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Transient Vibration Analysis of Refinery Steam Turbines using Labview Program

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ABSTRACT: Consistent power generation and low maintenance costs are the major goals of power plant department. Real time fault analysis system is very important to maintain the operation of steam turbine generator system (STGS) in captive power plants. Under abnormal situation the steam turbine may having the chances of being failure which disturb the electricity supply. A suitable fault diagnosis method is applied to prevent the steam turbine from the interruption of electricity supply. The vibration data from the steam turbines which consists of 6 channels of data will be acquired during start-up/coast down and the various transient analysis plots are displayed in the front panel of the Labview program.

KEYWORDS: Labview, Steam Turbine, Data Acquisition, Start up, Coast down

I. INTRODUCTION

Condition monitoring is the process of monitoring the condition of the machines using vibration analysis, in order to identify the various faults in the machines. Effective condition monitoring and health evaluation machines are the main goal of industry to reduce the costly machine downtime and improve the quality of production. The steam turbine generator systems (STGS) are commonly used in many power plants for power generation. The steam turbine is designed to run 24hr per day. In order to the operation of the power plant can run smoothly, development of a suitable real-time fault monitoring is necessary. [1]. the best way of monitoring the faults in a STGS during start up and coast down by the use of Transient vibration signal analysis. Transient vibration is the acquisition of vibration data taken when machines is being started or stopped. Transient analysis is applied to large, critical turbo machines .transient vibration provides wealth of information where that is not available from the steady state data. [2].The amplitude of vibration and frequency is measured when the speed of the machine changes from zero to full speed and vice versa. This type of analysis is called transient analysis. Transient analysis generally involves acquiring data from multiple transducers simultaneously. This information includes Unbalance” Heavy Spot” Locations, Shaft Centreline Movement or Alignment, Bearing Wear, Critical Speeds or Resonances. [3].

II. INDUSTRY PROFILE

The oil refinery MRPL (Mangalore refinery and petrochemicals limited) is set up in 1988, located at katipalla, Mangalore under the subsidiary of ONGC (oil natural & Gas Corporation). Company is producing various products such as naphtha, motor spirit, diesel, aviation turbine fuel, sulphur, polypropylene, Bitumen, coke etc. However there are 7 steam turbines are used in the company for power generation. The fault identification during start up and shut down of the turbines are implemented using Labview virtual instruments is considered in this paper.

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III. PROCESS DIAGRAM OF TRANSIENT ANALYSIS

Transient analysis includes many steps starting from acquiring the vibration signals from a machine and converting the signals to engineering units, waveform conditioning etc are shown below. [4].

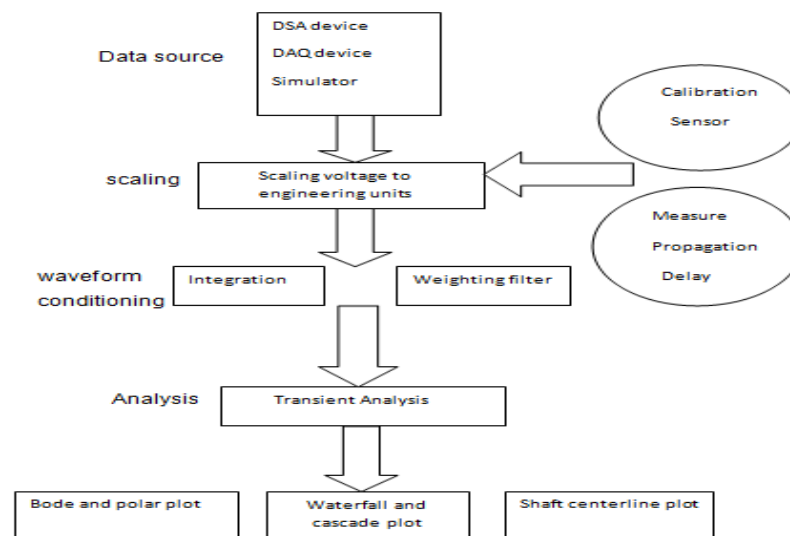


Figure 1 Flow diagram of transient analysis to the sound and vibration process

IV. DATA ACQUISITION PROGRAM

The data acquisition program is written to acquire the 6 channel of data from the steam turbine generator set. During run up or coast down, before acquiring the signals the value of initial speed, final speed, sensor sensitivity are mentioned on the front panel of the program. The analogue signals which are obtained from the steam turbine are in voltage units which are converted into engineering units. i.e. amplitude in microns. The signals are stored in the TDMS (Technical Data Management streaming) file.

