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# A REVIEW OF DIESEL ENGINE CONDITION MONITORING

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Abnormal running conditions for a diesel engine can vary widely in severity and consequences from slightly affecting an engine's performance to catastrophic equipment failure. These events can be expensive, sometimes dangerous, and occasionally cause environmental, and health and safety issues. Good CM can ensure the engine provides the required power under safe conditions with less fuel consumption, lower emissions and lower maintenance cost. Detecting faults and diagnosing the underlying problem as quickly as possible and providing assistance to correct the problem are the goals of engine abnormal situation prevention.

Condition monitoring of diesel engines can be assessed on a continuous or periodic basis from observation or measurement of selected parameters. The application of CM and fault diagnosis strategies to a diesel engine is a well-recognised method of increasing its operational efficiency and reducing consequential damage, spare parts inventories and breakdown maintenance.

The main job of most monitoring systems is to obtain information about the engine in the form of primary data and, through the use of modern signal processing techniques, to provide vital information to the engine operator and the engine control system, before any failure occurs with the engine in service. Good monitoring systems for diesel engines can achieve at least the following benefits:

- Improved decision making capability for selection of optimum engine operation conditions.
- Only defective equipment or assemblies are replaced, reducing time and cost of maintenance.
- Effective prediction and planning of maintenance operations. Time scheduled for maintenance can be used effectively since the nature of the fault is known in advance and both spare parts and labour can be organised accordingly.
- Reduction of engine emissions and fuel consumption.

This section presents the principal faults within a diesel engines and then outlines monitoring techniques used in engine condition monitoring.

Diesel engines are widely employed nowadays where high power production is necessary such as in heavy power generators, heavy road vehicles, most long-distance locomotives and most road vehicles have diesel engines also. In the 1950s and 60s diesel engines became increasingly popular for use in vans and taxis, however it was not until the sharp increases in oil prices in the 1970s that serious attention was paid to the small passenger car market. The last few years have seen the use of small diesel engines grow, largely due to better fuel economy and longer operating life, until nowadays all main European car producers offer at least one diesel engine model. The diesel engine when operating normally can give thousands of hours of uninterrupted service. However, if a fault develops, the growth of the fault tends to be fairly rapid and can lead to major failure which can cause loss of life, damage to property and incur high costs when it occurs in, for example, commercial transport vehicles or ships. This why, it is essential to implement reliable and sensitive engine condition monitoring techniques.

Diesel engines use high compression ratios, generating a sufficiently high pressure and temperature to cause spontaneous ignition of the injected fuel. Also the speed of engine rotation is 3000 rpm or more. The high speed, high pressure and high temperature increase the risk of faults occurring within the engine. Figure 1 shows classification of faults according to engine systems and components.

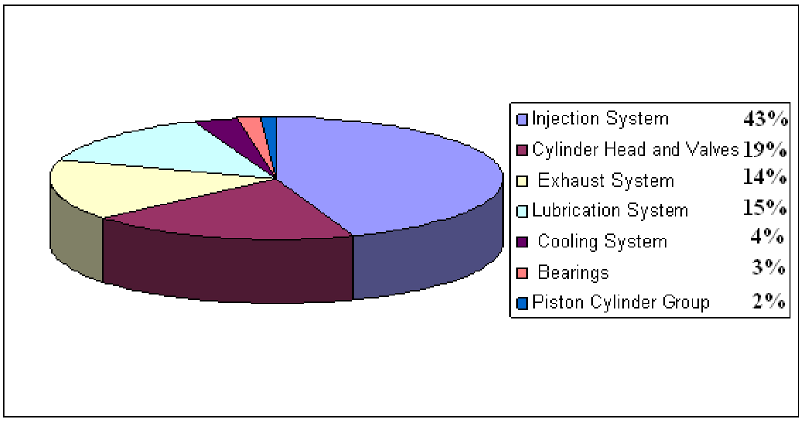


Figure 1 Principal faults in diesel engines

One of the most important elements is fuel injection system malfunction, which is responsible for about 43% of the engine faults. These system faults can also directly affect engine efficiency, exhaust emission, engine noise and other parameters.

Another important element is the lubrication system malfunction account for a high percentage of the engine faults. The lubrication system faults can directly affect the engine power, emission and other performance parameters, this is why it worthwhile to study this element of the system and associated faults.

Nowadays engine performance together with high economy is a very important operating characteristic, and CM is being used to ensure that this characteristic is not only maintained but optimised. The conventional attitude to engine upkeep has been to follow a fixed routine maintenance program based on the engine manufacturer's instructions. This approach has two disadvantages.

1. The maintenance schedule is based only on past experience of similar engines. There is no guarantee that an individual component would be in perfect condition throughout this interval.

2. The component is sometimes still in good condition even after the elapsed interval and it would be a waste of time and money to repair or replace a perfectly healthy component.

Many techniques are being used for machines condition monitoring; this subsection explains the use of some of these techniques for fault detection and diagnosis in diesel engines.

Vibration monitoring is one of the most important methods employed for identifying faults and predicting engine failures. This method, in particular, is becoming progressively more accepted as a predictive maintenance method and for engine maintenance decisions. This is why the understanding of vibration methods is of enormous significance to maintenance engineering. Vibration monitoring collects the vibration signals generated by an engine and analyses them to decide the engine's condition. There are numerous reasons for the wide application of this type of monitoring and one of the main reasons is that each engine produces vibrations of different types whilst working. The second reason is that the vibration system of the common engine and its structures are theoretically well-understood, making it possible to predict the features of the vibration signals detected using special instrumentation such as wide band transducers and convenient analysers. The third reason is that one can avoid considerable expense, for instance by avoiding the acquisition of an engine or the possible sudden loss of power output. Furthermore, improvements in computation and vibration signal processing methods have added to its large number of applications. Difficulties in using vibration monitoring might occur due to the mixture of various noise and vibration sources, both non-linear and non-stationary, and the influences of numerous different transmission paths. Nevertheless, vibration monitoring is not yet adequate to provide all-purpose condition monitoring of the diesel engine as it provides mostly vibration information which is related to the firing sequence of the engine.

While types of failures such as wear might not make significant changes to the vibration signal, vibration-based CM has evolved as a key method which employs transducers to measure the vibration at a point, and the point where the transducers should be placed is where the signal detected is dependent upon the failure (fault) to be diagnosed. It is particularly useful for analysing rotating machinery because it is normally easy to use in such circumstances and relatively cheap. Various methods exist for processing and saving of signals produced during vibration analysis some of which are:

1. Most simply, using peak, peak to peak or RMS values of signals to establish the mechanical condition of an engine.

2. Spectrum analysis which transforms the time-domain input signal using Fourier processes.

This is used mainly for tendency analysis and diagnosis, with particular frequencies related to particular components;

3. Envelope analysis, or high frequency resonance technique (HFRT), restricts the signals to those frequencies that are necessary to be monitored. It suppresses undesired background

vibrations, and allows the envelope near the signal to be analysed, cancelling unwanted low frequency vibrations; and

4. Cepstrum analysis is employed to identify a sequence of harmonics (or sidebands) in the spectrum and to estimate their relative strength. This is done by taking the logarithm of the amplitudes and reconstructing one or more spectrums using these latest values. This has the effect of increasing the comparative significance of the component of lowest frequency.

Usually the power Cepstrum is a frequency analysis of a frequency analysis.