

Failure of Angular Contact Bearing on Newly Overhauled Motor.

Introduction-

When a large vertical motor was due for inspection it was sent by the client to a specialist motor overhaul contractor for cleaning, inspection and re-certifying.

Standard procedure by the contractor was to remove the rotor, clean and inspect and then rebuild with new bearings and seals.

After overhaul the motor was dispatched directly back to site.

Description of the machine-

The motor is a 3.3kV three phase device that is used to drive a high speed single stage compressor via a speed increasing planetary gearbox assembly.

The unit is vertical with the compressor stage at the bottom, the gearbox installed above the compressor and the motor above the gearbox.

Due to fretting of the lubricated gear coupling previously used between the motor and the gearbox, I had earlier advised the plant to take the opportunity of the outage to change the coupling out to a flexible membrane type coupling.

This was done during the installation of the motor and the motor to gearbox alignment was set accurately using optical alignment equipment.

Failure-

When the motor was first run up it sounded fine, low vibration levels, quiet and all seemed well.

However, after a few minutes as the gearbox was warming up, the top bearing started to get noisy, it suddenly got very noisy indeed and smoke began to pour out of the top of the motor.

The motor was stopped and came rapidly to a stand still.

At this point there was considerable panic since the compressor was an integral part of a large single stream plant that was returning to service after a week long outage.

As there is no spare, the motor was removed overnight and taken back to the contractors workshop where it was stripped down.

Findings-

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The lower bearing (single row roller bearing) and the rotor were in generally perfect condition.

However, the top bearing (angular contact) that took the weight of the rotor was in a terrible condition.

The bearing was completely black, the cage was destroyed and the balls were completely misshapen and blackened.

As sometimes happens in extreme bearing failures, some of the balls had gone hollow.

Clearly, given the length of time that the bearing had run, something was definitely very wrong.

The bearing had been lubricated before start up so it came down to either bearing fitting or specifying.

On the outer race on the side could clearly be seen the bearing designation, without suffixes.

Having spent sometime earlier in the day studying the motor assembly drawings I was sure that the correct bearing had a suffix to the designation.

The bearings that had been removed from the motor at its first strip down were in fact still in the workshop waiting to be cleared away.

The bearing that had been removed clearly had the suffix "B" after the designation.

Enquiries made with the planning officer who was responsible for procuring the spare parts for motors in the workshop revealed that he did not know what the significance of any of the bearing suffixes meant.

In fact the workshop supervisor and engineer did not know either.

The only bearing designation suffix that they were aware of was "C3" for increased clearance.

The purchase requisition, order and the delivery note also showed that the planner had requested the bearing without the "B" suffix.

In fact the absence of the suffix in this angular contact bearing designation meant that the rolling element contact angle was incorrect.

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A suffix "B" in the bearing designation means that the contact angle of the bearing is 40 degrees.

The same bearing designation without the suffix has a lower contact angle and so a lower axial thrust capacity.

The entire integrity of the motor depends on the thrust capability of the top bearing. The considerable weight of the rotor and coupling is carried and located by the top bearing.

The bottom bearing is a roller bearing and thus only carries any radial load from the drive.

To add to the problems, the design speed rating of the bearing that was fitted is lower than the suffix "B" bearing. The net result is an overloaded bearing running above its maximum speed capability.

The effect was catastrophic, the bearing had a total failure within minutes of starting up.

Conclusion-

Unfortunately the entire responsibility for the failure rested firmly with the contractor.

It was accepted that there were significant holes in their knowledge about bearing specifications.

The workshop had a good general reputation and this carried it through, but the client lost three days production from their plant. This loss dwarfed the cost of the motor failure.

The client however, can take some of the blame for not specifying in the work scope exactly what was to be done and what was to be supplied by the workshop nor was any guidance provided regarding bearings types or specifications.

In fact no written work scope was given except a shipping note saying "Please Overhaul the Motor and Return to Site".

The client could have been criticised for not having a spare motor, but it is impossible to carry spares for everything. The motor had given good service over many years and the case for tying up capital in what should have been a fairly low risk spare was probably weak.

I carried out a training course to familiarise all the office and shop floor staff with bearing designations.

A system of cross checking the bearings that came out of machines with the bearings

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that were ordered and went back into machines was implemented.

Overall, it was a serious failure but it highlighted a weakness that could catch out a large number of clients and contract repair workshops alike.

The work scope given to a repairer from the client should detail the exact sizes, suffix, clearance grade, cage material and desired make of rolling bearings. Anything less leaves the client open to the bearing being chosen by the contractor who may not either understand fully the requirements or may often choose to fit a cheaper bearing to save on costs.

Additionally, this particular motor was a flameproof design and the documentation process should generally as a whole have been much more robust when overhauling and re-certifying the motor to Ex standards.

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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.

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.

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