International
Journal
Of Advanced Research in Engineering & Management (IJAREM)

Analysis of technical and financial systems to improve function of repairs and maintenance systemand reduce costs of organization

MarjanMohammadjafari[1]a,Mohammad javadkeshavarz[2]b, Mehdi zarepour[2]c

[a]Department of Industrial Engineering, Kerman branch, Islamic Azad University, kerman, Iran
[b]Ms.C. student, Department of Industrial Engineering, Kerman branch, Islamic Azad University, kerman, Iran
[c]Ms.C. student, Department of Industrial Engineering, Kerman branch, Islamic Azad University, kerman, Iran

ABSTRACT: The purpose of this paper is to identify the reasons for the high costs of the organization and analysis of the root causes of the mentioned reasons.The most cost of equipment is due to repaire and maintenance costs which areconsisting of personnel costs and consumable parts. This obligatory cost is considered as the one of high costs imposed to the industry. If it is possible to control and manage this part of the expenses, we would be able to reducethe large volumes of plant costs.In other words, efficient maintenance can greatlyhelpto this important matter with reducing stoppages and failures,also reduces industry cost.By analyzing financial indicators related to repaire and maintenance costs,analysis of the possible reasons can identify the reasons why some of the parameters increase.trying to remove them reduces maintenance and repairs costs.In this study, the repaire and maintenance cost of production is discussed.Then this index is calculated for the different departmentsand costly departments are identified.After thatthe reasons of high repairs and maintenance cost are discussed in the aforementioned departments.The high cost of the parts in those departmentsis recognized as one of the main reasons, then the group of commonlyconsumed parts will bediscussed. Finally,the root causes of failures of the components isdetected.At last the results and recommendations are presented to reduce downtime pieces and the cost of the organization.

Keywords: RCFA,Golgoharcompany,Bearing,SKF company, Electro motor, repairs and maintenance

1- Introduction

In the industrial world, the industry and the economy are intertwined with each other more than ever.So that today any industrial unit, regardless of the level of technolog, process and product breadth is viewed as a ((enterprise)) . ((Interest rate)) that returns to its shareholders, it is considered the most important indicator of the success or failure of the organization.

It Should be possible to reduce costs and increase profit organization.Therefore, efficient maintenance can greatly helps to this important case with reducing stoppages and failures and reducing industry cost.In Industrial Engineering as well as the gradual integration of a variety of science, mathematics , probability and statistics , management science and engineering principles of economy and infrastructureareconsidered as a system of Industrial Engineering. The Industrial Engineering unit can estimate the cost of the industry and efforts to reduce them[1].Simultaneous evaluation of technical and financial indicators with clear and accurate illustration of the process makes it possible rather than relying on the mind and imagination, based on documentary and accurate information to analyze maintenance and repairesystem.So about 3 years ago, we began the project inGolgoharmining and industrial Co.To study the technical and financial systems create structures that can be on the basis ofcreatinguseful information for analyzing system performance of maintenance and repairs system.

In this study , maintenance and repairs cost is comparedwith the production cost, then factors affecting on the increasing share of repairs and maintenance cost on the production costsis analyzed. The following is a review of the most important consumer goods and proposals for reducing the use of expensive goods offered.Thenexamines the reasons for the failure using RCFA on the use of a group of expensive goods will be discussed.Finally, the conclusions of this paper will be discussed.

2- Applied cost reduction method

2-1- Cost analysis

Comparison of repairs and maintenance costs with the production cost

Repairs and maintenance costs compared to the cost of production

The ratio of Repairs and maintenance expense to production cost is anindex that simply shows repairs and maintenanceplace on the production costs of a manufacturing unit.In the international sources of repairs and maintenance, the index is defined and the optimal level is between 10 and 15 percent.Inthe standard definition,repaires and maintenance costs include the costs of parts and consumables, all personnel costs such as salaries and benefits associated with the maintenance staff, contractors and outsourcing in the field of maintenance and repair.

Statistics show that in 1392,the ratio of net expense to production cost was 13% in the Golgohar company. So we can say this is in the permissible range (between 10 and 15 percent) and can be said that the total cost of maintenance is in good condition but if we examine the different parts separatelyit' s specified the number of units produced are less than the allowable number and number of unitshave costs more that allowable level.it' sneeded to analyze the factors affecting Repairs and maintenance cost of the units to identify and reduce the costs as possible.so that in future with reducing the net costs in production costs, we can go further in promoting the interests of our organization.

Analysis of factors affecting increasing share ofRepairs and maintenance cost on the production costs

Now, according to the diagram and determining departments that their repairs and maintenance cost to the production cost are larger(fig.1).

the question is : what factors lead to increased maintenance costs in 2000 and 3000 departments ?

