A Case Study - Failure Analysis of Needle Roller Bearing at Gudgeon Pin of Ginning Machine

Mr. A. D. Thakare[1] Mr. P. A. Chandak[2] Mr. S. P. Untawale[3]
[1]M. Tech Student [2]Assistant Professor [3]Principal
[1,2,3]DMIETR, Wardha

Abstract— This project deals with failure analysis of needle roller bearing at gudgeon pin vital in ginning industries to produce relative motion between connecting rod and head block, which further oscillates beater shaft assembly with high speed. A ginning machine under consideration having production capacity (Lint) 40 to 70 Kg/Hr. With motor providing power 5 H.P and speed 1000 rpm. After the study of existing ginning machine production line where 20 double roller machine are continuously running need to be stop after every 2 to 3 hours for around 30 min for providing lubricants, if this not done then there is definite failure of needle roller bearings occurs. The failure of bearings is mainly due to Brinelling tends to damage within a short period, in which the bearing surface turns scaly and peel off due to contact load repeatedly received on the raceways and rolling surface due to rotation. This result in roller and inner races surface of needle roller bearing get damage affects imbalance of overall mechanism from connecting rod to the beater shaft assembly and creates vibration in a machine. Also it will cause sudden breakage of other parts of machine like breakage of connecting rod, enlargement of holes of head pin in head block and also major reason for failure of Needle roller bearing mounted in between eccentric shaft and connecting rod. Eventually ginning machine will have to stop for the maintenance which also results into the stoppage of production line for almost half Hrs. for rectification of existing situation where life of the needle roller bearing is too small which affect on the production of industry and there is need to stop the machine while replacing the bearing. So it becomes essential to replace the bearings which will give desired life, and high dynamic loading capacity.

Key words: double roller ginning machine, Brinelling, needle roller bearing, production capacity

I. INTRODUCTION

In M.R.Ginning and pressing factory talegaon (s.p.) where 20 double roller ginning machine are working continuously for 24 hours, breakdown or stopping of machine is the major problem for production. Varieties of cotton purchase from farmers are sending to the ginning machine through conveyor system which is fully automatic. A quantity of cotton to be feed is managed by auto feeder which is mounted on the top side of the ginning machine. A cotton which is supplied by auto feeder to the beater shaft assembly which is oscillating about 1179 rpm, calculated value from relative velocity method. This beater shaft assembly is drives by 5 HP motor, which gives power to the eccentric shaft. From eccentric shaft on one side power is transmitted to the gear train and on another side to the connecting rod, head block and beater shaft. Gear train are used to drive the leather chrome roller whose function is to adhere with lint and carried forward to the downside. Eccentric motion from connecting rod transfer to head block by the help of needle roller bearing (RNA6902) are placed with gudgeon pin. After the discussion carried out at M.R.Ginning and pressing factory talegaon (s.p.) related to performance of machine, it is found that bearings used in between connecting rod and head pin which is inserted in headblock is Needle roller bearing having specification (RNA 6902) get fails within 3 to 4 hours if lubricant not provided properly, even it having higher dynamic load capacity. The oscillation of beater shaft assembly is for detaching the fibre from seed of the cotton. A moving knife which is attached with the assembly oscillates with 1179 rpm and time required for one oscillation is 0.0245 sec. and energy required for dethatching fibre is around 2800 joule/kg of lint and it varies from condition and varieties of cotton. So this kinetic energy of rotating masses results in excessive load on bearings causes' plastic deformation of the cage called brinelling. In the present work failure analysis of Needle roller bearing having dynamic load capacity of 17.3 KN is done.

Fig. 1: Failure of Needle roller bearing

II. OBJECTIVES

The sole purpose of this research is to find the reason of failure of needle roller bearing by understanding all aspect of ginning machine.

The outline objectives are summarized as below:

1) Causes of bearing failure
2) Work done
3) Investigation of failure of needle roller bearing
4) Life calculation of bearing

III. CAUSES OF BEARING FAILURE

A. Excessive Loads:

Excessive loads usually cause premature fatigue. Tight fits, brinelling and improper preloading can also bring about early fatigue failure. The solution is to reduce the load or redesign using a bearing with greater capacity. This causes damage of surface of bearings producing small cavities on surface of roller as well as inner races.

B. Overheating:

Symptoms are discoloration of the rings, rollers, and cages from gold to blue. Temperature in excess of 400F can anneal the ring and ball materials. The resulting loss in hardness reduces the bearing capacity causing early failure. In extreme cases, balls and rings will deform. The temperature rise can also degrade or destroy lubricant.

Fig. 2: Excessive Loads

Fig. 3: Corrosion

C. Lubricant Failure:

Discolored (blue/brown) ball tracks and rollers are symptoms of lubricant failure. Excessive wear of balls, ring, and cages will follow, resulting in overheating and subsequent catastrophic failure. Ball bearings depend on the continuous presence of a very thin -millionths of an inch - film of lubricant between rollers 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.

D. Corrosion:

Red/brown areas on rollers, race-way, cages, or bands of bearings are symptoms of corrosion. This condition results from exposing bearings to corrosive fluids or a corrosive atmosphere. In extreme cases, corrosion can initiate early fatigue failures.

