Brüel & Kjær Vibro

Application Note

VIBROCONTROL 6000™ at Huntly Power Station

Figure 1 Panorama view of Genesis Huntley Power Station

Introduction

Genesis Energy's Huntly Power Station is located on the banks of the Waikato River between Hamilton and Auckland in the North Island of New Zealand.

The station was commissioned from 1982 to 1985 and consists of four 250 MW, single reheat turbo-alternators made by Parsons in UK.

Figure 2 Machine Hall

Figure 3 Steel Foundation Structure

The Huntly machines are unique in that the foundations are designed with earthquake isolation in mind and are all steel.

The flexible nature of these foundations meant that the generator inboard bearing had a resonance at running speed and the generator 2nd critical was just below the running speed which makes these machines extremely sensitive to couple imbalance.

Monitoring Strategy

Figure 4 Classic Compass instrument rack.

In 1995 the OEM monitoring system was replaced with the Classic Compass system to facilitate better monitoring and protection.

In 2011 the Compass system on two of the units was upgraded to the new VC-6000™ system.

On the main machine the Compass system monitors relative shaft position and motion on each of the 8 main bearings, the eccentricity of the 3 turbine shafts, the differential

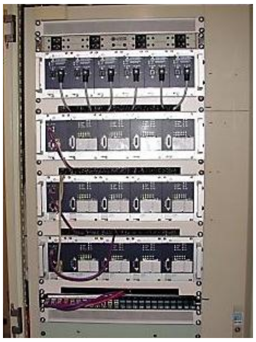

Figure 5 VC-6000™ rack

expansion of the 3 turbine shafts, the axial position of the shaft relative to the thrust bearing, and the pedestal vibration of each of the machine's 12 bearings. In addition, the Compass system monitors the casing expansion on both sides to check for crabbing or sticking of the sliding feet.

The differential expansion is measured using two proximity probes looking at a 6° tapered collar machined on the shaft.

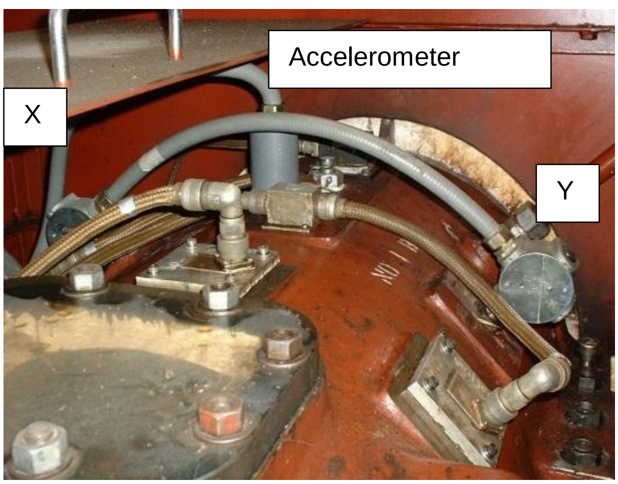

Figure 6 Bearing showing the X/Y transducers

Figure 7 Casing expansion transducers

The Compass system is also used to monitor the bearing vibration and thrust position on the steam turbine driven feed pump on each unit.

