosil bo'ladigan kuchlanish quyidagicha aniqlanadi:

$$\sigma_{ez}=\frac{2T}{dl_x(h-t_1)}\leq[\sigma_{ez}]$$

Bu yerda: T – uzatilayotgan moment;

d – valning diametri;

h – shponkaning balandligi;

t_1 - valdagi o'yiqchaning chuqurligi;

l_x - $(0,8-0,9)\,l_x$;

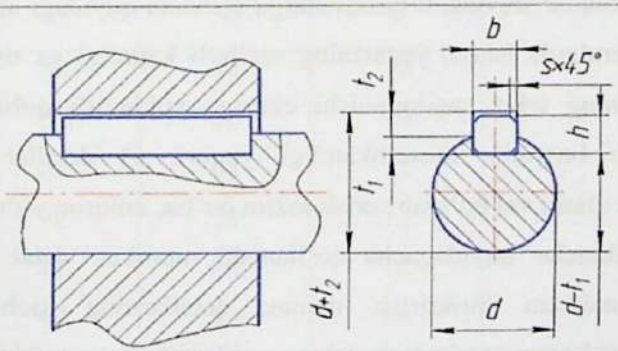
l_x - shponkaning uzunligi;

l_r - g'ildirak profilining uzunligi;

$[\sigma_{ez}] = 100$ MPa – ezilishdagi kuchlanishning chegaraviy qiymati.

Prizmatik shponkalarning o'lchamlari, mm

3.11– jadval



Valning diametri	Shponkalarning ko'ndalang	O'yiqchalarning chuqurligi, mm	Valning diametri d,	Shponkalarning ko'ndalang	O'yiqchalarning chuqurligi, mm

d, mm	kesimi $b\times h$	Valda t_1, mm	Vtulkada t_2, mm	mm	kesimi $b\times h$	Valda t_1, mm	Vtulkada t_2, mm
10÷12	4×4	2,5	1,8	50÷58	16×10	6	4,3
12÷17	5×5	3	2,3	58÷65	18×11	7	4,4
17÷22	6×6	3,5	2,8	65÷75	20×12	7,5	4,9
22÷30	8×7	4,0	3,3	75÷85	22×14	9	5,4
30÷38	10×8	5,0	3,3	85÷95	25×14	9	5,4
38÷44	12×8	5,0	3,3	95÷110	28×16	10	6,4
44÷50	14×9	5,5	3,8	110÷130	32×18	11	7,4

Shponkali birikmaning mustahkaligi σ_M=990 MPa;

Shponkaning shartli belgisi, masalan $b\times h$=12×8 uzunligi 50 mm; shponka 12×8×50

Shlitsali birikmalar

Shlisali birikmalar valni detal profiliga biriktirish uchun ishlatiladi. Shlisali birikmalar vallardagi tashqi tishlar va detal gupchagi teshigidagi ularga mos ichki tishlar – shlisalar orqali hosil qilinadi. Bu birikmalarni shponkalari val bilan yaxlit qilib tayyorlangan ko‘p shponkali birikma sifatida tasavvur etish mumkin. Ba’zan bu birikmalar tishli birikmalar deb ham yuritiladi.

Shlisali birikmalar shponkali birikmalarga nisbatan quyidagi afzalliklarga ega: a) bir xil o‘lchamlarda ishchi yuzasining sezilarli kattaligi va tishlar balandligi bo‘yicha bosimning tekis taqsimlanishi evaziga yuklanish qobiliyati ko‘p; b) valning toliqish bo‘yicha mustahkamligi yuqori; v) detallar valda yaxshi markazlanadi va ularni val bo‘ylab surish lozim bo‘lsa, aniqroq yo‘naltiradi.

Shlisali birikmalar quyidagacha qo‘llanishi mumkin: detal profilini valga qo‘zg‘almas, mahkam biriktirish uchun; detallarning kichik qiymatdagi o‘qdoshmasligani kompensasiyalash uchun; yuklanishsiz va yuklanish uzatadigan qo‘zg‘aluvchan (o‘q bo‘ylab suriladigan) birikma hosil qilish uchun.

O‘qdoshmaslikni kompensasiyalash detallarni tayyorlashdagi xatoliklar yoki o‘zi o‘rnashadigan konstruksiyalarga bog‘liq. Yuklanish holatida o‘q bo‘yicha surishlarga parmalash shpindeli, avtomobillarning kardan vallari; yuklanishsiz surishlarga – uzatmalar qutisidagi suriladigan tishli g‘ildiraklar misol bo‘ladi.

Shlitsalar to‘g‘ri to‘rtburchak, evolventali va uchburchak profilli bo‘lishi mumkin. Ulardan keng foydalaniladigani to‘g‘ri to‘rtburchak profilli shlitsalar bo‘lib, mazkur shlitsali birikmalarda silindirlarning yon yoqlari, tashqi va ichki diametrlari bo‘yicha markazlashtiriladi. To‘g‘ri to‘rtburchak shlitsalar o‘lchamlari 3.12 – jadvalda berilgan.

3.12 – jadval

Tishlar soni	d	D	b	f	r ning eng katta qiymati
Yengil seriya					
6	23 26 28	26 30 32	6 6 7	0,3	0,2
8	32 36 42 46	36 40 46 50	6 7 8 9	0,4	0,3
8	52 56 62 72 82 92	58 62 68 78 88 98	10 10 12 12 12 14	0,5	0,5
O‘rta seriya					
6	16	20	4	0,3	0,2

	18 21 23	22 25 28	5 5 6		
6	26 28	32 34	6 7	0,4	0,3
8	32 36 42	38 42 48	6 7 8	0,4	0,3
8	46 52 56 62	54 60 65 72	9 10 10 12	0,5	0,5
10	72 82 92	82 92 102	12 12 14	0,5	0,5
Og‘ir seriya					
10	16 18 21 23	20 23 26 29	2,5 3 3 4	0,3	0,2
10	26 28 32 36 42	32 35 40 45 52	4 4 5 5 6	0,4	0,3
10	46 52	56 60	7 5	0,5	0,5
16	56 62	65 72	5 6	0,5	0,5

	72	82	7		
20	82	92	6	0,5	0,5
20	92	102	7	0,5	0,5

Ilashish jarayonida shlitsalarning yon yoqlari ezuvchi, asosi esa kesuvchi va eguvchi kuchlanish bo'yicha hisoblanadi. Ezuvchi kuchlanish hisobiy qiymati quyidagicha aniqlanadi:

$$\sigma_{ez}=\frac{T}{0,1875Z\cdot A_{ez}(D+d)}\leq[\sigma_{ez}]$$

Bu yerda: T - burovchi moment;

Z - tishlar soni;

D - tashqi diametr;

d - ichki diametr;

A_{ez} - ezilgan yuza; to'g'ri to'rtburchak profilli shlitsalar uchun $A_{ez}=[0,5(D-d)-2f]l_r$

l_r - profilning uzunligi;

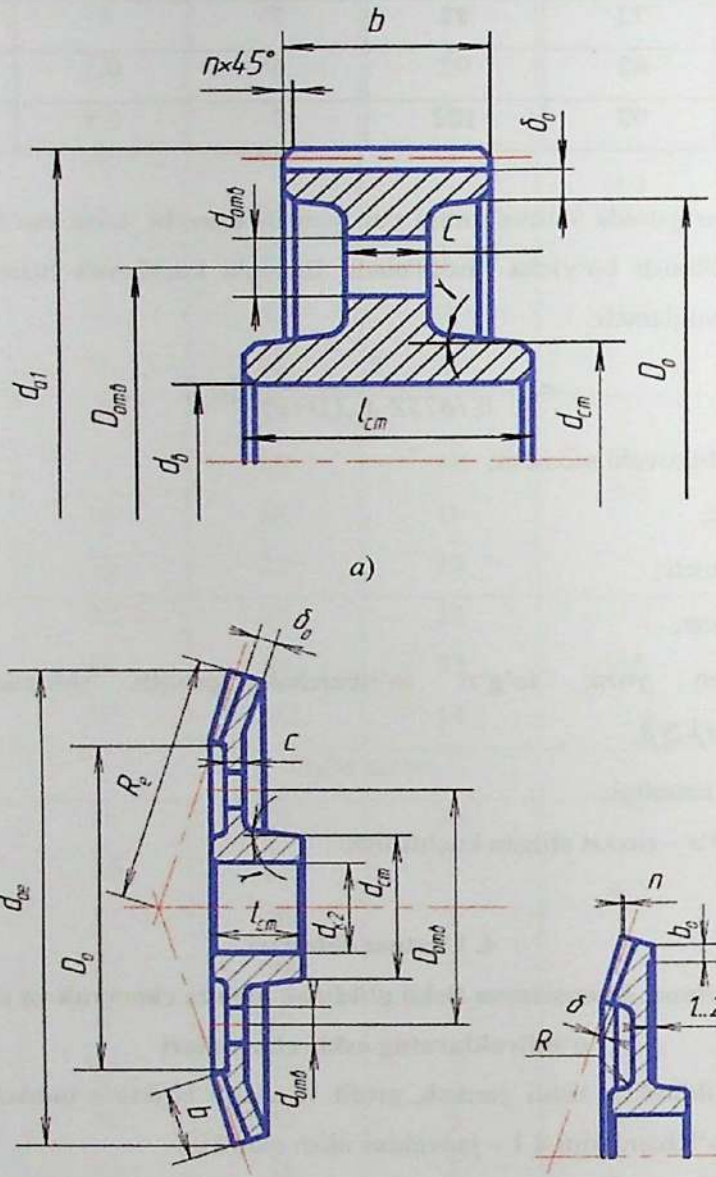
$[\sigma_{ez}]=100\ MPa$ – ruxsat etilgan kuchlanish.

4. Uzatma detallari

4.1. Silindirsimon, konussimon tishli g'ildirak hamda chervyak va chervyakli g'ildiraklarning eskiz chizmalari

Tishli g 'ildiraklar tishli gardish, profil va ularni biriktirib turuvchi diskdan iborat, uning o'lchamlarini 4.1 – jadvaldan olish mumkin.

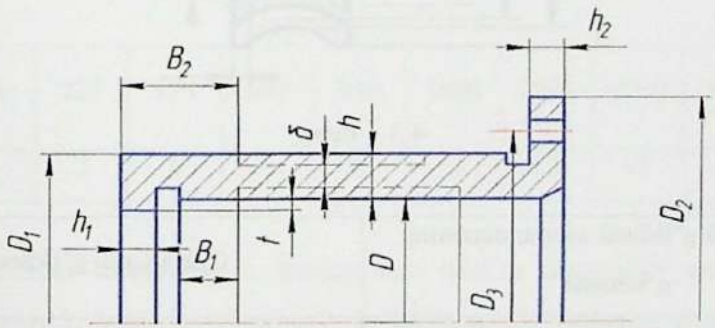
Silindirsimon va konussimon tishli g'ildiraklarning eskin chizmalari 4.1 – rasmlarda berilgan.



4.1 – rasm. *a* – silindirsimon tishli g'ildiraklarning eskin chizmalari; *b* – konussimon tishli g'ildiraklarning eskin chizmalari.

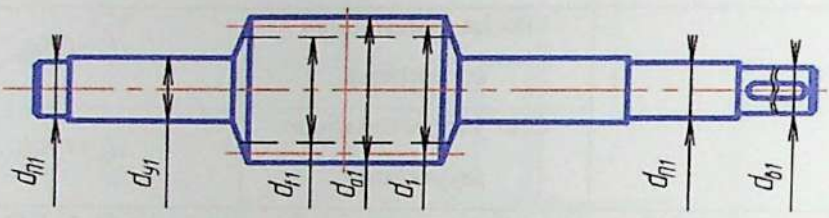
4.1 – jadval

Tishli g'ildirak element o'lchamlari	Silindirsimon tishli g'ildirak	Konussimon tishli g'ildirak	
Profil	Po'lat materialidan tayyorlansa	$d_p=1,6d_b$	
	Cho'yan materialidan tayyorlansa	$d_p=1,8d_b$	
Profilning uzunligi		$l_p=(1,2\div1,5)d_b$	
Gardishning qalinligi		$S>2,5m$	$S>1,6m_e$
Diskning qalinligi	Bolg'alash yo'li bilan tayyorlansa	$C\geq0,25b_2$	
	Shtamplash yo'li bilan tayyorlansa		
	Quyma yo'li bilan tayyorlansa		
Teshikchalar		$d_o\geq25mm$	
Egrilik radiuslari	$d_a<100$ mm gacha bo'lganda $R\geq1mm$ $d_a=100\text{-}500$ mm gacha bo'lganda $R\geq6mm$ $d_a>500$ mm gacha bo'lganda $R\geq10mm$		

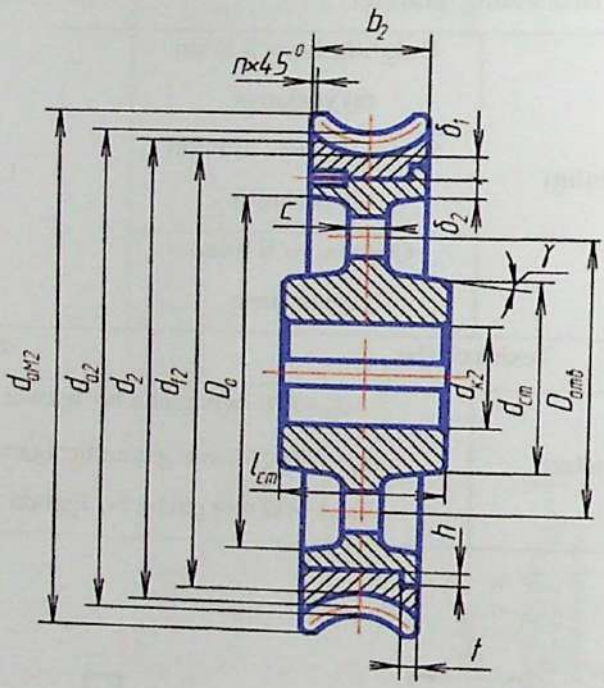


Stakan konstruksiyasi

Chervyak asosan val bilan birga tayyorlanadi (4.2 – rasm). Chervyakli g'ildirak elementlarining o'lchami 4.2 – jadvalda, eskis chizmasi 4.3 – rasmda berilgan.



4.2 – rasm



4.3 – rasm

4.2 – jadval

Chervyakli g'ildirak elementlarining o'lchami	Chervyakli g'ildirak
Tish bo 'luvchi aylanasining diametri	$d_2=mZ_2$
Tashqi diametr	$d_{a2}=d_2+2m$
Tish osti diametr	$d_{f2}=d_2-2,4m$

G'ildirakning eng katta tashqi diametri	$d_{aT2}=d_{a2}+\frac{6m}{Z_1+2}$
Profilning diametri	$d_r=(1,5\div1,6)d_b$
Profilning uzunligi	$l_r=(1\div1,5)d_b$
Diskning qalinligi	$C\geq0,25b_2$
Gardishning element o'lchamlari	$S=0,05d_2$ $S_o=1,2S$ $h=0,15b_2$ $t=0,8h$
Teshikning diametri Egrilik radiusi	$d_o\geq25mm$ $R\geq10$
G'ildirak tishli qismining eni	$Z_1=1;2$ bo'lganda $b_2\leq0,75d_{a1}$ $Z_1=4$ bo'lganda $b_2\leq0,67d_{a1}$

4.2. Qutilarni loyihalash va eskiz chizmalari

Uzatma devorning qalinligini uzatilayotgan burovchi momentning eng katta qiymatiga nisbatan quyidagicha formula, ya'ni $\delta=1,8\sqrt[4]{T_{max}}\geq6\ mm$ yordamida aniqlash mumkin yoki 4.3 – jadvaldan burovchi momentga nisbatan tanlash mumkin.

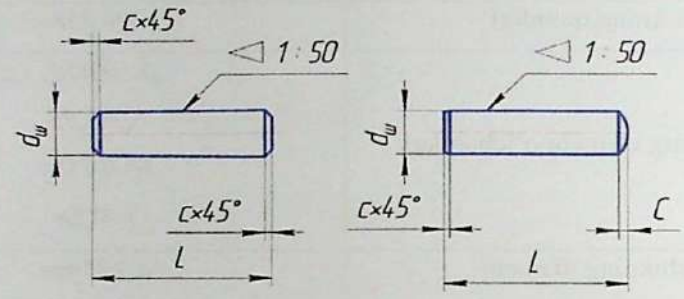
4.3 – jadval

T_{max}, $N\cdot m$	100	225	375	600	950	1400	2000	2700	3600	4600
δ, mm	6	7	8	9	10	11	12	13	14	15

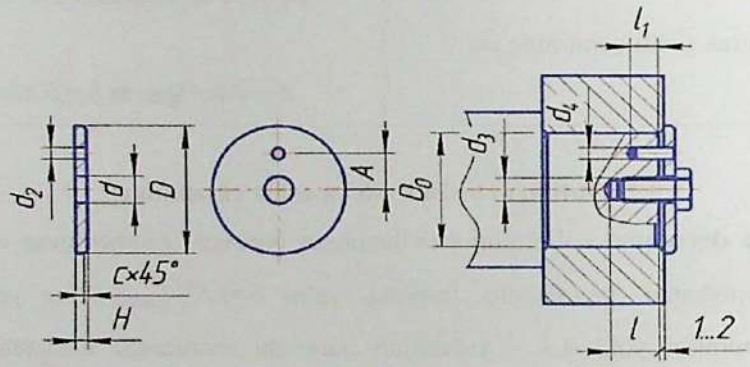
Bir pog'onali silindirsimon, konussimon hamda chervyakli uzatmalarning qutisi rasmlarda ko'rsatilgan. Quti ikki bo'lakdan, ya'ni qutining asosi va uning qopqog'idan iborat bo'lib, yig'ish oson bo'lishi uchun asosan val o'qi bo'yicha ajraladigan qilib tayyorlanadi.

4.3. Qutining detal va elementlari

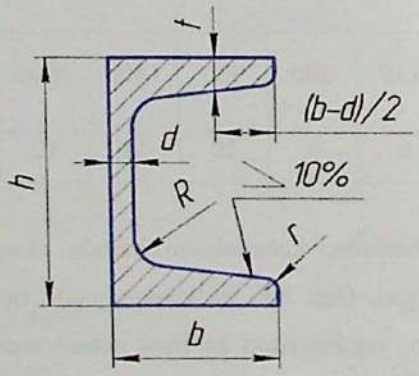
a) qutida podshipnik uchun mo'ljallangan uyalarni ochishda o'qdoshligini ta'minlash uchun qutining asosi bilan qutining qopqog'i o'zaro konussimon yoki silindirsimon shtif bilan biriktiriladi (4.4 – rasm).



