Determining Factors for Turbine Flowmeter Bearing Life

Ron Madison
Vice President, Sales & Marketing
Exact Flow

In the field of flow measurement, several important factors can cause accuracy concerns leading to premature flowmeter calibrations or bearing replacement. Precision turbine meter users need to understand the proper techniques to ensure their instrument will maintain its calibration over the intended period of use. Most importantly, while in service, these steps will ensure that a meter is performing to its original calibration and provide information that will influence its calibration life.

It should be noted that this discussion pertains to precision turbine flowmeters commonly used in the aerospace, automotive, fuel distribution, subsea systems and manufacturing industries, where clean fluids are present.

Background

Turbine flowmeters measure the volume of liquids in pipes, such as hydraulic fluids, diesel fuels, aviation fuels, chemicals, water and cryogenic liquids. High accuracy turbine meters are also available for custody transfer of hydrocarbons and truck distribution of diesel and propane fuels. Despite the advantages offered by the turbine design, users must be careful when introducing these devices to process fluids and piping environments to prevent premature calibration shifts.

To answer questions concerning the bearing life of a turbine flowmeter, four major variables must be considered:

1. Piping system cleanliness at start-up
2. Fluid lubricity
3. Fluid temperature
4. Fluid filtering

Essentially, turbine meter bearing life has less to do with the bearing itself, and more to do with what the bearing is subjected to. The good news is that the bearing will have a constant supply of fluid for lubrication and cooling. While this is an asset, it can also be a liability, depending on how the user acts on the four variables listed above.

Piping System Cleanliness

A wax or flux substance along with a filter fiber thread was lodged in the bearing during initial start-up.

Far too often, a new process or test stand is commissioned without an initial cleaning of the piping. The first time fluid is introduced to the piping system, it will flush out all existing debris and pass it through the bearing system of the turbine flowmeter. If lines are not purged prior to installing the meter, particulates such as pipe dope, metal shavings, Teflon® tape, flux, slag, dirt or even rags will be forced into the bearing system.

Another cleaning practice used is referred to as "blowing down" the process lines. As the name implies, high pressure air is used to purge the lines. If a liquid turbine meter is installed, the air velocity will over-speed the bearings, causing overheating and bearing degradation. Once this has occurred, the meter's calibration is no longer valid and the flow measurement will not be accurate. This will be more evident at the lowest flow measurement, where bearing friction has a larger influence on rotor RPM, which is directly proportional to frequency output.

Fluid Lubricity

The lubricity of the process fluid influences the life of turbine flowmeter bearings, since flowing fluid is used to lubricate the bearings. Water is less lubricating than fuels or oils; therefore, bearings used in lubricating fluids should be expected to last years longer.

Traditional turbine meter bearings are fabricated out of 440C stainless steel and the bearing retainers are fabricated from 440C, 303 and 410 stainless. The 440C bearing, even though classified as stainless steel, cannot be used in water or acids. Cryogenic applications involving liquid oxygen and liquid hydrogen provide no lubricity, and as such, require special bearings.

Ceramic bearings are ideal for water, hydrocarbons and cryogenic applications.

There is some good news on the bearing front, as there have been major advancements in ceramic bearing technology. Ceramic ball bearings have proven themselves to be superior in wear resistance and less susceptible to particulates. They are ideal for most fluids, including water and cryogenic applications, which have little to no lubricating properties. Water applications usually require high-friction tungsten carbide or ceramic journal bearings, which shorten the linear flow range of operation, while ceramic ball bearings have a low coefficient of friction and exhibit excellent wear resistant characteristics.

Exact Flow (Scottsdale, Ariz.) has performed dirt tests, in conjunction with endurance tests, to verify the durability of specially developed ceramic bearings. Two bearing types were tested:

- Stainless steel bearings with 440C races and balls
- Hybrid bearings with 440C races and ceramic (silicon nitride) balls

The dirt tests consisted of operating turbine flowmeters with 250 ppm of 5-micron dirt for 240 hours, followed by operating the meters with 250 ppm of 30-micron dirt for 240 hours. After each test, it was found there was a degradation of performance with the stainless steel ball bearings. In each case, the hybrid ceramic bearings demonstrated no degradation and maintained a repeatability of ±0.1% of reading. The 440C stainless steel bearings indicated a degradation of ±0.25% of reading.