The cost of mechanical repairs in the departments of 2000 and 3000

Studies show that about 52 percent of the cost of repairs in 92 year in the department of mechanical parts is related to consumble parts and 48% is related to personnel costs(fig.2).

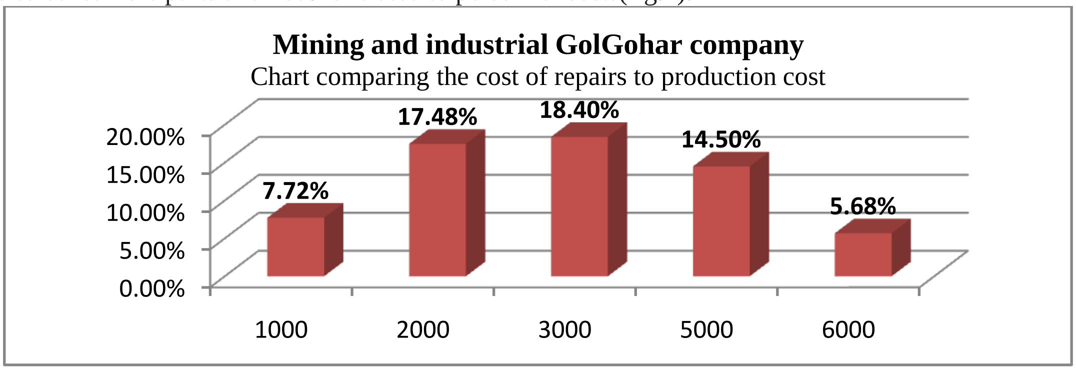


Fig.1

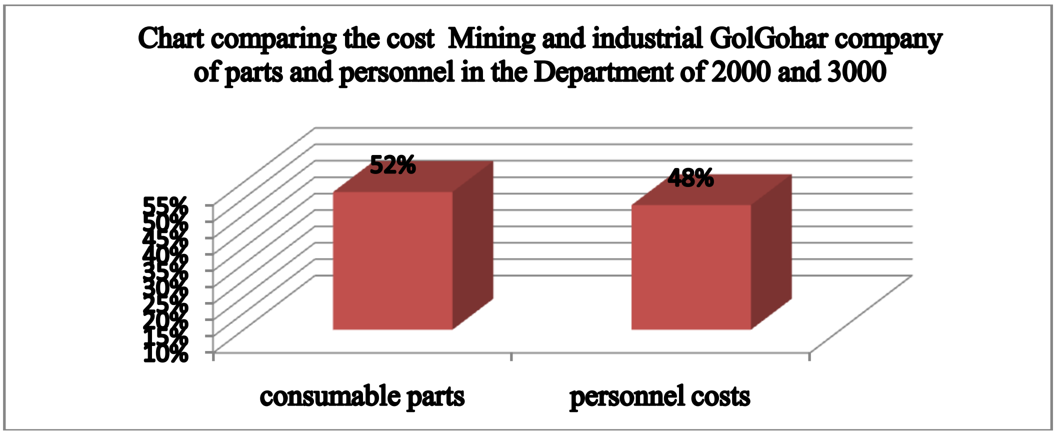


Fig.2

Basically, in the analysis of maintenance and repair the higher the share of the cost of parts used to personnel costs show depreciation of the perceived weakness of preventive maintenance although commodity prices and inflation could be effect this indicator.
In world industry, the share of parts cost in thetotal maintenance costs is 40 %, while in our industry, this indicator is about 70 % .Generally, in an ideal net system,the parts cost reduction process compared to personnel costsin considerd desirable.
On the other hand, the index given in the 1000 department approximately 29%, so to speak, inflation and prices can not be a major factor in the higher cost of parts used in 2000 and 3000 department.
It should be the main reason in ((high depreciation)) or ((weak preventive maintenance)) searched.
On the other hand, the average availability of 92 year in the 2000 department is 97% and in the 3000 department is 95 %. So the unscheduled stoppages mechanically in 92 year is good condition and weakness in the preventive maintenance program can not result in increasing the cost of parts.
To allowmore accurate assessment of the causes of the increase in the cost of parts used in these two departments,it is necessary in the next sections to look at the kind of consumable goods at these two departments.