4.4 – rasm

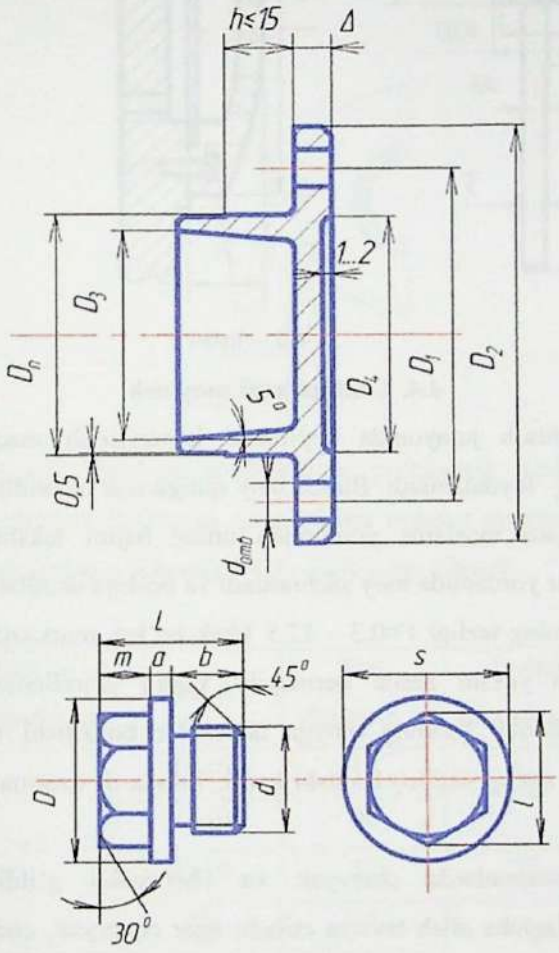


Mahkamlovchi shayba

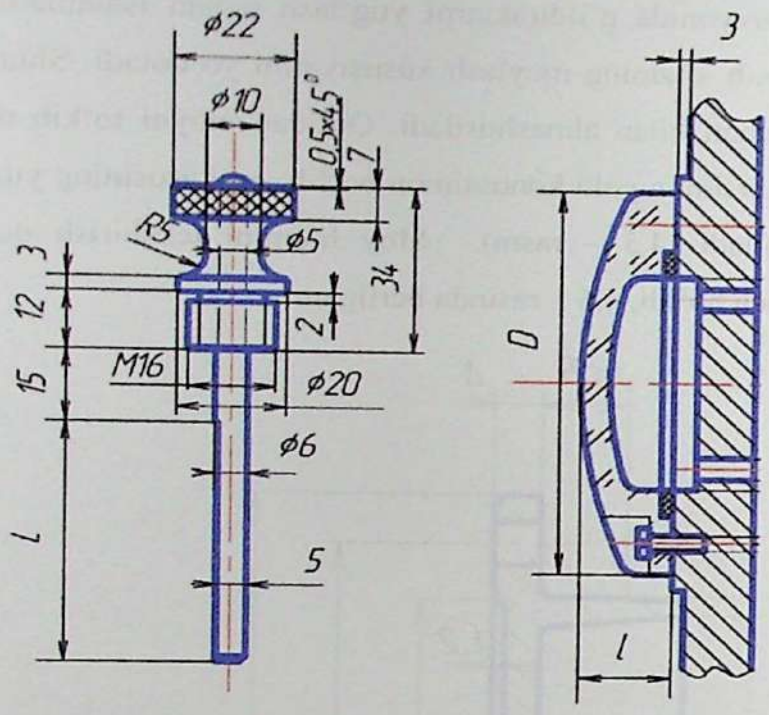


Shveller

b) uzatmalar ishlash jarayonida g'ildiraklarni yog'lash uchun ishlatiladigan moylar asta – sekin ifloslanib, o'zining moylash xususiyatini yo'qotadi. Shuning uchun bu moylar vaqti – vaqti bilan almashtiriladi. Qutidan moyni to'kib olish uchun ochilgan teshik silindirsimon yoki konussimon bo'lib, quti asosining yuziga 1° – 2° qiyalik bilan ochiladi (4.5 – rasm). Moy hajmini tekshirish uchun o'lchaqichlar turli ko'rinishda bo'lib, 4.6 – rasmda berilgan.



4.5 – rasm



4.6 – rasm

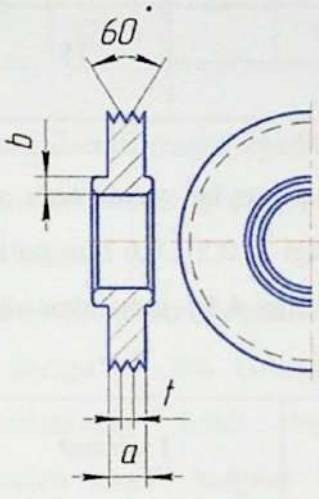
4.4. Uzatmalarni moylash

Uzatmalar ishlash jarayonida yeyilishni kamaytirish maqsadida moylash suyuqligidan keng foydalaniladi. Bunda moy qutiga tish balandligini ko'mguncha quyiladi va maxsus moslama yordamida uning hajmi tekshiriladi. G'ildirak aylanganida tishlar yordamida moy sachratiladi va boshqa detallar ham moylanadi. Tishli g'ildiraklarning tezligi V=0,3 – 12,5 1/sek bo'lsa, markazdan qochma kuch ta'sirida moylash yaxshi natija bermaydi. Yopiq silindirsimon uzatmalarda yetaklanuvchi g'ildirak tishning moyga qanchalik botirilishi rasmda berilgan. Botirilish kamida $m>h_M\leq 0,25d_2$ bo'lishi kerak, bunda m uzatma g'ildiraklarining moduli.

Chervyakli uzatmalarda chervyak va chervyakli g'ildiraklarni moyga botirilishini quyidagicha olish tavsiya etiladi: agar chervyak, chervyakli g'ildirak tagida joylashgan bo'lsa, $h_M=(0,1\div 0,5)d_a$, $h_{M\,min}=2,0\,m$ chervyakli g'ildirak moyga botirilsa $m>h_M\leq 0,25d_2$ bo'lishi kerak.

4.5. Zichlagich moslamalari

Podshipnikdan moylarning chiqib ketmasligi hamda tashqi muhitdan har xil iflosliklarning tushmasligi uchun podshipnik uzelida maxsus moslamalar ishlatiladi. Bu moslamalar ikki xil bo'lib, podshipnik qopqoqlarida yoki qopqoqni tashqi tomoniga joylashtiriladi, ikkinchisi esa podshipnik yon tomoniga ichki tomondan joylashtiriladi.



Tezligi $V \leq 10\ sek^{-1}$ bo'lgan uzatmalarda, podshipnik uzellari quyuq yoki suyuq moylar yordamida moylansa qopqoqlarda maxsus manjenitli zichlagichlar ishlatiladi. Zichlagichning o'lchamlari 4.4 – jadvaldan olinadi.

4.4 – jadval

Val diametri, d	Tashqi diametri, D	Eni, h	Val diametri, d	Tashqi diametri, D	Eni, h
20	40	8÷10	48	70	
21		8÷10	50		10
22		8÷10	52	75	10÷12
24		10	55	80	10÷12
25	42	8÷10	56		10
26	45	8÷10	58		12
28		10	60		
30	52		62		10÷12

32	52		63	90	10
35	58		65		
36			67		12
38			68		
40	60		70	95	12
42	62		71	95	10
44			75	100	10÷12
45	65				

Podshipnik uzellari suyuq moylar yordamida moylansa, moylarning oqib chiqib ketmasligi uchun qalinligi S=0,3…0,6 mm po'lat materialidan tayyorlangan moslamalar ishlatiladi. O'lchamlari 4.5 – jadvaldan olinadi.

4.5 – jadval

Podshipnik diametri		Umumiy o'lcham		I variant			II variant		
d	D	S	h	D_1	d	d_1	d_2	D	D_2
20	47	0,3	2	41,2	20	29	25,7	47	37
	52			44,8		33	27,2	52	40
25	52		2,5	47	25	36	31,5	52	42
	62			54,8		40	32,2	62	47
30	62			56,2	30	44	36,3	62	47
	72			64,8		48	37,2	72	56
35	72			64,8	35	48	43	72	56
	80			70,7		54	45	80	65
40	80			72,7	40	57	48	80	62
	90			80,5		60	51	90	70
45	85			77,8	45	61	53	85	68
	100			90,8		75	56	100	80
50	90		3	82,8	50	67	57,5	90	73

	110			9,9		80	62	110	86
55	100 120			90,8 108	55	75 89	64,5 67	100 120	80 93
60	110 120			100,8 117,5	60	85 95	70 73	110 130	85 102
65	120 140	0,5	3,5	110,5 127,5	65	90 100	74,5 72,5	120 140	95 100

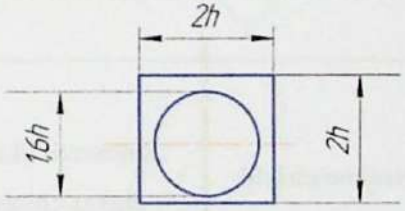
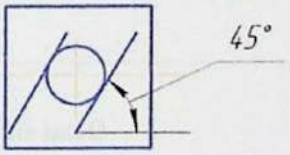
4.6. Uzatma detallarining ishchi chizmasi

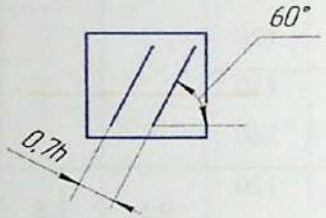
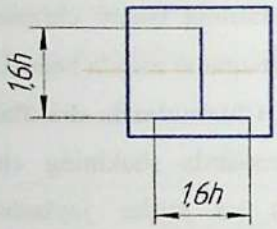
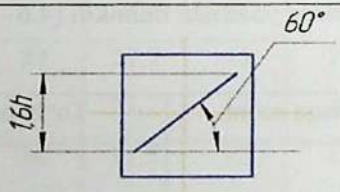
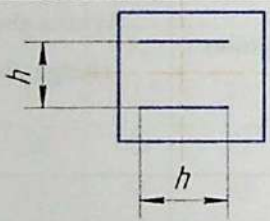
Detallarning ishchi chizmalari ularning asliga qarab tuzilgan eskizga yoki yig'ma chizmalar asoida bajariladi.

Chizmalarda shakllar va sirtlarni chekli chiqishini belgilash

Chizmalarda shaklning chetga chiqish (silindir emasligi, aylana shaklda emasligi) va sirtlar joylashishining chekli chetga chiqishi (noparallellik, nosimmetrik) detal chizmalarida shartli belgilar bilan qo'yilishi yoki texnik talablarda yozilishi mumkin (4.6 – jadval).

4.6 – jadval

	Qisqa nomi	To'la nomi	Belgisi
1.	Noaylanasimon	Aylana shakldan chetga chiqish	
2.	Nosilindrik	Silindrikdan chetga chiqish	

3.	Noparallellik	Parallellikdan chetga chiqish	
4.	Noperpendikulyar	Perpendikulyarlikdan chetga chiqish	
5.	Radial va yon tomoni tebranishi	Radial va yon tomoni tebranishi	
6.	Nosimmetriklik	Simmetriklikdan chetga chiqish	

Detal sirtining notekisligini belgilash

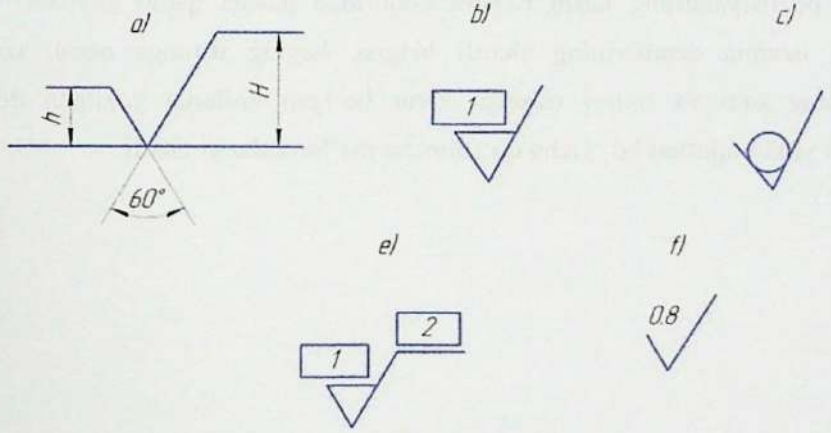
Sirtning notekisligini o‘lchash uchun belgilangan sohaning uzunligi baza uzunligi deyiladi. Notekisliklar R_a, R_z harflari bilan belgilanadi. Notekisliklarni aniqlash uchun profilning o‘rta chizig‘iga parallel chiziq o‘tkazilib, shu to‘g‘ri

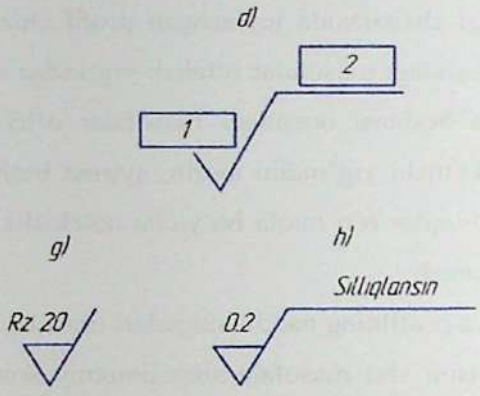
chiziq va baza uzunligi chegarasida joylashgan profil chiziqlaridan beshtasining eng yuqori nuqtalati orasidagi masofalar o'lchab yig'indisi olinadi, xuddi shunday eng quyi nuqtalaridan beshtasi orasidagi masofalar o'lchab yig'indisi olinadi. Birinchi yig'indidan ikkinchi yig'indini ayirib, ayirma beshga bo'linadi. Bu usul bo'yicha hisoblangan miqdor o'n nuqta bo'yicha notekisliklar balandligi deyiladi va R_z harfi bilan belgilanadi.

Agar o'rta chiziq va profilning barcha nuqtalari orasidagi masofani o'lchab, bu masofalarning yig'indisini shu masofalarning umumiy soniga bo'linsa, u holda profilning o'rniga chiziqdan o'rtacha arifmetik chetg chiqish hosil bo'ladi. Bu hisoblashlar baza uzunligi bilan chegaralansa profil sohasi uchun qabul qilinadi, hosil bo'lgan miqdor bilan R_a belgilanadi.

Detal sirtining notekisligi ko 'rsatilganda R_a shartli belgi yozilmaydi, (masalan 0,8), R_z bo'lganda esa yoziladi, R_z 20

Chizmaga detal sirtining notekisligini ko'rsatish uchun quyidagi shartli belgilar qabul qilingan:





Spetsifikatsiya

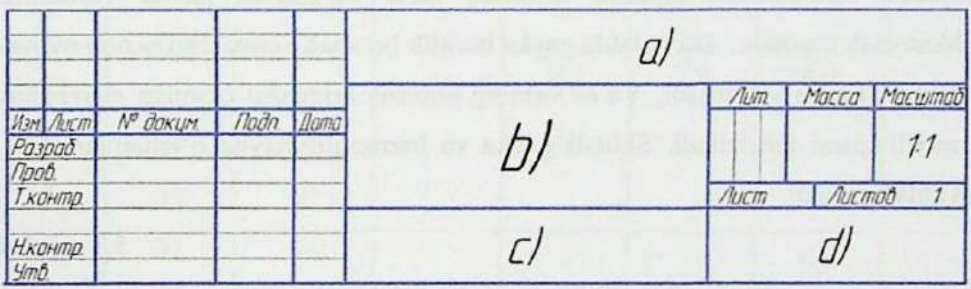
Har bir uzel uchun alohida chizma qog‘ozida spetsifikatsiya deb ataluvchi matnli hujjat tuziladi.

Spetsifikatsiya formasi A4 formatda bajariladi. Uni bajarish usuli quyidagicha:

Dastlabki ustunga chizma qog‘oz formatining shartli belgisi, ikkinchi ustun qismlariga bo‘lingan bo‘lsa, shu detal joylashgan qismning belgisi, uchinchi ustunga pozitsiyalarning tartib raqami yuqoridan pastga qarab yoziladi. Belgi ustuniga uzatma detallarining shartli belgisi, keying ustunga nomi, so‘ngra detallarning soni va oxirgi ustunga zarur bo‘lgan hollarda yozilgan detallar materiali yoki hujjatlari bo ‘yicha qo‘shimcha ma’lumotlar yoziladi.

Перв. примен.	Справ. №	Формат	Зона	Поз.	Обозначение	Наименование	Кол.	Приме-чание

Chizma ishlarida qo'llaniladigan burchak shtamp namunasi



a) Kurs loyiha (ishi) ning shifri;

b) Kurs loyiha(ishi) ning mavzusi;

c) Yig'ma detal materiali markasi;

d) Oliy ta'lim muassasasi nomi, fakultet, talabaning guruhi.

5. Dumalash podshipniklari

5.1. Dumalash podshipniklarining asosiy xarakteristikalari

Bir qatorli zoldirli podshipniklar *(a – rasm)*, asosan radial kuchlarni va chegaralangan darajada bo'ylama kuchlarni qabul qiladi. Podshipnikning tashqi xalqasi, ichki xalqasiga nisbatan 10′ gacha siljishi mumkin.

Bir qatorli zoldirli radial – tirak podshipniklar *(b – rasm)*, radial va bo'ylama kuchlar ta'sirida ishlash mumkin. Ruxsat etilgan bo'ylama kuchlarning qiymati kontakt burchagi α qiymatiga bog'liq. Bu kontakt burchakning qiymati $\alpha=12^o$, $\alpha=26^o$, $\alpha=36^o$ bo'lishi mumkin.

Konussimon rolikli radial – tirak podshipniklar *(c – rasm)*, radial va bo'ylama kuchlar ta'sirida ishlash mumkin. Bu podshipniklar tezligi nisbatan kam bo'lgan vallarda ishlatiladi. Podshipnikda konus burchagi qanchalik katta bo'lsa, shunchalik katta bo'ylama kuchlar ta'sirida ishlashi mumkin.

5.2. Podshipniklarni val va korpusga mahkamlash usullari

Podshipniklarni valga mahkamlashda podshipnikka ta'sir qiluvchi kuchlarning qiymati va yo'nalishi uning aylanish soni hisobga olinadi.

Podshipniklarni ichki xalqasi bo'yicha valga mahkamlashda bo 'ylama kuchlarning qiymati nisbatan katta bo'lmaganda ichki xalqani to'g'ri burchakli prujinali xalqa yordamida mahkamlanadi. O'lchamlari 5.1 – jadvalda berilgan. Bo'ylama kuchlarning qiymati nisbatan katta bo'lganda gayka yordamida mahkamlash mumkin. Bu holatda gayka buralib bo'shab ketmasligi uchun maxsus barmoqli shayba ishlatiladi. Ya'ni valning maxsus ariqchasi qismiga shaybaning barmoqli qismi kirgiziladi. Shlitsli gayka va barmoqli shayba o'lchamlari 5.2 – jadvalda berilgan.

5.1 – jadval

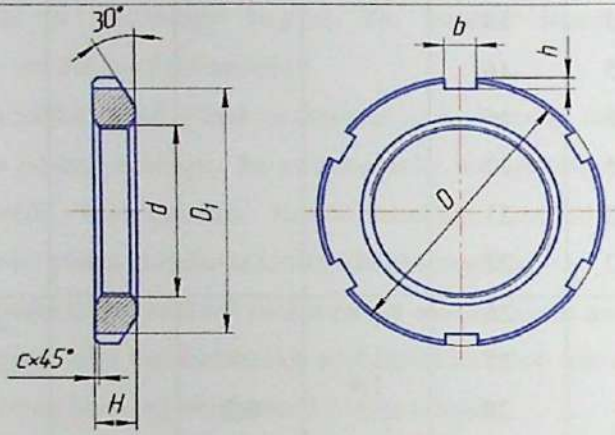
Prujinali halqa va ariqcha o'lchamlari, mm

Valning diametri, d	Valdagi chuqurchaning o'lchamlari				Xalqa		
	d_1	Ruxsat etilgan bo'ylama kuch	B	r	S	b	l
20	18,6	10	1,4	0,1	1,2	3,2	3,0
22	20,6	11				3,6	
23	21,5	12					

24	22,5	13					
25	23,5	14					
26	24,5	14					
28	26,5	16					
29	27,5	16					
30	28,5	17					
32	30,2	21					
34	32,2	22					
35	33	26	1,9	0,2		4,9	6,0
36	34	27					
37	35	28				5,5	
38	36	29					
40	37,5	38	2,2				
42	39,5	39		0,2	2,0	6,0	
45	42,5	42					
46	43,5	43					
48	45,5	45					
50	47	57					
52	49	59					
54	51	61	2,2	0,2	2,0	6,0	6,0
55	52	62				6,5	
56	53	64					
58	55	66	2,8	0,3	2,5	7,0	6,0
60	57	68					
62	59	71					
65	62	74					
68	65	78					
70	67	80					

5.2 – jadval

Shlitsli gayka o'lchamlari, mm



d – valning diametri	Rezba qadami	*D*	D_1	*C*	*H*	*b*	*h*
10	1,25	22	15	0,6	8	4	2,0
12	1,25	26	18				
14	1,5	28	20	0,6			
16		30	22	0,1		5	2,5
18		32	24				
20		34	27				
22		38	30	1,0	10		
24		42	34				
27		45	34				
30		48	39				
33		52	42			6	3
36		55	48				
39		60	48				
42		65	56				

45 48 52 56 60 64		70 75 80 85 90 95	56 64 64 72 72 80	1,0 1,6	12 12	8 8	4 4
68 72 76 80 85 90 96 100	2	100 105 110 115 120 125 130 135	80 90 90 100 105 110 110 120	1,6	15 18	10 12	5 6

35X po'latdan tayyorlangan, chekli chegarasi 6H, 9 mkm qalinlikda qoplangan. Rezba qadami 2 mm, diametri d=64 mm, aniqlik darajasi normal bo'lgan gaykaning shartli belgisi: gayka M64X2 6H.35X. 019

5.3. Podshipniklarni tanlash va hisoblash

Podshipniklarni 5.5, 5.6 va 5.7 – jadvallardan aylanish soni $n<1\ min^{-1}$ bo'lsa, statik ko'taruvchanlik $[C_o]$ bo'yicha, $n>1\ min^{-1}$ bo'lsa, dinamik ko'taruvchanlik $[C_r]$ bo'yicha tanlanadi.