The other parameters such as acquisition time, number of samples, DAQmx input, analysis filters, window function, FFT spectrums, selection of channels, speed change profile, averaging parameters, speed change profile, etc... are displayed in the data acquisition program.

The power generating steam Turbine at the MRPL, undergo critical speed in the range of 2100rpm to 2400rpm during run up or coast down. During this speed range turbine may having the chances of getting tripped. The 6 channels of vibration data which are obtained from the steam turbines are:

1. Turbine drive end horizontal
2. Turbine drive end vertical
3. Turbine non drive end horizontal
4. Turbine non drive end vertical
5. Gear box high speed horizontal
6. Gear box high speed vertical

DATA COLLECTION HARDWARE AND SENSORS

The hardware used for data acquisition may either a compact DAQ or a simple BNC 2120 signal acquisition front end. These front end hardware have been procured from national instruments. The hardware has multiple ports with BNC type collector for connecting the buffered output BNC pins through cables. Each buffered output from the panel is connected to BNC connector on the hardware. The BNC provided on the hardware are called channels. Each channel

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will have one analogue signal as output. The hardware front end can be used to measure analogue or digital data. The sensors used for vibration measurement are the proximity probes which are installed permanently on the turbomachines. Proximity probes send the measured vibration signal to the buffered output. The Data Acquisition hardware is connected to the buffered output terminals at the panel and the data is collected in to the hardware.

V. STEPS TO DEVELOP THE LABVIEW PROGRAM FOR TRANSIENT ANALYSIS

The program code is designed and written to execute following features to acquire and analyse the signals.

1. Acquire the analogue signals from the buffered output of the machine panel.
2. Use the configurable channels and channels assignment.
3. Data acquisition with or without saving the signals to file.
4. Simultaneous storage and display of processed data as per selection
5. Simultaneous display of all the channel data in different formats/ plots as selected by the user.
6. Selection of sampling rate and sample size based on the resolution and frequency requirements.
7. Read and display of stored data from files stored in *.dat format.
8. Measurements of real time machine speed and display the result

VI. TRANSIENT ANALYSIS PLOTS

Transient analysis includes many steps starting from acquiring the vibration signals from a machine and converting the signals to engineering units, waveform conditioning, analysis etc...From the Transient analysis the plots such as Bode plot, Polar plot, Cascade plot, Waterfall Plot and Shaft Centreline plots are obtained.

1. Bode Plot

Bode plot is used to study the dynamic behaviour of rotor systems. Bode plot display the amplitude and phase of the rotor with respect to the rotational speed or frequency. During run up or coast down tests, bode plot can help to identify the resonance speed of the rotor. By locating the peak in the vibration amplitude with the corresponding 180 degrees of phase shift, the natural frequency of the rotor can be determined. [3]. the amplitude reaches the peak when the rotor passes the resonance speed area at approximately 3,500 RPM. The phase shifts 180 degrees after the speed passes the resonance range, which is approximately from 1,300 RPM to 4,700 RPM. Bode plots are also called as unbalance response plot. It is also used for 2X, 3X vibration vectors. Bode and polar plots are usually slow roll compensated, depending on the slow roll speed range. Uncompensated bode plots are used to identify the slow roll speed range and slow roll vector. The compensated bode plots are used to extract the information from the displacement data. [5].

