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Roller Bearing Lubrication Failures on Hot Gas Fan.

Introduction-

As a part of their process a chemical manufacturing plant had a large horizontal rotating kiln.

The exhaust gases from the kiln were drawn off by an induced draft fan, known on the plant as the hot gas fan.

The plant was suffering from bearing failures where historically the bearings had been able to run trouble free between annual kiln overhauls.

Machinery Details-

The machine was a double entry centrifugal fan horizontally mounted with an inboard and an outboard bearing.

The shaft diameter was around 150mm and due to the configuration, the original manufacturers had specified split roller bearings at both the inboard and outboard bearing locations.

The drive was directly coupled from an electric motor via a flexible gear type coupling.

The fan was driven at 1500 revolutions per minute.

Initial investigations -

The plant did not have comprehensive maintenance records for this piece of machinery, however, conversations with both the operations and maintenance departments did support the opinion that despite its arduous duty, the fan had historically not been a source of major unreliability on the plant.

Problems with the fan did, however, have a major effect on the plant's business since if the fan broke down, the kiln stopped and the feed to five downstream plants was instantly interrupted resulting in major disruption to the manufacture of several products.

The fan was operating on flue gases with a temperature that could exceed 400 Celsius, so there was a significant amount of heat conducted into the bearings from the shaft via the inner bearing race.

Commissioning records had shown that when originally installed, the bearing housings had been water cooled.

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Early on in the start up of the plant there had been problems with the bearings overheating and failing.

Attempts to cure this by increasing the cooling water flow to the bearing housings had failed to solve the problem.

Eventually, the cooling water was removed from the bearing housings and the bearings then ran successfully.

What appeared to be happening was that the cooling water was keeping the outer bearing race cool, but the heat input to the bearing was via the inner race from the shaft.

It was thought that what was happening was that the outer race was being kept cool, but the heat input from the shaft via the inner bearing race was causing the internal clearance of the bearing to be lost.

Losing the internal clearance then caused internal heat generation in the bearing and eventually the bearing overheated and failed.

Turning the cooling water off may not have been the immediately intuitive thing to do when faced with an overheating failure, but it allowed the bearing to reach an equilibrium temperature where it would run quite satisfactorily between yearly overhauls.

What was not documented at this time was whether the clearance of the bearings were altered from the original specifications or not.

Further investigations -

Inspection of actual failed bearings showed that the races were badly spalled by fatigue.

There had clearly been a reduction in clearance caused by the heat generated in the bearing.

What was of special interest in fact though, was that there was a build up of some sort of material between the rollers and adhering to what remained of the bearing cage.

Some of this was scraped off and sent away to a lab for analysis.

The laboratory duly reported that the substance was clay.

In fact this tied in exactly with what was happening on the fan.

It seems that at some stage, standard clearance bearings had been supplied and had become the stocked spare.

The damaged bearings were certainly standard clearance and the spare bearings were too.

It was not known for sure if larger clearance bearings had ever been used due to lack of documentation.

But the duty certainly called for increased clearance when the bearing manufacturers criteria was examined.

Subsequent events appeared to confirm that standard clearance bearings were unsuitable for this duty.

What appeared to have been the course of events was that for whatever reason, standard bearings were fitted and after a couple of failures, the maintenance team decided to change the lubricant used.

Their grease supplier said that they should change to a Bentonite thickened grease due to the high temperature of the duty.

The maintenance department subsequently made the change.

In fact what then happened was that the heat generated within the bearings was evaporating the lubricant from the Bentonite grease leaving the clay compound behind.

The bearing, then effectively running without lubricant, continued to overheat and failure rapidly followed.

There were air hoses tied to the bearing housings which were turned on in an attempt to keep the bearings running longer when they were getting hot.

It became evident that the plant engineering team did not fully appreciate the consequences of the actual fan duty on the design of the bearings.

They were not aware that when a bearing has heat input from the shaft that the internal clearance of the bearing needs to be increased to compensate.

Due to the poor maintenance records on the plant it was not apparent that almost certainly a change from increased clearance bearings to standard clearance bearings must have occurred before the spate of failures happened.

The plant technicians did not understand about the design criteria of bearings on a hot duty and just used the parts issued by the planner.

In turn, the planner assumed that the parts held by the stores were correct.

The plant supervisor was under pressure to complete the workload and left the spares resourcing to the planner.

The plant engineer didn't understand the design requirements of the bearing arrangement.

So when problems happened there was nobody really there who could establish the root cause of the problems.

As a result of these investigations the following actions were put in place-

1 The bearings were re-specified to ones having greater clearance (C4 clearance).

2 The stock specification in the stores was changed to C4.

3 The Bentonite grease was disposed of.

4 NLGI2 Lithium complex grease was specified as the lubricant.

5 All shaft sizes and tolerances were checked and made sure that they were in tolerance.

6 Shaft alignment was checked with Laser alignment equipment.

7 The air hoses were removed.

8 The plant maintenance staff were given information regarding the bearings so that they understood why the problems had arisen and why the internal clearance of the bearings was important.

9 It was stressed to the plant that the maintenance department must keep better records of work carried out and investigate multiple failures thoroughly to prevent similar situations developing again in the future.

Conclusions-

The plant had apparently been a victim of a small change in the bearing clearance specification causing problems on the hot gas fan.

Due to a lack of understanding by all on the plant, poor documentation and a misplaced trust in the stores system, the root cause of the problem had been missed.

To compound the problem, the plant had turned to a supplier who had not understood the underlying issues and had supplied an unsuitable product in the place of a perfectly good lubricant.

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The plant maintenance team had their judgment clouded by the perceived need to act urgently and to be seen to be responding to recurring problems and being pro-active. Hence the change to an essentially not required Bentonite grease product.

The lubricant supplier was asked to take more care in understanding lubrication issues in the future before advising changes to lubricants that had previously been perfectly adequate.

It could be argued that the lubricant supplier, who was seen as an "expert" by the plant, should have explained that there were underlying problems with the bearings not really related to lubricant grade or type.

Furthermore, all parties were reminded that unapproved changes in lubricant were not allowed under the site's own control of change procedures. Control of change on the plant was in fact subject to rigorous procedures. As on many facilities, the procedure is designed to prompt the plant to formally ask questions and record the answers. This process would have revealed the presence of an underlying problem.

With the simple changes put in place, the hot gas fan continues to run between the annual kiln maintenance outages.

No further bearing problems have occurred on the hot gas fan now for a number of years.

As a bonus, having gone through the root cause analysis process on this machine, the maintenance team now have a much better understanding of the application of bearings

The maintenance team are lot better equipped to handle future problems on other machines as they occur.

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About the author-

Stephen H Shakeshaft is a Mechanical Engineer based in the United Kingdom. He is the Principal Consultant and Director of Stephen H Shakeshaft Consulting Ltd., an engineering consultancy specialising in optimisation of existing assets and engineering design of new build projects.

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Stephen has over 30 years experience of working at the “sharp end” as well as the “back room” of manufacturing industries with clients in the chemical, utility, metals, industrial gases and pharmaceutical businesses.

Stephen is a registered professional engineer in the UK and is a corporate member of both the Institution of Mechanical Engineers and the Institution of Engineering and Technology.

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The consultancy welcomes contact from all who are interested in plant and machinery maintenance, systems and development.