Review of the most important consumable goods
According to the chart below(Fig.3), we can see that the most widely used goods group related to Maintenance Unit include:

The mechanical unit :
1- Casting products ,Corrosio
2- lubricants
3- Bearings and gears

AC unit :
1- lubricants
2- Electrical items (due to coding problem may not provide a breakdown of the group)
3-Electro motor

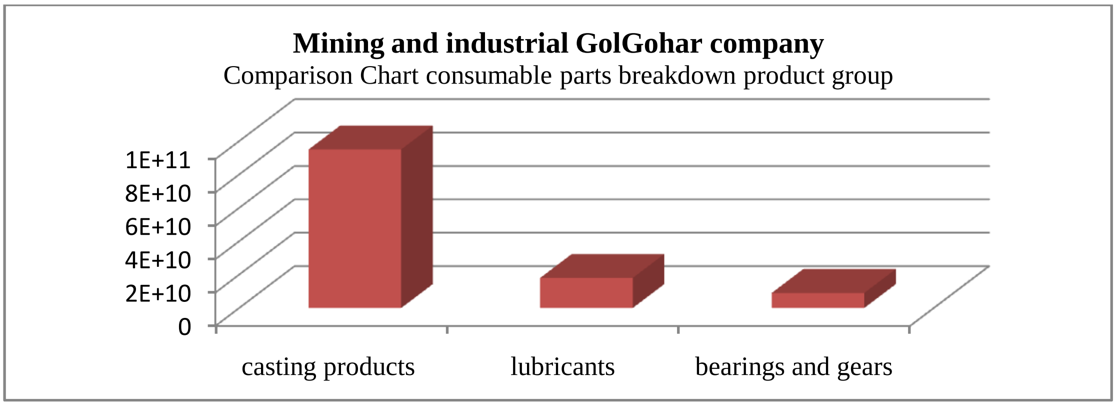


Fig.3

Cost of casting parts, including pellet and mill liners involved, a high share of the repairs and maintenance costs but according to national and international patterns,this cost inherent in the process and is considered acceptable.The credibility in this area has no authority to stop a process that can be conducive to further reduce costs.

Use of lubricants
Despite the decline in lubricant consumption per ton of product unfortunately in some machinery lubricant consumption exceeds plannedlevel that following strategies are given:
1-Oil Condition Monitoring and Analysis

2- Review the types of lubricants
3-Used oil filtration
In situations where the oil can not be used due to pollution and other parameters is suitable we can play an important role in reducing waste and costs by filtration and reuse.

Bearings and accessories
In 92year bearings with a cost of about one billion dollars were the mostlyconsumed items in the complex maintenance and repair in the factory.In situations where according to international standards for a gearbox , electric , fan or compressor over 20 thousand hours of operation at normal conditions is estimated,it seems that you can still take steps to extend the life of the bearing and improve conditions in the area.
According to research conducted by SKF in 20 years , the reason of short life of the bearing is in the following categories :
1- Lubrication 36 %
2- Fatigue 34 %
3- Improper installation of 16 %
4- Entry of pollution by 14%
However, in certain circumstances because of the widespread presence of poor bearings our country had, a large share of damage caused by the use of low-grade.Fortunately,by effective supervision and control of the factory, we apply this factor under control. Yet however, according to international research, improved lubrication conditions can have a significant impact on bearing life.It is recommended to use the automatic lubrication of modern methods of lubrication in the lubrication of bearings and conveyor belts, fans, and electric use
The advantages of using this approach are
1- Ensuring the lubrication, especially in remote areas
2- Gradual injection of grease and avoid unwanted temperature rise in the bearings and related problems.
3- Prevent the entry of contaminants into the bearing.
4- Dramatic reduction in the time required for lubrication
The precision of the bearing assembly is also an issue that is obvious forany oneand education and the provision of special tools, etc., can be very useful.Then, regarding to substantial share of the cost of bearing in net cost, departments of the 2000 and 3000 conducted studies on a sample of broken bearing.
The results are given below using the root causes of failure analysis RCFA.

2-2- Root cause analysis
Whatis RCFA ?

Measures to find and correct the cause of the failure causes done to avoid repetition.
Investigate the causes of bearing failure in Electric Motor of Fan

The root causes of the occurrence of failures is an undeniable necessity of analysis, related to maintenance and repair. The main objective of root analysis of failuresonly is not to find the culprit, but the basic approach to determine the root causes and factors likely to find ways to avoid their repetition.The main objective of this research and what will be paid in the following include: finding the root causes of failure in electro- bearing fan motor shaft, and a way to avoid their iteration in similar cases.It should be noted that due to the multiplicity of sources and references in this field by reputable manufacturers and scientific authorities around the world have been developing and all used the principles of common scientific and technical calculations and drafting of guidelines.according to the following reasons we study the technical documentation SKF, study and the conclusions we have put them[2] :
1. In general associated with the bearing, SKF technical documentation is generally accepted in the scientific and technical fields.
2. Bearing SKF product has been damaged and it is evident that according to the manufacturer's recommendations and specific guidelines they are necessary.