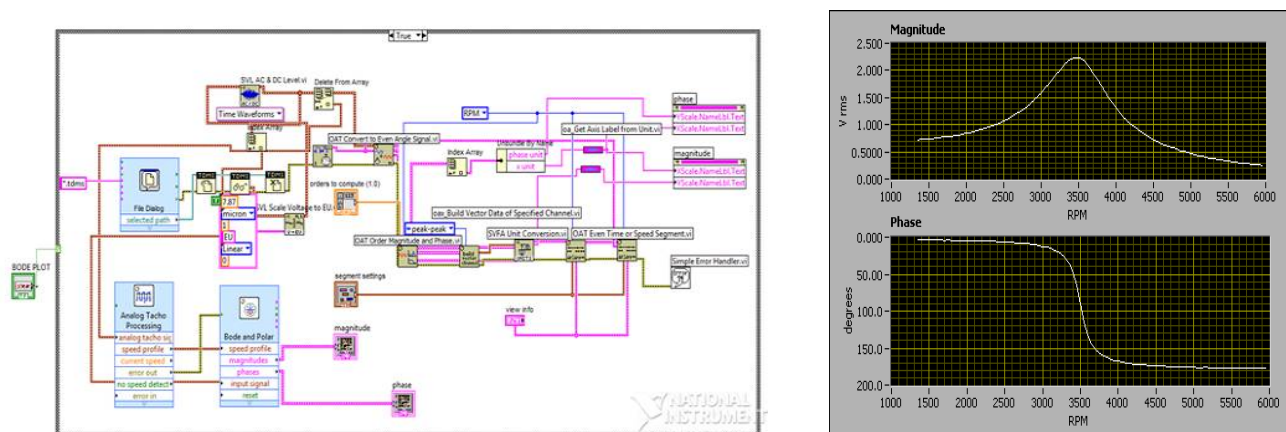


Figure 2 Labview program displaying Bode plot

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2. Polar Plot

It is a series of vibration vectors (usually 1X) plotted in polar coordinates as a function of shaft rotational speed. Polar plot is generated with a data from a single transducer. The polar plot is also a representation of the same three variables as considered in a Bode plot but the variables are plotted on polar coordinates instead of Cartesian coordinates. The polar plot is mainly used for rotor balancing. It shows the location of high spot, corrective balance and weight locations. Below figure shows that the shaft rotates in the counter clockwise direction, proximity probe is at zero degree location and phase lag increases in the opposite direction of shaft rotation.

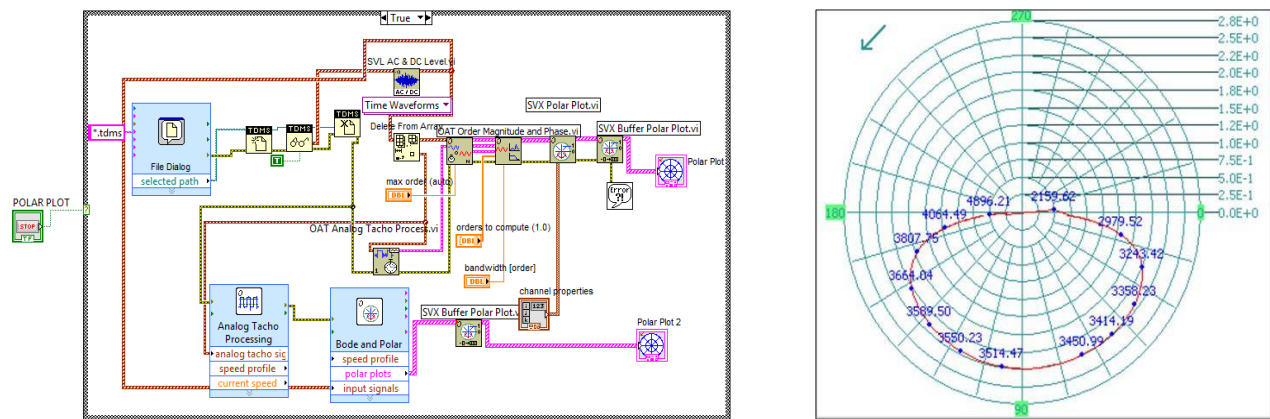


Figure 3 Labview program displaying polar plot

3. Cascade Plot

A cascade plot consists of series of spectra acquired at consecutive increasing or decreasing speeds. A cascade displays frequency or order changes versus rotative speed. A series of lines of spectra appear on the cascade plot during change of speed. By changing the speed of the machine the natural frequencies of rotor systems remains constant. Due to rub in the machine Harmonics are generated that causes a sudden change in direction of the shaft. [5].

