Department of Vehicles and Fundament of Machine Design

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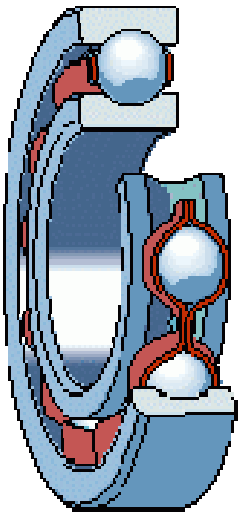
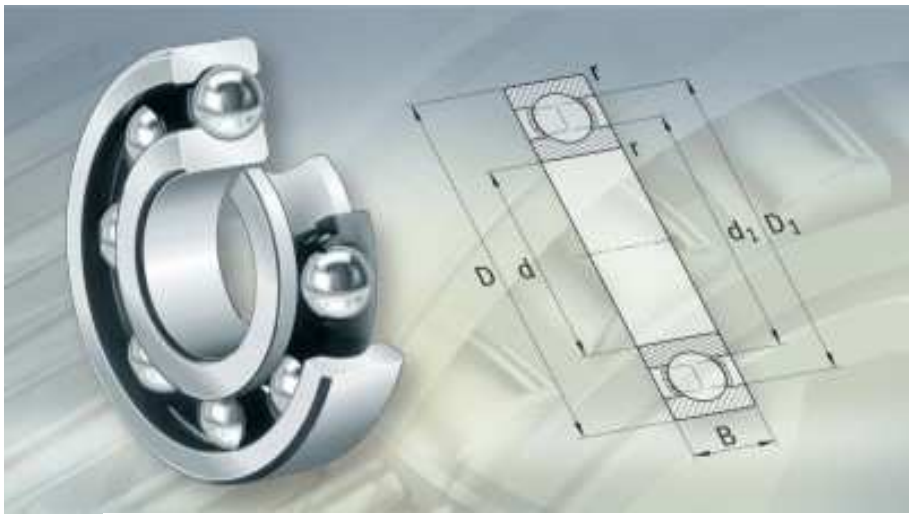
Üherealised radiaalkuullaagrid SKF

Deep groove ball bearings

single row

1. Joonis. View





2. Rakendus. Application

- radial load with possibility of low axial load. kasutatakse radiaal- ja väikse telgkoormuse korral.
- short rigid shafts. lühikesed jäigad võllid.
- high rotation speeds. võib kasutada küllalt kõrgete pöörlemissageduste juures.
- lowest friction among bearings. kõige väiksemad hõõrdetegurid veerelaagrite hulgas.
- low ability to angle swing.
- with seals unnecessary supervision. tihenditega pole vaja pidevalt laagri tööd kontrollida.

3. Laagri tähistus. Ball bearings signs

laagri seeria — bearing series

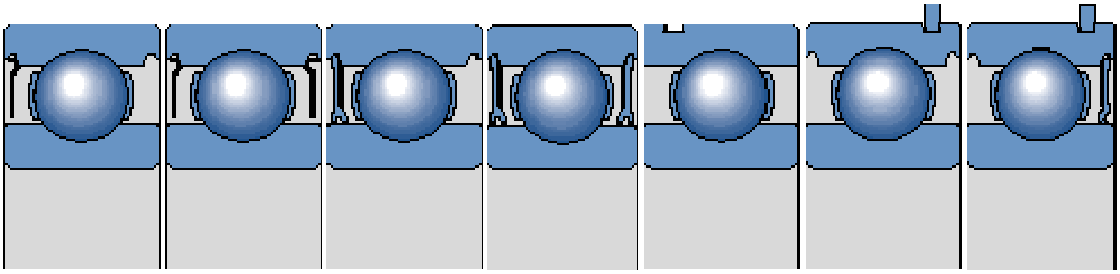
laagri siseläbimõõt d = 06x5 = 30 [mm] — bearing inner diameter- d= 06x5=30 [mm]

6 2 0 6

laagri tüüp. — kind of bearing

läbimõõdu või laiuse seeria. 2 - läbimõõdu kerge seeria. — diameter kind 2 – light

4. Raadiaalkuullaagrite konstruktsioone. Kinds of construction



RS 2RS Z ZZ N NR ZNR

RS - kontakttihendseib laagri ühel küljel. seal on one side.
2RS - kontakttihendseib laagri mõlemal küljel. seal on both sides.
Z - kaitseseib laagri ühel küljel (plastik või metall). shield on one side.
ZZ - kaitseseib laagri mõlemal küljel. shield both sides.
N - vedrurõnga soonega, ilma tihenditeta. with a snap ring groove, unsealed.
NR - vedrurõnga soovega ja tinedsoonega (ilma tihendita). with a snap ring groove, unsealed
ZNR - vedrurõnga soone ja ühe kaitserõngaga. with a snap ring groove, shield on one side.