The problem:
The bearing of rear electric fan shaft after 20,000 hours of operation , due to the unusual sound was sent to a workshop in Tehran to investigate the cause.After inspecting the equipment it was found that the cage bearing the rear electro motor is broken. Bearing used in the rear electric motors is roller

bearing with a technical issue NU 238 MA/C 3.MA term is this technical number indicates that material of cage is brass and the cage isepicenter tobearingouter.The main causes of bearing failure are shown in Fig.4. According to the available information and the type of damage (damage to the cage) , the number one and three in the charts are required in study.

Fit the bearing operating conditions and applications

One of the common causes of bearing failure is to use them in inappropriate circumstances. In other words improper use can cause an injury to bearing. To select the correct bearing, various parameters should be noted such as: The forces acting on the bearing, rotational speed, lubrication method and are considered Usually bearing manufacturers catalog is a complete description of the case.So the first thing that should be considered is bearing in proportion to the type of application and working, conditions. In this section, we have to answer the question: is the bearing used in the rear electric fan optimal with regard to correct working?

Before starting the discussion, it is necessary to briefly introduce some parameters.Speedparameter(ratespeed)A:

Oneof the important features is speed parameter.To determine the manner and according to the rotational speed and the size of the bearing lubrication interval is used. This parameter defined as follows

A= n*dm

A: speed factor mm per minute

n: rotational speed in rpm

dm: diameter bearing the following

dm = 0.5 (D + d)

The bearing shaft for the rear electric fan

d = 190 mm , D = 340 mm → dm = 265 mm

n = 990 rpm → A = 262,350 mm/min

So what was calculated, factor A for bearing the rear electric fan 262,350 mm / min is obtained. SKF application cylindrical bearings, that their cage is the same center with outer ring,First, for those who use the grease lubrication is normally not suitable.Secondly, the emphasis the bearing where the speed parameter is greater than 250,000 mm / min should not to be used. (Appendix 1 and 2).According to the clear suggestion of SKF and calculated speed for bearing the rear electric fan is 262,350 mm / min to say, application cylindrical bearing with MA cage in the rear Electric motor fan with respect to the cage type, size, speed, time and type of lubricant, is not a good choice.

Check the lubrication

Re- lubrication period **tf** for bearing on horizontal shaft and the inner ring circulate under natural conditions as a function of the speed parameter A, the bearing factor bf ratio C/P is determined using the following formula:

tf = n * dm * bf = A* bf

Refer to the table (Appendix 3)

Referring to the diagram (Appendix 4)

bf = 1.5 → tf≅ 3200 hr

So, considering the size, rotational speed and load on the bearing, the minimum interval for bearing lubrication rear electro motor fan will be 3200 hours. Lubrication of the application of this method can be obtained for the temperature 70 C ° and lithium grease with mineral base oil and good quality too.

On the other hand, refering to the instructions SKF (Appendix 5) it is observedthat SKF is expressly pointed out that when the bearing is used in a cylindrical,It is also central to the outer ring and the cage should be lubrication interval obtained according to by the method half.The appropriate interval corrected to lubricate the bearing electro- motor rear fan would be about 1600 hours. The interval of 3000 hours for bearing lubrication the bearing electro- motor rear fan, has led to inadequate lubrication.

