

**O'ZBEKISTON RESPUBLIKASI OLIY VA O'RTA MAXSUS  
TA'LIM VAZIRLIGI**

**BUXORO MUHANDISLIK - TEXNOLOGIYA INSTITUTI**

**«TEXNOLOGIYALAR VA JIHOZLAR»  
kafedrası**

**«MASHINA DETALLARI» fanidan  
KURS LOYIHASINI BAJARISH BO'YICHA**

# **USLUBIY KO`RSATMA**

**5321500- Texnologiyalar va jihozlar (mashinasozlik) hamda 5111000 – Kasb ta'limi (5320200 – Mashinasozlik texnologiyasi, mashinasozlik ishlab chiqarishini jihozlash va avtomatlashtirish) bakalavriat yo'nalishi bo'yicha ta'lim olayotgan talabalar uchun**

**Buxoro – 2016**

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Ushbu ko`rsatma «Texnologiyalar va jihozlar» kafedrası yig`ilishida 201\_\_ yil “  
” \_\_\_\_\_ № (bayonnoma) muhokama qilingan va tasdiqlash uchun tavsiya etilgan.

Uslubiy ko`rsatma Bux MTI ning uslubiy kengashida 201\_\_ yil  
“ ” \_\_\_\_\_ № (bayonnoma) tasdiqlangan va chop etishga tavsiya etilgan.

## **Kirish**

Yopiq korpus ichiga joylashgan, yetaklanuvchi val burchak tezligini kamaytirib uning aylantiruvchi momentini oshiradigan uzatma reduktor deb ataladi.

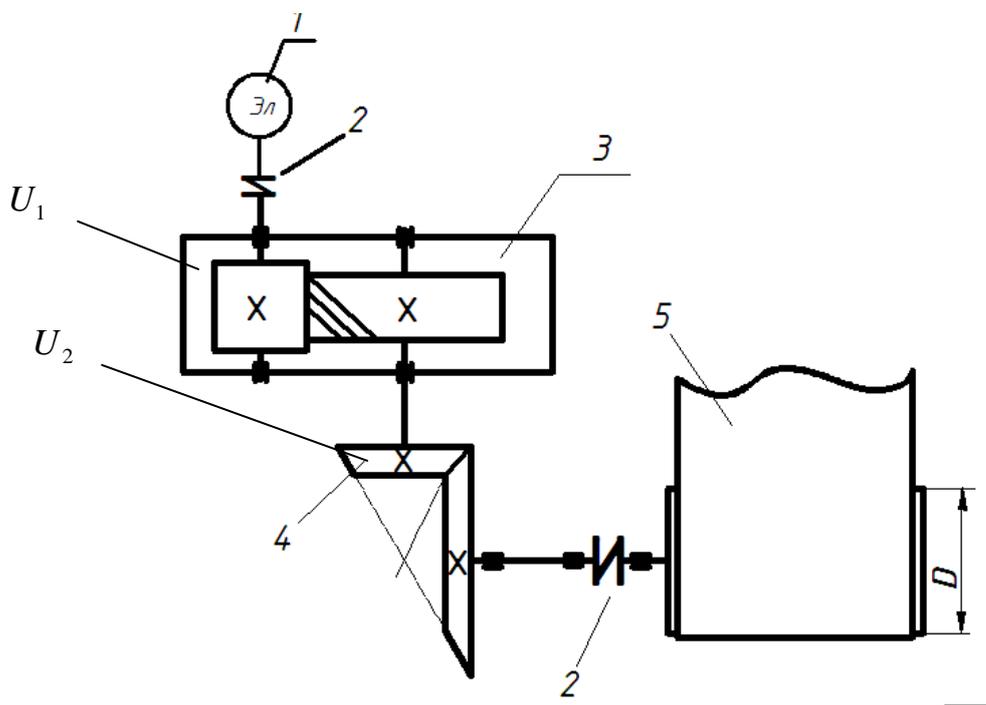
Uzatmani alohida yopiq korpus ichiga joylashtirish yig'ish aniqligini oshiradi hamda uni yaxshi moylanishini, FIK oshishini, yeyilishini kamayishini taminlaydi, chang va namlikdan muxofaza qiladi.

Reduktor tugallangan mexanizm bo'lib, mashinalar yuritmalarining tartibiga kiradi. U dvigatel va mashina ishchi organlariga turli xil muftalar, ochiq uzatmalar yoki boshqa ajraluvchi qurilmalar yordamida ulanadi.

Reduktor korpusida vallarga qo'zg'almas qilib biriktirilgan tishli g'ildiraklar joylashtirilgan. Vallar esa korpusdagi maxsus o'rindiqlarda joylashtirilgan podshipniklarga tayanadi. Reduktorlarda asosan dumalash podshipniklari qo'llaniladi. Podshipnik o'rindiqlari podshipnik qopqoqlari bilan berkitiladi.

Sanoatda keng qo'llaniladigan silindrsimon g'ildirakli reduktorlar bir pog'onali, ikki pog'onali va uch pog'onali qilib yasaladi. Ularning asosiy parametrlari, masalan uzatish nisbati, o'qlararo masofasi, reduktor ostidan vallar o'qigacha bo'lgan masofa standart qiymatga ega bo'ladi. Reduktorlarning belgisiga (markasiga) asosan ularni konstruksiyasi va asosiy parametrlaridan biri aks etgan bo'ladi.

**Bir pog`onali qiya tishli silindrsimon reduktor hamda ochiq konussimon uzatmalardan tashkil topgan yuritma.**



Berilgan

$$F_t = 1.5kN$$

$$v = 2.0m/s$$

$$D = 300mm$$

**Yuritmani kinematik hisobi**

**1. Yuritmani umumiy foydali ish koeffisientini hisoblash.**

$$\eta_{um} = \eta_{konus} \cdot \eta_{silindr} \cdot \eta_{pod}^3 = 0.93 \cdot 0.98 \cdot 0.99^3 = 0.884$$

(A1. 1.2.1-jadval)

**2. Ishchi valdagi quvvatni aniqlash.**

$$P_3 = F_t \cdot v = 1.5 \cdot 2 = 3.0kN$$

**3. Elektrodvigatelni tanlash uchun talab etiladigan quvvatni hisoblash**

$$P_{tal} = \frac{P_3}{\eta_{um}} = \frac{3.0}{0.884} = 3.4kvt$$

$P_{dv} = 4.0kvt$  quvvatga ega elektrodvigatel tanlaymiz. (A1. 1.2.2-jadval)

**4. Ishchi valning burchak tezligini aniqlash**

$$\omega_3 = \frac{2v}{D} = \frac{4.0}{0.3} = 13.3 \text{ rad/s}$$

### 5. Ishchi valning aylanish chastatasini aniqlash

$$n_3 = \frac{30\omega_3}{\pi} = \frac{30 \cdot 13.3}{3.14} = 127.4 \text{ ayl/min}$$

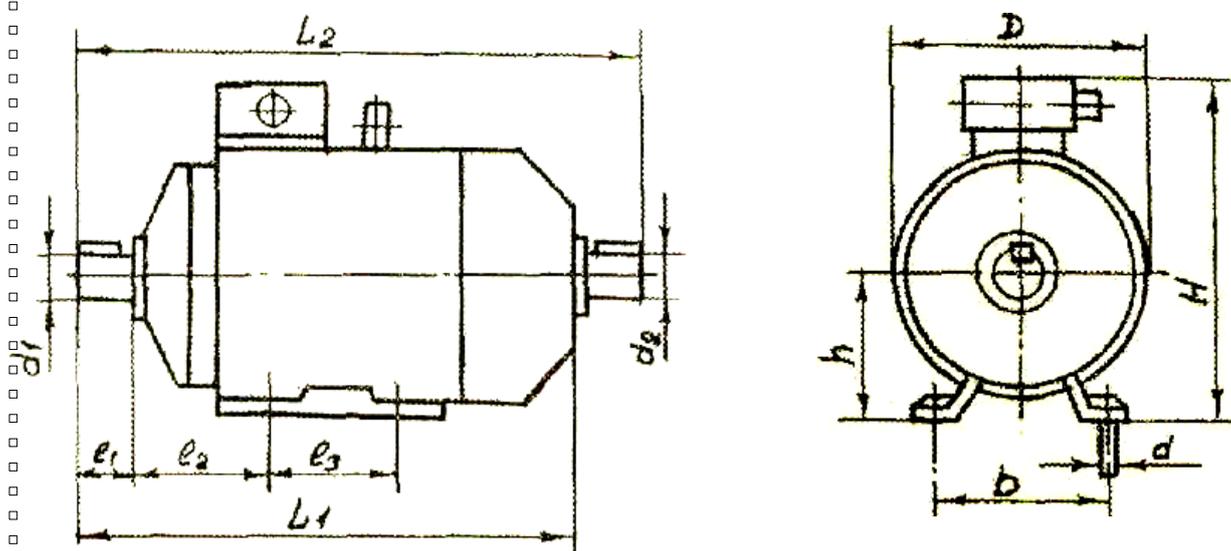
### 6. Elektrodvigatelni markalarni tanlash

$$n_c = 1500 \text{ ayl/min}$$

100L4/1430

$$S = 4.66\%$$

Markali dvigatel tanladik. Tanlangan elektro dvigatelni eskiz chizmasini chizamiz.



| Dvigatel markasi | Polyuslar soni | Dvigatel o'lchamlari |     |     |                |                |                |                |     |                |     |
|------------------|----------------|----------------------|-----|-----|----------------|----------------|----------------|----------------|-----|----------------|-----|
|                  |                | L <sub>1</sub>       | H   | D   | d <sub>1</sub> | l <sub>1</sub> | l <sub>2</sub> | l <sub>3</sub> | b   | d <sub>0</sub> | h   |
| 4A100L           | 2,4,6,8        | 395                  | 230 | 235 | 28             | 60             | 63             | 132            | 160 | 12             | 100 |

Dvigatel parametrlari A1. 1.2.3-jadvaldan olindi.

