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LUBRICANT FAILURE ANALYSIS OF ROLL NECK BEARINGS OF WIRE ROD MILL: A CASE STUDY

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Abstract - *Wire Rod Mill is a high speed roll mill of modern technological design, including equipment for controlled cooling of product from rolling heat. Steel wire rods are an all-round talent since they are the key product of steel industry with multiple uses. They are used as the material for fasteners, springs, bearings, wire ropes, chains, cables, wire meshes, wire fencings, tyre cord, reinforcement in railway sleepers, and many other uses. Further, it is necessary that the wire rod mills are able to achieve very high precision with rolling stands designed to withstand high loads and changing temperature requirements. In this project we find the causes for frequent failure of ball neck bearings and preventing the failures in bearings. Insufficient lubricant supply and inappropriate lubricant type (Viscosity and Temperature) causes the roll neck bearings to fail during working of wire rod mill. Due to improper lubrication, contamination, installation and misapplication of the bearings, and can be considered as premature since they will not achieve the calculated life. Countermeasures to premature failures generally deal with improvements in the application, installation, cleanliness and lubrication improvements. This paper will discuss various damage and failure modes of bearings used in wire rod mills, as well as the countermeasures to consider in the operating environment of typical wire rod mill applications. Case study done on Wire Rod Mill at Rashtriya Ispat Nigam Ltd (Vizag Steel), is a Public steel producer, Based in Visakhapatnam. A detailed study on the failed bearing was made including visual examination, hardness, microstructure, scanning electron microscope (SEM) studies.*

Keywords – Case Study, Failure Analysis, Lubricant, SEM, Wire and Rod Mill.

1. Introduction

Rolling element bearing failure is one of the foremost causes of breakdown in rotating machinery [1]. Bearings fail prematurely in service due to contamination, poor lubrication, poor fits, misalignments, etc. Motor bearing faults account for more than 40% of the induction motor's failure [2].

For industrial equipment, the rotating shaft is more valuable than the supporting bearings. Therefore, the bearing inner diameter is lined with a sacrificial material to absorb damage and to protect the journal surface (for radial bearings) or thrust collar (for thrust bearings) from damage. To serve as a sacrificial material, this lining should be softer than the journal surface and accept contact from hard contaminants in the lubricant [4,5].

The bearings faults can be caused by material fatigue, overheating, harsh environments, inadequate storage, contamination, corrosion, wrong handling and installation, etc. But the main cause of their failure is due to poor lubrication, which can be easily avoided by a correct maintenance plan [3].

The bearing faults do not cause immediate breakdown, but they evolve in time until they produce a critical failure of the machine[6]. Unfortunately these failures finally results both in costly repair costs and long downtimes.

Damage to the bearing surfaces and/or a loss or degradation of the lubricant cause increases in the temperature of the bearing and its average vibration level [8]. Recent years have seen a number of workers utilize a range of novel non-destructive techniques to aid the early measurement of bearing failure and diagnose its cause.

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A fluid lubricant, such as a synthetic or mineral oil, has several functions in a rolling element bearing. It provides elastohydrodynamic lubrication between the races and the rolling elements and hydrodynamic lubrication between the cage or separator and its locating surface. It serves as a coolant if either circulated through the bearing to an external heat exchanger or simply brought into contact with the bearing housing and the machine casing [7]. A circulating lubricant also serves to flush out wear debris and carry it to a filter where it can be removed from the system. It also provides corrosion protection. If the lubricant film at the rolling element "contact" collapses for any length of time, then heating and wear of the contacting components occurs rapidly and eventually the bearing will fail.

Bearing condition monitoring is therefore of major interest to a range of industries [6], particularly those continuously operating expensive and safety-critical plants such as those in the marine, power generation, and process sectors

This paper demonstrates the monitoring of lubricant film failure in rolling element bearings using SEM Analysis. This is a critical step forward from previous studies in which the bearing was operating normally. As the bearing failed, the temperature of the bearing and the vibration of the bearing housing are also measured simultaneously. The results are used to explain the failure process of the ball bearing [8].