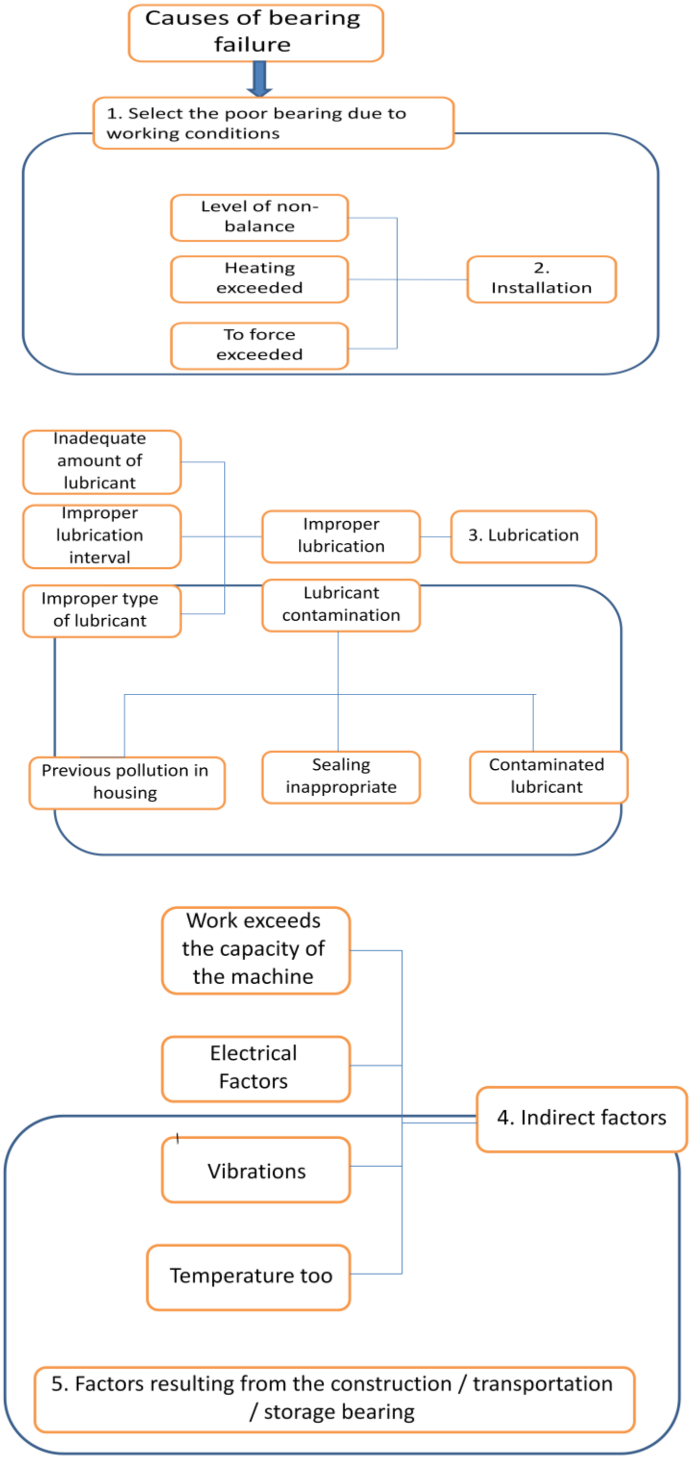

Causes of bearing failure
1. Select the poor bearing due to working conditions
Level of non-balance
Heating exceeded
To force exceeded
2. Installation
Inadequate amount of lubricant
Improper lubrication interval
Improper type of lubricant
Improper lubrication
3. Lubrication
Lubricant contamination
Previous pollution in housing
Sealing inappropriate
Contaminated lubricant
Work exceeds the capacity of the machine
Electrical Factors
4. Indirect factors
Vibrations
Temperature too
5. Factors resulting from the construction / transportation / storage bearing

Fig.4

Appropriate amount of lubricant

Appropriate amount of fresh grease (for injection from the side of the bearing) can be obtained from the following equation :

Gp = 0.005 * D * B

In which:

Gp : amount of fresh grease should be added in grams .

D : Bearing outside diameter in mm

B : total width of the bearing (bearing the floor to gather height H) mm

To bearing electro- motor rear fan :

$Gp = 0.005 \times 340 \times 55 = 93.5$ gr

3- Conclusions

In this paperto reduce expensesof Gol e gohar company, costly departments are identified. After that the reasons of high repairs and maintenance cost are discussed. The high cost of the parts in those departments is recognized as one of the main reasons, then the group commonly consumed parts will be discussed. Finally, the root causes of failures of the bearing were detected. recommendations are the application for the MA Series cylindrical bearing rear fan electromotor desire by ABB is not a good choice. For this application, type M, and then the ML type options are much better.Set 3000 hour interval by ABB bearing lubrication interval is not good at all and must be corrected immediately.As shown, proper lubrication interval is 1600 hours. While using the Dial Set software of company SKF that hs used to determine lubrication intervals of bearings, the lubrication interval is 1600 h.The appropriate amount of grease to lubricate the bearing rear fan electromotor as shown is about 100 grams.

Appendix 1

1 Product information	2 Recommendations	3 Product data
Page 3	Page 16	Bearing data

Speed ratings

The limiting speed is determined by criteria that include the form stability and strength of the cage, lubrication of the cage guiding surfaces, centrifugal and gyratory forces acting on the rolling elements, precision etc.

The values listed in the product table are valid for the appropriate standard cage. To estimate the limiting speed for bearings with an alternative cage, table 4 provides the appropriate conversion factors.

Bearings with an outer ring centred brass cage are not particularly suited for grease lubrication. If grease lubricated, they should not be used at speeds higher than $n \times d_m = 250\ 000$ mm/min and the relubrication intervals should be shortened.