### 7. Elektrodvigatel valining aylanishlar sonini aniqlaymiz.

$$n_{dv} = 1500(1 - S) = 1500(1 - 0.0466) = 1430 \text{ ayl/min}$$

### 8. Yuritmani umumiy uzatish sonini hisoblash

$$U_{um} = \frac{n_{dv}}{n_3} = \frac{1430}{127.4} = 11.2$$

### 9. Umumiy uzatish sonini aniq pog'onalarga taqsimlash

Uzatish sonini silindrsimon uzatma uchun standartga muvofiq tanladik.  $U_1 = 4$

(A1. 12-bet)

$$U_{um} = U_1 \cdot U_2$$

$$U_2 = \frac{U_{um}}{U_1} = \frac{11.2}{4} = 2.8$$

**10. Har bir val uchun quvvat (P), aylanishlar soni (n), burovchi moment (T), burchak tezligi ( $\omega$ ) hisoblanadi**

I val:

$$P_1 = P_{tal} = 3.4kvt$$

$$n_1 = n_{dv} = 1430 \text{ min}^{-1}$$

$$T_1 = 9550 \cdot \frac{P_1}{n_1} = 9550 \cdot \frac{3.4}{1430} = 39.9Nm$$

$$\omega_1 = \frac{\pi \cdot n_1}{30} = \frac{3.14 \cdot 1430}{30} = 150 \text{ rad/s}$$

II val:

$$P_2 = P_1 \cdot \eta_{silindr} \cdot \eta_{nod} = 3.4 \cdot 0.98 \cdot 0.99 = 3.3kvt$$

$$n_2 = \frac{n_1}{U_1} = \frac{1430}{4} = 357.5 \text{ ayl/min}$$

$$T_2 = T_1 \cdot U_1 \cdot \eta_{silindr} \cdot \eta_{nod} = 39.9 \cdot 4 \cdot 0.98 \cdot 0.99 = 152.8Nm$$

$$\omega_2 = \frac{\omega_1}{U_1} = \frac{150}{4} = 35.5 \text{ s}^{-1}$$

III val:

$$P_3 = P_2 \cdot \eta_{konus} \cdot \eta_{nod} = 3.3 \cdot 0.93 \cdot 0.99 = 3.03kvt$$

$$n_3 = \frac{n_2}{U_2} = \frac{357.5}{2.8} = 127.5 \text{ ayl/min}$$

$$T_3 = T_2 \cdot U_2 \cdot \eta_{konus} \cdot \eta_{nod} = 152.8 \cdot 2.8 \cdot 0.93 \cdot 0.99 = 330Nm$$

$$\omega_3 = \frac{\omega_2}{U_2} = \frac{35.5}{2.8} = 12.6 \text{ s}^{-1}$$

Ushbu parametrlarni o`zaro taqqoslaymiz.

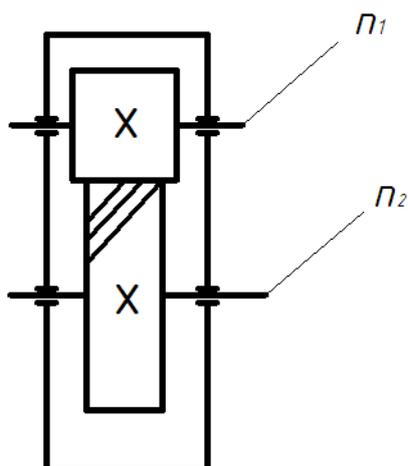
$$T_1 < T_2 < T_3$$

$$\omega_1 > \omega_2 > \omega_3$$

$$n_1 > n_2 > n_3$$

$$P_1 > P_2 > P_3$$

## Bir pog'onali qiya tishli silindrsimon yopiq uzatmaning hisobi



Yuqoridagi masalaning natijalaridan olingan qiymatlar:

$$T_1 = 39.9 Nm$$

$$T_2 = 152 Nm$$

$$n_1 = 1430 \text{ min}^{-1}$$

$$n_2 = 357.5 \text{ min}^{-1}$$

$$U = 4$$

$$L_n = 25000 \text{ soat}$$

### 1. Tishli g'ildirak uchun material tanlash.

Reduktorning tishli g'ildiraklariga material sifatida St 40X markali po'lat materialini tanlaymiz va uni qattiqligini oshirish uchun termik qayta ishlov berishni tanlaymiz. Yetaklovchi va yetaklanuvchi tishli g'ildiraklar uchun 40x markali po'lat material tanlaymiz. Bunda termik qayta ishlash yaxshilanish tish yuzasining qattiqligi (235...262)HB<sub>2</sub>; (269...302)HB<sub>1</sub>.

#### 1.1. G'ildirak tishlarning o'rtacha qattiqligi.

$$HB_{10'r} = (269 + 302) / 2 = 285,5$$

$$HB_{20'r} = (235 + 262) / 2 = 248,5$$

2. Yetaklovchi va yetaklanuvchi tishli g'ildiraklar uchun kontakt kuchlanishni ruxsat etilgan qiymatini aniqlaymiz.

$$[\sigma_H] = K_{HL} \cdot [\sigma_{HO}] \text{ MPa.}$$

a) Yetaklanuvchi tishli g'ildirak uchun

$$[\sigma_H]_2 = K_{HL2} \cdot [\sigma_{HO}]_2 \text{ MPa.}$$

Bunda  $[\sigma_{HO}]_2$  - bazoviy sikllarga to'g'ri kelgan kontakt kuchlanish qiymati (A1.1.4.1-jadvalga qaralsin)

$$[\sigma_{HO}]_2 = 1,8 \text{ HB}_{0,1} + 67 = (1,8 * 248,5) + 67 = 514 \text{ N/mm}^2;$$

$K_{HL2}$  - ishlash muddatini hisobga oluvchi koeffitsenti

$$K_{HL2} = \sqrt[6]{\frac{N_{HO2}}{N_2}} \leq K_{HL\max}$$

bunda  $N_{HO2} = (\text{HB}_{20,1})^3 = (248,5)^3 = 15 * 10^6$  – bazoviy sikllar soni.

$N_2 = 60 \cdot n_3 \cdot L_n = 60 * 93 * 25000 = 139,5 * 10^6$  – hisobiy sikllar soni.

Natijada

$$K_{HL2} = \sqrt[6]{\frac{N_{HO2}}{N_2}} = \sqrt[6]{\frac{15 \cdot 10^6}{139,5 \cdot 10^6}} = 1,0 \text{ chunki } N_{HO2} < N_2 \text{ (A1. 15-bet)}$$

Etaklanuvchi tishli g'ildirak uchun kontakt kuchlanishni qiymati

$$[\sigma_H]_2 = 514 * 1,0 = 514 \text{ N/mm}^2$$

b) Yetaklovchi tishli g'ildirak uchun kontakt kuchlanishni ruxsat etilgan qiymati.

$$[\sigma_n] = [\sigma_{no}]_1 \cdot K_{HL1} \text{ MPa,}$$

Bunda:  $[\sigma_{HO}]_1 = 1,8 \text{ NV}_{0,1} + 67 = (1,8 * 285,5) + 67 = 581 \text{ N/mm}^2$

$$K_{HL1} = \sqrt[6]{\frac{N_{HO1}}{N_1}} \leq K_{HL\max} .$$

$N_{HO1} = 15 * 10^6$  sikll,  $N_1 = N_2 \cdot U_I = 139,5 * 10^6 * 5 = 697,5 * 10^6$  sikll.  $N_{HO1} < N_1$  bo'lgani uchun  $K_{HL1} = 1,0$  (A1. 15-bet)

Yetaklovchi tishli g'ildirak uchun kontakt kuchlanishni ruxsat etilgan qiymati.

$$[\sigma_H]_1 = 581 * 1,0 = 581 \text{ N/mm}^2$$

v) Yetaklanuvchi tishli g'ildirak uchun egilishdagi kuchlanishni ruxsat etilgan qiymati

$$[\sigma_F]_2 = [\sigma_{FO}]_2 \cdot K_{FL2} \text{ N/mm}^2$$

bunda  $[\sigma_{FO}]_2$  – bazoviy sikllarga to'g'ri kelgan egilishdagi kuchlanish qiymati.

$$[\sigma_{FO}]_2 = 1.03 \text{ NV}_{o'r} = 1.03 \cdot 248.5 = 256 \text{ N/mm}^2;$$

bunda  $N_{FO} = 4 \cdot 10^6$  - bazoviy sikllar soni;  $N_2 = 139.5 \cdot 10^6$  sikl.