5. Laagri valiku metoodika. Theoretical basis

Suurim koormus, mida laager on võimeline taluma ilma, et üksi tema detail plastselt deformeeruks.

Laagri staatiline kandevõime. Static basic load rating C_0

Static basic load rating C_0 – static bearing load which work in nominal direction cause stress of Hertz σ_H =4200 MPa (value for ball bearing) between most loaded element and the race.

Suurim koormus, mida 90 %-le laagritele võib rakendada ilma, et laager 1 000 000 täispöörete vältel tõrguks.

Laagri dünaamiline kandevõime. Dynamic basic load rating C

Dynamic basic load rating C = bearing load under which 90% of bearing population reach durability 1 000 000 rotation.

1

6. Laagri tööea ehk ressursi arvututus. Life's calculation basis

Life's equation (Lundberg&Palmgren)

$$L = \left(\frac{C}{P}\right)^p$$ [mln. revolutions or – mln. cycles] [miljon pööret]

$$L_h = \frac{10^6}{60 * n}\left(\frac{C}{P}\right)^p$$ [hrs] [tundi]

C – dynamic basic load rating [N]. dünaamiline kandevõime.
P- equivalent bearing load [N]. taandatud koormus.
p – exponent factor (p=3 for ball bearings). astmenäitaja, kuullaagritele p=3.
n – rotational speed [rpm]. pöörlemissagedus [1/min].

Laagri taandatud dünaamiline koormus. **Equivalent bearing load**

$$\boldsymbol{P = XF_r + Y\mathrm{F_a}} \quad [\mathrm{N}]$$

F_r – laagrile mõjuv radiaalkoormus. radial load
F_a –laagrile mõjuv telgkoormus. axial load
X – laagri radiaalkoormuse tegur. radial load factor
Y – laagri telgkoormuse tegur. axial load factor

Laagri radiaal ja telgkoormuse tegurid X ja Y. Values of X and Y factor

	relative axial load	e	if $\mathbf{F_a/F_r \leq e}$		if $\mathbf{F_a/F_r > e}$	
	$\mathbf{F_a/C_0}$		X	Y	X	Y
Deep groove ball bearing, single row, normal clearance	0,014	0,19	1	0	0,56	2,30
	0,028	0,22				1,99
	0,056	0,26				1,71
	0,084	0,28				1,55
	0,110	0,30				1,45
	0,170	0,34				1,31
	0,280	0,38				1,15
	0,420	0,42				1,04
	0,520	0,44				1,00

Table 1. Laagri radiaal ja telgkoormuse tegurid X ja Y. Values of X and Y factors

Laagrite radiaal ja telgkoormuse tegurite X ja Y arvutus. **Procedure of X and Y factor value calculation**

- find value of C (dynamic load) and C_0 (static load) for given bearing. Leia C ja Co väärtused. (Those data contains bearings catalogue f.e. http://www.skf.com/portal/skf/home/products?maincatalogue=1&newlink=first&lang=en)
- calculate value F_a/C_0 . Arvuta Fa/Co suhe.
- from table 1. read value of “e” factor. Leia tabelist 1. faktori "e" väärtus.
- calculate value F_a/F_r . Arvuta Fa/Fr suhe.
- read value of X and Y factor from table 1.checking if value $F_a/F_r \leq e$ or $F_a/F_r > e$. Kui Fa/Fr < = e, siis X = 1 ja Y = 0. Kui Fa/Fr > e, siis X ja Y tegurite väärtused valitakse vastavalt tabelis 1. toodud väärtustele.

Efektiivne dünaamiline kandevõime. Effective dynamic load C_e

$$C_e = C * f_t$$

f_t – temperatuuritegur. temperature factor

Work temperature [°C]	f_t factor value
150	1.00
200	0.90
250	0.75
300	0.60

Table 2. Temperatuuritegur. Temperature factor f_t

Efektiivne taandatud koormus. Effective equivalent load

$$P_e = P * f_d$$

f_d – dünaamilise koormuse tegur. dynamic load factor

Machine work condition. Koormuse tüüp	f_d
Smooth, without strokes. Rahulik	1
Smooth with possibility overloading to 25%, light shocks. Ülekoormus 25%.	1-1,2
Normal work condition, possibility overloading to 50%, shocks and strokes	1,2-1,8
Work with big load. Rasked koormused.	1,8-2,5
Hard work, big shocks and strokes.Löökkoorm	2,5-3,5

