Turbine Health Monitoring Blade Vibration Measurement and Analysis.

System Information Sheet

Blade Tip Timing Gas and Steam Turbine System – ECSBTT
Introduction

PrOXisense has developed a robust turbine blade vibration monitoring, analysis and diagnostic system capable of operating continuously in-service and providing data analysis and assessment in real time. The system is able to provide valuable data during installation and commissioning to aid blade and rotor characterisation and turbine start-up and shutdown sequencing. Once Turbines have been handed over for service the system provides a rich data set to help owners and operators mitigate risk through real-time monitoring of vibration, clearance and blade deflection and avoid unplanned outages and catastrophic failure through the long-term monitoring of performance to detect progression and trends that could lead to potential failures.

The PrOXisense system utilises an Eddy Current Sensor which has proven reliability with over 200 sensors in service on Industrial turbines worldwide. The sensor is driven by a T3i trigger electronics which has been significantly enhance through extensive field trials and can provide very accurate blade tip timing data in both analogue and digital form in real time. The T3i signals feed directly into a Digital Signal Processor (DSP) which is capable of simultaneously processing up to 12 inputs from not only T3i output but also other sensor output signals as desired. The DSP can be configured to operate with a wide range of interface mediums from a dedicated Micro PC, to interfacing with specific turbine controls systems and software, to being able to be accessed via an internet connection from anywhere in the world.

The PrOXisense system provides a robust and reliable method of Turbine health monitoring that not only allows owners and operators to detect in-service event as the occur but the real time continues nature of the system allows trends overtime to be measured and from this continues data decision on performance optimisation, preventative maintenance scheduling and predictive failure event avoidance. The systems long service life and low maintenance cost represent excellent value when set against reliability and availability downtime and the significant cost of an unplanned failure outage.
Sensor

The sensor is a directional eddy current sensor that provides optimisation for blade tip timing measurement. A standard selection of sensors are available with diameters of 2mm to 47mm. Typically the probe range will be just over half the diameter of the probe. Sensors with other ranges and dimensions can be supplied per specifications on request.

The probe unit consists of an encapsulated coil assembly hermetically sealed with an integral coaxial cable and connector. Sensors can be supplied with armoured or non-armoured cable, in lengths from 1 to 10 metres (10 metres standard).

When connected to the driver unit the sensor produces a high frequency oscillating voltage that induces eddy currents in the target material. Reciprocal sensing of these currents provides an accurate source of blade information, which is then processed by the driver unit in real time to accurate blade tip timing information.

Driver

The driver unit is powered by a 15-30V DC supply via a standard co-axial plug connection.

Three outputs are available via female BNC connectors:

1. Raw eddy current analogue signal
2. Processed blade tip arrival time pulse
3. Once-Per-Rev
The second of these outputs, the blade tip pulse arrival time derived from the raw signal, will often be the most useful output. The reliability of this output is assured using a TTL square wave pulse trigger algorithm.

The three outputs are also available in digital form via an RS485 female connector, capable of supporting up to 100m of cable. The three BNC connectors are also available for use as diagnostic tools. The unit has “Plug and Play” compatibility with a wide range of tip-timing data acquisition systems and can be connected very simply as shown in Figure 1.

The interface box can take up to twelve inputs of various cable types, which feed into the Digital signal processor. This will then process the data and store it in a Micro PC and/or a data collection unit such as a laptop if the data is required to be observed in real time.

**Figure 1**
The target blades must be made of electrically conductive material. The T3i can be successfully used with ferrous materials but is ideally suited to non-ferrous materials such as titanium, nickel super-alloys, titanium composites and aluminium.

The Sensor should be carefully aligned to achieve maximum response. This is achieved by mounting the probe so that the axis formed by the cable entry gland and the diametrically opposite mounting hole lies parallel to the camber line of the blade, thus forming an angle to the direction of rotation equal to the angle of incidence of the blade. (dotted line = camber)

Driver Unit Installation

The driver unit is housed in a robust, compact metal enclosure measuring just 62.5 x 29.5 x 78.8mm and can be mounted at any convenient location on or around the target machine. As can be seen from Figure 1 (T3i), the set-up is very simple and is in fact less complicated than that required for an optical sensor-based system.

Digital Signal Processor for Autonomous Blade Health Monitoring
The 12 channel Digital Signal Processor has the capability to monitor blade tip timing sensors, oil condition, temperature and acoustic emissions in real time. The unit will store and process information in real time collected from the 12-channel system. The data and results are transmitted via an Ethernet link to a web page and can be accessed in real time from anywhere in the world.

The unit can be located up to 100m from the T3i trigger electronics box. The unit has 12 configurable channels that can be used for any type of sensor. There are 4 additional inputs available via SMC connectors.

The DSP card itself is contained within a robust cast aluminium casing with a single D-Connector for inputs and Ethernet connectivity for output, where all the data inputs are located on one side and the processed data outputs on the other. A 12V DC power supply is used to power the system using a Lumberg DC connector.

The processed data, which can be accessed via the web, includes:

- Blade tip deflection for all blades
- Blade passing frequency
- Waterfall plot
- Blade stack plot
- Engine speed including Once-Per-Rev
- Maximum blade tip deflection with setting for triggered alarm
- Synchronous and Asynchronous resonances
- Blade flutter

**Web Client**
PrOXisense has a web client that displays the processed information from the DSP.

The connection is linked via an Ethernet cable which can go into any server that the customer wishes. An internal static IP address must be assigned to the DSP which will enable any remote client to log into the customer’s internal server where this web page can be accessed.

There are 12 input channels on the DSP which can be displayed on this page with many different headings. The setup displayed here has 4 eddy current sensors measuring various properties of the blades.

This page can display numerous real time graphs of processed information leaving the DSP. This includes temperature, oil condition and anything else that can be configured through the DSP.
Graphical Display of RPM gauge, RPM chart, individual blade deflection and a waterfall plot.
Here a blade break is being shown as it happened in real time. The individual blade that broke is visually represented and is counted by each sensor. The T3i can be set up to count any number of blades making it a versatile piece of equipment that can be tailored to many different turbines.