Detailed information on reference and limiting speeds can be found in the SKF General Catalogue or the SKF Interactive Engineering Catalogue, available on CD-ROM or online at www.skf.com.

Minimum load

In order to provide satisfactory operation, single row cylindrical roller bearings, like all ball and roller bearings, must always be subjected to a given minimum load, particularly if they are to operate at high speeds or are subjected to high accelerations or rapid changes in the direction of load. Under such conditions, the inertia forces of the rollers and cage, and the friction in the lubricant, can have a detrimental influence on the rolling conditions in the bearing arrangement and may cause damaging sliding movements to occur between the rollers and raceways.

The requisite minimum load to be applied to single row cylindrical roller bearings can be estimated using

$$F_{rm} = k_r \left(6 + \frac{4\,n}{n_r}\right)\left(\frac{d_m}{100}\right)^2$$

where

F_{rm} = minimum radial load, kN
k_r = minimum load factor (→ product table)
n = rotational speed, r/min
n_r = reference speed, r/min (→ product table)
d_m = bearing mean diameter = 0,5 (d + D), mm

When starting up at low temperatures or when the lubricant is highly viscous, even greater minimum loads may be required. The weight of the components supported by the bearing, together with external forces, generally exceeds the requisite minimum load. If this is not the case, the single row cylindrical roller bearing must be subjected to an additional radial load.

Table 4

Bearing with standard cage	alternative standard cage P, J, M, MR	MA, MB	ML, MP
P, J, M, MR	1	1,3	1,5
MA, MB	0,75	1	1,2
ML, MP	0,65	0,85	1

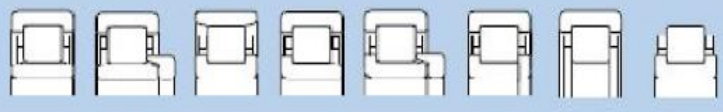
Conversion factors for limiting speeds

SKF 29

Appendix 2

Overview of the characteristics of the various standard designs of single row cylindrical roller bearings

Matrix



Characteristics Suitability of bearing for	Cage design	Standard designs NU	NU + HJ	N	NJ	NJ + HJ	NUP	RNU	RN
Radial loads	All	+++	+++	+++	+++	+++	+++	+++ ■	+++ ■
Combined loads	All	−−	+ ←	−−	+ ←	+ ←→	+ ←→	−−	−−
Non-locating positions	All	+++	++ −	+++	++ −	−−	−−	+++	+++
Locating positions	All	−−	+ ←	−−	+ ←	+ ←→	+ ←→	−−	−−
High running accuracy	All	+++	++	+++	++	++	++	+++ ■	+++ ■
Loads smaller than minimum load	P	−	−	+	−	−	−	−	+
High speeds + grease lubrication	P, M J MA, ML, MP	++ I −	++ I −	++ ● −	++ I −	++ I −	++ I −	++ I −	++ ● −
High speeds + oil lubrication	P, M J MA, ML, MP	++ I +++	++ I +++	++ ● +++	++ I +++	++ I +++	++ I +++	++ I +++	++ ● +++
High accelerations	P, M J MA, ML, MP	+ − +++	+ − +++	+ ● +++	+ − +++	+ − +++	+ − +++	+ − +++	+ ● +++
High radial accelerations + vibrations	P, M J MA, ML, MP	− + +++	− + +++	− ● +++	− + +++	− + +++	− + +++	− + +++	− ● +++
High operating temperatures	P J M, ML, MP	− ++ ++	− ++ ++	− ● ++	− ++ ++	− ++ ++	− ++ ++	− ++ ++	− ● ++

Symbols:

+++ eminently suitable
++ very suitable
+ suitable
− less suitable
−− unsuitable
← in one direction
←→ in both directions
● not applicable
■ presupposes shaft or housing raceway of bearing quality

Cages

J Pressed steel cage, roller centred
M Two-piece machined brass cage, roller centred
MA Two-piece machined brass cage, outer-ring centred
MI One-piece form-turned window-type brass cage, inner or outer ring centred
MP One piece window type brass cage with milled, reamed or broached pockets, inner or outer ring centred
P Injection moulded cage of glass fibre reinforced polyamide 6,6, roller centred