Table 3. Dünaamilise koormuse tegur. Dynamic load factor f_d

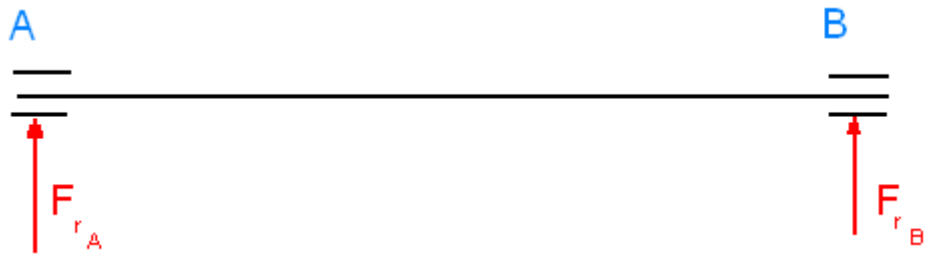
Efektiivne laagri tööiga. Effective life

$$L_e = \left(\frac{C_e}{P_e}\right)^p \quad \text{[mln. revolutions or Mc]}$$

$$L_{he} = \frac{10^6}{60*n}\left(\frac{C_e}{P_e}\right)^p \quad \text{[h]}$$

7. Example 1.

Shaft load sketch



Data

A and B bearings – 6406
F_{rA} =5000 N
F_{rB} =3000 N
F_a =0
n= 1500 1/min
Bearing temperature 150^0 C
Possible overload 25% - ülekoormus 25%.

Calculation

From bearings catalogue
(http://www.skf.com/skf/productcatalogue/jsp/viewers/productTableViewer.jsp?&lang=en&newlink=1&tableName=1_1_1&presentationType=3&startnum=15)

Deep groove ball bearings, single row

SKF

Principal dimensions			Basic load ratings		Fatigue load limit	Speed ratings		Mass	Designation	
			dynamic	static		Reference speed	Limiting speed			
d	D	B	C	C_0	P_u					
mm			kN		kN	r/min		kg	-	
30	62	16	20,3	11,2	0,475	-	7000	0,20	6206-RSI *	
30	62	16	20,3	11,2	0,475	24000	15000	0,20	6206-RZ *	
30	62	16	20,3	11,2	0,475	24000	15000	0,20	6206-Z *	
30	62	20	19,5	11,2	0,475	-	7500	0,24	62206-2RS1	
30	72	19	29,6	16	0,67	20000	13000	0,35	6306 *	
30	72	19	32,5	17,3	0,735	22000	14000	0,33	6306 ETN9	
30	72	19	29,6	16	0,67	-	6300	0,35	6306-2RS1 *	
30	72	19	29,6	16	0,67	20000	11000	0,36	6306 2RZ *	
30	72	19	29,6	16	0,67	20000	11000	0,36	6306 2Z *	
30	72	19	29,6	16	0,67	-	6300	0,35	6306-RSI *	
30	72	19	29,6	16	0,67	20000	13000	0,35	6306-RZ *	
30	72	19	29,6	16	0,67	20000	13000	0,35	6306-Z *	
30	72	27	28,1	16	0,67	-	6300	0,48	62306-2RS1	
30	90	23	43,6	23,6	1	18000	11000	0,74	6406	
31,75	69,85	17,462	22,5	13,2	0,55	20000	14000	0,30	RLS 10	Aftermarket only
31,75	69,85	17,462	22,5	13,2	0,55	-	7000	0,30	RLS 10-2RS1	Aftermarket only
31,75	69,00	17,462	22,0	13,2	0,00	20000	10000	0,30	RLS 10-2Z	Aftermarket only
31,75	79,375	22,225	33,2	19	0,815	17000	12000	0,50	RMS 10	Aftermarket only
34,925	76,2	17,462	27	15,6	0,655	16000	13000	0,35	RLS 11	Aftermarket only
34,925	88,9	22,225	41	24	1,02	15000	11000	0,63	RMS 11	Aftermarket only
35	47	7	4,75	3,2	0,166	28000	18000	0,030	61807	
35	47	7	4,75	3,2	0,166	-	8000	0,030	61807-2RS1	
35	47	7	4,75	3,2	0,166	28000	14000	0,030	61807-2RZ	
35	55	10	9,56	6,8	0,29	26000	16000	0,060	61907	
35	55	10	9,56	6,8	0,29	-	7500	0,060	61907-2RS1	

