ABSTRACT. Modern trends in machinery vibration monitoring and fault detection are based in highly sophisticated instrumentation and integrated hardware-software computer systems. Despite the rapid evolution in the past few years towards "expert" or "intelligent" analysis systems the knowledge behind it is based on the same type of information: vibration signature analysis. Measurements of machinery vibration behaviour rely on transducers, their signals being displayed in the time domain and/or frequency domain for interpretation. The present lecture is an overall review of the principles upon which vibration analysis instrumentation is based and data are displayed for interpretation.

1. INTRODUCTION

Smaller safety margins in machinery design, in parallel with higher speeds and power levels, and along with rocketing costs of repairs and manning are increasingly accelerating trends which have hastened the implementation of formal machinery analysis programs. These programs are usually implemented in order to reach an accurate assessment of the machinery health. Reduced to its essentials, the procedure consists of measuring some vibration parameter (e.g. overall level, spike energy, spectrum) at regular intervals and performing comparisons to detect increases which may be associated with developing mechanical faults. For this purpose a number of parameters such as motion, pressure, bearing temperature and lubricating oil condition are measured at varying intervals, normalized and compared. The storage of these data, along with dates and other pertinent information contributes to a data base which can subsequently be used for fault diagnostics. Examples of this are overlays of spectra measured at different dates, "cascade" maps and curve-fitting problematic frequency components for predicting time-to-failure. An historical record of the changes with time of a machine's vibrational characteristics can later serve as input to modify and refine the criteria used to assess the severity of a vibration increase, for estimating the probable time-to-failure and for scheduling shut-downs.

Conditions such as unbalance, bearing instability, misalignment and improper clearances are responsible for higher values of the dynamic stresses applied to components of the machines and are manifested as vibration characteristics. Though one cannot ignore oil conditions, temperature and pressure as important measurable variables, motion, and therefore vibration, is probably the best operating parameter to judge dynamic conditions.

Successful vibration measurement and analysis requires an intimate familiarity with types of measurement, sensor characteristics and application, as well as the capabilities and limitations of the remaining elements of the measuring system. This lecture is aimed at giving a general
review about measuring equipment, and data presentation and interpretation in rotating machinery vibrations analysis.

The basic main elements of a dynamic measuring system are shown in Figure 1.

![Figure 1 - Main components of a dynamic measuring system](image)

The transducer (or sensor) is a device which converts the measurable input into an electrical quantity that can be more easily amplified and conditioned before it is processed.

The signal conditioning part of the measurement system usually consists of electronic circuits that convert, compensate, amplify, filter (in the frequency domain) or manipulate the transducer output into a more usable form.

The signal processor is a device that displays the measurement in a form that can be read, interpreted and stored as a permanent record.

There are three basic vibration measurement parameters: displacement, velocity and acceleration. In machine work, the question of which vibration parameter should be measured, always arises. The correct choice of the parameter to be measured and selection of the adequate transducer depends on the information needed. If shaft motion relative to the bearing housings or relative to space is of interest, then displacement sensors are necessary. If a bearing housing motion, relative to space, is needed, then a velocity sensor is probably a good choice.

The useful frequency range and sensitivity are characteristics that have also to be taken into account when choosing a transducer.

Structural motion and relative motion in bearings and casings are commonly measured with displacement transducers such as proximity sensors, their average useful frequency range being from 0 to 1500 Hz.

General machinery condition, involving medium frequency vibrations in the range 10 - 2000 Hz, can be assessed using a velocity pick-up.

Accelerometers are needed in cases in which vibrational frequencies above 1000 Hz are encountered and acceleration must be measured on the bearing cap or casing.

Apart from characteristics such as the frequency range and sensitivity, other important factors have to be considered when choosing a transducer, namely environmental conditions such as influence of oil, pressure, temperature and accessibility.

2. TRANSDUCERS

2.1. Displacement Transducers

The most widely used displacement transducers, in machinery vibration measurements, are of the non-contact type and generally operate on eddy-current principles though there are capacitance and even reluctance transducers in certain areas.

Non-contact displacement transducers are extremely useful as shaft position monitoring sensors. Two sensors 90° apart give cartesian coordinates that are very helpful in development of