SKF 19

پیوست شماره دو

Appendix 3

Table 7

Bearing factors and recommended limits for the speed factor A

Bearing type[1]	Bearing factor b_f	Recommended limits for the speed factor A, for load ratio		
		C/P ≥ 15	C/P ≈ 8	C/P ≈ 4
–	–	mm/min		
Deep groove ball bearings	1	500 000	400 000	300 000
Angular contact ball bearings	1	500 000	400 000	300 000
Self-aligning ball bearings	1	500 000	400 000	300 000
Cylindrical roller bearings				
• non-locating bearing	1,5	450 000	300 000	150 000
• locating bearing, without external axial loads or with light but alternating axial loads	2	300 000	200 000	100 000
• locating bearing, with constantly acting light axial load	4	200 000	120 000	60 000
• without a cage, full complement[2]	4	NA[3]	NA[3]	20 000
Tapered roller bearings	2	350 000	300 000	200 000
Spherical roller bearings				
• when $F_a/F_r \leq e$ and $d_m \leq 800$ mm				
– series 213, 222, 238, 239	2	350 000	200 000	100 000
– series 223, 230, 231, 232, 240, 248, 249	2	250 000	150 000	80 000
– series 241	2	150 000	80 000[4]	50 000[4]
• when $F_a/F_r \leq e$ and $d_m > 800$ mm				
– series 238, 239	2	230 000	130 000	65 000
– series 230, 231, 240, 248, 249	2	170 000	100 000	50 000
– series 241	2	100 000	50 000[4]	30 000[4]
• when $F_a/F_r > e$				
– all series	6	150 000	50 000[4]	30 000[4]
CARB toroidal roller bearings				
• with a cage	2	350 000	200 000	100 000
• without a cage, full complement[2]	4	NA[3]	NA[3]	20 000
Thrust ball bearings	2	200 000	150 000	100 000
Cylindrical roller thrust bearings	10	100 000	60 000	30 000
Spherical roller thrust bearings				
• rotating shaft washer	4	200 000	120 000	60 000

[1] The bearing factors and recommended practical limits for the speed factor A apply to bearings with standard internal geometry and standard cages. For alternative internal bearing designs and special cages, contact the SKF application engineering service.
[2] The t_f value obtained from **diagram 1, page 193** needs to be divided by a factor of 10.
[3] Not applicable. For these C/P values, SKF does not recommend a full complement bearing, but a bearing with a cage instead.
[4] For higher speeds, oil lubrication is recommended.