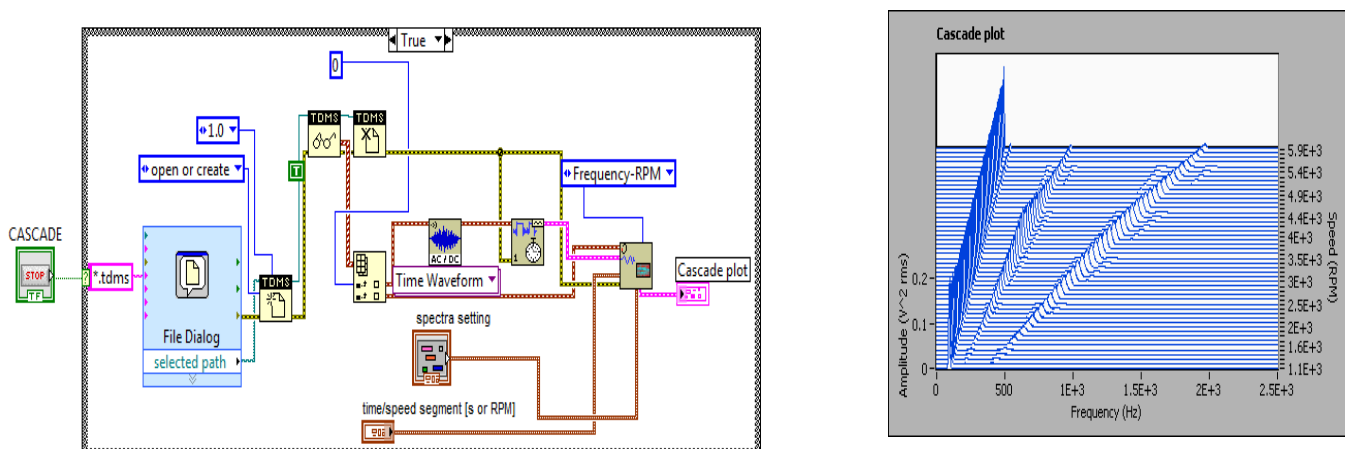


Figure 4 Labview program displaying Cascade plot

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4. Waterfall Plot

Waterfall plot is a 3 dimensional plot displaying the amplitude of spectral components as a function of both time and frequency. For each specified time waterfall plot display the frequency spectrum. Waterfall plots are used to study the machine vibration that changes with time. Waterfall plots are collection of spectra obtained usually during steady state operating conditions and plotted with respect to time. Waterfall plots also generate half spectra or full spectra. Spectrum plots are mainly used to identify the frequencies of running speed, sub and super synchronous vibration frequencies, rolling element bearing defect frequencies, vane and blade pass frequencies etc. [5].

