Addendum to “Low Speed Bearing Analysis” Paper

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May 2015

1. Cost of outages for bearing replacement and production losses during those outages were not included in the original paper.

2. The real root cause of the bearing failures was not included in the original paper.

Updates on both of the above are included here.

Discussion on Item 1 above:
An unplanned outage due to seal failure caused by a destroyed bearing was a 7 day event due to the cool down, replacement time and heat up time of the reactor IF everything went as planned. Some repairs with difficulties took up to 10 days.

Equipment and labor during an unscheduled changeout was about $200,00 and production losses for 7 days were roughly $3,000,000. So an unscheduled outage costs 3.2 million dollars.

There were a few RANDOM scheduled outages during the year in some years. If bearing issues could be predicted, the changeout could occur during one of these PLANNED outages thereby only costing $200,000 for labor and equipment costs and there would be no $3 Million loss associated with production.

An UNPLANNED seal failure costs us $3.2 million.

Before we became able to accurately predict bearing destruction (and thereby a major seal leak) there were SOME seals changed out where the bearings were actually unharmed. These incorrect calls cost us $3.2 million also.
In addition there were MANY instances where the seals (both ends) were changed on a time basis where the bearings were unharmed. These preemptive changeouts cost between $200,000 and $270,00 for equipment and labor costs alone. There were MANY of these. These preemptive changes were always during a PLANNED outage.

Once we used the techniques described in the paper we were able to predict with 100% accuracy WHEN to change the seals. This let us do changeouts during some Of the PLANNED opportunities and let us avoid those $3 million dollar production losses.

In the WORST year we suffered 5 unplanned outages on a worldwide basis for a total of $16 million lost production. We also had 2 incorrect calls for $6,400,000 cost.

For about a 2 year period BEFORE we found the root cause and fixed it, we had NO production losses due to bearing or seal changeout because we accurately PREDICTED them and were able to SCHEDULE the changeouts so they were not unplanned.

So comparing the worst year of $21million production loss to the best years of $0 production loss due to bearing failure and seal leakage we see what a HUGE economic advantage accurate prediction can give us.

We did find the combined root cause of the incidents but it took us almost 1 ½ years to order the new parts and get our cure in place in ALL locations.

With the new modifications failures became a thing of the past and the seals that displayed a 1.0 year MTBF had NO failures in the next 8 years before we sold the division the reactors were in to another company.

So now lets talk about the real root cause.

Discussion on item 2 above:

Reactor locations were in Germany, Canada and Mexico. Although the basic design was Copied for all these locations, SOME design differences existed between locations.

Half the problem could be finally traced to differently designed bellows that were used to compensate for heating and axial growth from end to end of the reactor.

All failures occurred in Canada and Germany where the bellows had a significantly higher spring rate and where bellows fabrication led to internal misalignment.

This ultimately caused the misaligned condition of the bearing in the seal as shown In Fig1 attached. The misalignment was so severe the rollers actually ran over the corners of the deep groove ball bearings as shown in the original paper.

The second half of the root cause was INADEQUATE lubrication.

The seal manufacturer OEM used the lubricant their oil supplier recommended on a world wide basis. After we proved this recommendation was incorrect they changed it on a world wide basis.

The basic problem is that most lubrication from either oil or grease is HYDRODYNAMIC in nature. You may also see it referred to as EHL (elasto hydrodynamic lubrication) This means the oil develops a "pressure wedge" so to speak which greatly increases the pressure (and load carrying ability) of the oil used to lubricate.

DYNAMIC is a KEY part of this principle. Refer to FAG Publication "Rolling Bearing Lubrication " for the theory concerning EHL. FIG 2 is a graph from this publication that Can help you decide what base oil viscosity is needed for your application.

So the obvious question is what provides the load carrying ability at these low speeds. The answer is mostly oil viscosity even though some oil suppliers say an EP (extreme pressure) package in the oil is helpful.

Grease being used in Canada and Germany had a base oil in it of 220 ISO. Mexico had always departed from OEM specs and used an grease with 460 ISO base oil. After much investigating we settled on Mobilith SHC 1500. We never experienced another failure once we switched to Mobilith SHC 1500 with the base oil viscosity of ISO 1500.

One word of caution! Mobilith 1500 would not save a bearing where pits and other damage had already started. When used in new bearings it simply prevented the spalls from happening in the first place.

Curing the misalignment in Germany was also a major part of the fix. We never found out, but I don't think Mobilith 1500 in Germany ALONE would have solved the problem.

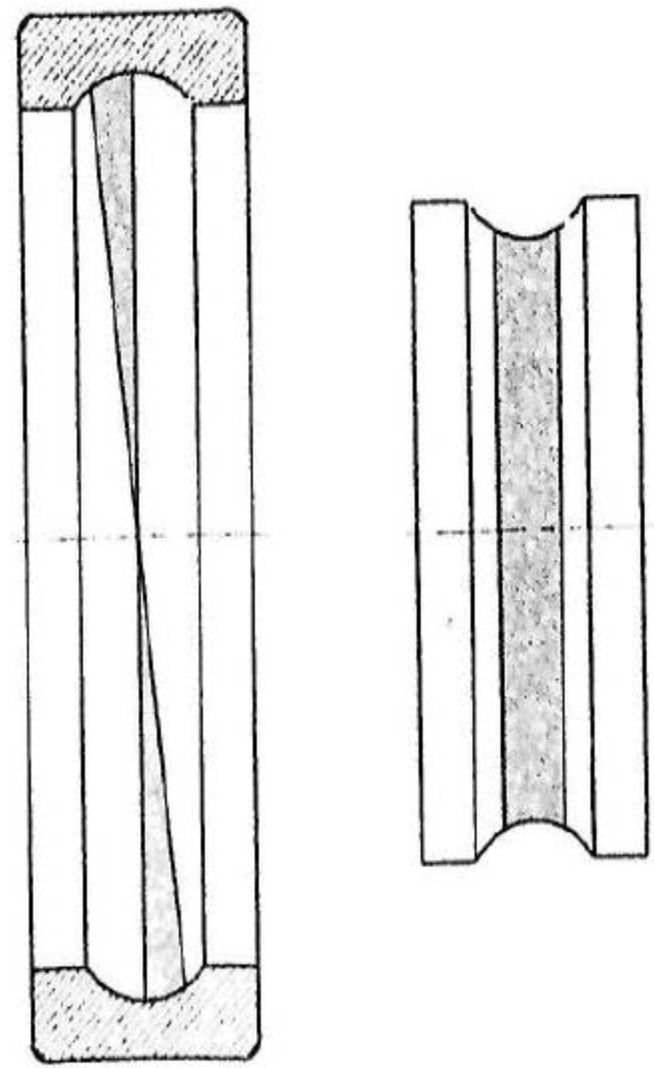
MANY people, including oil salesmen, are not fully appreciative of the phenomenon explained above. MOST people do not have to work with equipment at these slow speeds.

If you do have important equipment at these low speeds you should consider what I have explained above concerning lubrication and EHL.

“Tracks of a misaligned deep groove ball bearing with rotating inner ring”

Courtesy of FAG from “Rolling Bearing Damage” catalog page 26, item c

Fig. 1



C

FIG . 2

“Rated viscosity, v_1, depending
On bearing speed:
D=bearing
OD, d=bore diameter” from
Page 6 of FAG publication
“Rolling Bearing Lubrication”
WL81 115/4
EC/ED/97/6/2000

Note: For a FAG 619/500 deep grove ball bearing with dm= 460 at 3 rpm a viscosity of over 800 Is needed

This led us to Mobilith SHC 1500