For oil-air lubricated bearings, the influence of the hydraulic oil cleaning and air cleaning processes on the bearing failure is highly important. In our study, we collected a large number of failed bearings from maintenance shops to determine the main failure modes and mechanisms in practical bearing applications, which can have great engineering significance [7].

2. Common Reasons of Bearing Failure

The chart above lists the major causes of premature bearing failure, along with percentage figures which indicate prime contributor to a bearing's destruction. In many cases a premature bearing failure is due to a combination of several of these causes.

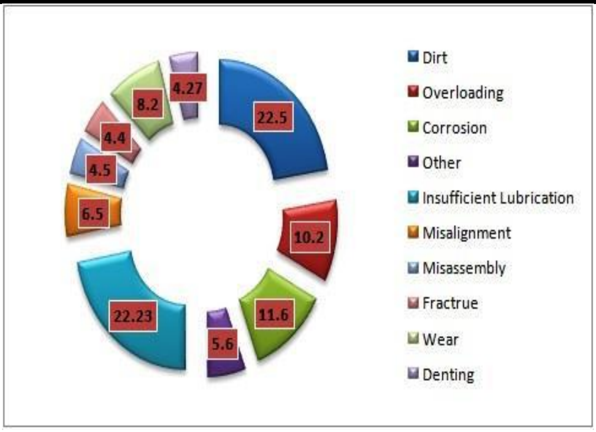

Fig.1: Major Causes of failure in Wire Rod Mills (in %)

3. Wire and Rod Mills – Bearing Failures

Wire, rod, and bar mills operate similar to the rolling mills for plate and other product. Operating conditions in these mills tend to subject the bearings to high temperatures, water spray, high loads and marginal sealing arrangements, resulting in short bearing lives [1,2].

Fig.2: Wire Rod Mill in Vizag Steel Plant

In addition to the failures presented in earlier sections, wire and rod mills can also be susceptible to failures due to cage deformation and insufficient lubrication. This can be caused by sudden acceleration and deceleration of the bearings, causing the rolling elements to deform the cage pillars. Installation and shock loading can also cause damage to the cage [4,5]. Countermeasures include ensuring proper installation, loading conditions and, if needed, changes to more robust cage designs.

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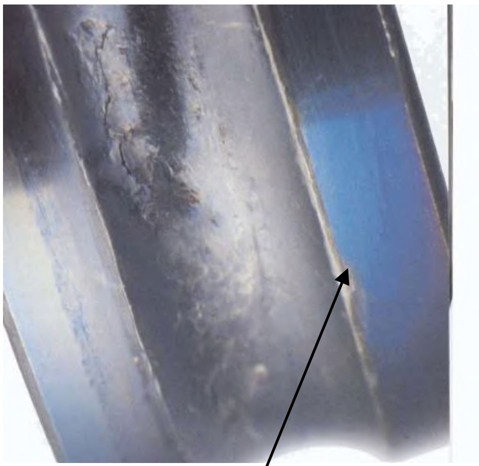

Fig.3: Discoloured ball tracks and damaged surface an example

Fig.4: Discoloured Outer Ring of Roll Neck Bearings

Lubricant failure will lead to excessive wear, overheating and subsequent bearing failure. Discoloured ball tracks and balls are the symptoms of bearing failures. Ball bearings depend on the continuous presence-of very thin-millionths of an inch-film of lubricant between balls and races, and between the cage, bearing rings and balls. Failures are typically caused by restricted lubricant flow or excessive temperatures that degrade the lubricant's properties [5].

Also, any steps taken to correct improper fit control preload better, and cool the shafts and housings will reduce bearing temperatures and improve lubricant life.

3.1 Damages

- Grease including large quantity of water mixed in.
- Foreign matter attachments and corrosion occurs.
- Seizure and adhesion of raceways, roller and cage.
- Looseness and breaking of pin.