Natijada

$$K_{FL2} = \sqrt[6]{\frac{N_{FO}}{N_2}} = \sqrt[6]{\frac{4 \cdot 10^6}{139.5 \cdot 10^6}} = 1.0 \text{ chunki } N_{FO} < N_2 \text{ (A1. 15-bet)}$$

Yetaklanuvchi tishli g'ildirak uchun egilishdagi kuchlanishni ruxsat etilgan qiymati

$$[\sigma_H]_2 = 256 \cdot 1.0 = 256 \text{ N/mm}^2$$

2.1. Yetaklovchi tishli g'ildirak uchun egilishdagi kuchlanishni ruxsat etilgan qiymati

$$[\sigma_F]_1 = [\sigma_{FO}]_1 \cdot K_{FL1} \text{ N/mm}^2;$$

bunda  $[\sigma_{FO}]_1 = 1.03 \text{ NV}_{o'r} = 1.03 \cdot 285.5 = 294 \text{ MPa}$ ;

$$K_{FL1} = \sqrt[6]{\frac{N_{FO}}{N_1}} = \sqrt[6]{\frac{4 \cdot 10^6}{697 \cdot 10^6}} = 1.0 \text{ chunki } N_{FO} < N_1 \text{ (A1. 15-bet)}$$

Yetaklovchi tishli g'ildirak uchun egilishdagi kuchlanishni ruxsat etilgan qiymati

$$[\sigma_F]_1 = 294 \cdot 1.0 = 294 \text{ N/mm}^2;$$

Demak, ruxsat etilgan kontakt va egilishdagi kuchlanishlarni qiymatlari:

$$[\sigma_H]_1 = 514 \text{ MPa}; \quad [\sigma_F]_1 = 256 \text{ MPa};$$

$$[\sigma_H]_2 = 581 \text{ MPa}; \quad [\sigma_F]_2 = 294 \text{ MPa}.$$

### 3. Uzatmaning o'qlararo masofasini aniqlash

$$a_{\omega} = K_a \cdot (U + 1) \cdot \sqrt[3]{\frac{K_{H\beta} \cdot T_2 \cdot 10^3}{[\sigma_H]_1^2 \cdot U^2 \cdot \psi_a}} \text{ mm}$$

bu yerda:

$K_a$  -hisobiy koeffisient bo'lib, to'g'ri tishli uzatma uchun  $K_a = 49.5$  ga teng, qiya tishli uzatma uchun esa  $K_a = 43$  gat eng. (A1. 18-bet)

U-uzatmaning uzatish soni

$[\sigma_H]$  -ruxsat etilgan kontakt kuchlanishning MPa hisobida

$T_2$  -sekin aylanuvchi g'ildirak valining burovchi momenti.

$K_{HB}$  -yuklanishni tish yuzasiga notekis taqsimlanishni hisobga oluvchi

koeffisienti tish yuzasining notekisligi HB ga, tish eni koeffisienti  $\psi_a$  va uzatma g'ildiraklarining tayanchi nuqtasiga joylashishiga nisbatan olinadi. (A1. 1.4.4-jadval)

$\psi_a$  -tish eni koeffisienti bo'lib, uzatma g'ildiraklarini tayanchga nisbatan joylashishiga qarab tanlanadi. (A1. 1.4.4-jadval)

$$a_{\omega} = K \cdot (U + 1) \cdot \sqrt[3]{\frac{T_2 \cdot 10^3 \cdot K_{H\beta}}{[\sigma_H]^2 \cdot U^2 \cdot \psi_a}} = 43 \cdot 6 \cdot \sqrt[3]{\frac{258 \cdot 10^3 \cdot 1}{(514 \cdot 10^6)^2 \cdot 5^2 \cdot 0.4}} = 119 \text{ mm}$$

Standart bo'yicha  $a_{\omega} = 125 \text{ mm}$  ga teng. (A1. 19-bet)

#### 4. Tishli g'ildiraklarning dastlabki o'lchamlari

4.1 G'ildirak bo'luvchi aylana diametrini hisoblash.

$$d_2 = \frac{2 \cdot a_{\omega} \cdot U}{U + 1} = \frac{2 \cdot 125 \cdot 5}{6} = 208.3 \text{ mm}$$

4.2 G'ildirak eni

$$b_2 = \psi_a \cdot a_{\omega} = 0.4 \cdot 125 = 50 \text{ mm} \quad b_1 = 1.12 \cdot b_2 = 1.12 \cdot 50 = 56 \text{ mm}$$

#### 5. Ilashish modulini aniqlash

$$m \geq \frac{2 \cdot K_m \cdot T_2 \cdot 10^3}{d_2 \cdot b_2 \cdot [\sigma_F]_1} = \frac{2 \cdot 5.8 \cdot 258000}{208.3 \cdot 10^{-3} \cdot 50 \cdot 10^{-3} \cdot 256 \cdot 10^6} = 1.12 \text{ mm}$$

Standart bo'yicha  $m = 1.5 \text{ mm}$  deb qabul qilamiz. (A1. 22-bet)

Bu yerda:  $K_m$ - modul koeffitsienti bo'lib qiya tishli g'ildirak uchun 5.8 ga teng.

## 6. Uzatma tishlarining qiyalik burchagi va umumiy tishlar soni

6.1 Qiyalik burchagining eng kichik qiymatini aniqlash

$$\beta_{\min} = \arcsin\left(\frac{4m}{b_2}\right) = \arcsin\left(\frac{4 \cdot 1.5}{50}\right) = 7^\circ$$

5.2 Uzatma umumiy tishlar soni

$$z_y = \frac{2 \cdot a_\omega \cdot \cos \beta_{\min}}{m} = \frac{2 \cdot 125 \cdot 0.99}{1.5} = 165$$

## 7. Yetaklovchi va yetaklanuvchi tishli g'ildirak tishlar soni

$$z_1 = z_y / (U + 1) = 165 / 6 = 27.5 = 28$$

$$z_2 = z_y - z_1 = 165 - 28 = 137$$

## 8. Uzatmaning geometrik o'lchamlari

a) Tish bo'luvchi aylana diametri

$$d_1 = \frac{m \cdot z_1}{\cos \beta} = \frac{1.5 \cdot 28}{0.99} = 42.4 \text{ mm}$$

$$d_2 = \frac{m \cdot z_2}{\cos \beta} = \frac{1.5 \cdot 137}{0.99} = 208.3 \text{ mm}$$

b) Tish ostidan o'tgan aylana diametri

$$d_{f_1} = d_1 - 2.5m = 42.4 - 2.5 \cdot 1.5 = 38.65 \text{ mm}$$

$$d_{f_2} = d_2 - 2.5m = 208.3 - 2.5 \cdot 1.5 = 204.55 \text{ mm}$$

c) Tish ustidan o'tgan aylana diametri

$$d_{a_1} = d_1 + 2m = 42.4 + 3 = 45.4 \text{ mm}$$

$$d_{a_2} = d_2 + 2m = 208.3 + 3 = 211.3 \text{ mm}$$

## 9. O'qlararo masofani tekshirish

$$a_\omega = \frac{(d_1 + d_2)}{2} = \frac{42.4 + 208.3}{2} = 125.3 \text{ mm}$$

## 10. Ilashishda hosil bo'ladigan kuchlar

### 10.1 Aylanma kuch

$$F_t = \frac{2 \cdot T_2}{d_2} = \frac{2 \cdot 258 \cdot 10^3}{208,3} = 2477,2 N$$

### 10.2 Radial kuch $\alpha = 20^\circ$

$$F_r = F_t \cdot \frac{\operatorname{tg} 20^\circ}{\cos \beta} = 2477,2 \cdot \frac{0,364}{0,99} = 910 N$$

### 10.3 Bo'ylama kuch

$$F_a = F_t \cdot \operatorname{tg} \beta = 2477,2 \cdot \operatorname{tg} 7^\circ = 2477,2 \cdot 0,122 = 304 N$$

## 10. Kontakt kuchlanishni hisoblash

$$\sigma_H = K \cdot \sqrt{\frac{F_t(U+1)}{d_2 \cdot b_2} \cdot K_{H\beta} \cdot K_{H\alpha} \cdot K_{H\nu}} = 376 \cdot \sqrt{\frac{2477,2 \cdot 6}{208,3 \cdot 50} \cdot 1,03 \cdot 1 \cdot 1,1} = 477 MPa$$

$K$  – qo'shimcha koeffitsient bo'lib, qiya tishlig'ildiraklar uchun  $K = 376$  ga teng.