Podshipniklarni hisobiy dinamik ko'taruvchanlik yoki ishlash muddati quyidagicha aniqlanadi:

$$C_x = R_{ek}\sqrt[m]{\frac{573\omega L_h}{10^6}} \geq [C_r]$$

$$L_x = \frac{10^6}{573\omega}\left(\frac{C_r}{R_{ek}}\right)^m \leq L_h$$

Bu yerda: C_x- podshipniklarni hisobiy dinamik ko'taruvchanlik qiymati;

R_{ek}- tayanchdagi reaksiya qiymatlarining ekvivalent qiymati;

ω - podshipnik o'tkazilgan valning burchak tezligi;

L_h - uzatma val tayanchlariga o 'tkazilgan podshipniklarning ishlash muddati soat hisobida. Chervyakli uzatma val tayanchlarida $L_h \geq 5000$ *soat;* silindirsimon uzatmalarda $L_h \geq 10000$ *soat*, L_x - podshipnikning hisobiy ishlash muddati soat hisobida;

m - daraja ko'rsatkichi bo'lib, zoldirli podshipniklar uchun m=3,0 roliksimon podshipniklar uchun m=3,3;

C_x, L_x - qiymatlari har turli podshipniklar uchun har xil yo'llar bilan aniqlanadi.

1. Bo'ylama kuch ta'sir qiluvchi bir qatorli zoldirli radial podshipniklar uchun C_x, L_x qiymatlarini aniqlash tartibi. Bunda F_a kuch ta'sirida tayanchlarda shu kuchga teng R_{aA}, R_{aB} kuchlar hosil bo'ladi C_x, L_x qiymatlari nisbatan katta yuklangan tayanch uchun aniqlanadi.

a) $\frac{F_a}{C_o}$ ga nisbatan e – koeffitsiyent qiymati 5.3 – jadvaldan olinadi.

5.3 – jadval

Bir qatorli radial podshipniklar uchun X, Y, *e* koeffitsiyent qiymatlari

$\frac{F_a}{C_o}$	$\frac{F_a}{R_r} < e$		$\frac{F_a}{R_r} > e$		e
	X	Y	X	Y	
0,014				2,3	0,19
0,028				1,8	0,22
0,056				1,71	0,26
0,084				1,55	0,28
0,11	1,0	0	0,56	1,45	0,3
0,17				1,31	0,34
0,28				1,15	0,38
0,42				1,04	0,42
0,56				1,00	0,44

b) Ekvivalent yuklanish qiymatlari R_{ek} aniqlanadi.

$\frac{F_a}{VR_r} > e$ bo'lganda $R_{ek}=(XVR_r+VF_a)K_1 \cdot K_2$

$\frac{F_a}{VR_r} < e$ bo'lganda $R_{ek}=R_r \cdot K_1 \cdot K_2$

c) C_x, L_x qiymatlarini aniqlanadi.

Bu yerda: F_a - bo'ylama kuch;

C_o- statik yuk ko'taruvchanlik;

R_r- tayanchdagi reaksiya qiymatlarining umumlashgan qiymati, valning A tayanchi uchun

$$R_{rA}=\sqrt{\left(R_A^H\right)^2+\left(R_A^V\right)^2}$$

B tayanch uchun

$$R_{rB}=\sqrt{\left(R_B^H\right)^2+\left(R_B^V\right)^2}$$

e – radiyal va bo'ylama kuchlarni hisobga oluvchi koeffitsiyent;

X – radiyal kuchlarni hisobga oluvchi koeffitsiyent;

Y – bo'ylama kuchlarni hisobga oluvchi koeffitsiyent;

K_1 - uzatmaning shu rejimini hisobga oluvchi koeffitsiyent, yuklanish bir tekisda bo'lsa, K_1=1,0; nisbatan notekis bo'lsa, K_1=1,3÷1,5; qattiq zarb bilan bo'lganda K_1=2,5÷3,0

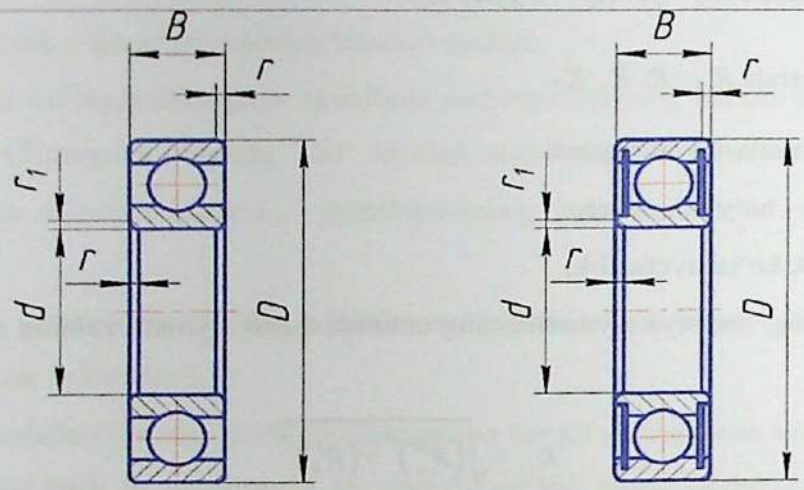
K_2 - uzatmaning qizishini hisobga oluvchi koeffitsiyent, qiymati 5.4 – jadvaldan olinadi.

5.4 – jadval

t_2^o	100°	125°	150°	175°	200°	225°	250°
K_2	1,0	1,05	1,1	1,15	1,25	1,35	1,4

5.5 – jadval

Bir qatorli radial podshipniklar o‘lchami, mm



Podshipnik shartli belgisi	d	D	B	r	Yuk ko‘taruvchanlik, kN	
					C_r	C_o
1	2	3	4	5	6	7
Juda yengil seriya						
100	10	26	8	0,5	4,62	1,96
101	12	28	8	0,5	5,07	2,24
104	20	42	12	1	9,36	4,5
105	25	47	12	1	11,2	5,6
106	30	55	13	1,5	13,3	6,8
107	35	62	14	1,5	15,9	8,5
108	40	68	15	1,5	16,8	9,3
109	45	75	16	1,5	21,2	12,2
110	50	80	16	1,5	21,6	13,2
111	55	90	18	2	28,1	17
112	60	95	18	2	29,6	18,3
113	65	100	18	2	30,7	19,6
114	70	110	20	2	37,7	24,5

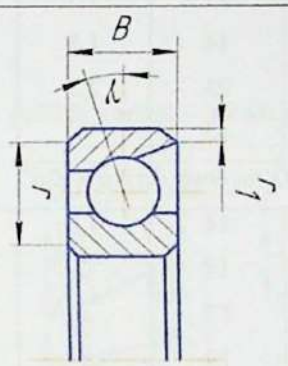
115	75	115	20	2	39,7	26
116	80	125	22	2	47,7	31,5
117	85	130	22	2	49,4	33,5
118	90	140	24	2,5	57,2	39
119	95	145	24	2,5	60,5	41,5
120	100	150	24	2,5	60,5	41,5
Yengil seriya						
200	10	30	9	1	5,9	2,65
201	12	32	10	1	6,89	3,1
202	15	35	11	1	7,8	3,55
203	17	40	12	1	9,56	4,5
204	20	47	14	1,5	12,7	6,2
205	25	52	15	1,5	14	6,95
206	30	62	16	1,5	19,5	10
207	35	72	17	2	25,5	13,7
208	40	80	18	2	32	17,8
209	45	85	19	2	33,2	18,6
210	50	90	20	2	35,1	19,8
211	55	100	21	2,5	43,6	28
212	60	110	22	2,5	52	31
213	65	120	23	2,5	56	34
214	70	125	24	2,5	61,8	37,5
215	75	130	25	2,5	66,3	41
216	80	140	26	3	70,2	45
217	85	150	28	3	89,5	53
218	90	160	30	3	95,6	62
219	95	170	32	3,5	108	69,5
220	100	180	34	3,5	124	79
O'rta seriya						

300	10	35	11	1	8,06	3,75
301	12	37	12	1,5	9,75	4,65
302	15	42	13	1,5	11,4	5,4
303	17	47	14	1,5	13,5	6,65
304	20	52	15	2	15,9	7,8
305	25	62	17	2	22,5	11,4
306	30	72	19	2	29,1	14,6
307	35	80	21	2,5	33,2	18
308	40	90	23	2,5	41	22,4
309	45	100	25	2,5	52,7	30
310	50	100	27	3	61,8	36
311	55	120	29	3	71,5	41,5
312	60	130	31	3,5	81,9	48
313	65	140	33	3,5	92,3	56
314	70	150	35	3,5	104	63
315	75	160	37	3,5	112	72,5
316	80	170	39	3,5	124	80
317	85	180	41	4	133	90
318	90	190	43	4	143	99
319	95	200	45	4	153	110
320	100	215	47	4	174	132
Og'ir seriya						
403	17	62	17	2	22,9	11,8
405	25	80	21	2,5	36,4	20,4
406	30	90	23	2,5	47	26,7
407	35	100	25	2,5	55,3	31
408	40	110	27	3	63,7	36,5
409	45	120	29	3	76,1	45,5
410	50	130	31	3,5	87,1	52

411	55	140	33	3,5	100	63
412	60	150	35	3,5	108	70
413	65	160	37	3,5	119	78,1
414	70	180	42	4	143	105
416	80	200	48	4	163	125
417	85	210	52	5	174	135

5.6 – jadval

Zoldirli radial – tirak podshipnink o'lchami, mm



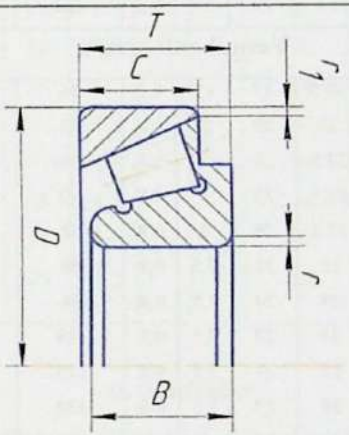
Podshipnik shartli belgisi	d	D	B	r	r_1	Yuk ko'taruvchanlik, kN	
						C_r	C_o
1	2	3	4	5	6	7	8
Juda yengil seriya $\alpha=12^o$							
36104	20	42	12	1	0,5	10,6	5,32
36105	25	47	12	1	0,5	11,8	6,29
36106	30	55	13	1,5	0,5	15,3	8,57
36107	35	62	14	1,5	0,5	19,1	11,3
Yengil ensiz seriya $\alpha=12^o$							
36204	20	47	14	1,5	0,5	15,7	8,31
36205	25	52	15	1,5	0,5	16,7	9,1
36206	30	62	16	1,5	0,5	22	12
36207	35	72	17	2	1	30,8	17,8
36208	40	80	18	2	1	38	23,2

36209	45	85	19	2	1	31,2	25,1
36210	50	90	20	2	1	43,2	27
36211	55	100	21	2,5	1,2	58,4	34,2
36212	60	110	22	2,5	1,2	61,5	39,3
36214	70	125	24	2,5	1,2	80,2	54,8
36216	80	140	26	3	1,5	93,6	65
36217	85	150	28	3	1,5	101	70,8
36218	90	160	30	3	1,5	118	83
36219	95	170	32	3,5	2	134	95
O'rta ensiz seriya $\alpha=12^{\circ}$							
36302	15	42	13	1,5	0,5	13,6	6,8
36303	17	47	14	1,5	0,5	17,2	8,7
36308	40	90	23	2,5	1,2	53,9	32,8
36318	90	190	43	4	2	189	145
O'rta ensiz seriya $\alpha=26^{\circ}$							
46303	17	47	14	1,5	0,5	16,1	8
46304	20	52	15	2	1	17,8	9
46305	25	62	17	2	1	26,9	14,6
46306	30	72	19	2	1	32,6	18,3
46307	35	80	21	2,5	1,2	42,6	24,7
46308	40	90	23	2,5	1,2	50,8	31,1
46309	45	100	25	2,5	1,2	61,4	37
46310	50	110	27	3	1,5	71,8	44
46312	60	130	31	3,5	2	100	65,3
46313	65	140	33	3,5	2	113	75
46314	70	150	35	3,5	2	127	85,3
46316	80	170	39	3,5	2	136	99
46318	90	190	43	4	2	165	122
46320	100	215	47	4	2	213	177
Yengil ensiz seriya $\alpha=36^{\circ}$							
66207	35	72	17	2,5	1,2	17	14,7
66211	55	100	21	2,5	1,2	46,3	28,4
66215	75	130	25	2,5	1,2	71,5	49
66219	95	170	32	3,5	2	121	85

66221	105	190	36	3,5	2	148	108
O'rta ensiz seriya α=36°							
66309	45	100	25	3	1,5	60,8	36,4
66312	60	130	31	3,5	2	93,7	58,8
66314	70	150	35	3,5	2	119	76,8
Og'ir ensiz seriya α=36°							
66406	30	90	23	2,5	1,2	43,8	27
66408	40	110	27	3	1,5	72,2	42,3
66409	45	120	29	3	1,5	81,6	47,3
66410	50	130	31	3,5	2	98,9	60,1

5.6 – jadval

Konussimon rolikli radial – tirak o'lchami, mm



Podshipnik shartli belgisi	d	D	T	B	C	r	r_1	Yuk ko'taruvchanli, kN		Koeffitsiyentlar		
								C_r	C_r	e	Y	X_o
1	2	3	4	5	6	7	8	9	10	11	12	13
Yengil seriya α=12°-16°												
7202	15	35	12	11	9	1	0,3	10,5	6,1	0.451	1,320	0,731
7203	17	40	13,5	12	11	1,5	0,5	14	9	0,314	1.909	1,050
7204	20	47	15,5	14	12	1,5	0,5	21	13	0,360	1,666	0,916

7205	25	52	16,5	15	13	1,5	0,5	24	17,5	0,360	1,666	0,916
7206	30	62	17,5	16	14	1,5	0,5	31	22	0,365	1,645	0,905
7207	35	72	18,5	17	15	2	0,8	38,5	26	0,369	1,624	0,803
7208	40	80	20	19	16	2	0,8	46,5	32,5	0,383	1,565	0,861
7209	45	85	21	20	16	2	0,8	50	33	0,414	1,450	0,798
7210	50	90	22	21	17	2	0,8	56	40	0,374	1,604	0,882
Yengil seriya												
7211	55	100	23	21	18	2,5	0,8	65	46	0,411	1,459	0802
7212	60	100	24	23	19	2,5	0,8	78	58	0,351	1,710	0,940
7214	70	125	26,5	26	21	2,5	0,8	96	82	0,369	1,624	0,893
7215	75	130	27,5	26	22	2,5	0,8	107	84	0,388	1,547	0,851
7216	80	140	28,5	26	22	3	1	112	95	0,421	1,426	0,784
7217	85	150	31	28	24	3	1	130	109	0,430	1,380	0,759
7218	90	160	33	31	26	3	1	158	125	0,383	1,565	0,861
7219	95	170	35	32	27	3,5	1,2	168	131	0,407	1,476	0,812
7220	100	180	37,5	34	29	3,5	1,2	185	146	0,402	1,493	0,821
Yengil enli seriya												
7506	30	62	21,5	20,5	17	1,5	0,5	36	27	0,365	1,645	0,905
7507	35	72	24,5	23	20	2	0,8	53	40	0,346	1,733	0,953
7508	40	80	25	23,5	20	2	0,8	56	44	0,381	1,575	0,866
7509	45	85	25	23,5	20	2	0,8	60	46	0,416	1,442	0,793
7510	50	90	25	23,5	20	2	0,8	62	54	0,421	1,426	0,784
7511	55	100	27	25	21	2,5	0,8	80	61	0,360	1,666	0,916
7512	60	110	30	28	24	2,5	0,8	94	75	0,392	1,528	0,840
7513	65	120	33	31	27	2,5	0,8	119	98	0,369	1,624	0,893
7514	70	125	33,5	31	27	2,5	0,8	125	101	0,388	1,547	0,851
7515	75	130	33,5	31	27	2,5	0,8	130	108	0,407	1,476	0,812
7516	80	140	35,5	33	28	3	1	143	126	0,402	1,493	0,821
7517	85	150	39	36	30	3	1	162	141	0,388	1,547	0,851
7518	90	160	48	40	34	3	1	190	171	0,388	1,547	0,851
7519	95	170	46	45	37	3,5	1,2	230	225	0,383	1,565	0,861
7520	100	180	49,5	46	39	3,5	1,2	250	236	0,402	1,493	0821
O‘rta seriya												
7304	20	52	16,5	16	13			26	17	0,296	2,026	1,114
7305	25	62	18,5	17	15	2,0		33	23,2	0,360	1,666	0,916
7306	30	72	21	19	17		0,8	43	20,5	0,337	1,780	0,979
7307	35	80	23	21	18	2,5		54	38	0,319	1,881	1,035
7308	40	90	25,5	23	20	2,5		66	47,5	0,278	2,158	1,187
	45	100	27,5	26	22	2,5		83	60	0,287	1,090	1,180

7309	50	110	29,5	29	23			100	75,5	0,310	1,937	1,065
7310	55	120	32	29	25	3,0	1,0	107	81,5	0,332	1,804	0,992
7311	60	130	34	31	27			128	96,5	0,305	1,966	1,081
7312	65	140	36,5	33	28			146	112	0,305	1,966	1,081
7313	70	150	38,5	37	30	3,5		170	137	0,310	1,937	1,065
7314	75	160	40,5	37	31		1,2	180	148	0,328	1,829	1,006
7315	85	180	45	41	35			230		1,909	1,195	1,050
7317	90	190	47	43	36	4,0	1,5	250	201	0,319	1,881	1,035
7318												
O'rta enli seriya												
7604	20	52	22,5	21	18,5			31,5	22	0,298	2,011	1,106
7605	25	62	25,5	24	21	2,0	0,8	47,5	36,6	0,273	2,164	1,205
7606	30	72	29	29	23			63	51	0,319	1,882	1,035
7607	35	80	33	31	27			76	61,5	0,296	2,026	1,114
7608	40	90	35,5	33	28,5	2,5	0,8	90	67,5	0,296	2,026	1,114
7609	45	100	38,5	36	31			114	90,5	0,291	2,058	1,131
7611	55	120	46	44,5	36,5	3,0	1,0	160	140	0,323	1,855	1,020
7612	60	130	49	47,5	39			186	157	0,305	1,966	1,081
7613	65	140	51,5	48	41			210	168	0,328	1,829	1,006
7614	70	150	54,5	51	43	3,5	1,2	240	186	0,351	1,710	0,940
7615	75	160	58,5	55	46,5			280	235	0,301	1,996	1,198

6. Muftalar

6.1. Doimiy biriktiriladigan muftalar

Flanetsli va vtulkali mustalar rasmlarda ko'rsatilgan. Muftalar 6.1 va 6.2 – jadvallardan valning diametriga hamda uzatilayotgan burovchi momentga nisbatan tanlanadi.

$$T_x = K \cdot T \leq [T]$$

Bu yerda: K - muftaning ishlash sharoitini hisobga oluvchi koeffitsiyent, yuklanish bir tekisda bo'lganda $K = 1{,}15 \div 1{,}5$; yuklanish notekis bo'lganda $K = 1{,}7 \div 2{,}0$; yuklanish zarb ta'sirida bo'lgada $K = 2{,}5 \div 3{,}0$.

$[T]$ – burovchi momentning ruxsat etilgan qiymati 6.1 – jadvaldan olinadi.

T - mufta validagi burovchi moment.