IV. WORK DONE

In ginning industry in present design, 21 bearings of different sizes and types are used which makes the maintenance complicated and costly. Also lubrication points are more i.e. 18 in number (Swing lever 8 points, hub 1 point, wrist pin 1 point, gear side pipe 2 points, weight lever 4 points, beater shaft 2 points). Uniform pressure between fixed knife and roller plays an important role in quality and output of the lint. In present design the roller is pressed against fixed knife with the help of hanging dead weights (total weight of 1158 N i.e. 324 N and 255 N/roller on gear box side and offside respectively) mounted on the weight lever of 495 mm in length. This method does not ensure uniform pressure between roller and fixed knife, occupies more space, and also makes it difficult to remove the roller for maintenance. Presently rollers are made of chrome composite leather washers and wear rate of roller is 0.02 mm/h of working (i.e. it has life of around 1200 working hours). Besides this in rainy season it has tendency to absorb water and get swelled to reduce the life of material further. Studies revealed that chromium particles generated during the process of ginning produce deleterious effect on the people working in the vicinity theoretically energy required to remove 1 kg lint (fibres) varies between 1075 to 2775 joules but actual energy consumed by present DR is about 118000 joules/kg lint. This is about 60 to 120 times more. This poor energy utilization efficiency is mainly due to improper design of gearbox, unscientific way of applying pressure etc. Machine noise level is reasonably high (93 dB) due to the reciprocating action of beater and gearbox. Noise levels of 85 dB and above have shown to cause hearing impairment.

V. MODELING OF BEATER SHAFT ASSEMBLY WITH BEARING

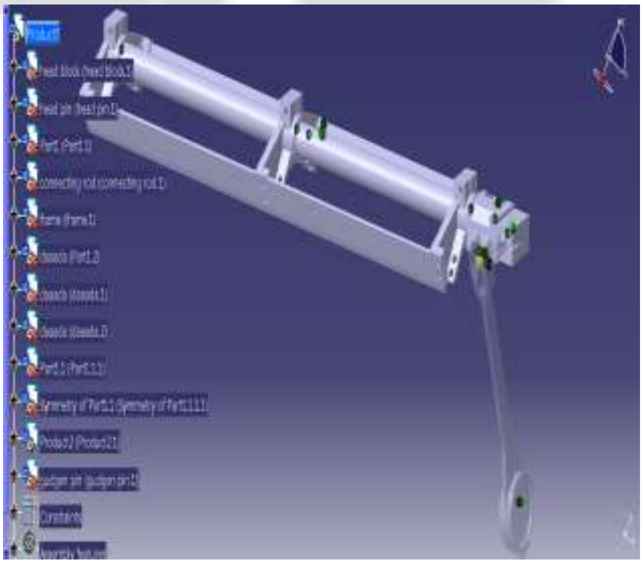

Fig. 4: assembly of beater shaft assembly

Where

It construct by a part eccentric shaft, connecting rod, head pin, head block, beater shaft, beater traugh, moving knife, and grid rail.

Fig. 4: actual photograph of parts of assembly

VI. Investigation of Failure of Needle Roller Bearing

Needle roller bearings are smaller than general bearings but have a greater load carrying capacity. This advantage allows for more compact designs for bearings as well as for bearing housings. A Double roller ginning machine work on the principle of eccentric motion from eccentric shaft converted into oscillating motion of the beater shaft assembly, needed for continuous beating of cotton comes in between moving knife and fixed knife in order to detach fibre from the cotton. A Needle roller bearing is fixed in head pin with interference. A gudgeon pin is used to connect head pin with connecting rod and relative motion between them is done by this bearing.

A needle roller bearing (RNA6902) having dynamic capacity of 17300N taking reference from NSK bearing catalogue are subjected to a repetitive heavy load. As this is rolling element bearing it is subjected to radial load, according to company specification it is need to be lubricated after every 2 hours so the life of bearing is too small. So it becomes necessary to calculate the life of the bearing. Also need to find out the actual load to be imparted on the bearing which results in failure.

Load acting on the bearing are calculated by taking into account all static load on bearing. Load acting by inertia masses which rotate with respect to bearing and force required to detach the fibre from seed. in order to find the load acting on the bearing we have data by prof. P.G.Patil and Prof P.M.Padole. andS.B.Jadhao and K.M.Parlikar gives information about energy required for detaching the fibre from the seed, observed wide variation among the different varieties of cotton, and related it to the strength of attachment of fibre from the seed. This is about 2800 j/kg of lint.

The needle roller bearing investigated for failure of bearing. It is found that cage of the bearing are subjected to plastic deformation and also needle are sleep out from cage contact. This is due to high impact load acting on the bearing and such type failures are brinneling failure.

VII. Bearing Life

A. Calculation for Bearing Life:

Bearing rating life in vibratory applications is dependent on the factors:

- Equivalent bearing load P (KN),
- Rotational speed N (r/min),
- Contamination level ηc,
- Lubricant viscosity ν at the operating temperature (mm^2/s).