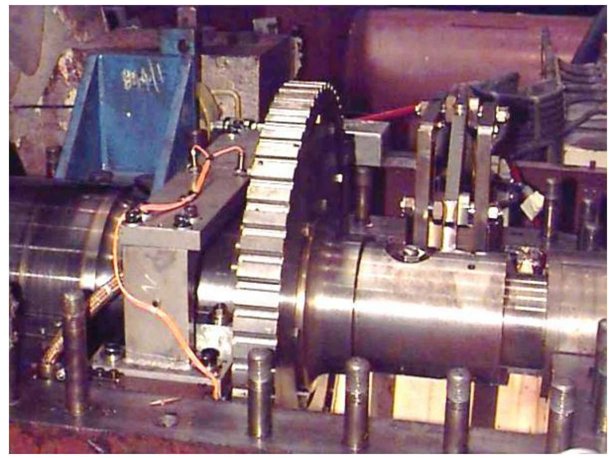

Figure 8 HP Differential expansion transducers

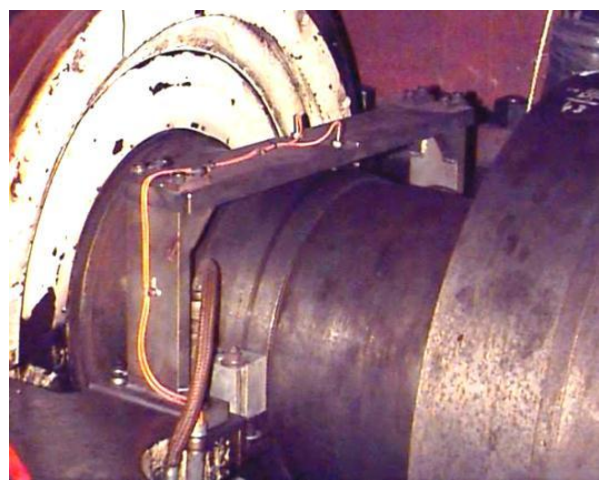

Figure 9 IP Differential expansion transducers

Over the last few years Huntly has upgraded the control system from analogue to a DCS and during this process the Compass system was integrated into the controls and various Compass alarms either hold the run up or the loading, and at higher levels trip the machine.

Figure 10 Analogue control and DCS for one Unit

Case Story 1 - Differential Expansion Issues

One of the critical measurements on a steam turbine is its differential expansion. This is a measurement of the relative expansion between the turbine shaft and the turbine casing. The design of the turbine is such that the thermal inertia of each component is as close as possible. Matching these expansions is quite hard as the shaft is totally surrounded by steam whereas the casing only has steam on the inside. A turbine will typically experience differential expansion problems on start up. If the start-up is from cold, then the shaft will expand faster than the cylinder, in the direction towards the rear of the turbine. By the machine manufacturer's convention this is referred to as a negative differential. If the start-up is from hot then it is possible for the shaft to contract and the differential will go in the positive direction, i.e. towards the front of the turbine. This measurement is critical because of the small clearances between the front of the turbine blades and the stationary cylinder components. This clearance is kept as small as possible to reduce steam leakage around the blades (i.e. to reduce efficiency losses), whereas the clearance on the back of the blades is much larger because of the lesser sensitivity to efficiency losses. The positive differential limits are therefore quite small and on the Huntly HP turbine the alert limits are 0.5mm +ve and 6.35mm –ve.

The key to controlling the differential expansion is to match the steam to metal temperatures and by holding the load to allow the turbine to "heat soak". As can be seen in the Compass VC-6000™ plot below, the load (blue trace) is held for a period of time which allows the HP differential (white trace) to stabilize.

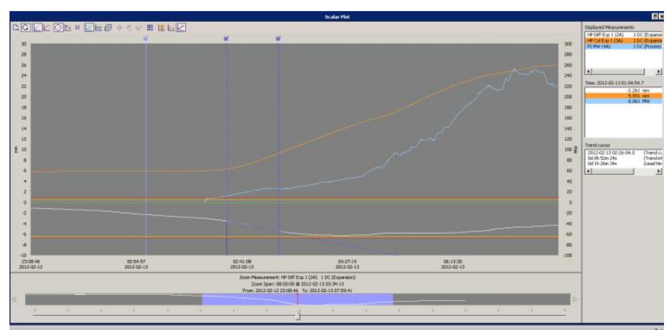

Figure 11 Trend of the differential expansion

Case Story 2 - Unit 4 Generator

In 2010 we noticed that the 1x vibration on the generator outboard bearing had some variation from one run up to the next. These units are very sensitive to a small degree of balance change and a few years ago we noticed a similar behavior on unit 4 but on the inboard bearing. At that time we arranged to remove the generator end-cap as we suspected that the end winding blocks were loose and were shifting causing a balance shift. On removal of the end cap this proved to be the case and the blocks had been shifting causing some insulation damage and small balance changes from run to run.

In this case our immediate action was to limit, as far as possible, the number of stops and starts as we again suspected shifting end blocks. By the end of 2011 the variation was up to 6 mm/s.

A number of concerns with the quality of the rotor winding insulation prompted a decision to carry out a complete rewind of the generator rotor during an extended survey in 2012.