(A1. 19-bet)

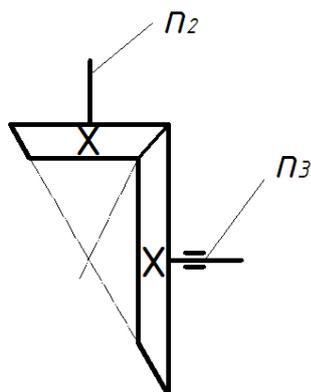
$K_H = K_{H\beta} \cdot K_{H\alpha} \cdot K_{H\nu}$  – yuklanish koeffitsienti. (A1. 1.4.6-jadval)

Chiqqan qiymat quyidagi oralig'da bo'lishi kerak

$$\sigma_H = (0,9 - 1,05)[\sigma_H] = (462,6 - 539,7) MPa$$

$\sigma_H \leq [\sigma_H]$  demak shart bajarildi.

## Ochiq konussimon uzatmaning hisobi



Oldigi masalani echimlaridan quyidagilarni olamiz:

$$T_2 = 258 Nm$$

$$n_2 = 292 \text{ min}^{-1}$$

$$T_3 = 1563 Nm$$

$$P_2 = 7.9 kVt$$

$$n_3 = 47.7 \text{ min}^{-1}$$

$$P_3 = 7.2 kVt$$

$$U_2 = 6.12$$

1. Uzatma g'ildiraklari uchun material tanlanadi (yopiq uzatma uchun tanlangan qabul qilamiz)

2 Demak, ruxsat etilgan kontakt va egilishdagi kuchlanishlarni qiymatlari:

$$[\sigma_H]_1 = 514 \text{ MPa}; \quad [\sigma_F]_1 = 256 \text{ MPa};$$

$$[\sigma_H]_2 = 581 \text{ MPa}; \quad [\sigma_F]_2 = 294 \text{ MPa}.$$

3. Yetaklanuvchi tishli g'ildirakning bo'luvchi aylana diametri

$$d_{e2} = 165_3 \sqrt{\frac{K_{H\beta} \cdot U_2 \cdot T_3 \cdot 10^3}{\nu_H \cdot [\sigma_H]_1^2}} \text{ mm},$$

a)  $\nu_H$  – to'g'ri tishli konussimon g'ildirak tishlarini tsilindrsimon g'ildirak mustaxkamligini kamligini bildiruvchi koeffitsient – 0,85. (A1. 25-bet)

b)  $K_{H\beta}$  – yuklanishni tish eni bo'yicha notekis taqsimlanishini hisobga oluvchi koeffitsient. G'ildirak tishlarining qattiqligi  $\leq 350 \text{ NV}$  bo'lganda – 1,0;  $> 350 \text{ NV}$  bo'lganda formula yordamida aniqlanadi.

$$K_{H\beta} = 1,0 \text{ ga teng. (A1. 1.4.8-jadval)}$$

$$d_{e2} = 165_3 \sqrt{\frac{K_{H\beta} \cdot U_2 \cdot T_3 \cdot 10^3}{\nu_H \cdot [\sigma_H]_1^2}} = 165_3 \sqrt{\frac{1.0 \cdot 6.12 \cdot 1563 \cdot 10^3}{0.85 \cdot (514 \cdot 10^6)^2}} = 576 \text{ mm}, \quad \text{yaxlitlab}$$

$d_{e2} = 580 \text{ mm}$  qabul qilamiz.

2. Uzatma g'ildiraklarining o'lchamlari aniqlaymiz.

a) boshlang'ich konus burchagi

$$\varphi_1 = \arctg \frac{1}{U_2} = \arctg \frac{1}{6.12} = 9^{\circ}50' \quad \varphi_2 = 90 - 9^{\circ}50' = 80^{\circ}50'$$

b) Tashqi konus uzunligi:

$$R_e = d_{e2} / 2 \cos \varphi_1 = 580 / 2 \cos 9^{\circ}50' = 580 / (2 \cdot 0,986) = 294 \text{ mm}$$

c) G'ildirak tishining eni

$$b = 0,285 R_e = 0,285 \cdot 294 = 83,78 \text{ mm yaxlitlanib } b = 84 \text{ qabul qilinadi}$$

3. Uzatma g'ildirak tishlarining ilashish moduli

$$m_e \geq \frac{14 \cdot K_{F\beta} \cdot T_3 \cdot 10^3}{v_F \cdot b_2 \cdot d_{e2} [\sigma_F]} \text{ mm}$$

bunda  $v_F$  – konussimon g'ildirak tishlarini tsilindirsimon g'ildirak tishlariga nisbatan mustaxkamligini kamligini ko'rsatuvchi koeffitsient, qiymati – 0,85;  $K_{F\beta}$  – yuklanishni notekis taqsimlanishni hisobga oluvchi koeffitsient, qiymati uzatma g'ildirak tishlarining qattiqligi  $\leq 350 \text{ NV}$  bo'lganda – 1,0;  $\geq 350 \text{ NV}$  bo'lganda qiymati

$$K_{F\beta} = 1 + \frac{1,5\psi_\alpha}{S} \leq 1,7; \quad \psi_\alpha = 0,45$$

natijada  $K_{F\beta} = 1 + (1,5 \cdot 0,45) / 2 = 1,34$  (A1. 1.4.9-jadval)

Aniqlangan va tanlangan qiymatlarni formulaga qo'yib ilashish modulini hisobiy qiymatini aniqlaymiz

$$m_e = \frac{14 \cdot 1563 \cdot 10^3 \cdot 1,34}{0,85 \cdot 84 \cdot 580 \cdot 256} = 2,76 \text{ mm}$$

Modulning qiymatini standartga asosan  $m_e = 3 \text{ mm}$  deb tanlaymiz. (A1. 22-bet)

4. Uzatma g'ildiraklarining tishlari soni

$$Z_2 = \frac{d_{e2}}{m_e} = \frac{580}{3} = 193,3 \text{ yaxlitlab } Z_2 = 193 \text{ ta deb qabul qilamiz.}$$

$$Z_1 = \frac{Z_2}{U_2} = \frac{193}{6.12} = 31,6 \text{ yaxlitlab } Z_1 = 32 \text{ qabul qilamiz}$$

5. Uzatish sonining hisobiy qiymati

$$u_x = Z_2 / Z_1 = 193 / 32 = 6,03$$

$$\Delta u = \left| \frac{u - u_x}{u} \right| \cdot 100\% = \frac{|6.12 - 6.03|}{6.12} \cdot 100 = 1,46\% < [4\%]$$

6. Tishli g'ildiraklarni geometrik o'lchamlarni

a) Bo'luvchi aylana o'lchami

$$d_{e1} = m_e \cdot Z_1 = 3 \cdot 32 = 96 \text{ mm}$$

$$d_{e2} = m_e \cdot Z_2 = 3 \cdot 193 = 579 \text{ mm}$$

b) Tashqi aylana o'lchami

$$d_{ae1} = d_{e1} + 2 \cdot m_e \cos \varphi_1 = 96 + 2 \cdot 3 \cdot 0,986 = 101,9 \text{ mm}$$

$$d_{ae2} = d_{e2} + 2 \cdot m_e \cos \varphi_2 = 579 + 2 \cdot 3 \cdot 0,165 = 580 \text{ mm}$$

v) Tish osti aylana o'lchami.

$$d_{ae1} = d_{e1} - 2,5m_e \cos \varphi_1 = 96 - 2,5 \cdot 3 \cdot 0,986 = 88,6 \text{ mm}$$

$$d_{ae2} = d_{e2} - 2,5m_e \cos \varphi_2 = 579 - 2,5 \cdot 3 \cdot 0,165 = 577,8 \text{ mm}$$

7. Ilashishda hosil bo'lgan kuchlar

a) Aylanma kuch

$$F_{t1} = 2T_2 / d_{m1} = 2 \cdot 258 \cdot 10^3 / 82,3 = 6270 \text{ N}$$

$$d_{m1} = 0,857d_{e2} = 0,857 \cdot 96 = 82,3 \text{ mm}$$

$$F_{t2} = 2T_3 / d_{m2} = 2 \cdot 1563 \cdot 10^3 / 496,2 = 6300 \text{ N}$$

$$d_{m2} = 0,857d_{e2} = 0,857 \cdot 579 = 496,2 \text{ mm}$$

b) yetaklovchi tishli g'ildirak uchun bo'ylama kuch

$$F_{a1} = F_{r2} = F_t \cdot \operatorname{tg} \alpha \cdot \sin \varphi_1 = 6300 \cdot 0,364 \cdot 0,165 = 387,5 \text{ N}$$

$$\operatorname{tg} \alpha = \operatorname{tg} 20^\circ = 0,364. \quad \sin \varphi_1 = \sin 9^\circ 50' = 0,165$$

v) yetaklovchi tishli g'ildirak uchun markazga intiluvchi kuch

$$F_{r1} = F_{a2} = F_t \cdot \operatorname{tg} \alpha \cdot \cos \varphi_1 = 6300 \cdot 0,364 \cdot 0,986 = 2261,8 \text{ N}$$

8. Kontakt kuchlanishni hisobiy qiymati

$$\sigma_H = 2120 \sqrt{\frac{T_3 \cdot u_2 \cdot K_{H\beta}}{d_{e2}^3 \cdot V_H}} = 2120 \sqrt{\frac{1563 \cdot 10^3 \cdot 6,12 \cdot 1,0}{(579)^3 \cdot 0,85}} = 510 \text{ MPa}$$

$$\sigma_H < [\sigma_H] \quad 510 < 514. \quad \text{o'ta yuklanish 5\% gacha bo'lishi mumkin.}$$

