International Journal of scientific research and management (IJSRM)
||Volume||3||Issue||10||Pages|| 3601-3607||2015||
Website: www.ijsrm.in ISSN (e): 2321-3418

A Review on Lubrication and Wear in IC Engine Using Acoustic Emission

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Abstract

The lubricant contamination against of engine component wear, leading to loss of engine performance and life, The dynamic lubricant oil films separating moving component surfaces cause a major portion of engine wear. The lubrication in the engine was successfully monitored based on the acoustic emission technique generated by captured using an AE wide band transducer that was bonded outside the engine block and located at the lower part of the bottom dead centre (BDC). The acoustic emission technique can assist the owner of the engine in determining the engine oil's condition before replacing it. In engine monitoring of the proper lubrication oil supply the cylinder is essential in achieving better efficiency for the engine in term of power, flue, and consumption. The AE analysis is an effective technique for on-line assessment of engine friction and wear, which provides to support the development of new engine fuels and new lubricants. The proper machine condition monitoring procedures. Need to attain high levels of asset availability, reliability and the cost of maintenance.

Keywords - Acoustic emission, engine oil , lubrication , wear, and engine.

1. Introduction

Acoustic emissions (AE) are defined as transient elastic waves generated from a rapid release of strain energy caused by a deformation on the surface of a material as a condition of wear and tear [1]. Acoustic emission (AE) is generated on the surface of a material by fundamental processes that define lubrication and wear such as deformation and micro-fracture. Measurement of these propagating waves on the surface of the material is an appropriate transducer and acquisition system.[2] The lubrication systems of the engines can justifiably by producing high performances in engines and it may be fair to say that without adequate engine oils and systems for employing them, the engine would quickly cease to function. The engine oil performs several important functions in the engine, among which include lubricating, cooling, sealing, cleaning and protecting against wear and tear, as well as corrosion. The base oil stock alone is not capable of performing all these functions, thus additive agents are used to enhance the performance.[3].AE technology also can provide comprehensive information of continuous and repetitive stress waves which is generated by behaviour of interacting materials between stressed components of reciprocating mechanical movement. Therefore, the process of plastic strain, phase transformations and physical transformations of the surfaces may cause friction and wear failures that are sources of AE. Moreover, a change in the parameters, such as materials in contact, the efficiency of lubricants, the roughness of the contacting surfaces, relative velocity between the contacting materials and contact pressure can be monitored by AE technique.[4]

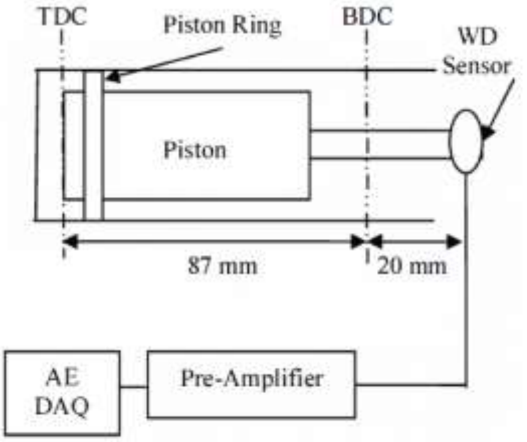

Fig.1.1 engine and AE setup process.

H. S. Benabdallah and D. A. Aguilar investigate the relationships between friction and wear properties and the characteristics of acoustic emission was conducted in the case of dry and grease-lubricated sliding contact using a ball-on-cylinder testing apparatus. The results revealed a good correlation between the friction coefficient and acoustic emission (AE) RMS voltage for dry sliding. It was also determined that the friction work correlated well with the corresponding integrated AE voltage over time, intRMS. The detection of the sliding speed threshold beyond which accelerated wear would occur was possible from the intRMS variation. Proportionality between the theoretical-ly determined grease film thickness and the intRMS was observed. [5]

2. Acoustic Emission in Engine

Acoustic emission used in engine which is the material's internal stress wave stretches across the non-homogeneous area and finally knocks out the material surface. This wave bounces back due to the material surface's percussion. Due to this internal material friction, the movement of wave is replaced by heat and this phenomenon causes the wave to disappear [6].