Fig.4: Damaged bearing in Wire Rod Mill

Improper or inadequate lubrication can result in a breakdown of the oil film between the rolling elements and raceways. The resulting metal to metal contact generates excessive heat which reduces the hardness of the metal. Localized welding of the rollers or balls to the raceways will rapidly seize the bearing. Fracture of cage side edges damages due to poor lubrication. Insufficient lubrication, resulting in an increase in friction and material stressing at the raceway surface.

3.2 Prevention

Carefully select the proper amount and type of lubricant that will maintain a film between the rolling elements and raceways.

- ✓ Remember to pre-lubricate whenever necessary before installation.
- ✓ If the temperature cannot be lowered, review the possibility of change to high temperature grease.
- ✓ Avoid improper sealing.
- ✓ Provision of load carrying lubricant film (additives, if necessary), increase in lubricant quantity.
- ✓ Filter lubricant.
- ✓ Mount Carefully.

4. Experimental Details

A detailed study on the failed bearing was made including visual examination, hardness, microstructure, scanning electron microscope (SEM) studies. Visual examination was carried out using a stereo zoom microscope. Bakelite mounted and polished cut sections were used for metallographic observation and hardness measurements. The microstructure was studied after etching with 3% Nital [3, 4].

5. Results

Below table represents the material composition of bearings used in Wire Rod Mill at Vizag Steel Plant.

5.1 Material Composition
Bearing parts composition is given in Table 1.

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Four Row Cylindrical Roller Bearings are commonly used on Rod and Bar Type Mills as Work Roll Bearings and in Hot and Cold Mills as Back Up bearings. These products can range from 100mm to over 1100mm bore. In this paper variety of solutions for maximizing the life of these critical bearings for steel mills was presented.

Angular Contact Ball Bearings are used as thrust bearings for Rod and Bar Mill Stands as well as critical bearings within mill drives. These bearings are typically arranged to accommodate thrust loads for specific applications [8].

TABLE.1: Composition of bearing parts (wt %)

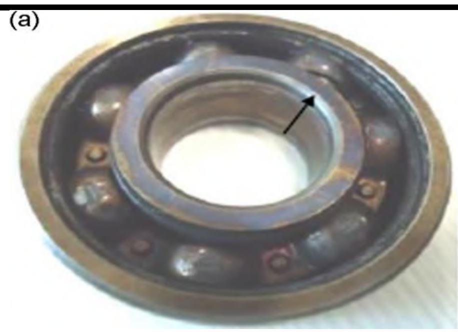
Element	***C***	***Mn***	***Al***	***Si***	***Ni***	***Cr***	***Fe***	***V***	***S***
Cage	0.95	0.40	0.66	0.64	3.95	2.95	90.41	**0.002**	0.03
Rollers	0.90	0.44	0.65	0.66	4.25	3.20	89.87	0.001	0.02
Race ways	0.65	0.50	0.70	0.71	4.75	3.50	89.14	0.003	0.04
Rings	0.98	0.60	0.90	0.89	5.26	3.76	87.55	0.005	0.05

Fig.5: Roll neck bearings in Wire Rod Mill (Tapered rollers) an example

5.2 Macroscopic analysis

The Rings, Cage, Balls and race ways in received condition is shown in below figures. . Using a trinocular stereo zoom microscope, one end of the rollers was found to be severely damaged than the other. This feature was seen in all the rollers. In the rings and along with pit marks on the race way; a crack was also observed on the inner surface of the rings. After dismantling the bearing, dried grease and stains were observed along the raceway of both inner and outer rings. Damage observed on the cage in the as-received condition is shown in below figure [5,6].