## VALLARNING TAXMINIY HISOBI

**1. Birinchi val uchi konsol qismining diametri quydagicha aniqlanadi:**

$$d_1 = \sqrt[3]{\frac{T_1 \cdot 10^3}{0,2[\tau]}} = \sqrt[3]{\frac{53,2 \cdot 10^3}{0,2 \cdot 15}} = 26 \text{ mm}$$

Bu yerda:

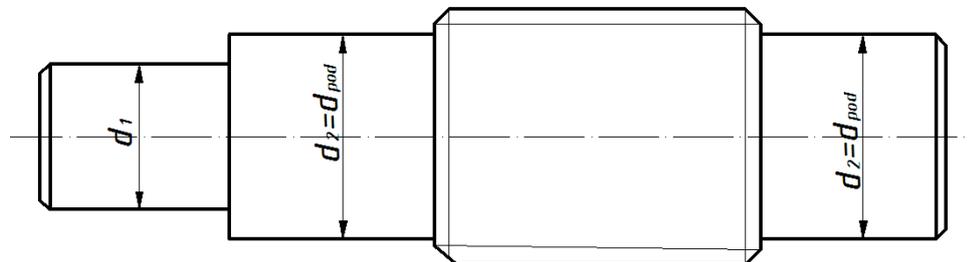
$$[\tau] - \text{buralishdagi ruxsat etilgan kuchlanish } [\tau] = 15 \div 25 \text{ MPa}$$

$d_1$  ning aniqlangan qiymati standart bo'yicha yaxlitlanib, val qolgan qismlarining diametri aniqlanib, valning eskizi chizib olinadi.  $d_1 = 30$

$$d_1 = 30mm \quad d_{pod} = d_2 = d_1 + 2t = 30 + 2 \cdot 2.2 = 34.4mm \quad t=2.2 \text{ ga}$$

teng. (A1. 2.8.1-jadaval)

$d_2$  ning qiymatini yaxlitlab,  $d_2=35 \text{ mm}$  deb olamiz.



## 2. Ikkinchi val uchun konsol qismining diametri

$$d_3 = \sqrt[3]{\frac{T_2 \cdot}{0.2 \cdot [\tau]}} = \sqrt[3]{\frac{258 \cdot 10^3}{0.2 \cdot 15}} = 44.1mm \approx 44mm$$

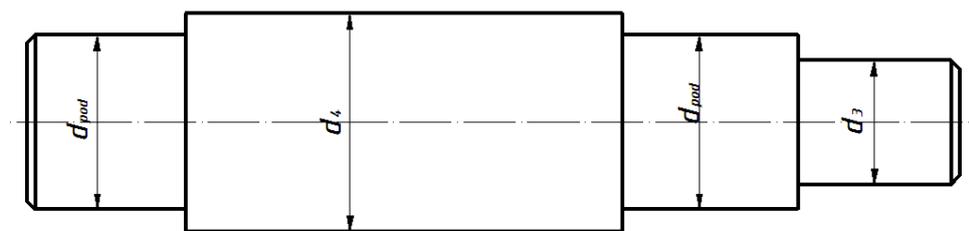
Ikkinchi valning qolgan qismlarining diametrini aniqlab, eskiz chizamiz.

$$d_{pod} = d_3 + 2t = 44 + 2 \cdot 3 = 50mm$$

$$d_4 = d_{pod} + 3.2 \cdot r = 50 + 3.2 \cdot 3 = 59.6mm \approx 60mm$$

$t$  va  $r$  larning qiymatlari A1. 2.8.1-jadvaldan tanlanadi.

$d_4$  ning qiymatini yaxlitlab,  $d_4=60 \text{ mm}$  deb qalub qilamiz.



## 3. Uchinchi val uchun konsol qismining diametri

$$d_5 = \sqrt[3]{\frac{T_3 \cdot 10^3}{0.2 \cdot [\tau]}} = \sqrt[3]{\frac{1563 \cdot 10^3}{0.2 \cdot 25}} = 67.8mm \approx 68mm$$

Valning qolgan qismlarining diametrini aniqlab eskiz chizamiz

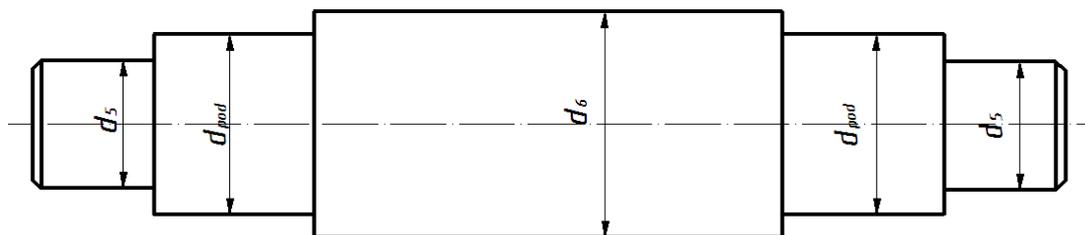
$$d_{pod} = d_5 + 2t = 68 + 2 \cdot 3 = 74mm \text{ . Valning bu qismiga podshipnik o`rnatilishini}$$

inobatga olib,  $d_{pod} = 75mm$  deb qabul qilamiz.

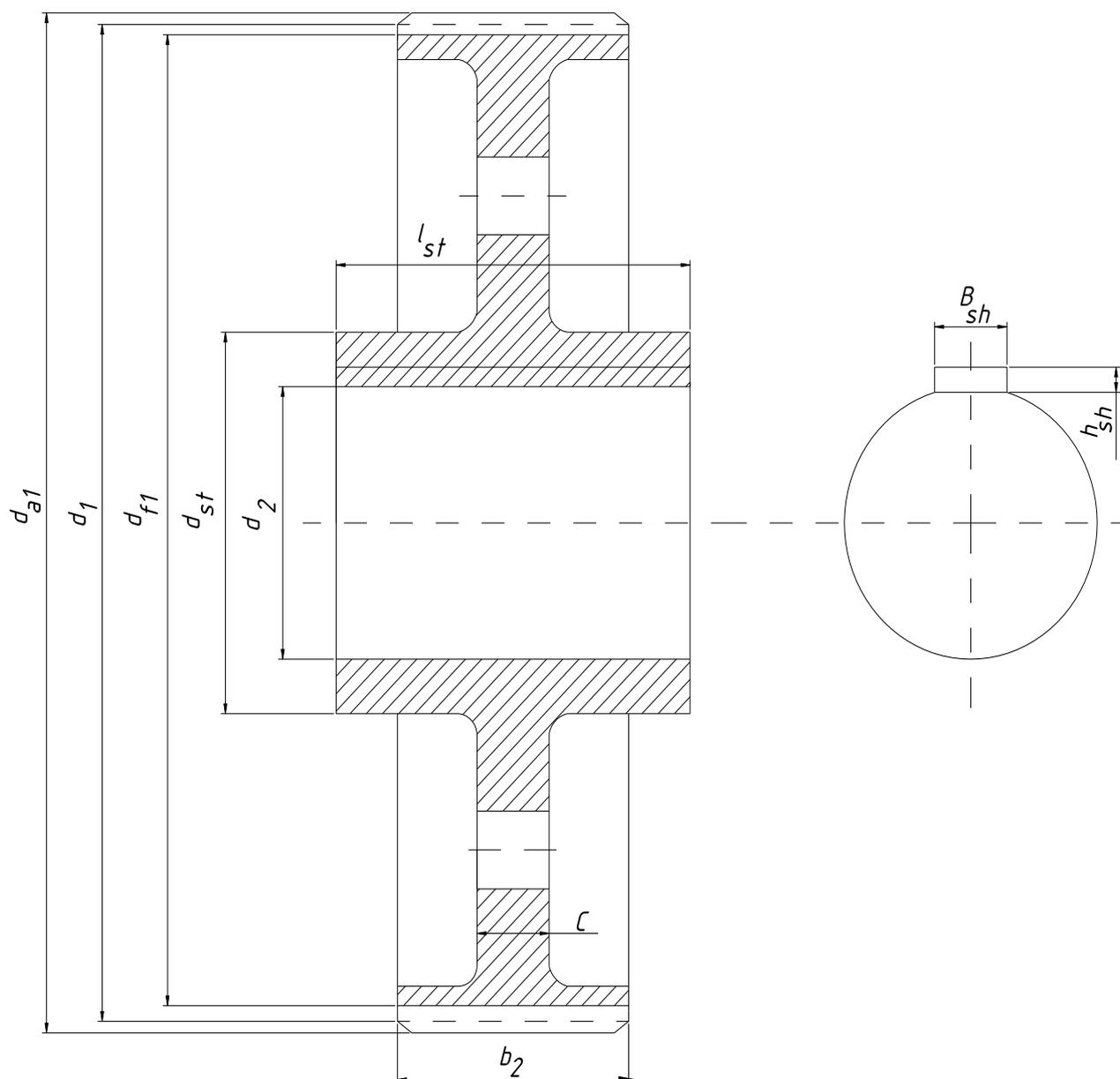
$$d_6 = d_{pod} + 3.2r = 75 + 3.2 \cdot 3 = 84.6mm, \text{ diametr qiymatini yaxlitlab,}$$

$d_6 = 85\text{mm}$  deb qabul qilamiz.