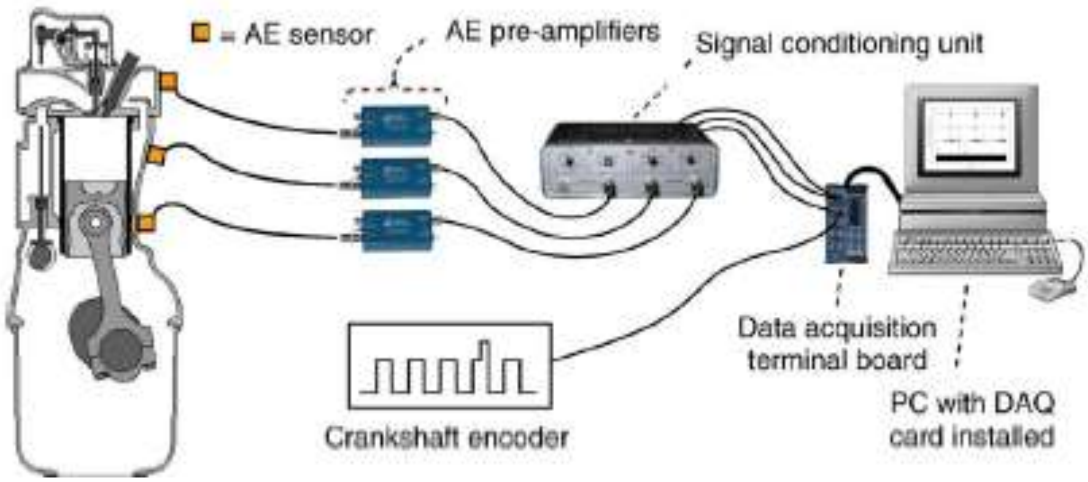

Fig.2.1.Using AE Technique in Engine

An engine has plenty of moving parts all of which are good source of friction, since friction is a major source of AE. it can be unitized as a very efficiency tool in studying the condition of any moving part non-intrusively. This is possible only if the sensor can be mounted in a suitable position on the engine to pick up the emission. The major source of AE

1) Engine piston movement inside the cylinder
2) Gear meshing
3) Bearing movement
4) Engine valves opening and closing events and so it.
5) Lubrication in engine
6) Wears in engine check out[7]

DOI: 10.18535/ijsrm/v3i10.4

3. Lubrication

The engine oil performs several important functions in the engine, among which include lubricating, cooling, sealing, cleaning and protecting against wear and tear, as well as corrosion. [8].

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Type of the lubrication in basis of engine used is

1. Hydrodynamic lubricant.
2. Elastohydrodynamic lubrication.
3.Boundary lubrication.

Table1.Contamination of Diesel Lube Oil

Type	Primary source	Major problems
Metallic particles	Engine wear	Abrasion ,fatigue and lubrication breakdown
Sand &dust	Combustion blow by	Abrasion and fatigue corrosion
Metal oxides	Engine wear and corrosion	Abrasion and fatigue
Soot	Combustion blow by	Lubrication breakdown
Exhaust gases	Combustion blow by	Lubrication breakdown
Fuel water	Combustion blow by	Corrosion and Lubrication breakdown
Acids	Combustion blow by and lubricant breakdown	Corrosion

The predominant types of diesel engine oil contaminants, Along with primary sources and major problems these impurities cause, are listed in Table 1. [9]

4. Mechanisms of Wear

The process of particles wearing surfaces and generating new particles that in turn cause more wear is known as the chain-reaction-of-wear. There are five forms of wear that occur in IC engine components: abrasion, fatigue, adhesion, corrosion, and lubricant breakdown. Abrasion, fatigue, and adhesion involve

mechanical damaging of surfaces. Metallic wear particles accelerate oil oxidation, resulting in sludge's and oil acidity. Soot, a product of incomplete fuel combustion, is similar to lamp black. By virtue of its tremendous total surface area, soot can leach out additives from the engine oil. [10]

4.1. Lubrication against Wear in Engine

There is an important relationship between the size of contaminant particles and the thickness of dynamic lubricant films separating opposing surfaces. These particles bridge the gap maintained by the oil film, making simultaneous contact with both surfaces this focuses the force between the surfaces, causing damage and resulting in component wear. An extensive survey of the technical literature for oil film thicknesses in diesel engine components are summarized in Table 2. Most of these dynamic clearances are between 0 and 20 microns. Contaminant particles the size of or larger than these dynamic clearances produce a major portion of the wear experienced by engine oil wetted components.[11]