B. Bearing Load (Fr):

The load applied on the bearing generally include the weight of the body to be supported by the bearing, the weight of the revolving element themselves, the transmission power of gears and belting, the load produced by the operation of the machine in which the bearing are used, etc. these load are theoretically calculated, but some of them difficult to estimate.

C. Load Factor (Fw):

When radial or axial load has been mathematically calculated, the actual load on the bearing may be greater than calculated load because of vibration and shock present during operation of the machine. The actual load can be calculated using the following equation:

$$\mathrm{Fr} = \mathrm{Lf} \times \mathrm{Ft}$$

Where,
Fr = load applied on the bearing
Lf = load factor
Ft = Theoretically calculated load

D. Equivalent Bearing Load P (KN):

$$\mathrm{P} = (\mathrm{XF_r} + \mathrm{YF_a})\mathrm{K_s K_o K_r}$$

Where,

- F_r = Radial Load (KN)
- F_a = Axial Load (KN)
- X, Y= Constant for bearing selected from table
- K_s = Service Factor
- K_o = Oscillation Factor
- K_r= Rotational Factor

(All values of factors selected from design data book table [5])

E. Life of Bearing:

$$\mathrm{L} = \left(\frac{\mathrm{C}}{\mathrm{P}}\right)^{\mathrm{n}} * \mathrm{K_{ret}}$$

Where,

- *L* = Life in million cycles
- C = Dynamic load capacity (KN)
- P = Equivalent Bearing Load (KN)
- n = 3.33 for roller bearing
- K_{ret} = Reliability factor select from table

F. Life of Bearing (In Hours):

$$\mathrm{L\ (in\ hours)} = \left(\frac{10^6 \mathrm{L(in\ million\ cycles)}}{60\ \mathrm{N}}\right)$$

Where,
N = Rotational speed in rpm

VIII. Conclusion

From the above case study regarding Needle roller bearing failure at gudgeon pin of ginning machine, it is revealed that failure of bearing mainly occurs due to brinelling. This type of bearing failure is avoided by using bearing of higher dynamic load capacity.

ACKNOWLEDGMENT

The author would also like to thank M.R.Ginning and pressing factory Talegaon (s.p.) for their contributions to the data and case studies in this paper.

REFERENCES

[1] P.B.Kondhia and Prof. P.H.Darji, “Contract stress analysis of needle roller bearing used in synchromesh gear box,” in IJTRE, vol. 1, issue 10, june 2014, pp.2347-4718.
[2] P.bharath,KRaju,M.Vigneshwar and R.Rohit, “Study of ginning and pressing mills,”in IJETIE, vol. 1, issue 14, april2015, pp.2394-6598.
[3] R. K. Upadhyay, L .A. Kumaraswamidhas and Md.SikandarAzam, “Rolling element bearing failure analysis: A case study,” in elsevier, (2013), pp. 15–17.
[4] U.A.Patel and R.Shukla,”Vibration analysis of self-align ball bearing having a local defect through FEA and its validation through experiment,”in IJMER, vol. 2, issue 3,may-junel2012, pp.1073-1080
[5] H.S.Deshpande,S.S.Kulkarni,B.S.Gandhare,“Investigation on effect of defect on cylindrical roller bearing by experimental and FEA approach,” in IJETAE, vol. 4, issue 6,junel2014,
[6] Hu zhanqi,Qixiaowen,FanBingli and Li wie, “research on service life prediction model of thrust needle bearing,”in TELKOMNIKA, vol. 10, no7, nov2012, pp.1621-1628.
[7] TomoyaSakaguchi,”Two dimensional dynamic analysis of cage stress for needle roller bearing that support connecting rod in reciprocating engine,” in NTN Technical review, no 79,2011.
[8] Jyoti K. Sinha, “Frequent And Premature Failure Of Anti-Friction Bearings: Diagnosis Approach?” 3rd International Conference on Integrity, Reliability and Failure, Porto/Portugal, 20-24 July 2009, pp. 1-8.
[9] Katsuyuki Kida, Takashi Honda and Edson Costa Santos, “Semi-circular surface cracks and flaking failures in silicon nitride bearings,”Published online by the VBRI press in 2011, pp. 336-340.
[10] F. Camcia, K. Medjaherb, N. Zerhounib and P. Nectouxb, “Feature Evaluation for Effective Bearing Prognostics,”published in "Quality and Reliability Engineering International”, 2012, pp. 1-15
[11] B. A. Kardile, “Bearing Life Improvement of Centrifugal Blowers by Vibration Analysis,” in IJMER, Vol.2, Issue.6, 2012, pp. 4026-4029.
[12] P.G.patil, P.M.Padole, “Double roller cotton ginning machine: its drawbacks and possible modification,” An overview.
[13] P.G.Patil and VaishaliPatil,” Development of prototype double roller gin with improved power transmission and its performance evolution,” An overview.
[14] S.B.Jadhao,S.vanchewaran,N.C.Vijia and K R K iyer,”Roller and beater speed combination for higher lint out turn in double roller gin,",” in IJFTR, Vol.28, Dec 2003, pp. 377-384.
[15] Dr. H. Hirani, “Failure of Rolling Bearings: An Overview”