$t$  va  $r$  larning qiymatlari A1. 2.8.1-jadvaldan tanlanadi.



**Gildirak konstruksiyasini o'lchamlari**



Gubchak parametrlari:  $d_g = 1.6d_{val} = 1.6 \cdot 60 = 96mm$   
 $l_g = (1,2 \div 1,5)d_{val} = 72 \div 90mm$

Disk qalinligi:  $C \geq 0.25b_2 = 0.25 \cdot 50 = 12.5mm$

Gardishining qalinligi:  $S = 2.2m + 0.05b_2 = 2.2 \cdot 1.5 + 0.05 \cdot 50 = 5.8mm$

Tishli g'ildiraklar bu tishli gardish, gubchak va ularni biriktirib turadigan diskdan iborat bo'lib, bu elementlarning o'lchamlarini formulalar yordamida aniqlash mumkin. G'ildirakning tishli gardishi tashqi kuchga chidamli, ya'ni mustahkam, bikrligi yuqori bo'lishi kerak, buning uchun gardishning qalinligi silindrsimon tishli g'ildiraklar uchun  $S > 2.5mm$  olinadi.

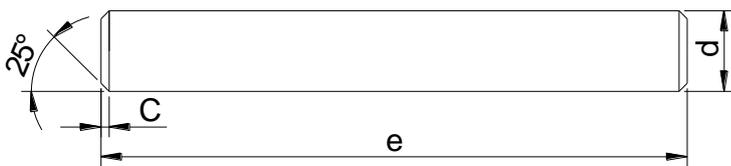
Tishli g'ildiraklarning gubchagi g'ildirakning valiga o'tqazilib ko'rinishi simmetrik yoki nosimmetrik bo'lishi mumkin. Gubchakning uzunligi valning diametriga hamda g'ildirakning materialiga bog'liq bo'ladi. G'ildirakning diski gubchakni gardish bilan biriktiradi, qalinligi g'ildirakni qanday yo'l bilan tayyorlanishiga bog'liq.

### Yopiq uzatma element o'lchamlari

| Element o'lchamlari   | Qiymatlari (mm)   |
|---|---|
| Yopiq uzatma devorining qalinligi   | $\delta = \sqrt[3]{10.5 \cdot T_2} =$   |
| Fundament bolti $d_1$ ni, hamda shu bolt o'rnatilgan o'yoqchanning o'lchamlari  | M14 (A1. 3.4.2-jadval)<br>$h_{01} = 2.5(d_1 + \delta) =$<br>$h_1 = 2.5\delta =$ $K_1 =$ $C_1 =$<br>$D_{01} =$ $b_{01} =$ $d_{01} =$ |
| Tayanchlarga o'rnatilgan podshipniklarni mahkamlash uchun ishlatiladigan bolt diametri $d_2$ ni hamda shu vint o'rnatiladigan o'yoqning o'lchamlari | M12 (A1. 3.4.3-jadval)<br>$h_3$ - qiymati chizmadan grafik davishda aniqlanadi $K_1 =$ $C_1 =$<br>$D_{01} =$ $b_{01} =$ $d_{01} =$  |
| Uzatma asosi bilan qopqog'ini mahkamlash uchun ishlatiladigan bolt diametri $d_3$ ni hamda shu bolt o'rnatiladigan o'yoqchanning o'lchamlari        | M10 (A1. 3.4.3-jadval)<br>$K_1 =$ $C_1 =$<br>$D_{01} =$ $b_{01} =$ $d_{01} =$   |
| Podshipnik qopqog'ini mahkamlash uchun ishlatiladigan bolt diametri, $d_4$  | Qiymati A1. 3.4.5-jadvaldan podshipnik tashqi diamertiga nisbatan tanlanadi.  |
| Qopqoqdagi darchaniberkitish uchun ishlatiladigan bolt diametri, $d_5$  | M6 (A1. 3.4.3-jadval)<br>$K_1 =$ $C_1 =$<br>$D_{01} =$ $b_{01} =$ $d_{01} =$  |

## Korpus elementlari o'lchamlari

Korpusda podshipnik uchun mo'ljallangan uyalarni ochishda o'qdosh-ligini ta'minlash uchun qutining asosi bilan qutining qopqog'i o'zaro konussimon yoki silindrsimon shtiv bilan biriktirilib, uyalar qayta ishlanadi. Shtivlarda ichki rezba bo'lishi mumkin, bu esa kerak paytda shtivni olib tashlashni osonlashtiradi. Shtivning o'lchamlari:

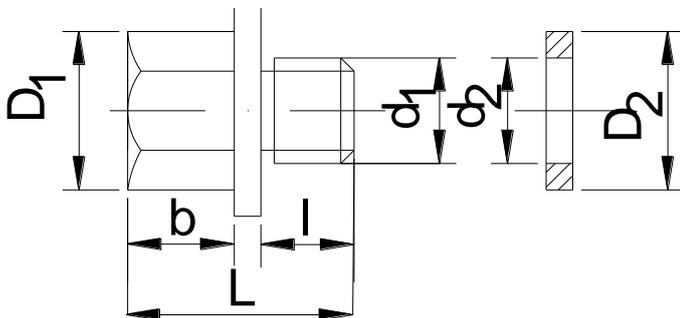


$$d = 10mm$$

$$c = 1,6mm$$

$$e = 30..60mm$$

Uzatmalar ishlash jarayonida g'ildiraklarni yog'lash uchun ishlatilgan moylar asta-sekin ifloslanib, o'zining moylash xususiyatini yoqotadi. Shuning uchun bu moylarni vaqti-vaqti bilan almashtirib turish kerak. Korpusning qopqog'idagi darchadan moy quyiladi. Moy hajmini tekshirish uchun hamda ishlatilgan moyni to'kish uchun korpus asosining yon tomonida teshik ochiladi. Moyni to'kish uchun ochilgan teshik silindrsimon yoki konussimon bo'lishi mumkin. Silindrsimon probka ishlatilsa moylar tirqishdan chiqib ketmasligi uchun rezinali moslama ishlatiladi, konussimon probkalarda bu moslamalar ishlatilmaydi. (A1. 94-bet)



$$d_1 = M 20x1,5$$

$$D_1 = 25.4mm$$

$$L = 28mm$$

$$l = 13mm$$

$$b = 4mm$$

$$d_2 = 20mm$$

$$D_2 = 32mm$$

$$b_2 = 3mm$$

## Uzatmani moylash.

Yopiq uzatmada tishli g'ildiraklarni moyga botirish yo'li bilan yog'lanadi, bunda yetaklanuvchi tishli g'ildiraklar tishlari moyga botiriladi. ishlatilayotgan moyning hajmi uzatilayotgan quvvatga bog'liq bo'lib u quyidagicha aniqlanadi.

$$V = 0.25 \cdot P_1 = 0.25 \cdot 8.14 = 2.035 dm^3$$

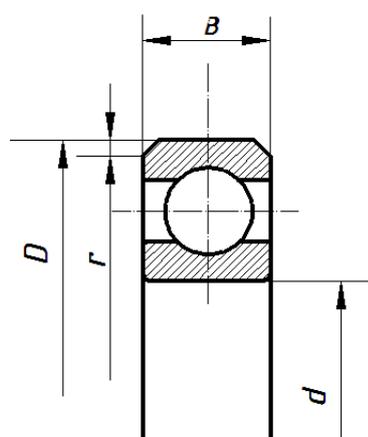
Moyni to'kishni tezlashtirish uchun teshiklar korpus asosining yuziga nisbatan 1-2 gradus qiyalik bilan ochiladi.

Moy hajmini o'lchagich moslamalar har xil ko'rinishda bo'ladi.

### Podshipnik tanlash

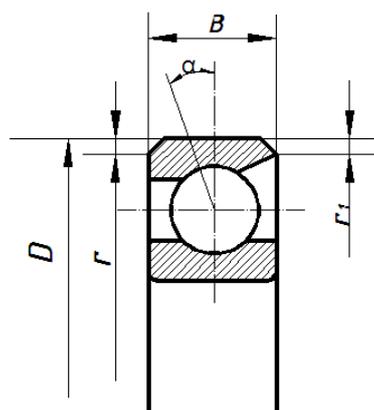
Podshipniklar val hamda o'qlarning shiplariga o'rnatilib, tayanch vazifasini o'taydi. O'q yoki val orqali tayanchga tushadigan kuchni bevosita podshipnik qabul qiladi. Mashinaning ishlash sifati podshipniklarga ko'p jihatdan bog'liq. Shuning uchun podshipniklarni tanlash, loyihalash va ish jarayonida ularni kuzatib turish masalalariga alohida e'tibor berish lozim.