Table 2. Diesel Engine Component Oil Film Thicknesses

Component	Oil film thickness(microns)
Ring/Cylinder	0.3-0.7
Rod bearing	0.5-20
Main shaft	0.8-50
Bearing	0.5-20
Turbocharger	0.5-15
bearing	0-1.5
Piston pin	
Gearing	

5. Experiment Setup

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The schematic of experimental setup is shown in Fig.2. AE signals were measured by AE sensor on the cylinder block, which is a wideband differential sensor with a very high sensitivity and has a very good frequency response over the range of 400 - 800 kHz. In addition the engine speed, cylinder pressure, crank angle position, vibration and acoustic were measured and recorded by the following measurements instrumentation. The engine was coupled with an eddy current dynamometer and a controller. Engine speed and load were controlled by varying excitation current to the eddy current dynamometer. The Crank Angle En-coder connects with the crankshaft to measure angular position within a single turn; the lubrication used on parts of the engine were measured using accelerometers with the sensitivity. [12]

The changes brought about by the lubrication condition change crank angle in fig.3. For Both sets of results, the values given at 0 h are from reference tests with normal lubrication conditions of the RMS AE energy over each acquisition of 400+ cycles. At both Sensor positions there are a general increase in the RMS AE. [13]

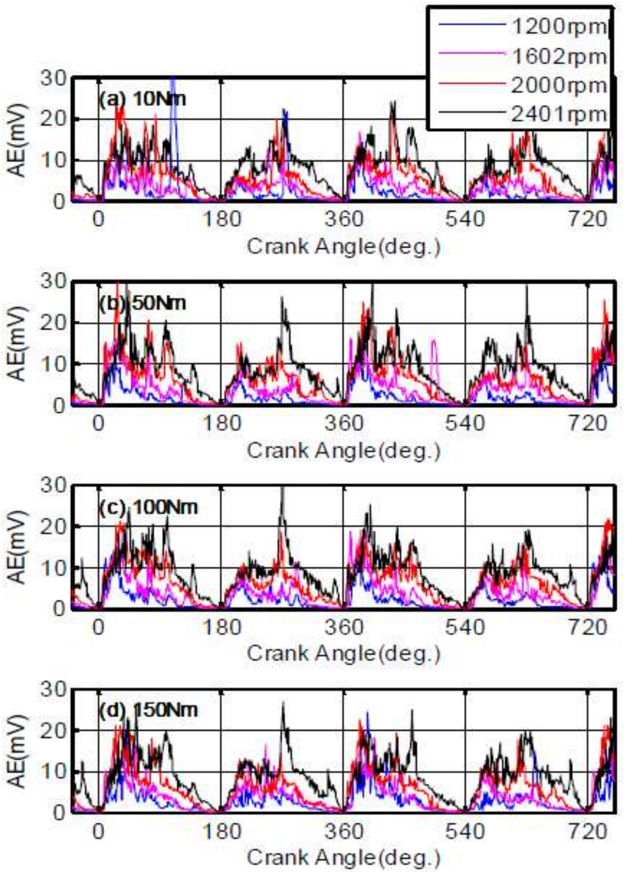

Fig.5.3. AE RMS Value Under Different Operating Conditions For Baseline Diesel Engine