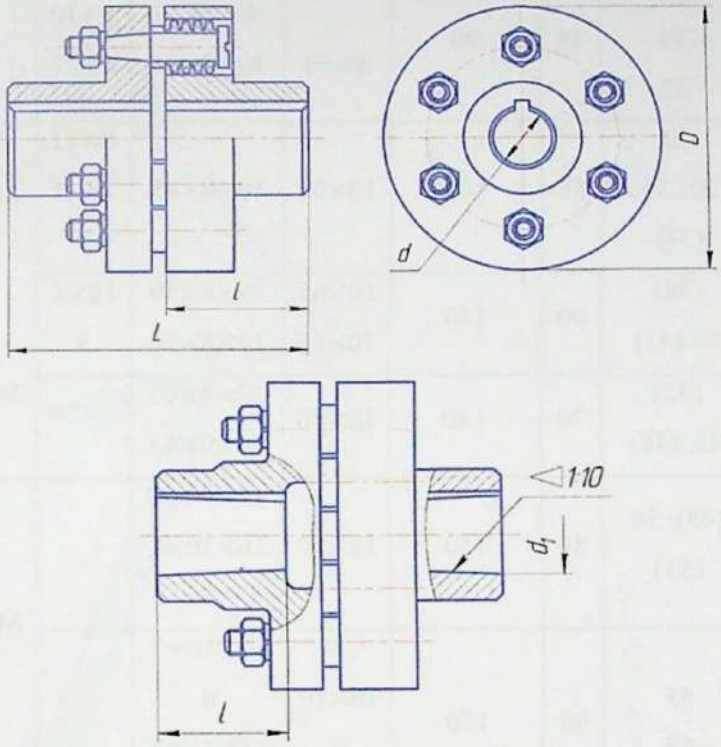
6.1 – jadval

Flanetsli muftaning o'lchamlari, mm

[T]	d	D	l – ning eng katta qiymati		L – ning eng katta qiymati	
			variantlar			
			1	2	3	4
16,5	16 18	80	40	28	84	60
31,5	16 18 20 22	90	40 50	28 36	84 104	60 76
63	20 18 25 22	100	50 60	36 42	104 124	76 83
125	25 28 30, 35, 36, 36	112	60 80	42 58	124 170	83 120
250	32, 35, 36 40 45	140	80 110	58 82	170 230	120 170
400	35 36 40, 45, 50	150	80 110	58 82	170 230	120 170
630	45, 50, 55 60	170	110 140	82 105	230 290	170 220
1000	50, 55 60, 63 70	180	110 140	82 105	230 290	170 220
1600	60, 63, 65, 70 75, 80	190	110 140	82 105	230 280	170 220
2500	70, 75 80, 85, 90, 95 100	224	140 130	105 130	290 350	220 270

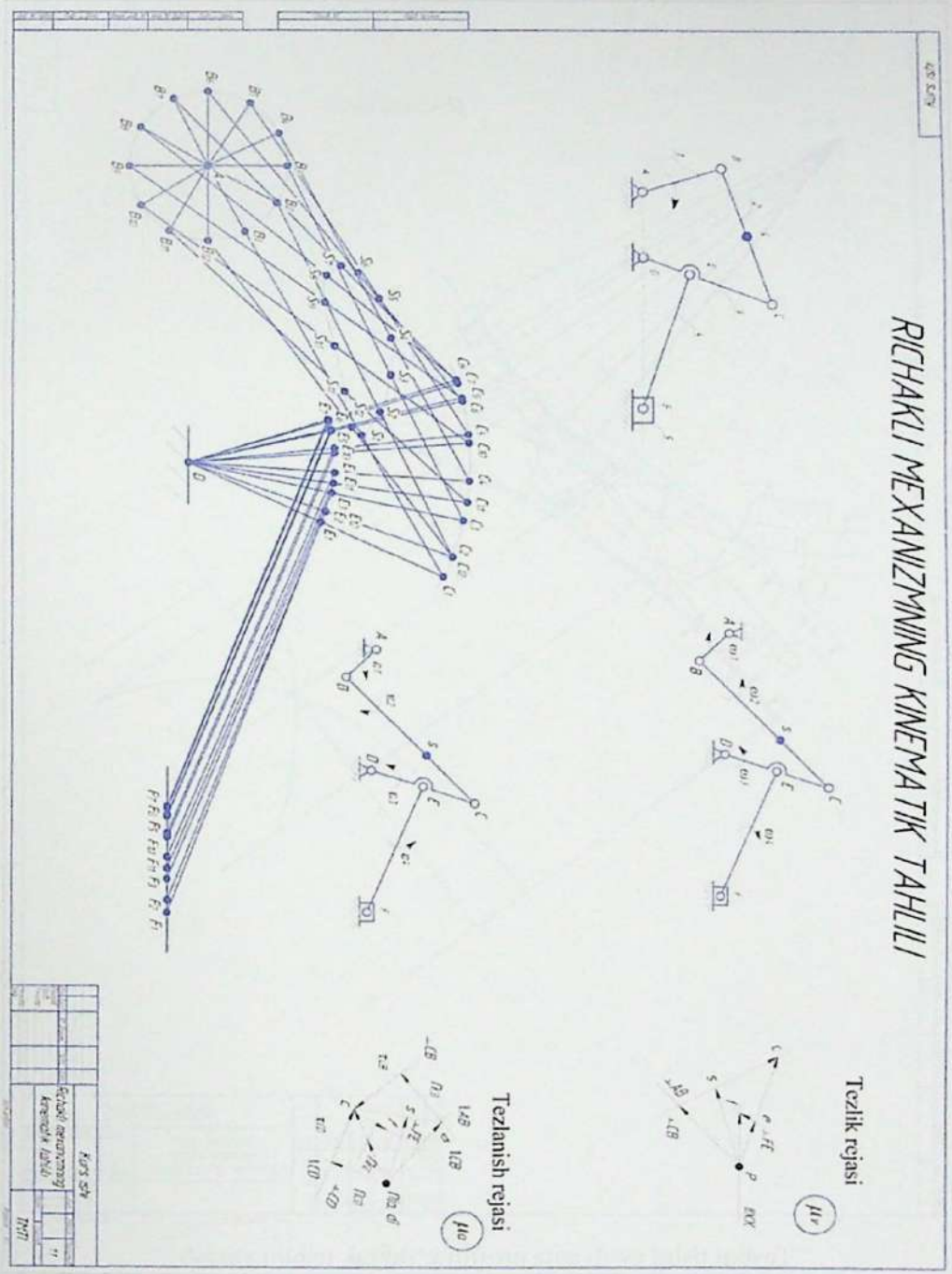
6.1 – jadval

Vtulkali muftaning o'lchamlari, mm

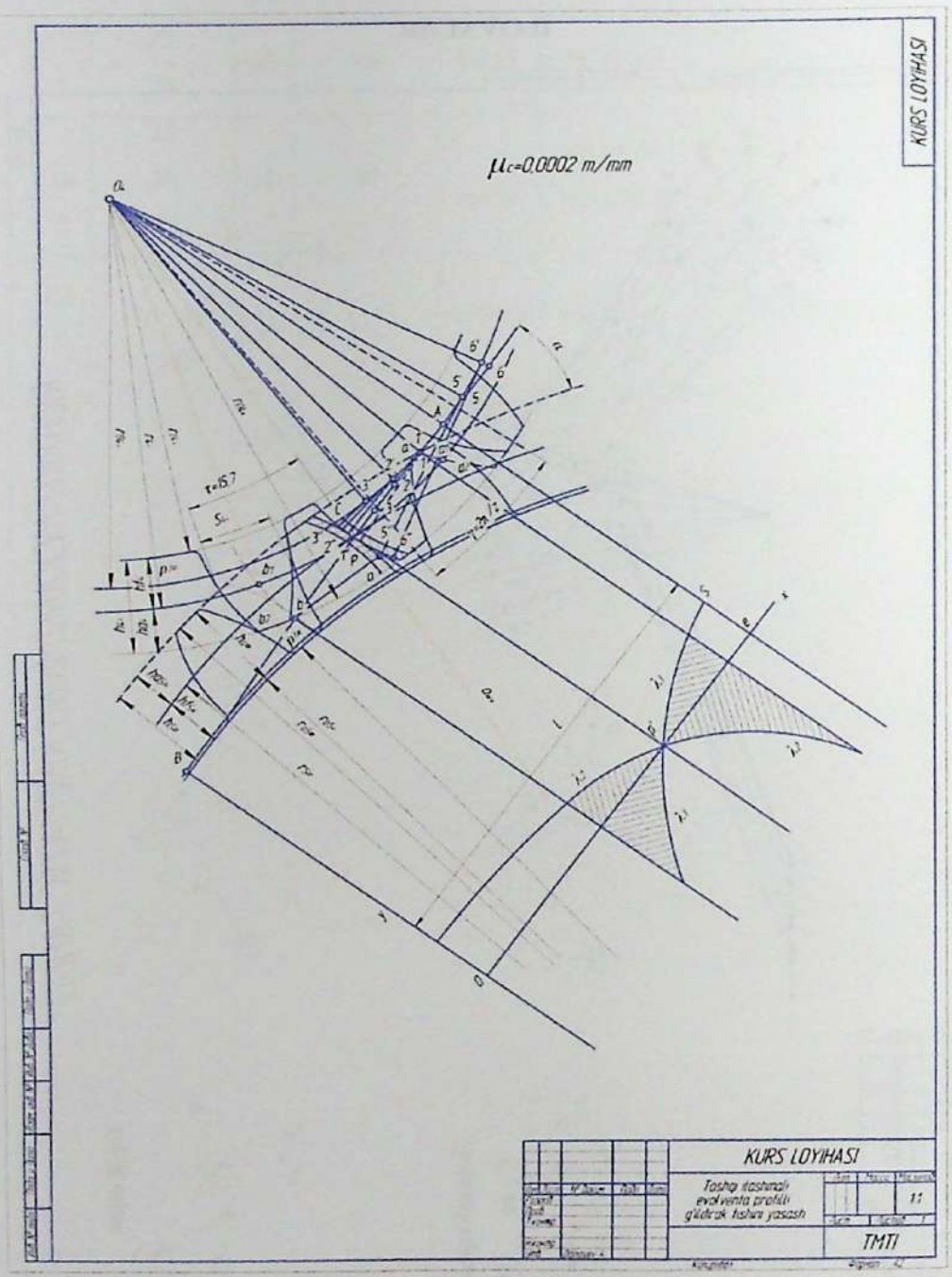


Har – xil variantlar uchun [T]		Har – xil variantlar uchun, mm		Har – xil variantlar uchun, mm	Har – xil variantlarda mahkamlash uchun ishlatiladigan elementlar			
1	2	1 – 2		1 – 2	1 shtif bilan	2 shponka bilan		2 vint bilan
16	–	14 – 16	28	45	4×30	–	4×7, 5	M6×8.66
31,5	–	18÷20	32	55	5×36	–	5×7, 5	
50	71	20; 22; 24	38	65	6×40	6×6×25	5×9	

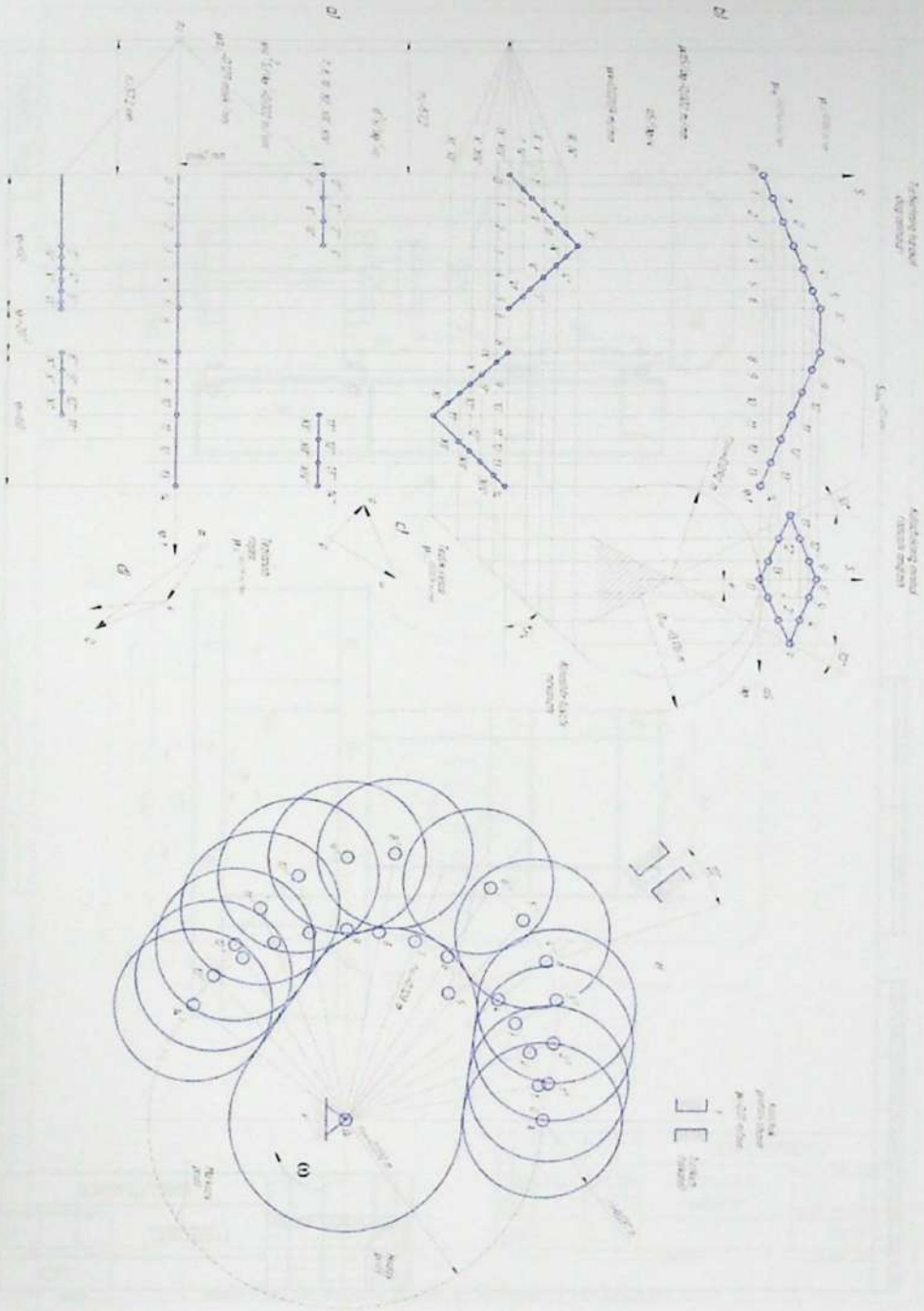
90	125	25 28	42	75	8×45	8×7×28	6×9 6×10	
125	180	23 30 32	48	90	8×50	8×7×36 10×8×36	8×10 8×11	
200	280	32 35; 36 (38)	55	105	10×60	10×8×45	8×11 10×13	M6×10.66
280	400	(38) 40 (42)	60	120	10×65 10×65	10×8×50 12×8×50	10×13	
400	560	(42) 45; (48)	70	140	12×80	12×8×63 14×9×63		M8×12.66
560	800	(48); 50 (53)	80	150	12×90	14×9×67 16×10×63		M10×16.66
800	1120	55 60	90	170	16×100	16×10×70 18×11×70		



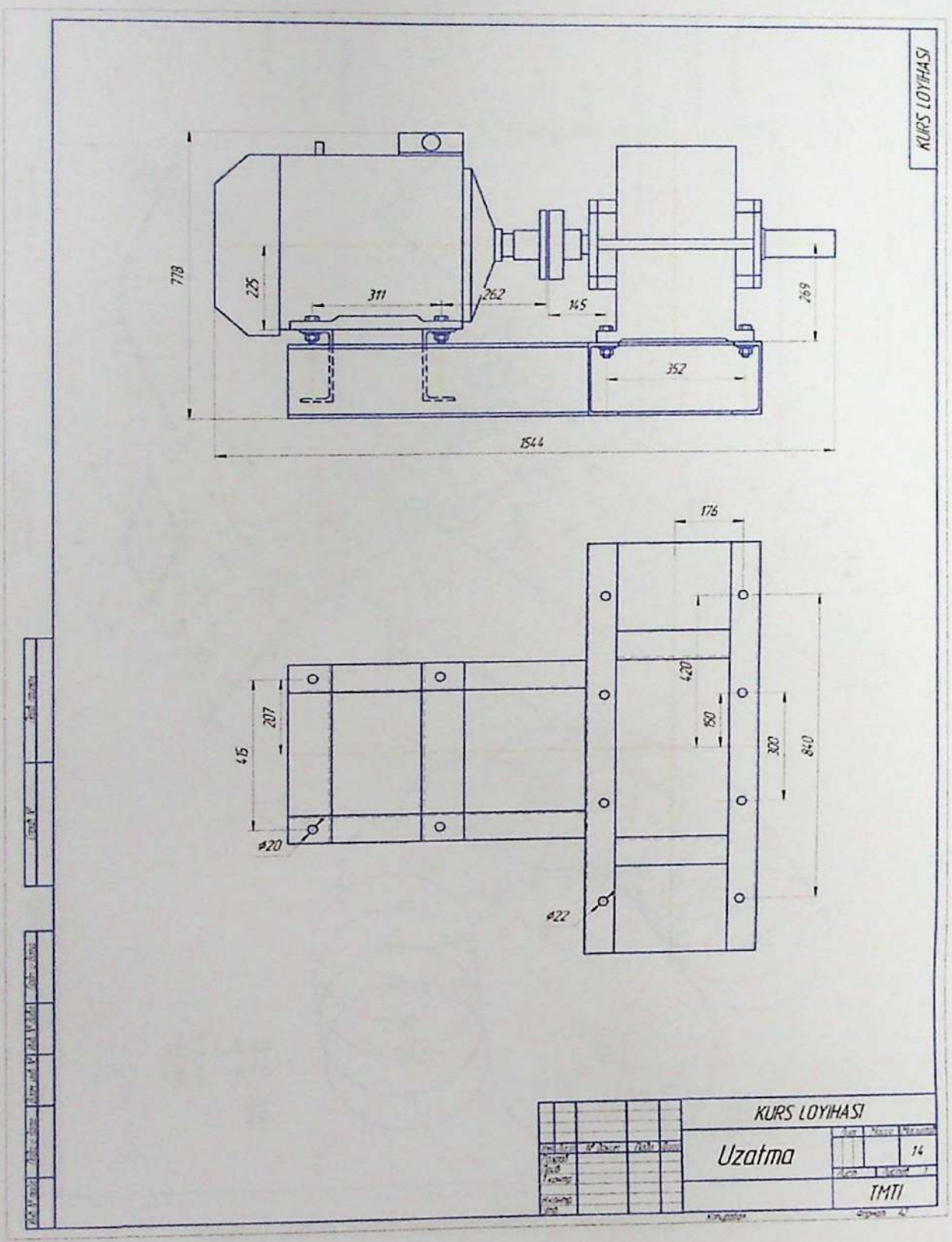
Richakli mexanizmning kinematik tahlil



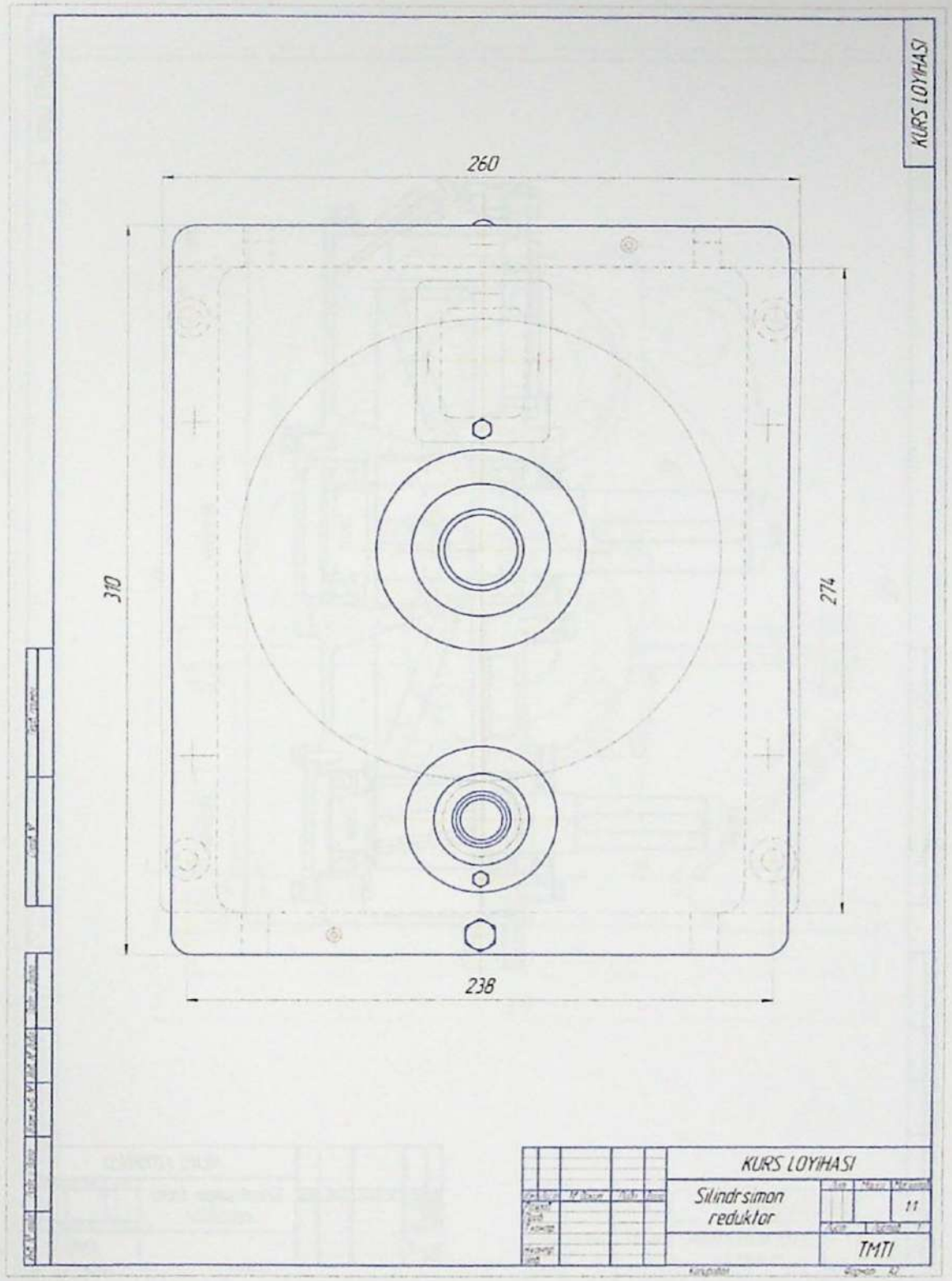
Tashqi tishli evolventa profilli g'ildirak tishini yasash