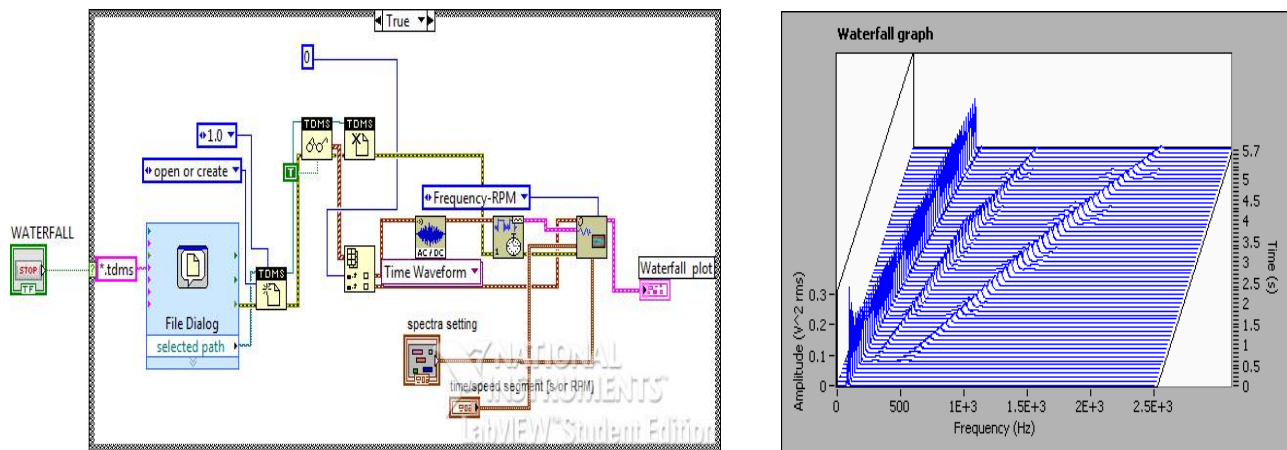


Figure 5 Labview program displaying Waterfall plot

4. Shaft Centerline Plot

Shaft centerline shows the location of the journal center, relative to the proximity probes and also how the shaft position changes with speed or time. From the DC component of the vibration signal, the actual shaft location is determined. The average shaft centreline plot is also called XY plot. The factor which determines the clearance boundary for shaft movement within the bearing is diametral clearance. The circle which is drawn on the shaft centreline plot represents the diametral clearance of the nearby bearing or seal.

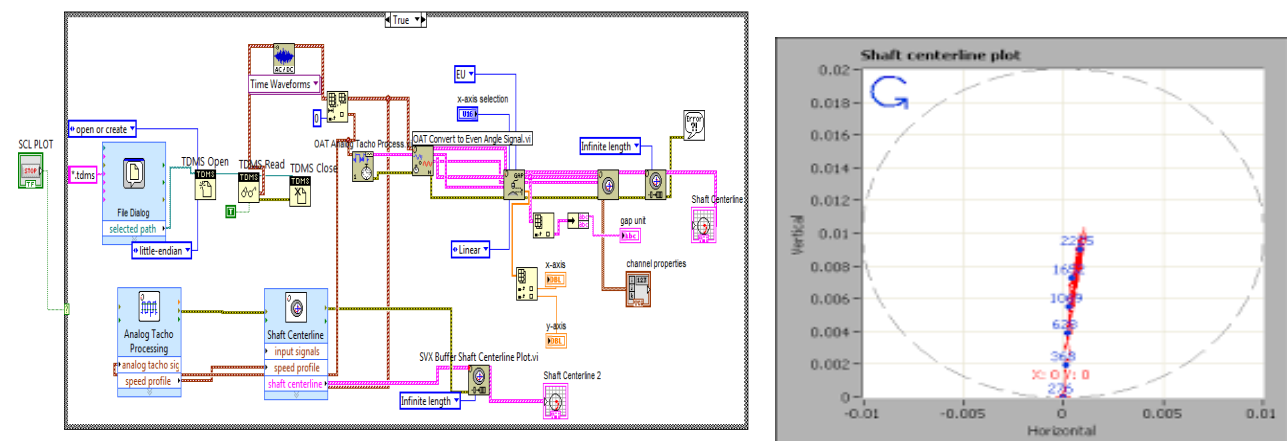


Figure 6 Labview program displaying Shaft Centreline plot

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VII. ADVANTAGES OF MULTICHANNEL DATA OVER DUAL CHANNEL ACQUISITION

1. The changes in the vibration amplitude and spectrum components can be analysed simultaneously on driver and driven machines.
2. The time Instant of all the data is same and hence all the transient and dynamic changes can be recorded to study the correlation.
3. The rotor mode operating shape can be determined more accurately by measuring phase & magnitude on all the bearings. With this it is easy to identify whether the rotor is in rigid mode or flexible mode.
4. The rotor dynamic studies can be done effectively only if the entire machine is analysed by taking multichannel inputs.
5. Problems like misalignment can be detected & confirmed by taking simultaneous measurements on the driver and driven machines.
6. Multichannel measurement and display enables analysis of problem in one screen and accuracy of analysis improves by analysing comprehensive data.

VIII. CONCLUSION

The behaviour of steam turbines can be analysed simultaneously by taking the six channels of vibration data from the panel. The Labview programs are developed for the various transient analysis plots like Bode plot, Polar plot, Cascade plot, Waterfall plot and Shaft centreline plot. These transient analysis plots are used to determine the natural frequency of the rotor and to identify the faults like unbalance, shaft misalignment, oil whirl, during the turbine start up and coast down.

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