C=43600 N, C_0 =23600 N

Because F_a =0

A- bearing equivalent load equals

$P_A = F_{rA}$ = 5000 N

B-bearing equivalent load equals

$P_B = F_{rB}$ =3000 N

From table 3.

f_d =1,2

Effective equivalent load of A bearing

$P_{eA}=P_A*f_d$ =5000*1,2= 6000 N

Effective equivalent load of B bearing

$P_{eB}=P_B*f_d$ =3000*1,2= 3600 N

From table 2.

f_t =1

Effective dynamic load

$C_{eA} = C_{eB} = C_e = C*f_t$ = 43600*1=43600

Bearing A effective life

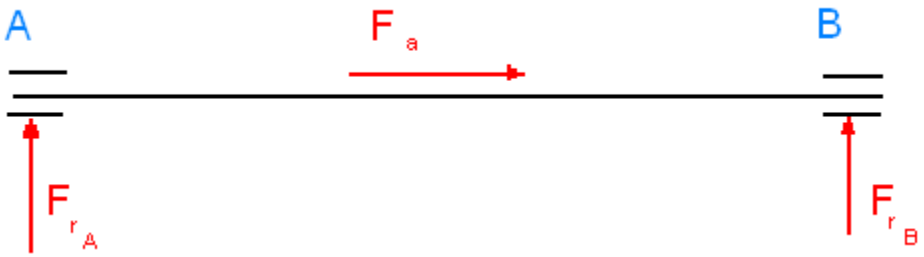
$$L_{ehA} = \frac{10^6}{60 * n}\left(\frac{C_{eA}}{P_{eA}}\right)^p = \frac{10^6}{60 * 1500}\left(\frac{43600}{\cancel{5000}\ 6000}\right)^3 = 4263,5\ [h]$$

Bearing B effective life

$$L_{ehB} = \frac{10^6}{60 * n}\left(\frac{C_{eB}}{P_{eB}}\right)^p = \frac{10^6}{60 * 1500}\left(\frac{43600}{3600}\right)^3 = 19738,3\ [h]$$

8. Example 2.

Shaft load sketch



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F_a =1000 N
n= 1500 1/min
Bearing temperature 150^0 C
Possible overload 25% - ülekoormus 25%.

Calculation

From bearings catalogue

C=43600 N, C_0 =23600 N

A Bearing

F_{aA}=0

Relative axial load $\mathbf{F_a/C_0}$

$$\frac{F_{aA}}{C_{0A}} = \frac{0}{23600} = 0 \qquad \Longrightarrow \qquad e = 0$$

X_A =1, Y_A =0

Bearing A equivalent load equals

$P_A = F_{rA}$ = 5000 N

Bearing B

$F_{aB} = F_a$=1000 N

Relative axial load $\mathbf{F_a/C_0}$

$$\frac{F_{aB}}{C_{0B}} = \frac{1000}{23600} = 0{,}042$$

From table 1.

e = 0,24

$$\frac{F_{aB}}{F_{rB}} = \frac{1000}{3000} = 0{,}3$$

$$\frac{F_{aB}}{F_{rB}} = \frac{1000}{3000} = 0{,}3 > e = 0{,}24$$

X_B =0,56, Y_B =1,85

Bearing B equivalent load

$$P_B = X_B F_{rB} + Y_B \mathrm{F_{aB}} = 1 * 3000 + 0{,}56 * 1000 = 3560 \text{ N}$$

From table 3.

f_d =1,2

Effective equivalent load of A bearing

$P_{eA}=P_A*f_d$ =5000*1,2= 6000 N

Effective equivalent load of B bearing

$P_{eB}=P_B*f_d$ =3560*1,2= 4272 N

From table 2.

f_t =1

Effective dynamic basic load rating

C_{eA} =C_{eB} = $C_e=C*f_t$ = 43600*1=43600

A Bearing effective life

$$\boldsymbol{L_{ehA} = \frac{10^6}{60 * n}\left(\frac{C_{eA}}{P_{eA}}\right)^p = \frac{10^6}{60 * 1500}\left(\frac{43600}{\cancel{5000}\ 6000}\right)^3 = 4263{,}5\ [h]}$$

B Bearing effective life

$$\boldsymbol{L_{ehB} = \frac{10^6}{60 * n}\left(\frac{C_{eB}}{P_{eB}}\right)^p = \frac{10^6}{60 * 1500}\left(\frac{43600}{4272}\right)^3 = 11812[h]}$$