Kulochokli mexanizm tahlili



Uzatma loyihasi



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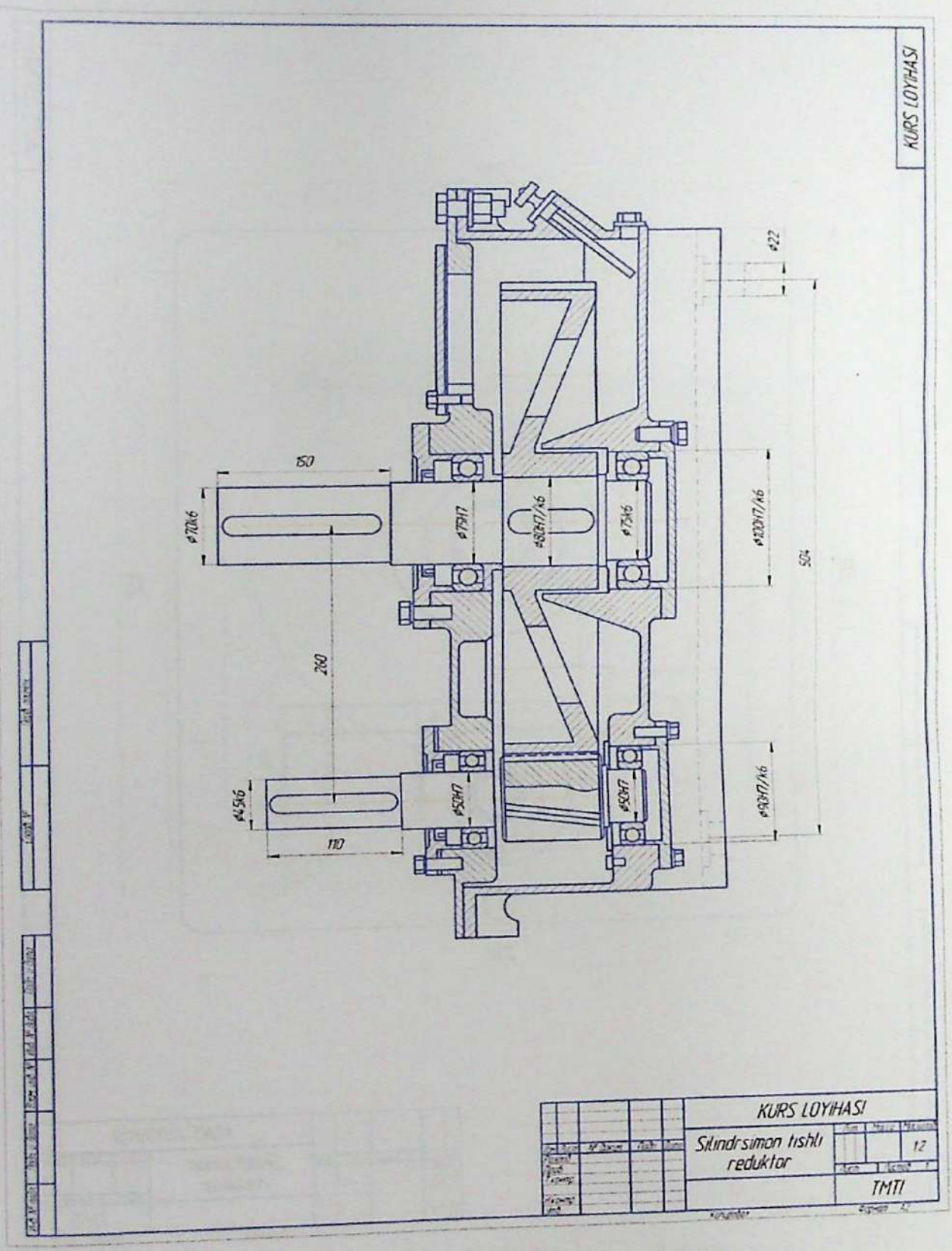

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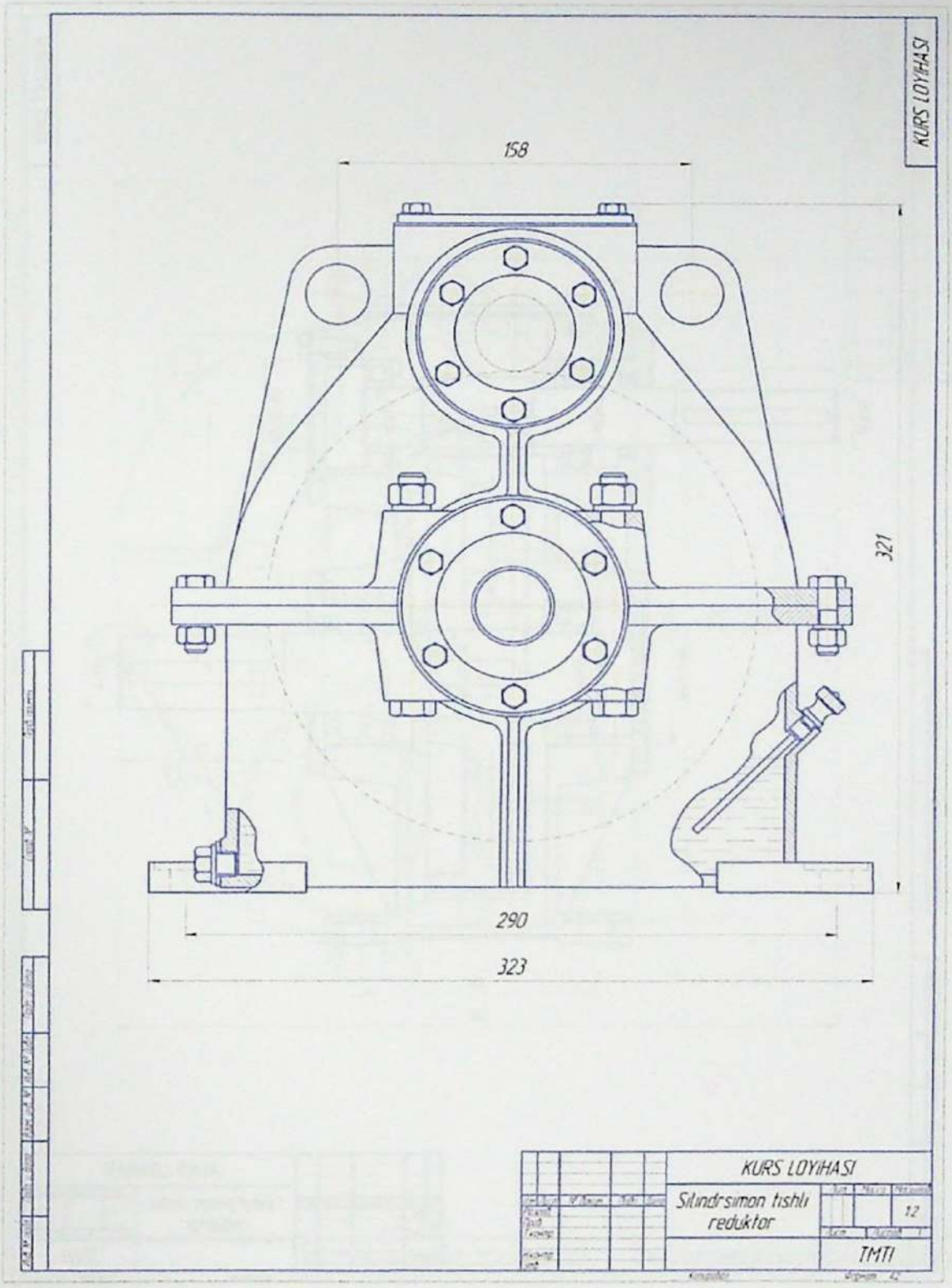

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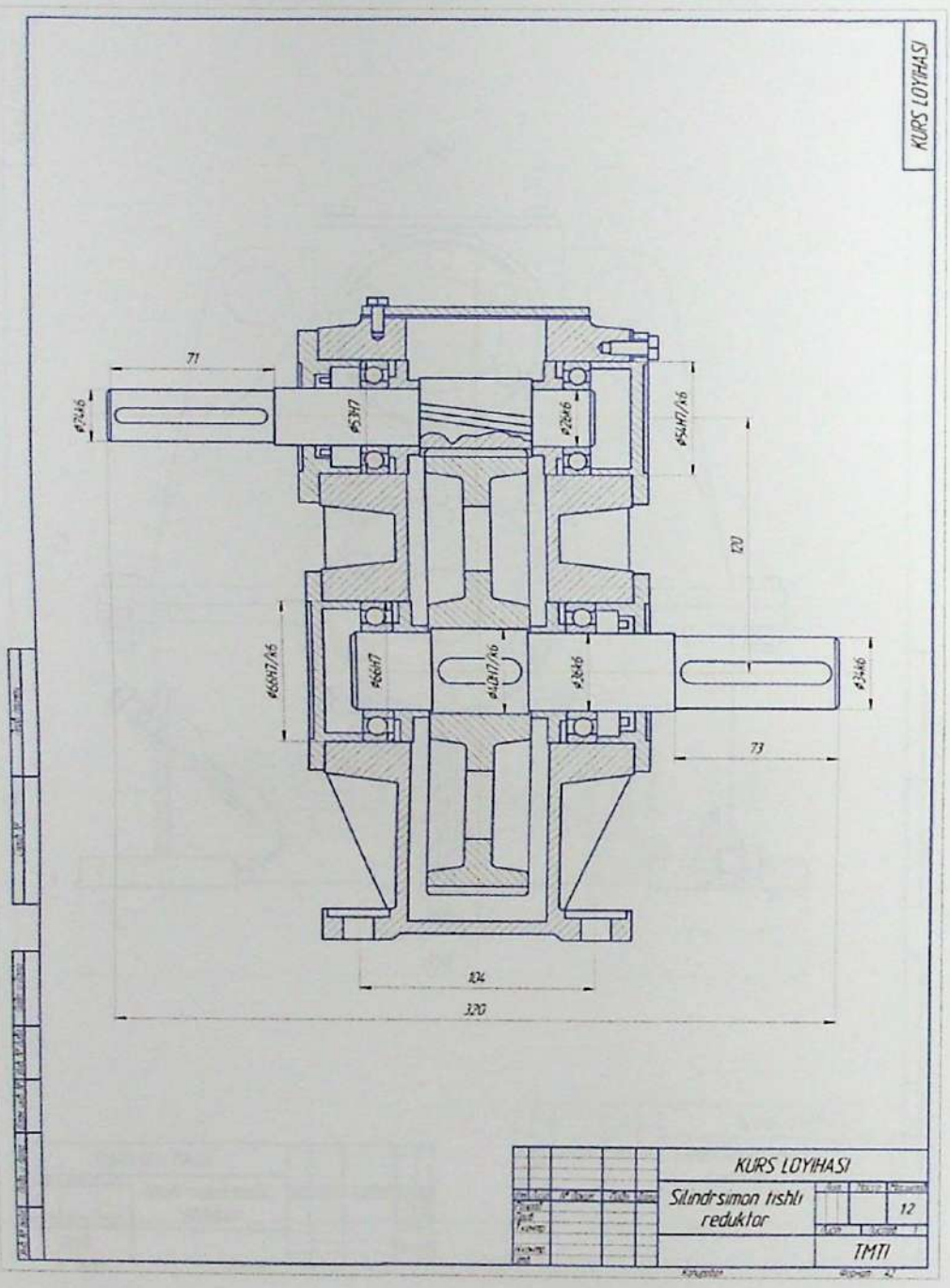

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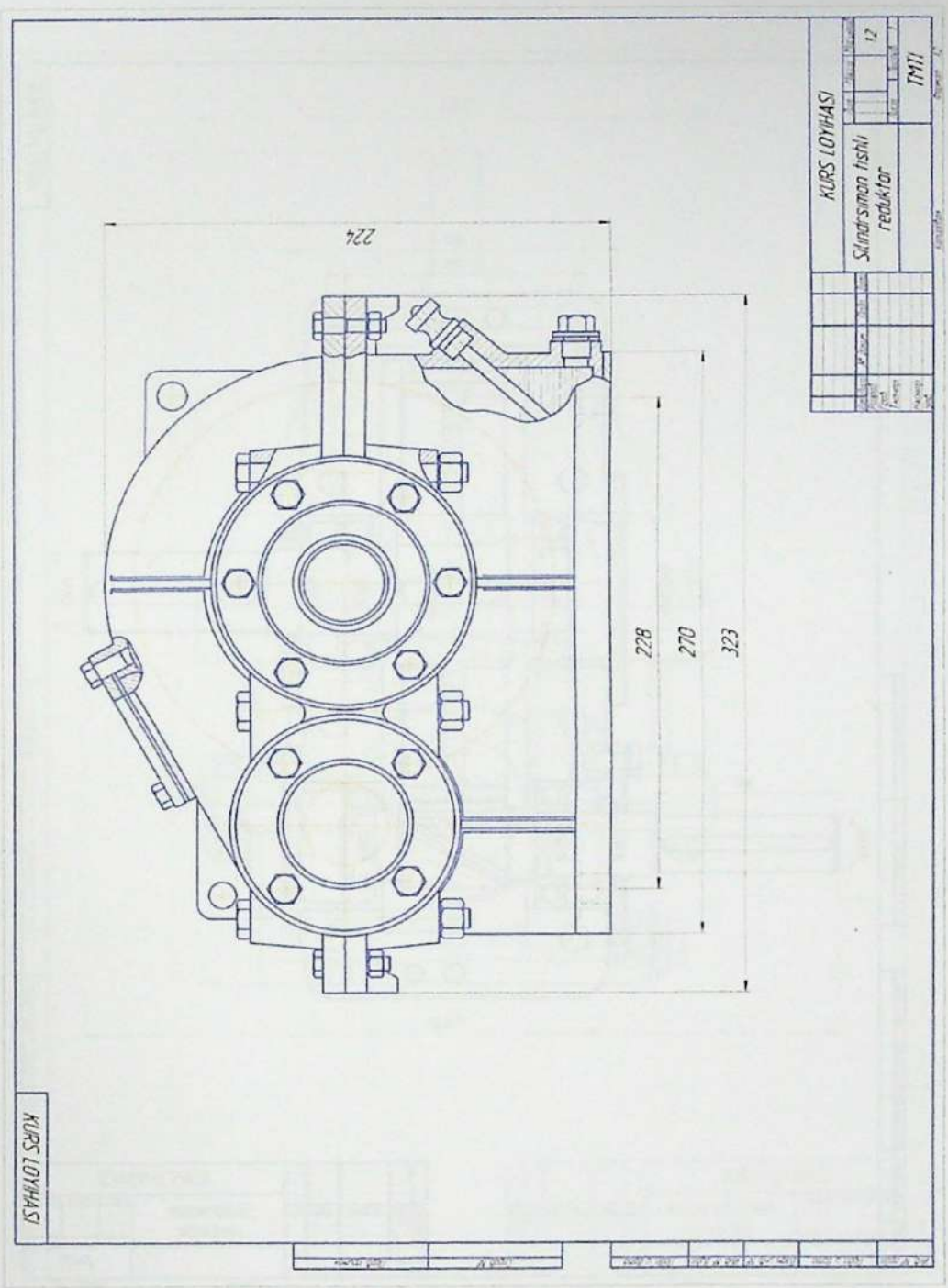

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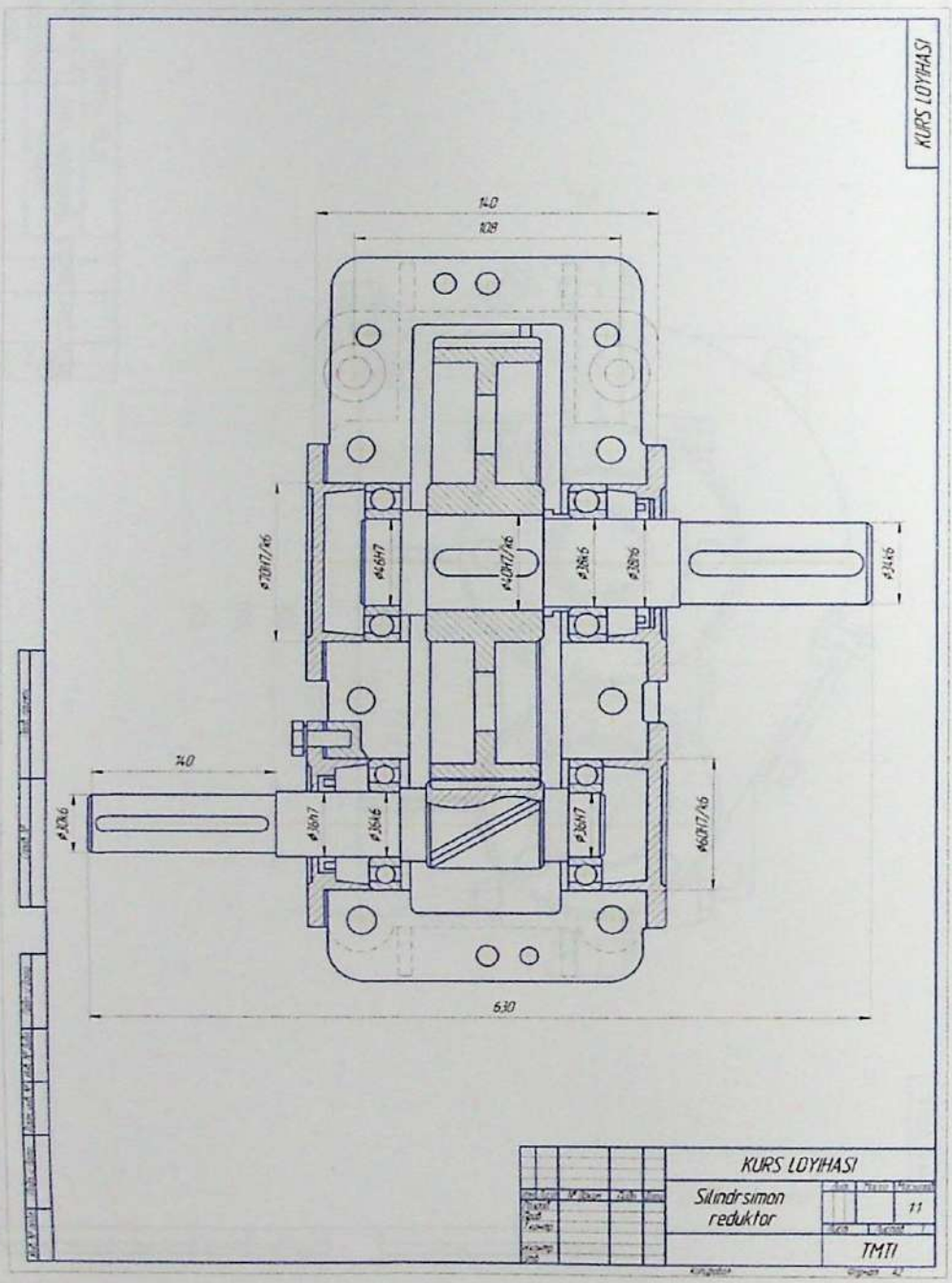