(a)



(b)

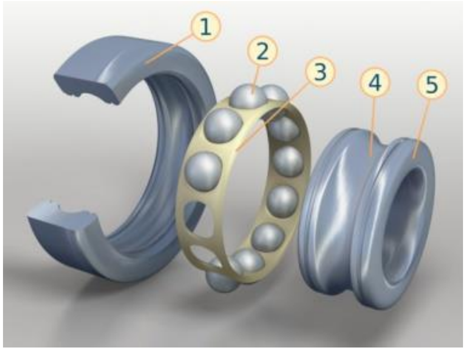


Fig.6 (a): Damage observed on the cage in the as received condition. Fig.6 (b): Separated view of bearings (1) Outer Ring. (2) Ball bearings. (3) Cage or retainer. (4) Raceway. (5) Inner ring.

5.3 Microstructural analysis

Roller and cage failure are showed that fine Pearlite with non uniform distribution of carbides network formed on the surface of the bearings. Microstructure observed on various bearing parts using SEM Analysis is shown in below figures [3].

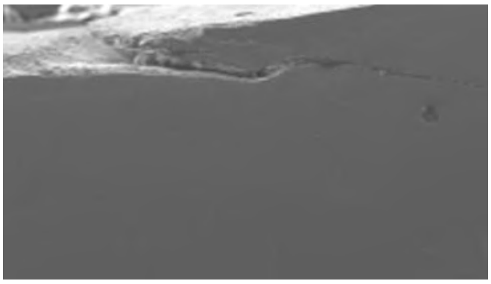


Fig.7: SEM Micrograph of damaged roller portion

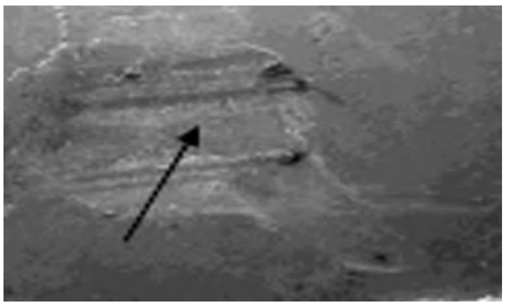


Fig.8: SEM Micrograph of damaged race way

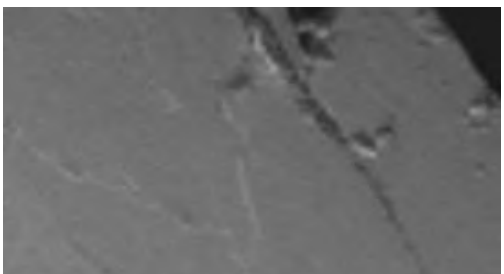


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Fig.9: SEM Micrograph of damaged cage portion

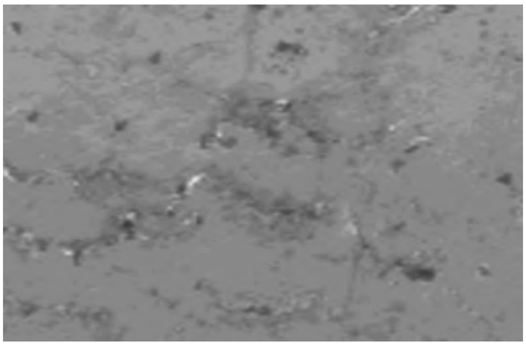

Fig.10: SEM Micrograph showing ring portion

5.4 Hardness analysis

Hardness profiles taken along the Cage, Race Ways and Rollers. The values of hardness are as follows.

Table.2: Hardenss Test Results

Sample	Number of samples	Average Hardness(BHN)
Cage	1	650
Race Ways	1	668
Rollers(tapered & Ball type)	1+1	512

6. Conclusion

This study guide should provide you with the basics for bearing care. Remember, it takes only a small mistake in handling, lubrication, installation or maintenance to result in large scale damage – not only to the bearing, but to the overall area in which it operates. The failure is not on account of any defect in material or heat treatment. This failure is predominantly due to the lack of lubricant supply, which caused uneven load distribution on the roller. Consequently the roller and cage, unable to balance the lubrication failure, experienced severe stress concentration at the entire roller and cage leading to premature failure of the bearing. Lubricant degradation ultimately resulting the complete seizure of the bearing itself.

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