KNIGHTHAWK TECH NOTES

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"Polymer Lubricated Bearings: When it's working, it's Working Well"

You have installed the largest melt pump in the world, one for each of the two trains. The management team is expecting record production rates in the new polymer plant. The maintenance group is thinking that there would be little or no problems with these melt pumps as the smaller size in other production facilities have worked well. There is celebration at the plant when the design production rates are met. That Friday evening you leave the plant, taking a look at the discharge pressure and temperature of the melt pump and all is well.

That weekend while relaxing you receive a call from the plant. The melt pumps have seized up. Then, the nightmare starts. You go to the plant and "all hands are on deck" to shut the plant down and pull the melt pump. Next there is a meeting in the Plant Managers conference room to discuss the plan to get up and running and root cause failure analysis. You are in charge of the root cause failure analysis (RCA). A team that management put together includes maintenance, engineering, process/controls engineering, and operations. It makes no sense why the pump failed because it had been running well within the design's capability.

In the first phase of the RCA, the process data is evaluated. You notice that the temperature of the polymer lubricated bearing had gotten much higher right before failure. That's not a mystery because the plant has started running fractional melts, which in layman's terms was a more vicious product. You have the rotating equipment engineers involved and they have run their "bearing program" and the unit loads were o.k. Polymers are typically "non-Newtonian" where the viscosity is a function of shear rate and temperature. The bearing program that was run is a constant viscosity and does not really address polymer lubricated bearings. After the melt pump was removed the metallurgical and materials group evaluated the bearings. The morphology of the failure suggested lack of lubrication. The silver Babbitt in the bearing had melted and froze the bearing to the shaft. The bearing were running fine with the same polymer up until production was ramped up.

In this problem, the RCA revealed that the root cause was lack of lubrication. The lack of lubrication was caused by several factors which were as follows.

- The polymer started to break down at the higher temperatures.
- The pump suction design would not let the teeth fill properly.
- The third issue was the feed vessel did not have a high enough level to prevent non condensables from getting into the polymers.
- The lube groove in the bearing did not allow for enough mass flow rate of polymer to lubricate the bearing.

To evaluate such a problem like this, one should take a multi discipline approach involving the metallurgical analysis, process, controls, mechanical, and operations as follows:

1. The polymer found in the bearing should be analyzed for breakdown. In fact, the rheology should be determined across the entire temperature and flow range.
2. Computational Fluid Dynamics Analysis (CFD) should be conducted to characterize the flow and temperature. The results of this analysis will determine the 3-D flow field including temperature and local pressure contained within the polymer film in the bearing.
3. Finite Element Analysis (FEA) should characterize the temperature distribution and shaft deflection.
4. Field Data Acquisition should be conducted to evaluate the flow and dynamic pressure.

From the analysis work conducted one can determine:

1. The feed conditions required to allow proper tooth filling for the inlet of the pump.
2. The lube groove design in the pump can be validated or redesigned to insure enough mass flow rate and the distribution is achieved in the bearings.
3. Based on the geometry of the bearings, the maximum rpm can be determined for reliable operation.

Polymer lubricated bearings are some of the most difficult to analyze. The non-Newtonian characteristics of the bearings make the bearing analysis challenging. Any analysis has to consider the viscosity as a function of shear rate and temperature to properly capture the fluid dynamics and heat transfer. The reaction center of pressure of the bearing loads are different than Newtonian bearding analysis. Field data acquisition is a key to understanding the performance of the bearing.

Cliff's Notes:

For over 25 years KnightHawk has analyzed polymer gear pump design and failure analysis. Our team has been involved with the most complex designs in industry. We have solved major failures and provided turnkey specialty engineering services involving gear pumps. We have modified OEM's design to improve flow characteristics and reliability at high flow rates (In some cases, record flow rates). In most cases, KnightHawk's effort is only a fraction of the loses experienced. Some KnightHawk team members have designed proprietary melt pumps that have been installed in world scale polymers plants.

On the personal side, I hope everyone is having a wonderful summer. Hope your AC works well if you are in Texas!

Take care and God Bless,

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KnightHawk Project Update

- Furnace Tube Failures
- Heat Exchanger Tube Failures
- Expansion Joint Failure and Repair Analysis
- Structural Analysis
- Methane Bottle Failure Analysis
- Motor Driven Structural Vibration
- Pump Design Assessment
- Impeller Resonance Testing
- Process Valve Fit for Service
- Corrosion Failure Analysis
- Structural Vibration Caused by Acoustic Pulsation.
- Steam Let down Valve Vibration
- TLE Failure Analysis
- Compressor Vibration
- 3rd Party Design Review
- Pump Failure
- Acoustical Vibration - Reciprocating Compressor
- Compressor Vibration Field Services
- TLE Design Audit
- Low Temperature Brittle Fracture Analysis