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Polymer lubricated bearings: A challenging design problem

Journal bearings are found throughout the industrial work for various applications for rotating equipment. Some equipment such as polymer gear pumps utilizes product-lubricated bearings to serve as the lubricant for the bearing. The reason is that the equipment turns at relatively low rpm and runs at high temperatures that are frequently above 400 F. In addition, the journal runs on boundary-type lubrication instead of a hydrodynamic film. Usually high bearing unit loads are present (frequently very high) and high shaft deflections are present. These types of pumps over the years have been susceptible to shaft and journal failures. These bearings are likely the most complex bearings in heavy industry to properly analyze. Many design approaches have yielded various successes while others have failed. The only way to analyze the bearing is to incorporate the fundamental physics involving the heat and mass transport that governs the bearing lubricity.

If you think what is described above is bad, wait until you hear what is next. Polymers exhibit non-Newtonian fluid characteristics thereby the viscosity varies with temperature and shear rate. The bearing center of pressure is a function of polymer flow, temperature, and shaft deflection. The shaft deflection is a function of the bearing center of pressure and therefore the solution to the problem is iterative in nature. Frequently, many different polymers are run through the same pump. All of these factors make this a real sporty problem and a good problem for the academic types to whet their appetite with.

As I indicated previously, this bearing analysis is known to be one of the world's toughest bearing analyses. These bearings have been in operation for many years. It has typically been on small gear pump designs that the technology has evolved. The design iterations have been mostly through trial and error approaches. Scale ups to world-class polymer plants have led to failures in these bearings and the necessity to create analysis methodologies to address these designs to make improvements. Successes have been made with computational fluid dynamics and finite element tools to assist in solving the problem.

Typically, a finite element model (FE) of the rotor is created to look at the structural response. A computational fluid dynamics (CFD) model is created to evaluate the flow through the bearing. The CFD model will incorporate the non-Newtonian characteristics of the polymer, including temperature effects. A pressure profile is determined with the CFD model and it serves as a boundary condition for the FE model. Deflections are obtained from the FE model. The CFD model incorporates the shaft deflection, thus we're on the way to an iterative solution to this nice technical problem.

If possible, field-testing of the gear pump will provide insight to tune the numerical models to provide best results. It is typical to measure the shaft position, polymer flow and bearing temperatures as a function of rpm. It is also a good idea to perform thermal imaging of the gear pump to evaluate the temperature distribution. One of the challenges is to locate the peak temperature in the bearing. Since the behavior of the bearing is different than a traditional bearing the location is different. Also, it is a good idea to check the polymer exiting the bearing for "black specs." This may be an indication of polymer degradation due to high temperatures.

Some key points to remember:

1. This type of problem cannot be solved nearly as quickly as a standard journal-bearing problem.
2. Polymer rheology must be evaluated at many different temperature levels.
3. A good mesh design will give better convergence.
4. Do not make big step changes in the iteration process.

As always, it is important that the bearing design be reviewed by a professional engineer competent in this type of work.

For more information, visit www.knighthawk.com or call (281) 282-9200.

NEWS **UPDATE**

Treasury, DOE award $2 billion in tax credits

WASHINGTON — As part of a partnership aimed at increasing economic development while setting our nation on the path to energy independence, the U.S. Department of Treasury and DOE have created a program to award $2.3 billion in tax credits for manufacturers of advanced energy equipment. Authorized by the American Recovery and Reinvestment Act, this new program will provide tax credits to manufacturers who produce clean energy equipment.

"This program will encourage innovation in design of clean energy technologies," said Treasury Secretary Tim Geithner. "This partnership between Treasury and Energy adds an important new dimension to the incentives created in the Recovery Act to increase U.S. manufacturing output, improve energy efficiency and develop alternative sources of energy."

The program authorizes the Treasury to provide developers with an investment tax credit of 30 percent for facilities that manufacture particular types of energy equipment. Qualifying manufacturers will produce solar, wind and geothermal energy equipment; fuel cells, microturbines and batteries; electric cars; electric grids to support the transmission of renewable energy; energy conservation technologies; and equipment that captures and sequesters carbon dioxide or reduces greenhouse gas emissions.

"These tax credits will help create thousands of high-quality manufacturing jobs in some of the highest growth segments of the economy," said Energy Secretary Steven Chu. "This is an opportunity to develop our global leadership in clean energy manufacturing and build a secure, sustained base of jobs for America's workers."

The manufacturing tax credit is capped at $2.3 billion, and credits are available for two years or until the cap is reached. Companies are expected to receive payments within 180 days of filing for the credit.

For more information, visit www.energy.gov or call (202) 586-5000.