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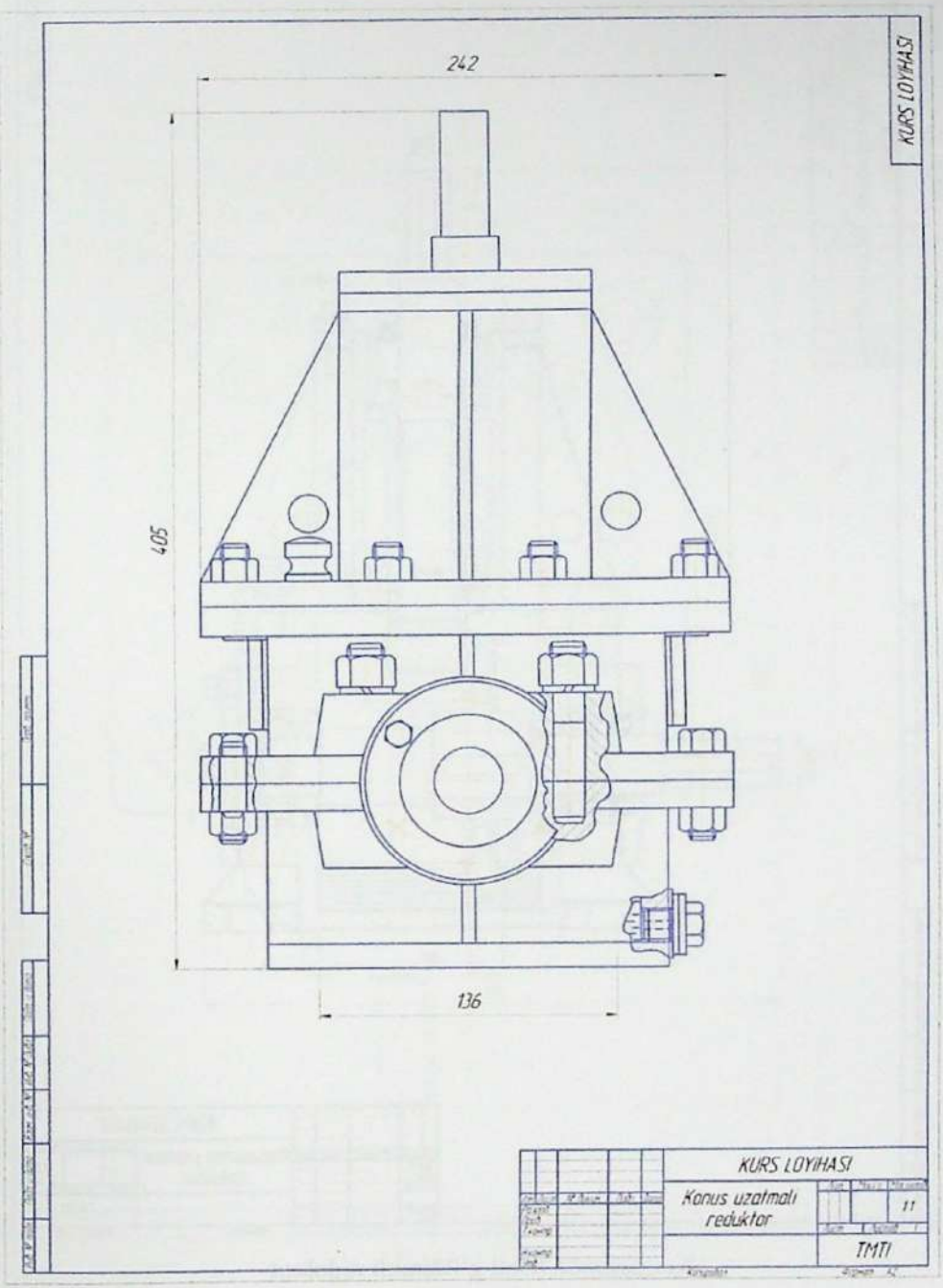

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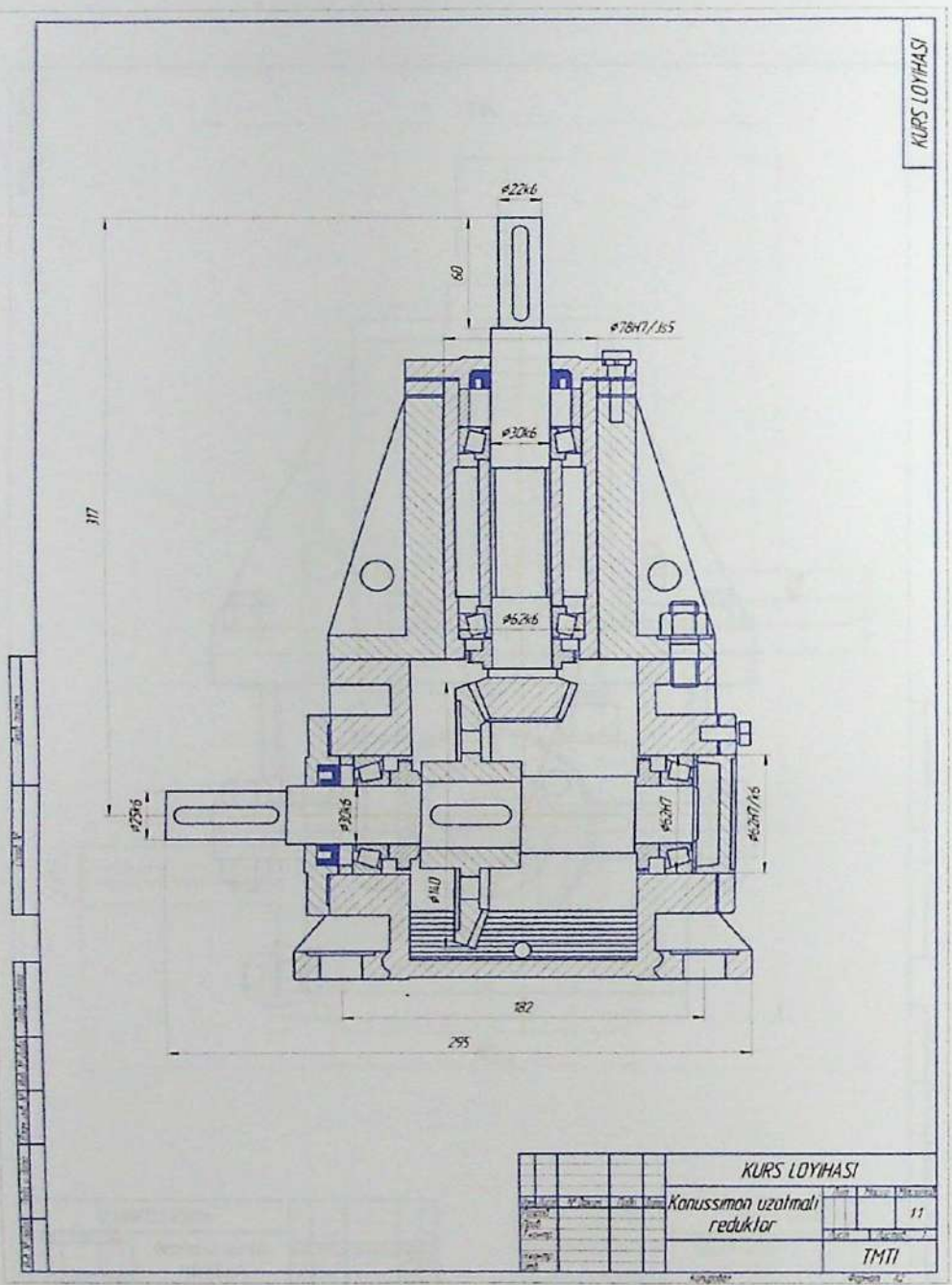

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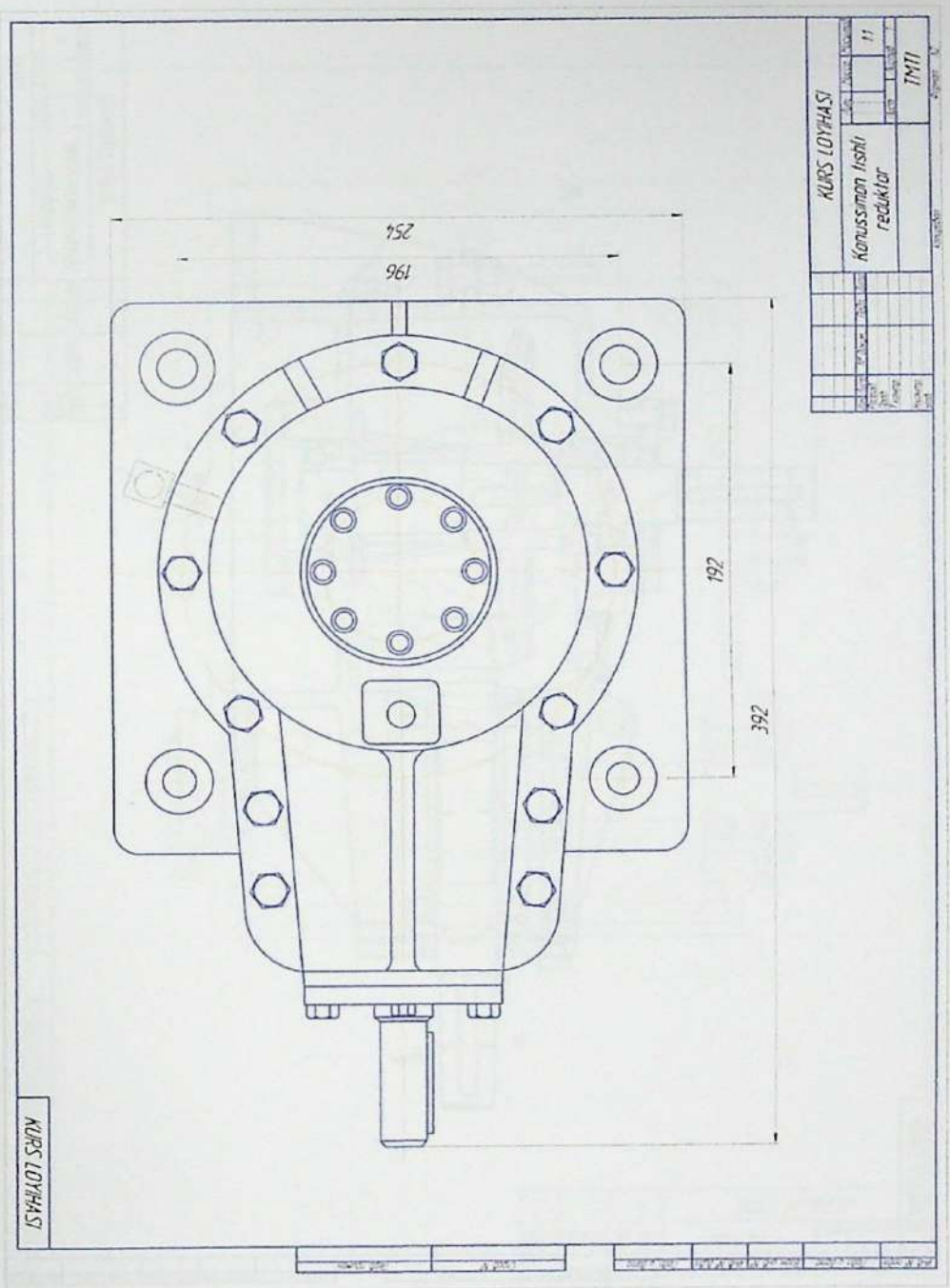

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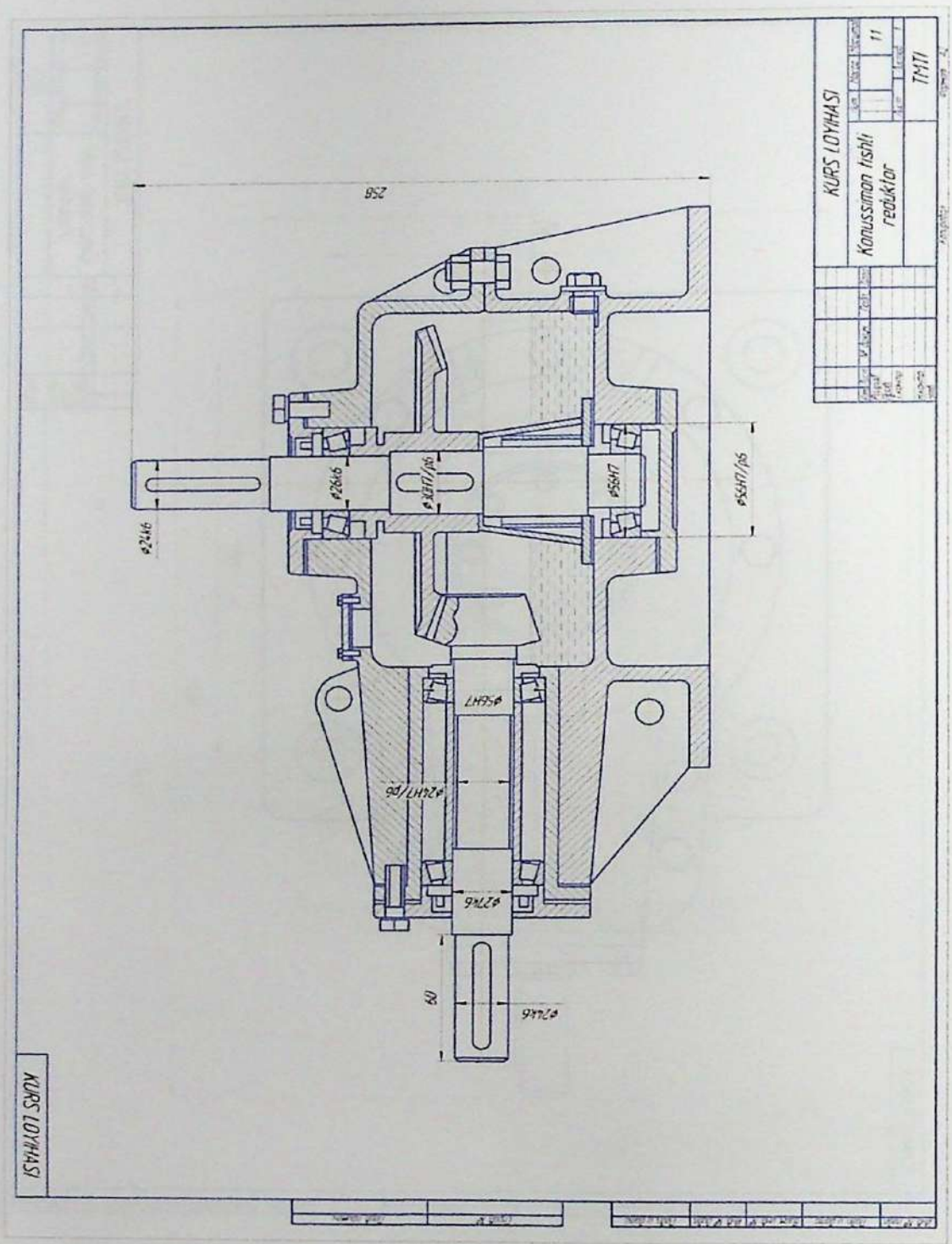

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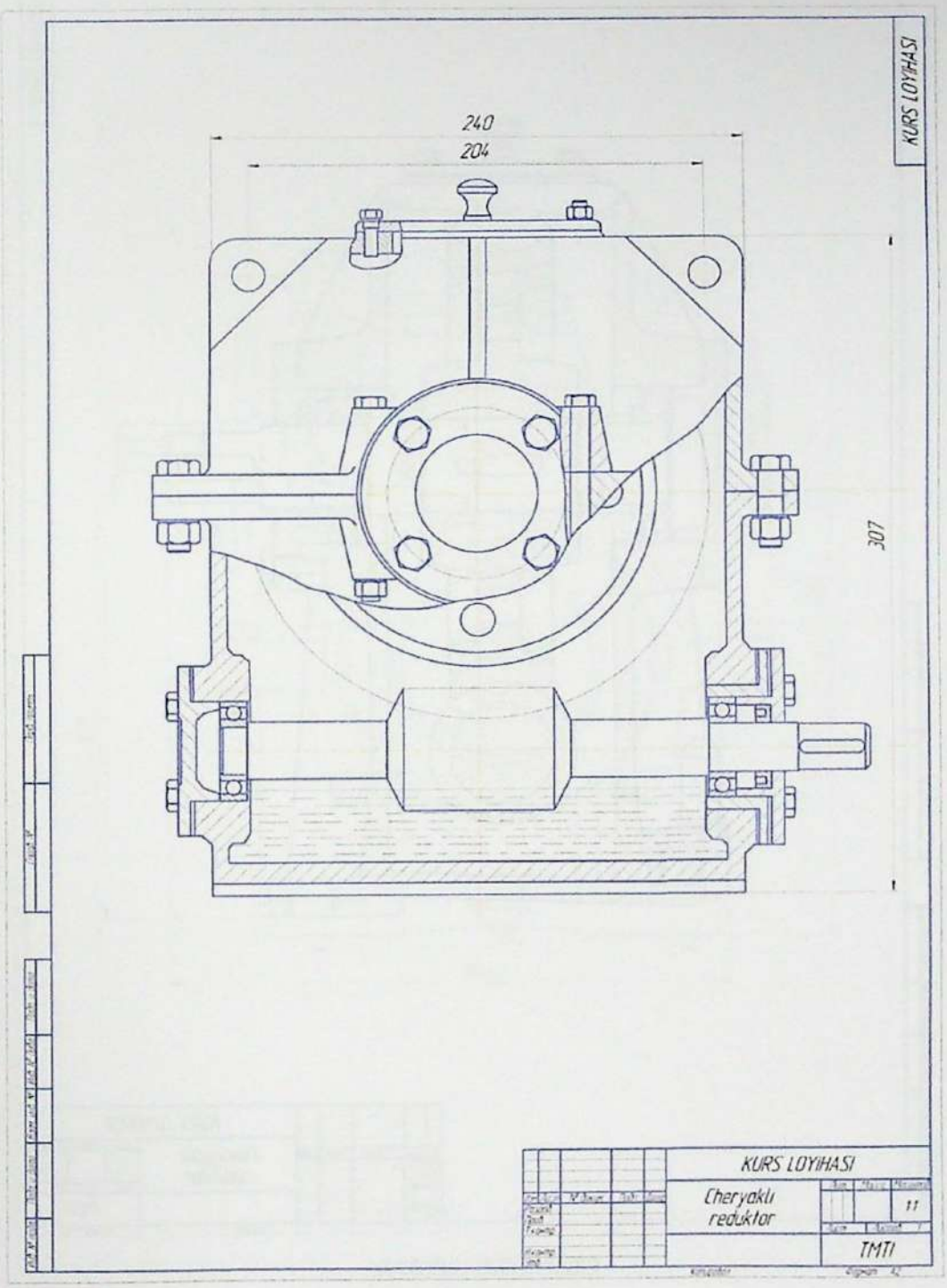