1. Yetaklovchi g'ildirak valiga o'rta seriyali bir qatorli zoldirli radial podshipnik tanlaymiz. Podshipnik markasi 307 (A1. 4.5.5-jadval)



$$\begin{aligned} d_1 &= 35mm \\ D &= 80mm \\ B &= 21mm \\ r &= 2.5mm \\ C_r &= 33.2kN \\ C_0 &= 18kN \end{aligned}$$

2. Yetaklanuvchi g'ildirak valiga yengil ensiz seriyali zoldirli radial-tirak podshipniklardan tanlaymiz.  $\alpha=12^\circ$  podshinik markasi 36210 (A1. 4.5.6-jadval)



$$\begin{aligned} d &= 50mm & r &= 2mm \\ D &= 90mm & r_1 &= 1mm \\ T &= 27,25mm & C_r &= 43.2N \\ B &= 20mm & C_0 &= 27.0kN \end{aligned}$$

## Vallarni egilishga tekshirish

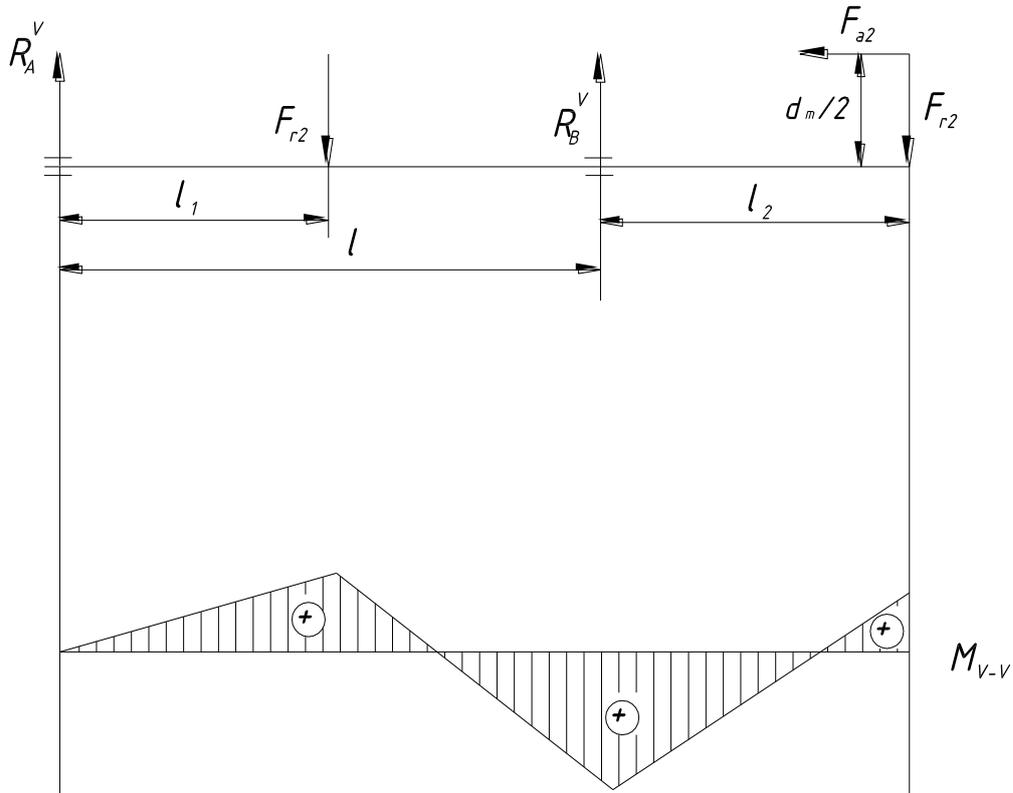
Valning hisobiy sxemasi tuzilib, tayanchlardagi reaksiya kuchlarning qiymatlari aniqlanib, vallar uchun eguvchi va burovchi moment epyurasi quriladi.

### 2- val uchun

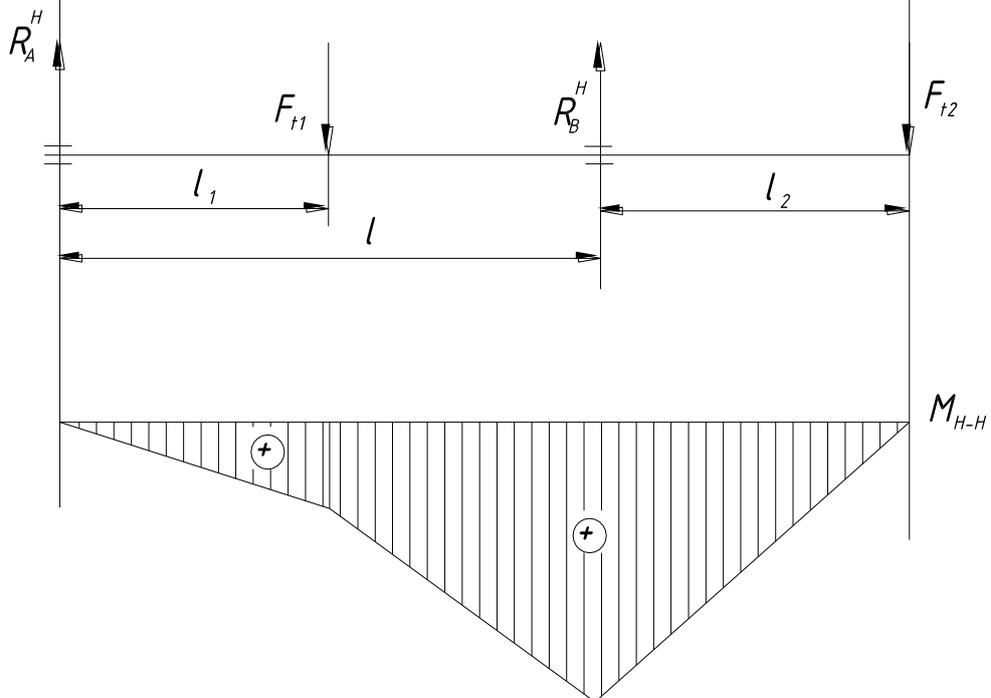
$$\begin{array}{ll} F_{t2} = 2477N & F_{a1} = 387.5N \\ F_{r2} = 910N & F_{r1} = 2261N \\ l = 130mm & F_{t1} = 6270N \\ \text{Berilgan: } l_g = l_2 = 96mm & d_m = 83.2mm \\ l_1 = 65mm & \end{array}$$

$$l = B_n + 2x + l_g = 20 + 14 + 96 = 130mm$$

*V-V tekislik*



*H-H tekislik*



## Vertikal tekislikda

$$\sum M_A = 0 \quad -R_B^V l - F_{a1} \cdot \frac{d_{m1}}{2} + F_{r1} \cdot (l_2 + l) + F_{r2} l_1 = 0$$

$$R_B^V = \frac{[-F_{a1} \cdot d_{m1} / 2 + F_{r1} \cdot (l_2 + l) + F_{r2} l_1]}{l} = \frac{-387.5 \cdot 41.6 + 2261 \cdot 226 + 910 \cdot 65}{130} = 4625N$$

$$\sum M_B = 0 \quad R_A^V \cdot l + F_{r1} \cdot l_2 - F_{r2} \cdot l_1 - F_{a1} \cdot d_{m2} / 2 = 0$$

$$R_A^V = \frac{[F_{a1} \cdot d_{m1} / 2 - F_{r1} \cdot l_2 + F_{r2} l_1]}{l} = \frac{387.5 \cdot 41.6 - 2261 \cdot 96 + 910 \cdot 65}{130} = -1454N$$

$$R_A^V + R_B^V - F_{r2} - F_{r1} = 0$$

Tekshirish:  $4625 - 1454 - 910 - 2261 = 0$

$$0 = 0$$

1-uchastka  $0 \leq x_1 \leq l_1$

$$M_{x_1} = R_A^V \cdot x_1 \quad x_1 = 0 \quad M_{x_1} = 0$$

$$x_1 = 65mm \quad M_{x_1} = 80Nm$$

2-uchastka  $0 \leq x_2 \leq l_2$

$$x_2 = 0$$

$$M_{x_2} = -F_{r1} \cdot x_2 + F_{a1} \frac{d_{m2}}{2} = 387.5 \cdot 41.6 = 16.1Nm$$

$$x_2 = 96mm$$

$$M_{x_2} = -F_{r1} \cdot x_2 + F_{a1} \frac{d_{m2}}{2} = -2261 \cdot 96 + 387.5 \cdot 41.6 = -210Nm$$