194 SKF

Appendix 4

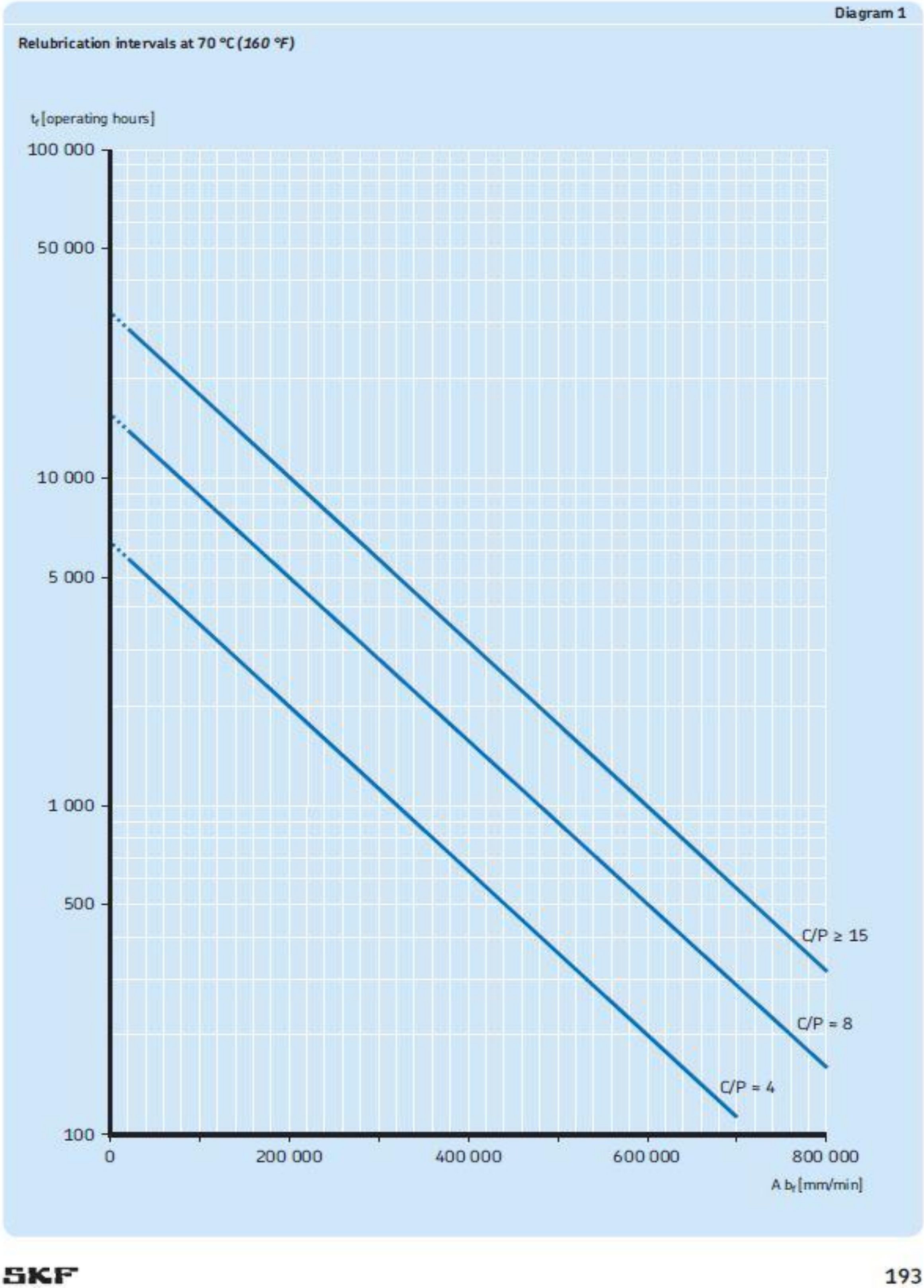


Diagram 1
Relubrication intervals at 70 °C (160 °F)
t_f [operating hours]
100 000
50 000
10 000
5 000
1 000
500
100
0
200 000
400 000
600 000
800 000
A b_f [mm/min]
C/P ≥ 15
C/P = 8
C/P = 4
SKF
193

Appendix 5

Very heavy loads

For bearings operating at a speed factor A > 20 000 and subjected to a load ratio C/P < 4 the relubrication interval is further reduced. Under these very heavy load conditions, continuous grease relubrication or oil bath lubrication is recommended.

In applications where the speed factor A < 20 000 and the load ratio C/P = 1–2, reference should be made to the information under "Very low speeds" on **page 240**. For heavy loads and high speeds circulating oil lubrication with cooling is generally recommended.

Very light loads

In many cases the relubrication interval may be extended if the loads are light (C/P = 30 to 50). To obtain satisfactory operation the bearings should be subjected at least to the minimum load as stated in the text preceding the relevant product tables.

Misalignment

A constant misalignment within the permissible limits does not adversely affect the grease life in spherical roller bearings, self-aligning ball bearings or toroidal roller bearings.

Large bearings

To establish a proper relubrication interval for line contact bearings, in particular large bearings (d > 300 mm) used in critical bearing arrangements in process industries, an interactive procedure is recommended. In these cases it is advisable to initially relubricate more frequently and adhere strictly to the recommended regreasing quantities (→ section "Relubrication procedures" on **page 242**).

Before regreasing, the appearance of the used grease and the degree of contamination due to particles and water should be checked. Also the seal should be checked completely, looking for wear, damage and leaks. When the condition of the grease and associated components is found to be satisfactory, the relubrication interval can be gradually increased.

A similar procedure is recommended for spherical roller thrust bearings, prototype machines and upgrades of high-density power equipment or wherever application experience is limited.

Cylindrical roller bearings

The relubrication intervals from **diagram 4**, **page 238**, are valid for cylindrical roller bearings fitted with

- an injection moulded cage of glass fibre reinforced polyamide 6,6, roller centred, designation suffix P
- a two-piece machined brass cage, roller centred, designation suffix M.

For cylindrical roller bearings with

- a pressed steel cage, roller centred, no designation suffix or suffix J, or
- a machined brass cage, inner or outer ring centred, designation suffixes MA, MB, ML or MP,

the value for the relubrication interval from **diagram 4** should be halved and a grease with good oil bleeding properties should be applied. Moreover, grease lubricated bearings with a MA, MB, ML or MP cage should not be operated at speeds exceeding the speed factor $A = n \times d_m$ = 250 000. For applications exceeding this value, please consult the SKF application engineering service. SKF generally recommends to lubricate these bearings with oil.

Observations

If the determined value for the relubrication interval t_f is too short for a particular application, it is recommended to

- check the bearing operating temperature
- check whether the grease is contaminated by solid particles or fluids
- check the bearing application conditions, such as load or misalignment

and, last but not least, a more suitable grease should be considered.

SKF 241

4- References

[1]. A. Tahsiri, A. Rahbari , An AHP Model for Classification of the Professional Competencies of Iranian Industrial Engineers, 2008
[2]. The catalog Manufacturers Bearing company SKF