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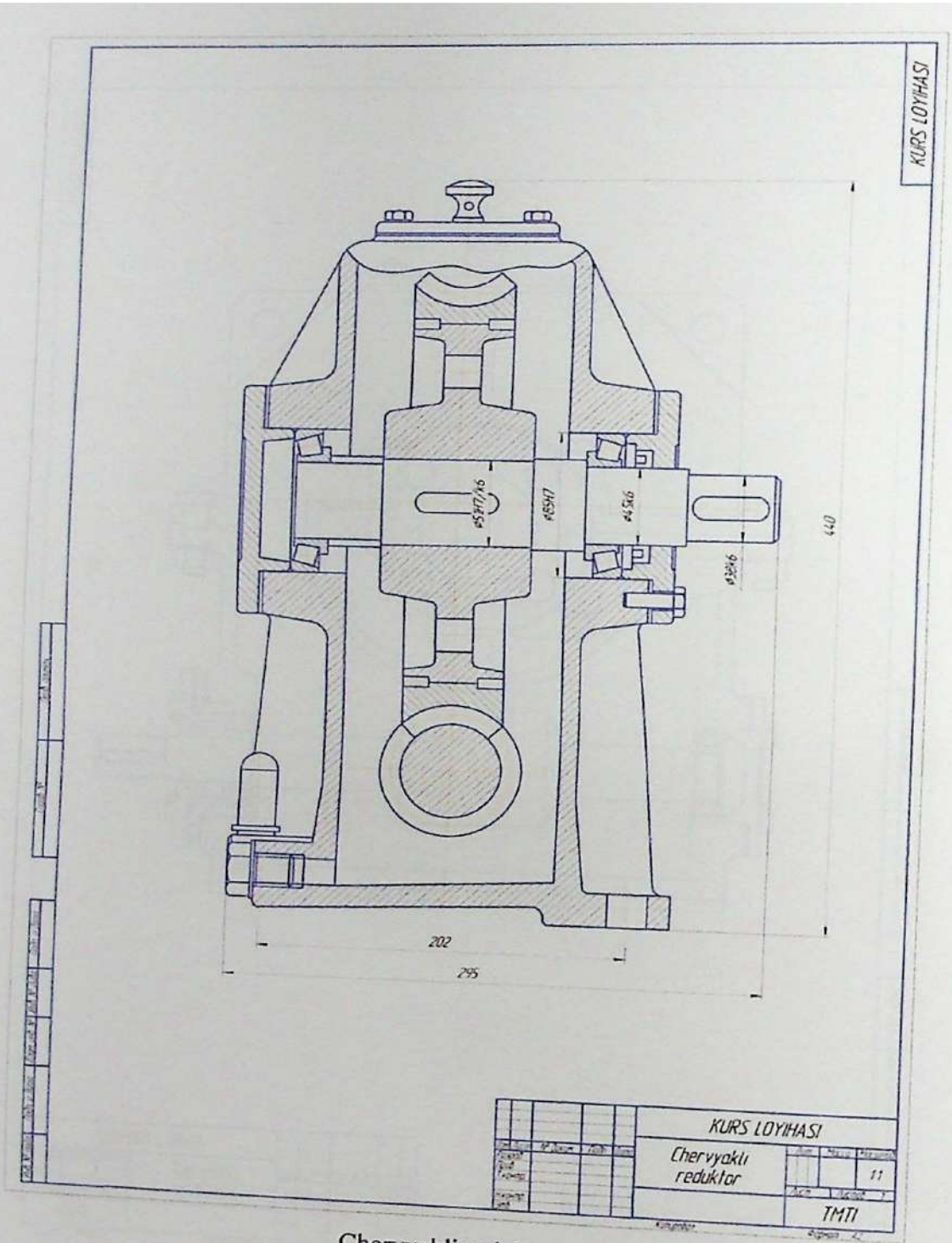

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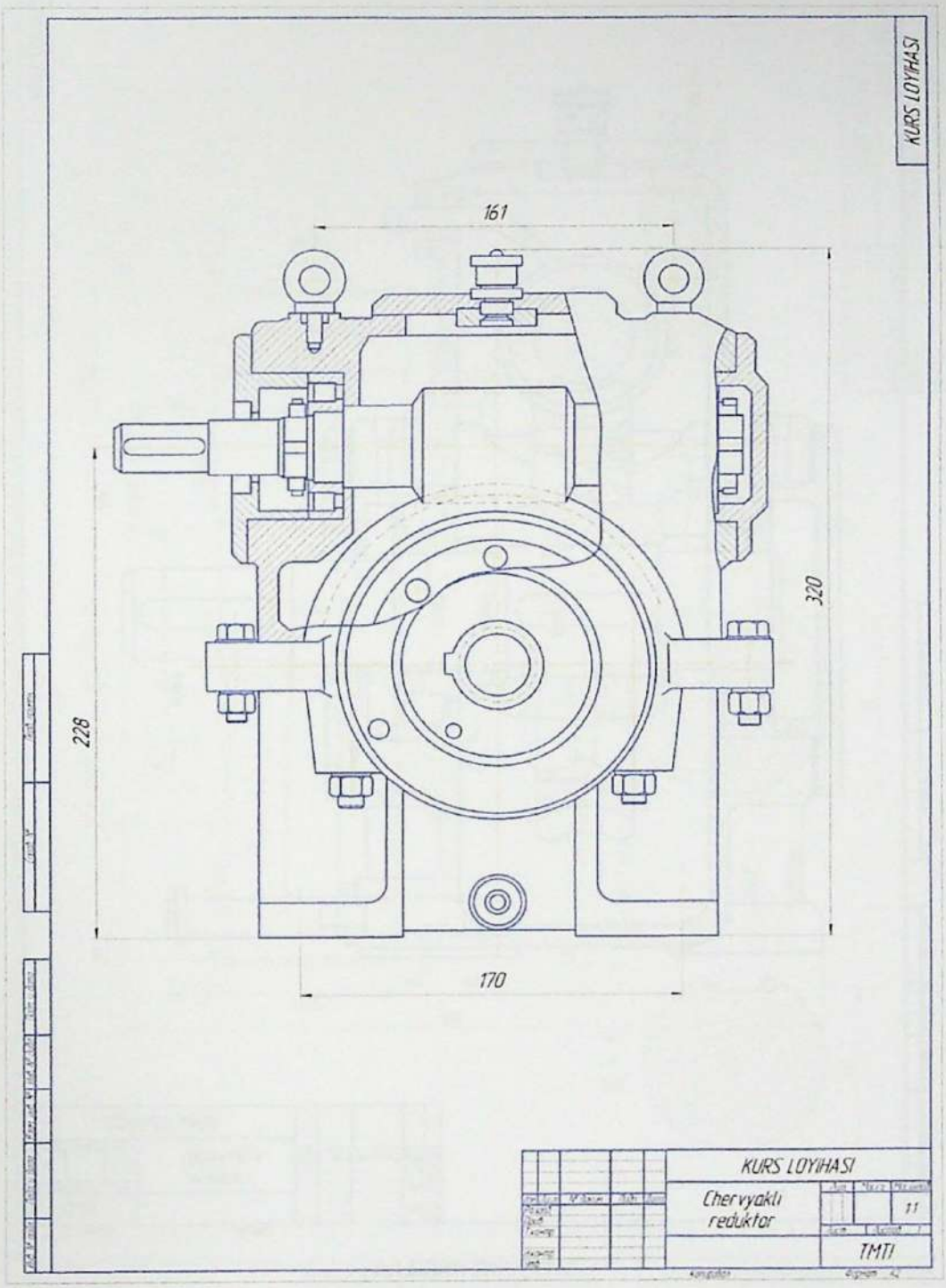

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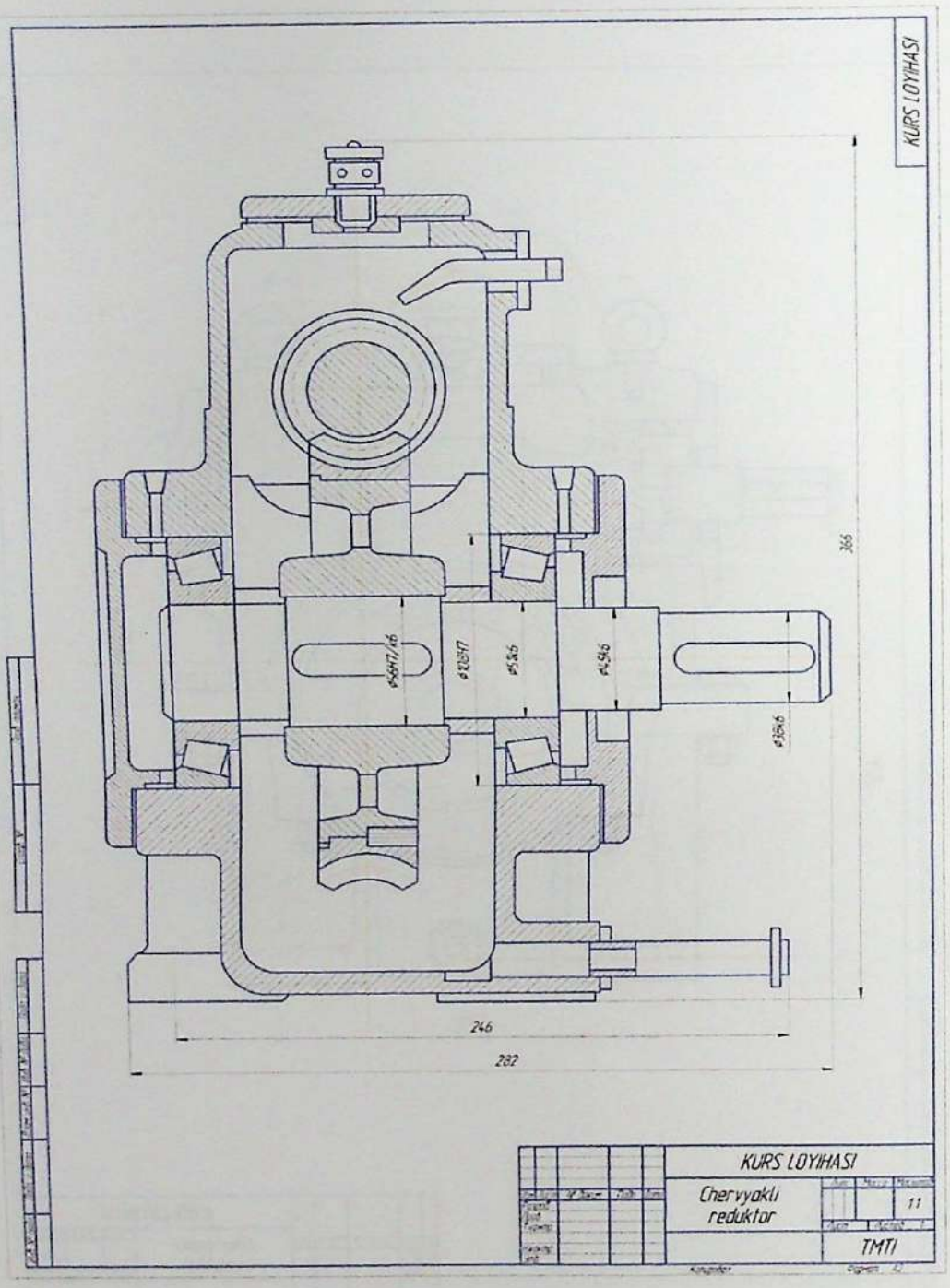

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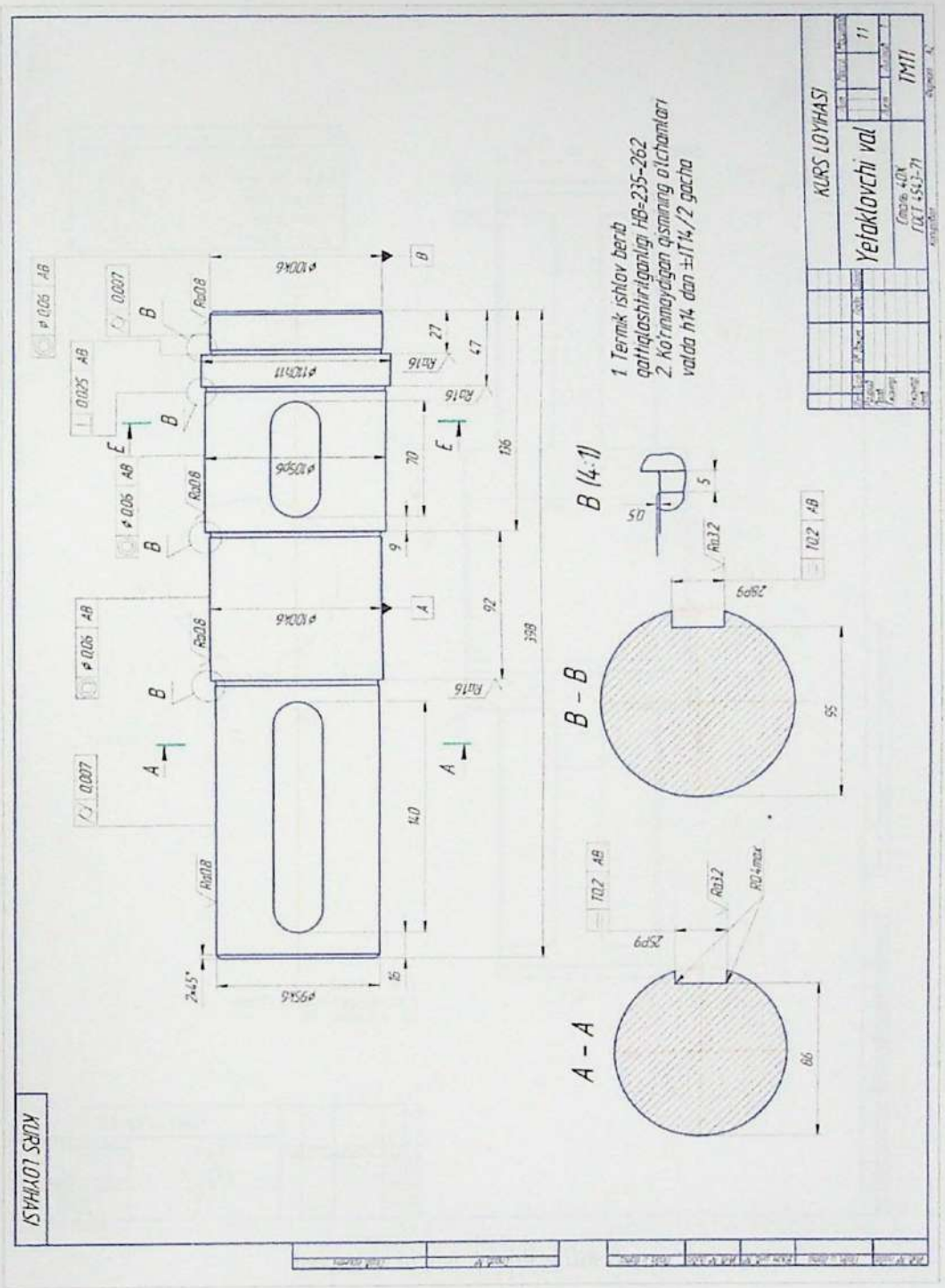

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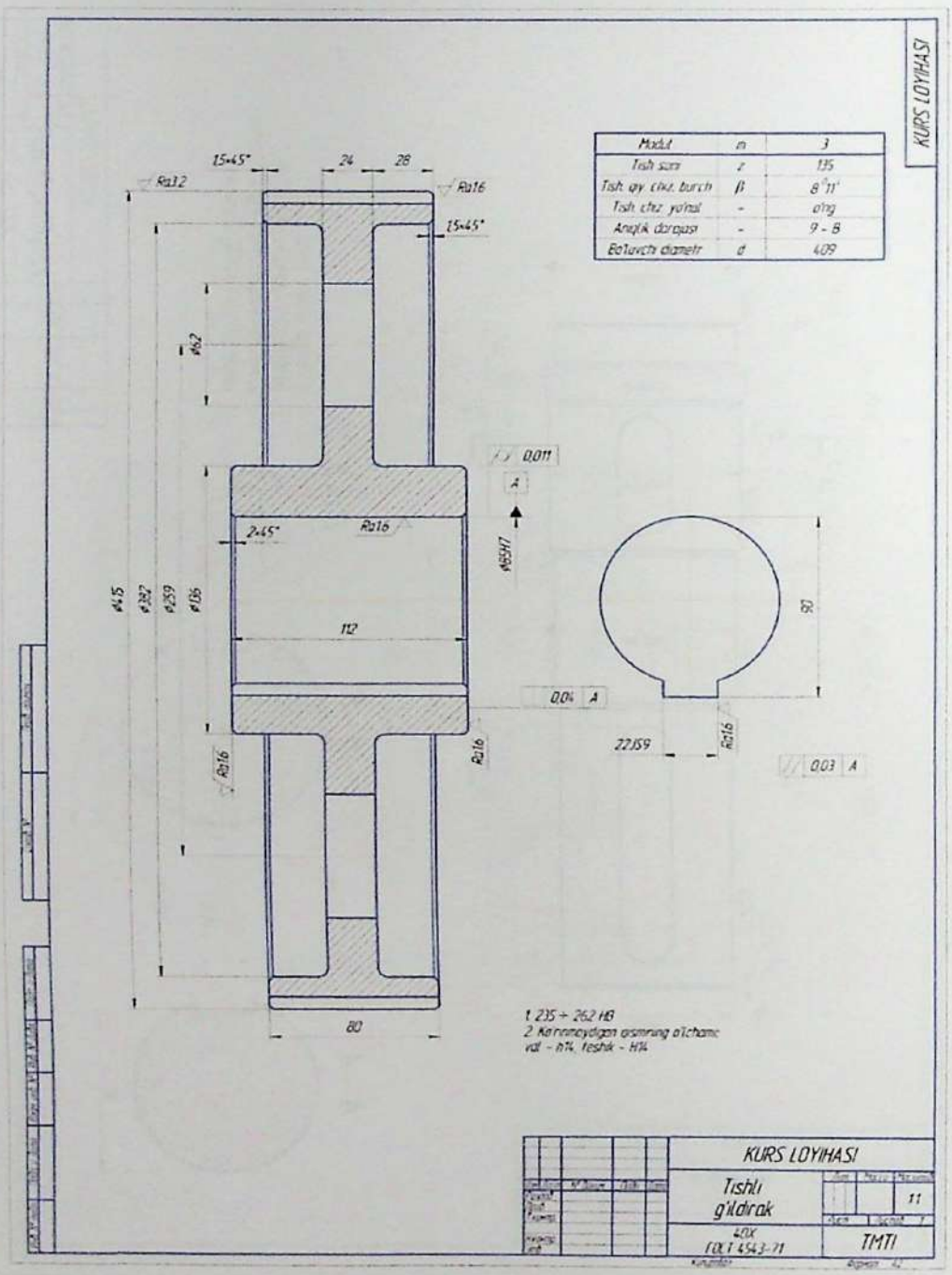

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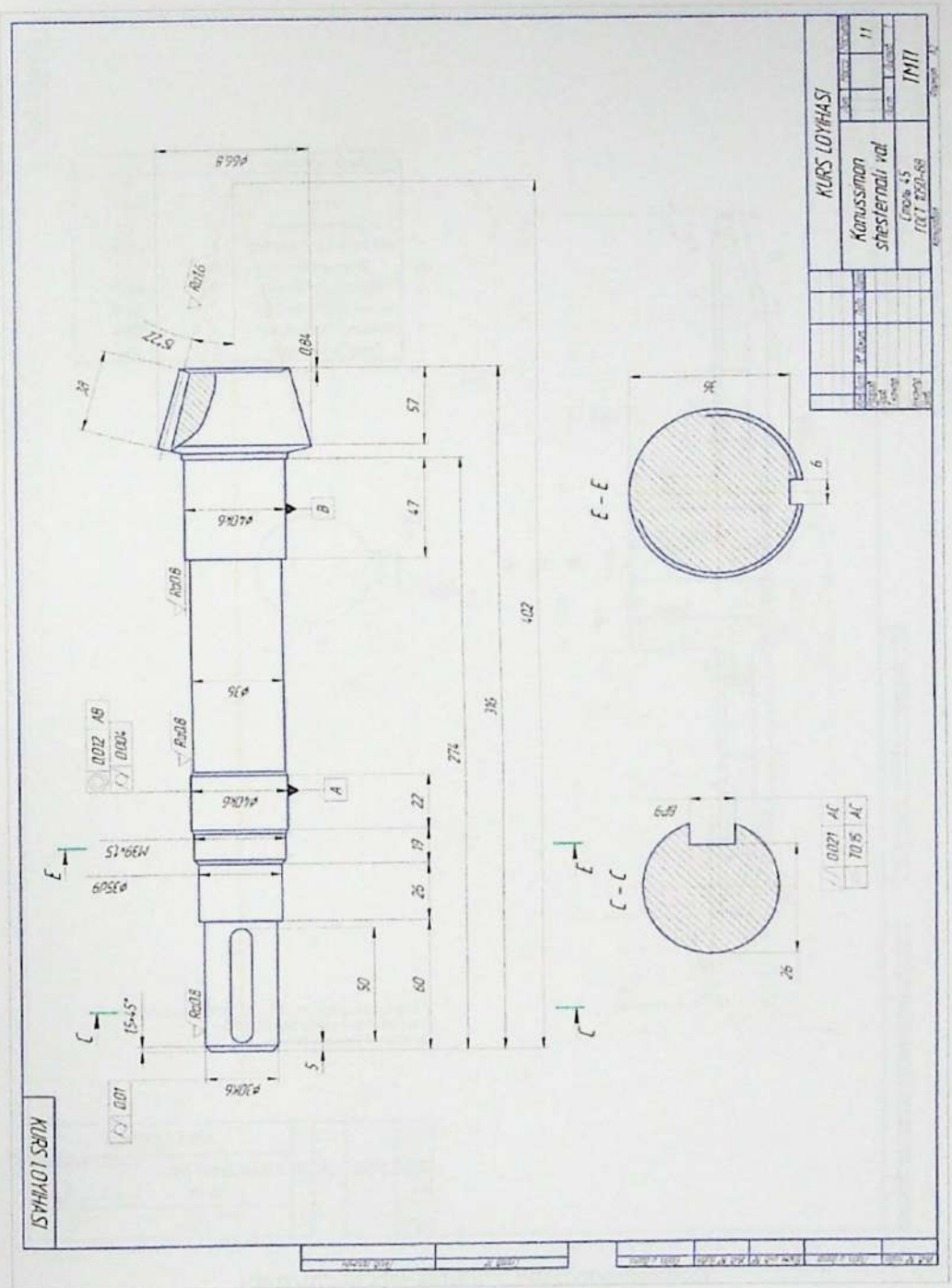