## Gorizantal tekislikda

$$\sum M_A = 0 \quad -R_B^H l + F_{t2} \cdot l_1 + F_{t1} (l + l_2) = 0$$

$$R_B^H = \frac{F_{t2} \cdot l_1 + F_{t1} (l + l_2)}{l} = \frac{2477 \cdot 65 + 6270 \cdot 226}{130} = 13208.5N$$

$$\sum M_B = 0 \quad R_A^H l - F_{t2} \cdot l_1 + F_{t1} \cdot l_2 = 0$$

$$R_A^H = \frac{F_{t2} \cdot l_1 - F_{t1} \cdot l_2}{l} = \frac{2477 \cdot 65 - 6270 \cdot 96}{130} = -4461.5N$$

$$R_A^H + R_B^H - F_{t1} - F_{t2} = 0$$

Tekshirish:  $13208.5 - 4461.5 - 2477 - 6270 = 0$   
 $0 = 0$

1-uchastka  $0 \leq x_1 \leq l_1$

$$M_{x_1} = R_A^r \cdot x_1 \quad x_1 = 0 \quad M_{x_1} = 0$$

$$x_1 = 65mm \quad M_{x_1} = -245.4Nm$$

2-uchastka  $0 \leq x_2 \leq l_2$

$$M_{x_2} = -F_{t1} \cdot x_2 \quad x_2 = 0 \quad M_{x_2} = 0$$

$$x_2 = 96mm \quad M_{x_2} = -627Nm$$

Umumiy reaksiya kuchi

$$R_A = \sqrt{(R_A^H)^2 + (R_A^V)^2} = \sqrt{(-4461.5)^2 + (-1454)^2} = 4692N$$

$$R_B = \sqrt{(R_B^r)^2 + (R_B^v)^2} = \sqrt{13208.5^2 + 4625^2} = 13994.8N$$

Eng katta eguvchi momentni aniqlaymiz

$$M_{eg,max} = \sqrt{(M_{V-V})^2 + (M_{r-r})^2} = \sqrt{(-210)^2 + (-627)^2} = 661.2Nm$$

**Tanlangan podshipnik uchun  $C_x$  hisobiy qiymatini aniqlash.**

$$N_0 = 36210$$

$$R_B = 13994.8N, \omega_2 = 30.4 \frac{rad}{s}$$

$$d = 50mm \quad C_0 = 27.0kN \quad C_r = 43.2N$$

$$F_{a1} = 387.5N, R_A = 4692N$$

$$\frac{F_a}{C_0} = \frac{387.5}{27000} = 0.014 \text{ bunda } e = 0.19 \text{ ga teng. (A1. 4.5.1-jadval)}$$

$$X=0.56, \quad Y=2.30 \text{ ga teng. (A1. 4.5.1-jadval)}$$

1. Radial kuchlar ta'sirida hosil bo'lgan bo'ylama kuchlarning qo'shimcha qiymati

$$F_{SA} = 0.83eR_{rA} = 0.83 \cdot 0.19 \cdot 4692 = 740N$$

$$F_{SB} = 0.83eR_{rB} = 0.83 \cdot 0.19 \cdot 13994 = 2207N$$

2. Bo'ylama kuchlarning umumlashgan qiymati.

$$\sum X = 0 \quad -F_{aA} + F_{aB} - F_a = 0$$

$F_{SA} = F_{SB} = 2207N$  qabul qilamiz. Natijada

$$F_{aA} = F_{aB} + F_a = 2207 - 387.5 = 1819.5N > F_{SA} \text{ shart bajarildi.}$$

3. Tayanchlarga ta'sir qiluvchi ekvivalent qiymatini aniqlaymiz.

A tayanch uchun

$$R_{ekv} = (XVR_{rA} + YF_{aA})K_1 \cdot K_2$$

$$R_A = P_r = 4692N$$

$$P_a = F_a = 1271N$$

$$K_1 = 1.2$$

$$K_2 = 1.0$$

$$\frac{P_a}{C_0} = \frac{1271}{98 \cdot 10^3} = 0.0129 \quad l = 0.19$$

$$\frac{P_a}{F_r} = \frac{1271}{2980} = 0.42 > l$$

$$P_{ekv} = (xVP_r + yVP_a)K_1 \cdot K_2 = 4692 \cdot 1 \cdot 1.2 = 5448N$$

Podshipnikni ishlash muddatini hisoblaymiz (soat hisobida)

$$L_x = \left( \frac{C_r}{P_{ekv}} \right)^3 = \left( \frac{119 \cdot 10^3}{5448} \right)^3 = 104173 \text{ mil. aylanishlar soni}$$

$$L_h = \frac{L_x \cdot 10^6}{n_1 \cdot 60} = \frac{5448 \cdot 10^6}{74.05 \cdot 60} = 1.22 \cdot 10^6 \text{ soat}$$

### Vallarning xavfsizlik koeffitsienti

Vallarning eng xavfli kesimining xavfsizlik koeffitsientini aniqlashda egilishdagi kuchlanish simmertik holatda burovchi moment pulsatsiyalanuvchi siklda o'zgaradi deb qabul qilingan

#### 1. Val uchun material tanlaymiz

Stal 45

## 2. Termik ishlovni normalash

$$\sigma_B = 570N / mm^2$$

Chidamlilik chegarasi normal kuchlanish

$$\delta_1 = (0.4 \div 0.45)\delta_B = 0.43 \cdot \delta_B = 0.43 \cdot 570 = 246N / mm^2$$

Urinma kuchlanish bo'yicha

$$\tau_1 = 0.58 \cdot \delta_1 = 0.58 \cdot 246 = 142N / mm^2$$

## 3. Mustahkamlik zonasi

$$S = \frac{S_\delta \cdot S_\tau}{\sqrt{S_\delta^2 + S_\tau^2}} = 2 \div 2.5 = [\tau]$$

Normal kuch bo'lsa zona

$$S_\delta = \frac{\delta_{-1}}{\frac{K\delta}{E\delta} \cdot \delta_a + \psi_\delta \cdot \delta_m} \quad S_\tau = \frac{\tau_{-1}}{\frac{K\tau}{E\tau} \cdot \tau_a + \psi_\tau \cdot \tau_m}$$

$$K\delta = 1.59$$

$$K\tau = 1.49 \quad (\text{A1. 4.5.2-jadval})$$

$E\delta, E\tau$  -masshtab koeffisienti

$$E\delta = 0.77$$

$$E\tau = 0.67 \quad (\text{A1.4.5.1-jadval})$$

$\psi_\delta, \psi_\tau$  -sezgirlik koeffisienti

$$\psi_\delta = 0.15$$

$$\psi_\tau = 0.1 \quad (\text{A1. 4.5.3-jadval})$$

$$\delta_a = \delta_{\max} = \frac{M_{eg.\max}}{W_x} = \frac{51 \cdot 10^3}{7777.5} = 6.55$$

$$W_x = 0.1 \cdot d^3 - \frac{b_{sh} \cdot t_1 (d^3 - t_1^2)}{2d} = 0.1 \cdot 45^3 - \frac{14 \cdot 5.5 (45 - 5.5)^2}{2 \cdot 45} = 7777.5 mm^3$$

$$\tau_a = \tau_m = \frac{\tau_{\max}}{2} = \frac{T_2}{2 \cdot W_p} = \frac{263.09 \cdot 10^3}{2 \cdot 16890} = 7.7$$

$$W_p = 0.2 \cdot d^3 - \frac{b_{sh} \cdot t_1 (d^3 - t_1^2)}{2d} = 0.2 \cdot 45^3 - \frac{14 \cdot 5.5 (45^3 - 5.5^2)}{2 \cdot 45} =$$

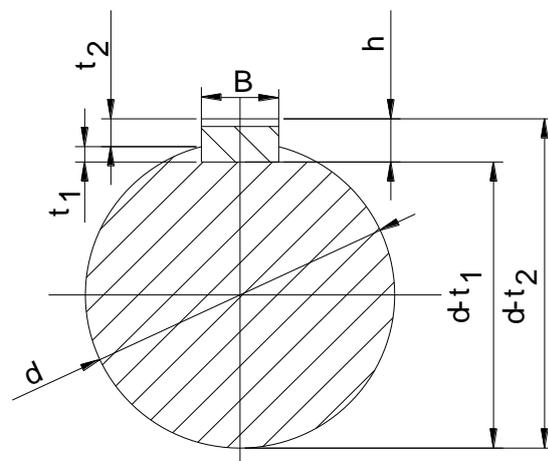
$$= 18225 - 1335 = 16890 \text{ mm}^3$$

$$S_\delta = \frac{\delta_1}{\left( \frac{K_\sigma}{\varepsilon_\sigma} \delta_a + \psi_\sigma \delta_m \right)} = \frac{246}{\frac{1.59}{0.77} \cdot 6.55 + 0} = 18.2$$

$$S_\tau = \frac{\tau_1}{\left( \frac{K_\tau}{\varepsilon_\tau} \delta_a + \psi_\tau \tau_m \right)} = \frac{142}{\frac{1.49}{0.67} \cdot 7.7 + 0.1 \cdot 7.7} = 16.8$$

$$S = \frac{18.2 \cdot 16.8}{\sqrt{18.2^2 + 16.8^2}} = \frac{305.76}{24.76} = 12 \geq 2 \div 2.5$$

### Shponka tanlash



$$T_3 = 1563 \text{ Nm} \quad d = 80 \text{ mm} \quad l = 90 \text{ mm} \quad t_1 = 7.5 \text{ mm} \quad h = 18 \text{ mm}$$

$$b = 22 \text{ mm}$$

$$\delta_{ez} = \frac{2 \cdot T_2}{d(l-b)(h-t_1)} = \frac{2 \cdot 1563 \cdot 10^3}{80(90-22)(18-7.5)} = 27 \text{MPa} \leq [\delta_{ez}] = 100 \div 120 \text{MPa}$$

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