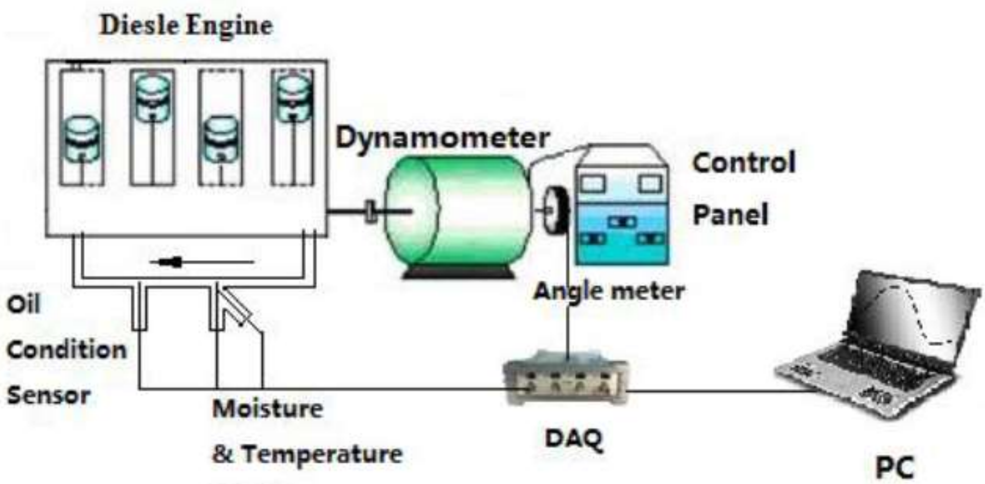

Fig.5.1. Experimental setup diagram

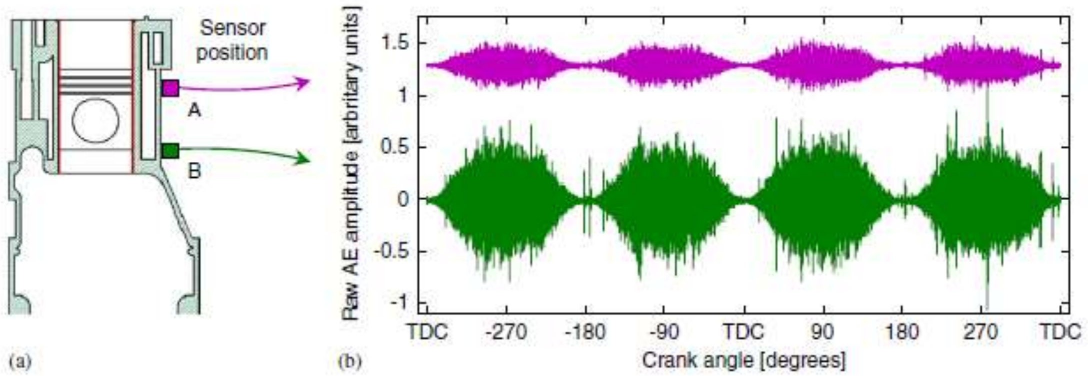

Fig.5.2. Motored Engine A: (A) Cross-Section Showing AE Sensor Positions, And (B) Measured Raw AE Against Cylinder 3 Crank Angle.

6. Experimental procedure

The engine is running at high speed in which high fuel consumption to the micro-80 AE were mounted on the outer skirt of the engine cylinder, The Acoustic Emission was converted into digital from and was fed to a PC with a custom developed Lab VIEW program acting as the interface. The engine was run at lubricant oil against wear so which is AE signals were recorded [14].

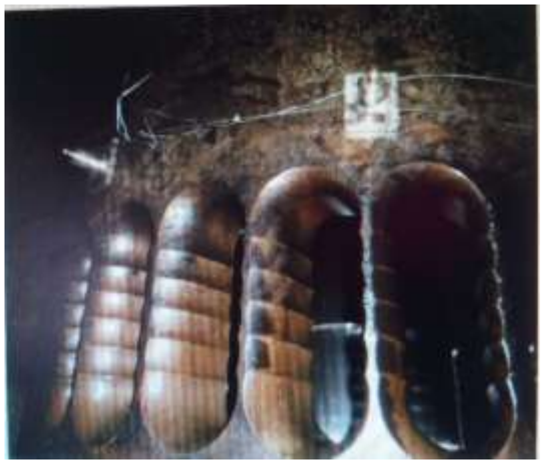

Fig.6.1 AE sensor attached to inside the engine

Result

The acoustic emission signals under different IC engine condition for analysis the lubrication and wear parts in engine.This paper conducted to assess the monitoring capabilities used acoustic emission analysis. It focuses on the possibility of using acoustic emission signals to monitor the engine oil and wearing parts of engine