As the rewind process involves a major balance change on the rotor and a number of other factors it was decided to ship the rotor to a facility in Australia which could rewind the rotor and also to carry out an over speed test and a full speed balance of the rotor.

The over speed (3600 RPM) has two functions; it centrifuges the windings which settles them in the winding slots, and secondly the over speed causes the end caps to “float” on the interference fit and thus centralize. The over speed test is carried out twice and then the rotor is trim balanced at its operating speed.

It is crucial to be able to do this in a balancing pit as it gives full access to the rotor body balance weight positions which are not accessible once the rotor is back in the machine.

What was found when the end caps were removed and the excitation leads were disconnected from the windings was that the exciter leads had work hardened and fatigued to the extent that they were no longer fully connected and had arcing damage inside the insulation. This was, in fact, the cause of the balance variation we had seen in service.

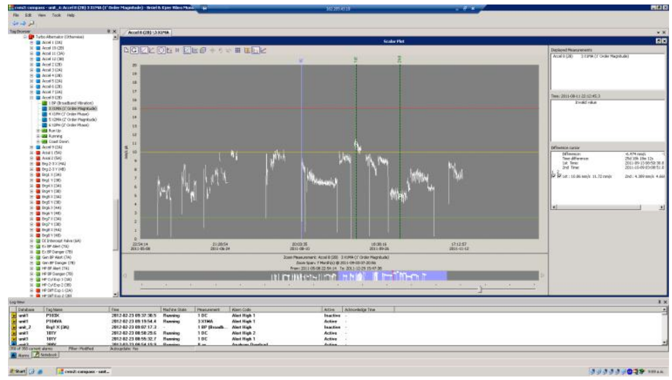

Figure 12 Trend of the bearing vibration

Case Story 3 - Unit 4 Main Boiler Feed Pump Thrust Failure

It is our experience that thrust bearings can fail totally with very little warning. The damage from such a failure can be quite extensive as the loss of axial control leads to axial component damage.

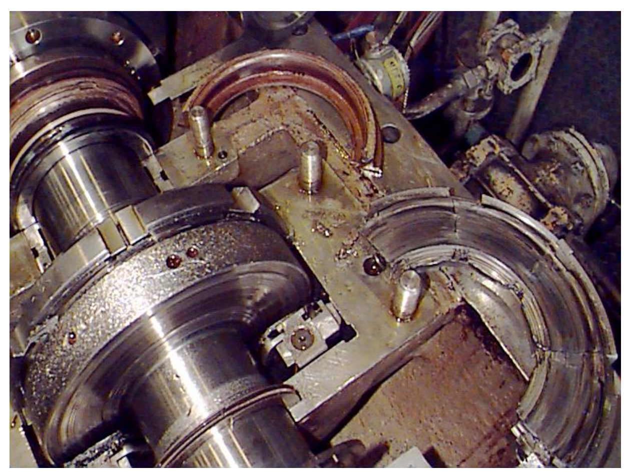

Figure 13 Feed pump thrust bearing failure

In the case above, the thrust bearing white metal failed in service with the pump operating at 5400 RPM, while being driven by a 9 MW steam turbine. This allowed the shaft to move axially about 6 mm resulting in loss of internal clearances and rotating components friction welding to stationary components. The result was the pump came to rest from 5400 RPM and accelerates back to 5400 RPM when the friction welded components let go all in about 20 seconds.

With the integration of the VC-6000™ into the control system it was our intention to trip the machine should the thrust position go to a danger level. The thrust is monitored with dual proximity probes and both probes are required to be in a danger condition to trip the unit.

In the case of unit 4 recently the activation of the trip in the DCS had not been implemented when an internal component failure caused the thrust bearing to be over loaded. As can be seen from the plot trace shown below, both thrust indications went to the danger level but the unit had to be manually tripped.

Figure 14 Thrust failure

Acknowledgements

We wish to thank Simon Hurricks, Machine Dynamics Engineer at Genesis Energy Ltd., for submitting this story. This is his second story; the first was entitled “Excessive vibrations on 250-MW turbo-generator bearings due to flexible steel foundations”

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