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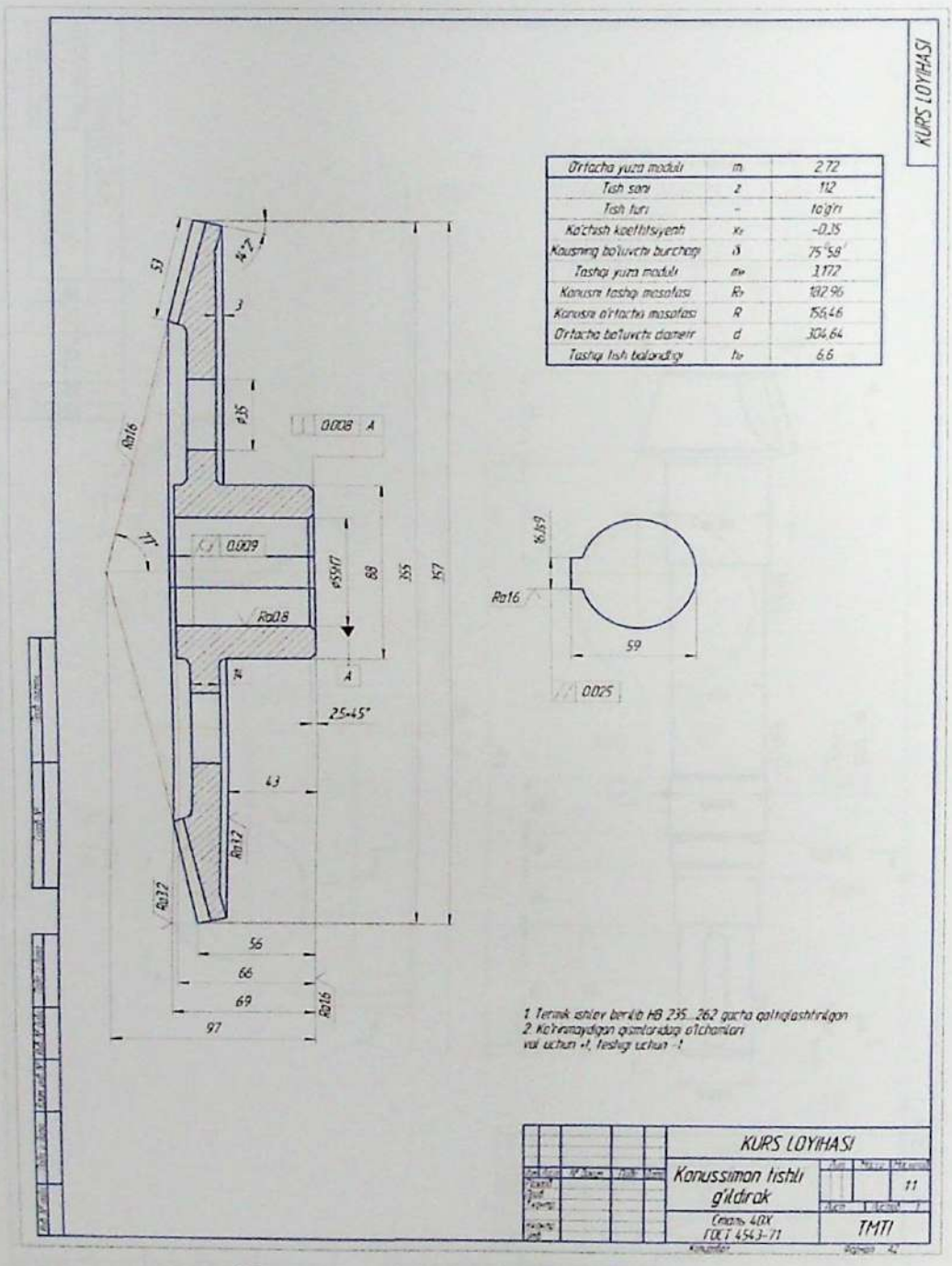

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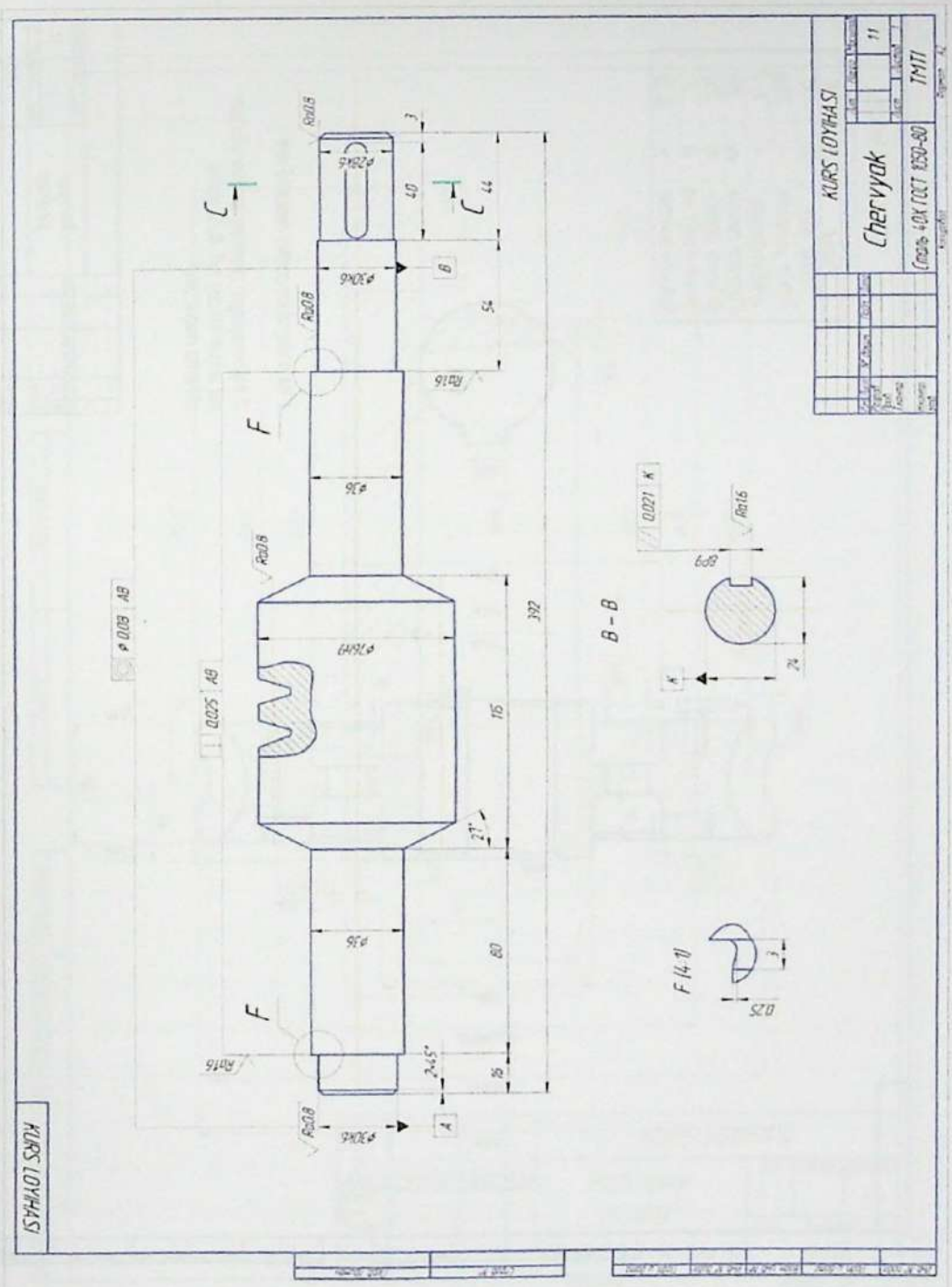

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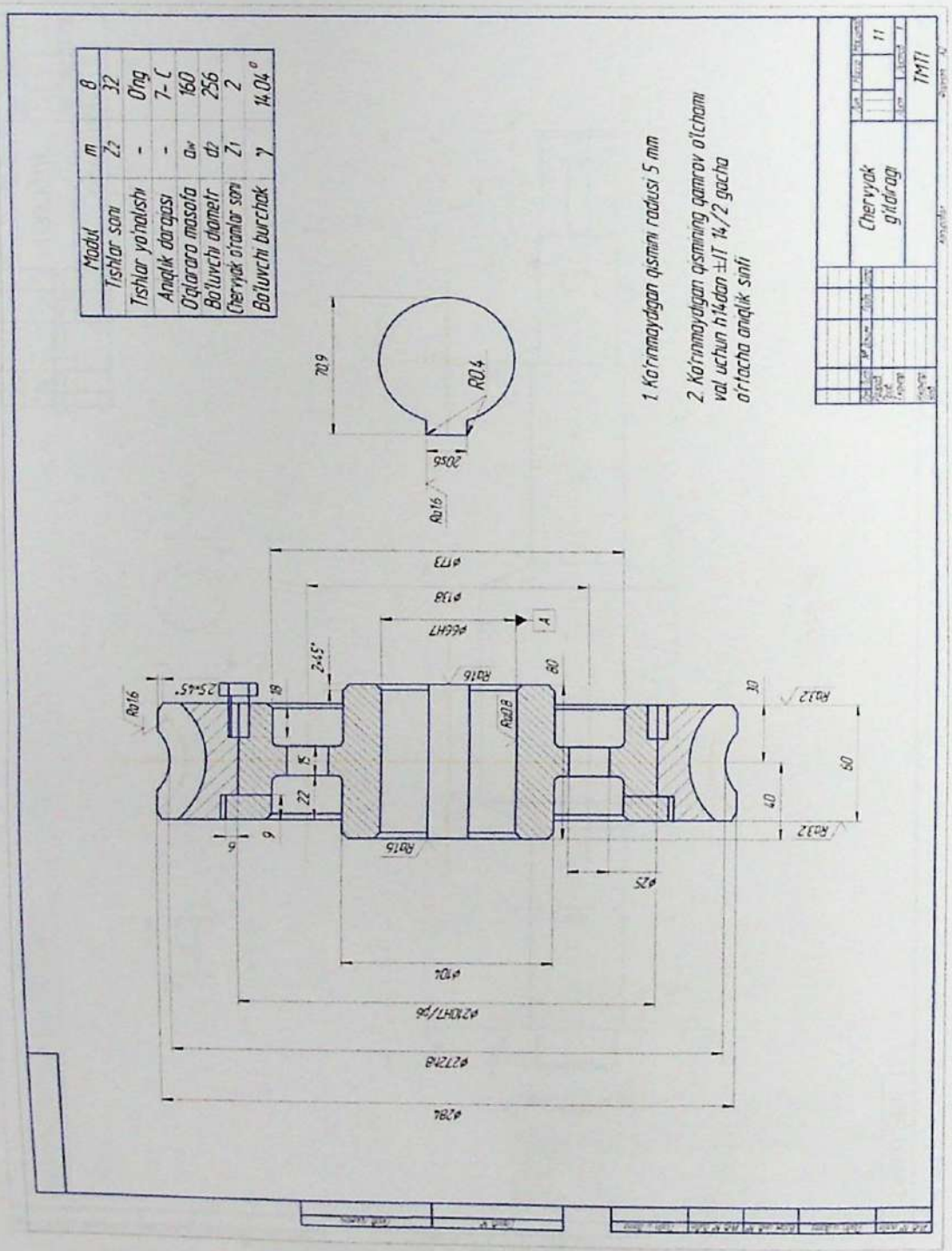

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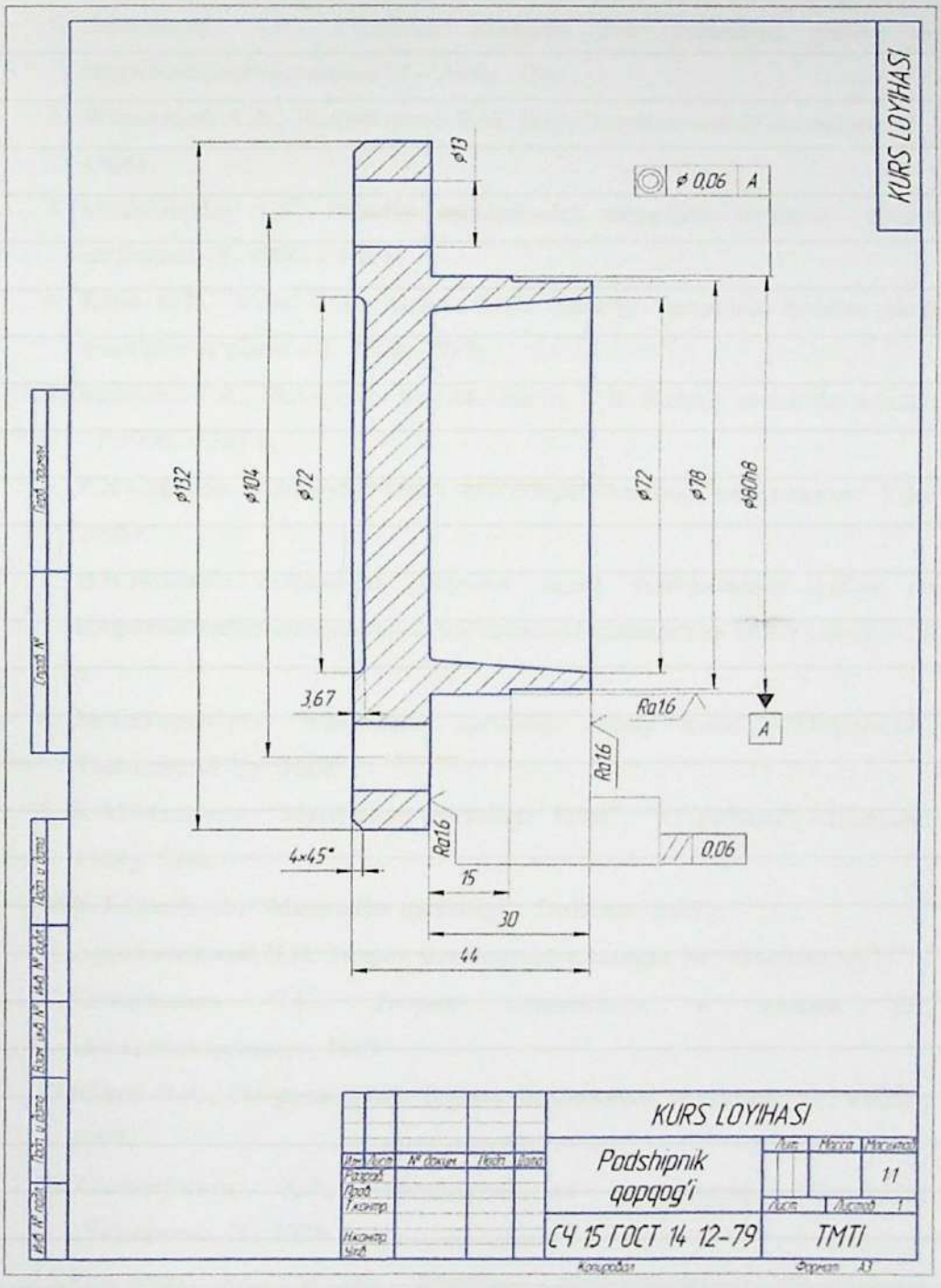

Podshipnik qopqog'i

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MUNDARIJA

M.R. KARIMOV, O.M.ALIMNAZAROV

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O'zbekiston Respublikasi Oliy ta'lim, fan va innovatsiyalar vazirligi tomonidan o'quv qo'llanma sifatida tavsiya etilgan

Muharrir: S. T. Xashimov
Musahhih: H. Zakirova
Sahifalovchi: A. Hidoyatov
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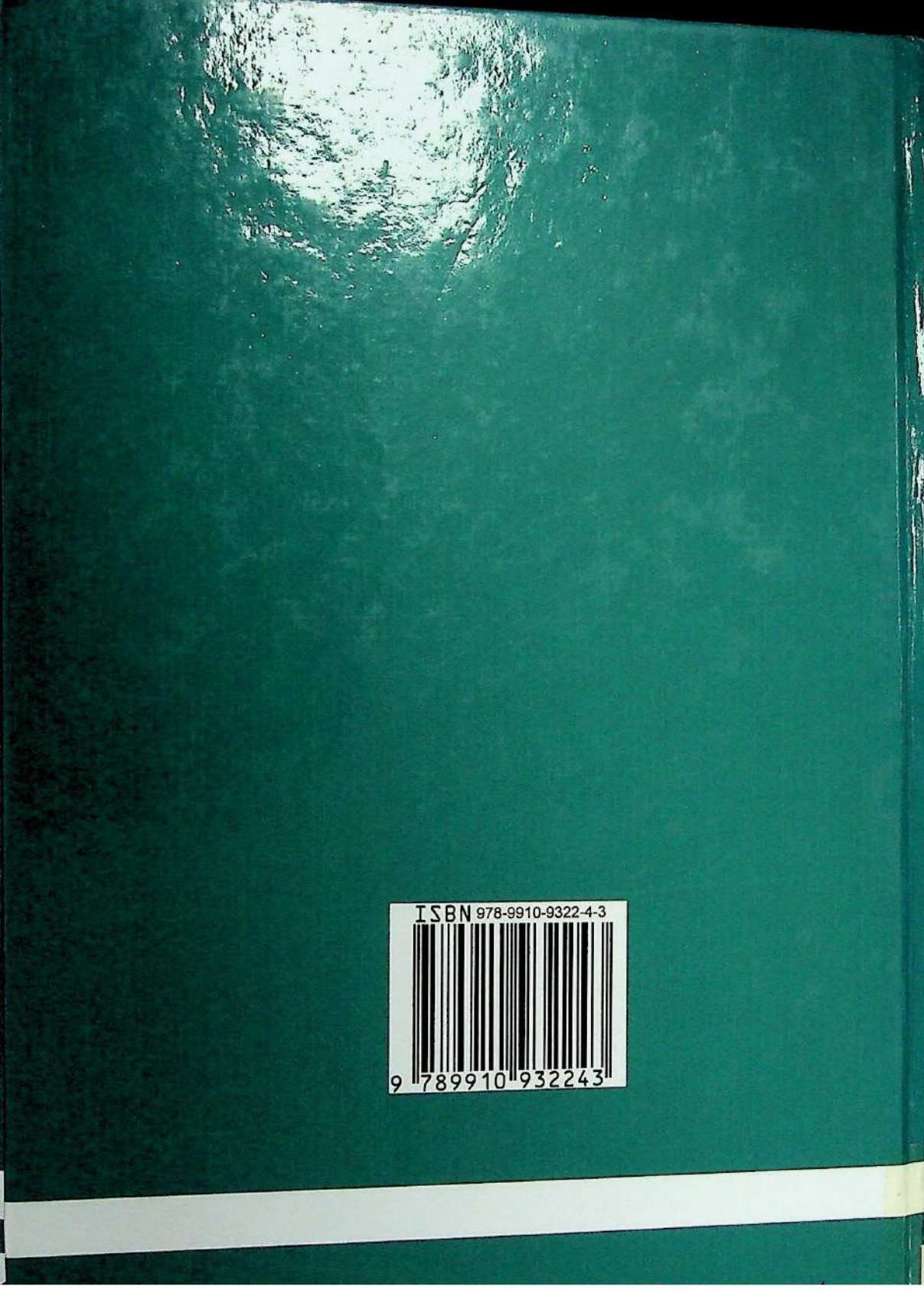
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