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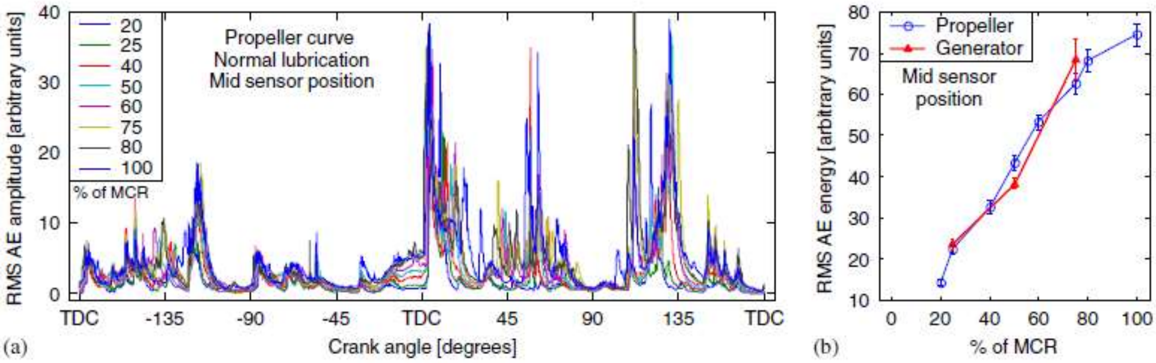

Fig. Average RMS AE for data acquired from the mid-sensor position at various points on the propeller curve with normal lubricating conditions, and (b) RMS AE energy during period 25–51 before TDC

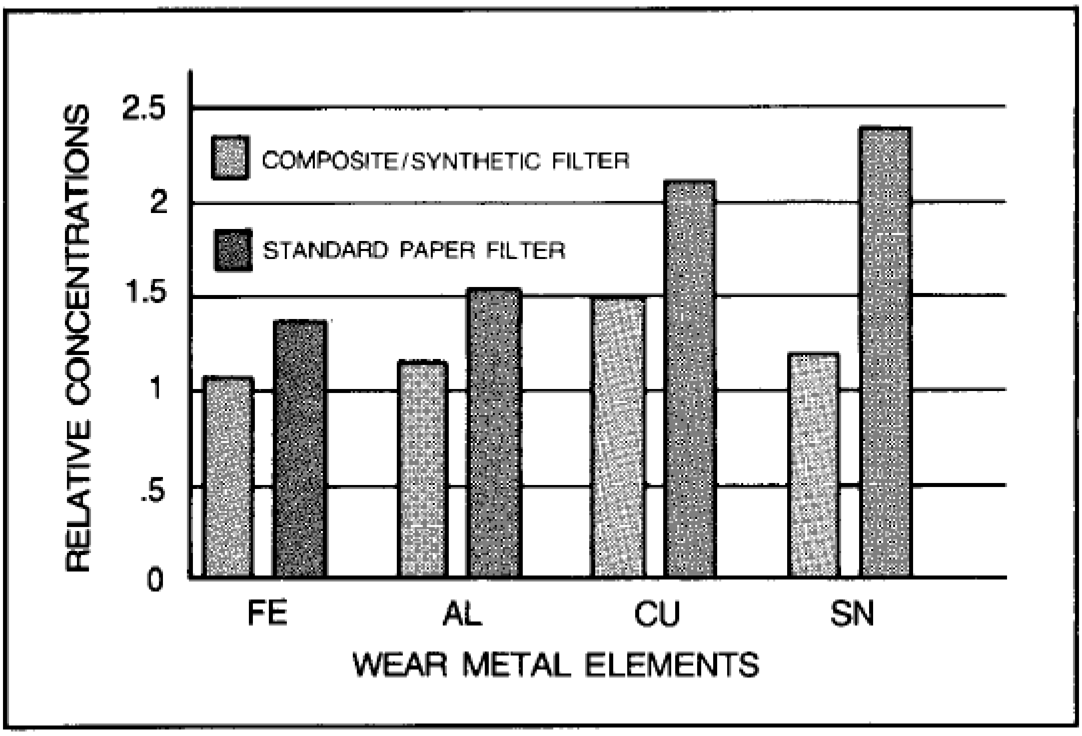

Fig. Wear metal elements concentrations

Conclusions

The engine lubrication oil cleaning include improved engine performance , longer engine life, reduced maintenance cost and longer lube oil service life. The acoustic emission monitoring technique has demonstrated its capability in assessing the variation of single of engine oil.

This investigated the acoustic emission signals under different engine conditions for analysing the lubrication and wear on engine. The wear rates and lubricant performance and could significantly aid condition-based monitoring strategies.

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