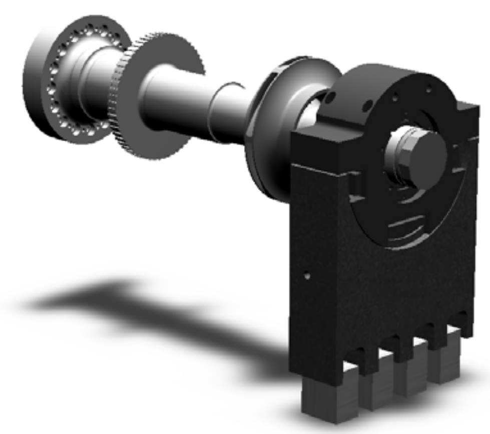
Transmission & Bearing Corp.

Technical Notes by Dr. Mel

January 2005

TRI Solutions For Common Problems of Extension Shafts, Oil Pumps and Steady Rest Bearings For Westinghouse Large Steam Turbine Generators



New TRI Extension Shaft and Steady Rest Bearing for Westinghouse Steam Turbine-Generators

P.O. Box 454
212 Welsh Pool Rd.
Lionville, PA 19353

Tel: 610-363-8570
Fax: 610-524-6326

info@turboresearch.com
www.turboresearch.com

The extension shafts of Westinghouse large steam turbine-generators are used to drive main oil pumps, support a thrust bearing, hold a mechanical overspeed bolt, and/or to power a fluid drive and boiler feed pump. The design and maintenance of these extension shafts have been the sources of many problems over the years. TRI Transmission & Bearing Corp. has designed and installed proven solutions to these problems, as described below.

The principal problems associated with extensions shafts are:

- Very high amplitude vibrations of the extension shaft result when the HP turbine experience high vibrations, a bow in the turbine shaft, the extension shaft has a bow, or the coupling to the extension shaft is made-up improperly.
- Mechanical overspeed bolt does not “trip” at the preset speed.
- Floating Seal Rings on Main Oil Pump Impellers are damaged or break due to high rotor vibration, and subsequently damage the Main Oil Pump Impellers.
- Vibrations of HP Turbine Rotor are influenced by vibrations of a long overhung extension shaft, which has a node of vibration at or near the Number 1 Journal Bearing.

Additional problems can arise when a Westinghouse steady rest bearing already exists and the extension shaft drives a fluid drive and a boiler feed pump:

- The tips of the pad support bolts in the 4-pad steady rest bearing pound out repeatedly, opening the bearing clearance permitting excessive vibrations of the extension shaft.

- If a "crank" exists in the flexible coupling between the extension shaft and the fluid drive input shaft, excessive rotor vibrations of both the extension shaft and the fluid drive input shaft result.

Discussion of the Problems

When no steady rest bearing exists, the bulk of the vibration problems occur because the cantilevered overhang of the extension shaft from Bearing #1 is 5 to 7 feet. Vibration amplitudes at the end of the extension shaft can easily approach 0.050" peak-to-peak, and 0.020" pk-pk at the main oil pump impeller.

The overspeed bolt does not operate (or trip) at the same speed all of the time. The cause of this unreliable performance can be traced to vibration. A 0.050" pk-pk vibration corresponds to 0.025" vibration (0-pk) of the geometric centerline of the shaft relative to the centerline of rotation. Depending on the phase angle, this vibration can cause the trip speed to vary approximately ±2.5% from the typical 3960 rpm set point, or +/- 100 rpm, and therefore, it is not considered to be very reliable. The use of mechanical overspeed bolts was the only choice when these machines were built, but this is no longer the case.

When a Westinghouse 4-pad steady rest bearing does exist, it has these problems: Each pad is supported by a skinny bolt, with the maximum contact area for each pad being about 0.5" diameter. When the ends of the bolts become pounded out, the journal bearing assembled clearance opens, and the shaft vibration increases. Vibration amplitudes up to 0.050" have been measured with reliable proximity probes.

Solutions

When no steady rest bearing exists, the preferred solution is to replace the existing extension shaft with a new TRI extension shaft and install a very substantial steady rest bearing at the outboard end of the extension shaft. The TRI Align-A-Pad ® Bearing has proven to be an ideal solution.

When a 4-pad Westinghouse steady rest bearing already exists, the preferred solution is to replace it with a new TRI Align-A-Pad ® design.

The TRI Align-A-Pad ® Bearing for this Steady Rest application has 5 tilting pads with heavy duty pad support contacts. A new heavy pedestal is included in the design, which can be modified to extend down to the floor of the front standard and/or attached to the front wall of the front standard. The bearing is equipped with 3 "saddle blocks" or alignment pads to align the bearing relative to the new heavy pedestal. This TRI solution has been in service for over 10 years with very low vibration and almost no maintenance.

A new TRI extension shaft preferably is made to be sufficiently flexible so that a bow in the HP turbine rotor will bend the extension shaft in order that eccentricity probes located approximately half-way between the Bearing #1 and the new steady-rest bearing will be effective for measuring that HP Turbine rotor bow.

Overspeed bolts should be replaced with all electronic overspeed systems for the following reasons: (1) Standard equipment for new turbines today includes only electronic overspeed packages. (2) The principal cause of failure of LP turbine buckets (blades) is overspeed testing, particularly, when the bolt trips at a speed at or above the set point. (3) Today, electronic systems are quite reliable, more reliable than the mechanical overspeed bolts because the systems can operate on both "rate of change" and at specific "set point speeds". It is not necessary to test the overspeed systems by running the turbines up to the set point trip speed.

New TRI extension shafts for use with electronic overspeed systems are made with disks with multiple teeth on the OD and flat axial faces for differential expansion probes. Thrust collars can be included. TRI designs and manufactures new oil pump impellers from cast stainless steel.

For Turbines with Fluid Drives and BFPs: The original Westinghouse flexible diaphragm couplings, often called "banjo couplings", can distort resulting in a "crank" between the two connected shafts. The distortions generally arise during maintenance from uneven heating of the couplings and by improper removal techniques. This distortion causes vibration.

Distorted Westinghouse flexible diaphragm couplings can be replaced with new flex couplings. TRI usually specifies new couplings with longer distances between shaft ends in order to increase the amount of parallel offset misalignment that can be accommodated. Fluid drive input shafts can be shortened, reducing the overhang length and reducing the vibrations of the fluid drive.

This Technical Note was written by Dr. Melbourne F. Giberson, P.E., President of TRI Transmission & Bearing Corp., Turbo Research, Inc. The objectives of Technical Notes are to disseminate information and experience on understanding problems and how to solve them. We attempt to send this Technical Note only to those people for whom the information might be useful. Over the years, many people have asked to be added to the distribution list (see our website). Occasionally, a few individuals inform us that they do not wish to receive the information. Should you desire not to receive future Technical Notes, please advise TRI by info@turboresearch.com or click visit the removal page on the TRI web site MFG 1/2005