After the dirt tests were completed, the hybrid ceramic bearing meters were subjected to endurance tests performed with automobile gasoline. The flow rate varied from 0.5 to 65 gallons per minute (GPM). The accuracy of the meters was checked after every 100,000 gallons. After 3 million gallons, each accuracy check was within ±0.1%. After 6 million gallons, most of the checks remained within ±0.1% of reading. All accuracy checks were within ±0.15% of reading. These tests were performed in conjunction with the gasoline dispensing industry, which defined a 30-year life as 3 million gallons measured through the meter. All of the meters under test (qty. 6) exceeded the 30-year life and some exceeded 6 million gallons or a 60-year life. These excellent characteristics make ceramic ball bearings desirable for most flow measurement applications.

If flowmeters are removed often from piping, they should be flushed out with solvent to remove the fluid residue and install end caps. This will prevent fluid residue from forming a coating on the bearings, which (depending on the fluid) can become dry and form a film when exposed to air. If the fluid doesn’t create a film on the bearing and remains liquid, it might be hydroscopic—attracting moisture or particulates. Obviously, the fluid characteristics are important to understand in order to protect bearing. Plastic end-caps, which are shipped with the flowmeters, can be re-installed to prevent this type of contamination during storage.

Fluid Temperature

The user’s process environment dictates operating temperature, therefore, little can be done to extend bearing life other than select a bearing compatible with the min/max temperature. If the temperature is above 149˚C (300˚F), this will degrade the standard 440C ball bearing life. Special bearings, which have been specially heat treated, can be used in temperatures up to 400˚C (750˚F). Again, ceramic ball bearings are an excellent choice, with temperature limits of 425˚C (800˚F).

440C bearings do offer a low temperature capability of -270˚C (-450˚F). However, the flowmeter manufacturer must take precautions to ensure their meter's coefficient of expansion matches that of the rotor shaft material in order to maintain proper mechanical fit in varying temperatures. Ceramic bearings are also rated down to -270˚C (-450˚F).

Fluid Filtering

Installing a filter in process or test stand lines is the best way to remove fluid particulates—and thus extend turbine meter bearing life. The smaller the flowmeter size, the finer the filter must be. For example, 10 microns is suggested for meters below one-inch in size. Sometimes, particulates can be metal shavings coming from such things as upstream pipe threads or sediment from the bottom of a supply tank.

Recently, an end-user reported that his high precision, dual-rotor turbine meter was providing an improper signal. He went through the usual electrical checks and determined a signal was present, but that it was grossly in error. It would have been easy to blame the pickoff, amplifier or incorrect wiring for this problem. Further investigation revealed that the problem only existed on the leading rotor; the second rotor was outputting a signal. Upstream of the flowmeter, the user had removed and reinstalled some instrumentation in the piping. In the process, a large piece of metal was carried downstream and lodged in the first rotor, preventing it from rotating. The ratio of the rotors changed; thus, it was an indication that the leading rotor was restricted. Monitoring the rotor ratio is a unique feature to the Exact Flow dual-rotor turbine meter and is an indicator of bearing health during operation.

Conclusion

Ensuring cleanliness of piping prior to installing precision turbine flowmeters will maintain calibration integrity and extend bearing life. Users must select the proper bearing material for both fluid lubricity and process temperature to ensure long-term reliability. Ceramic bearings offer excellent temperature and wear characteristics, making cryogenic and water applications possible with improved linearity and flow range capability. Providing upstream filtering of the process fluid is the best insurance to keep particulates out of the meter's bearing system.

Lastly, flowmeter users should maintain good records providing factual evidence of historical calibration data for their meter and its bearing system (see, Determining a Calibration Schedule for Precision Turbine Flowmeters).

Exact Flow
15555 North 79th Place, Scottsdale, AZ 85260
Phone: (480) 948-3789
sales@exactflow.com
www.exactflow.com