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THE USE OF ENGINE VIBRATION AS A MEANS OF ENGINE FAULTS DIAGNOSIS

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BY

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CONTENTS

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LIST OF FIGURES

DESCRIPTION

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DESCRIPTION

DESCRIPTION

FIGURE
NO.

NOMENCLATURE

ϕ_d	The duration of valve opening.	Degrees
ϕ_a	The angle of advanced opening of valve.	Degrees
ϕ_r	The angle of retarded closing of valve.	Degrees
ϕ_o	Camshaft angle.	Degrees
C	Tappet clearance.	m
S	Piston displacement.	m
V	Piston velocity.	m/s
a	Piston acceleration	m/s2
o	Piston-pin offset.	m
θ	Crank angle.	Degrees
r	Crank radius.	m
l	Connecting-rod length.	m
P_g	Gas pressure force.	KN
P_a	Net force along the cylinder.	KN
P_s	Side-thrust force.	KN
ϕ	Connecting rod angle.	Degrees
q	Force acting along connecting-rod.	KN
w	Angular engine speed.	Rad/sec
m.p	Piston Mass.	Kg
P_c	Force acting on the crankpin by the crank.	KN
F	Centrifugale force.	KN
K	Force directed along the crank radius.	KN
Rc.p.	Load on crankpin	KN
t	Tangential force at the crank pin	KN

SUMMARY

Many techniques have been used as a means of engine's faults diagnosis, some measures pressure vs volume or noise level but the analysis of the vibration signals radiated by an engine is one of the most powerful techniques because it contains precise information on individual components especially those which needs the engine to be dismanteled and disassembled into parts to detect the fault causing noise or vibration.

The present work was carried out using vibration measurements in the time domain and acceleration as a measuring parameter, instead of displacement or velocity because it covers high frequency vibration components, to diagnose some of the operational events due to faults occuring in a petrol, 4-stroke, 4-cylinders engine.

A Fiat engine used in the 128 passenger car, which is assembled in Egypt and most commonly used, was studied as a means of faults diagnosis which occur due to the increase in valve tappet clearance, connecting-rod small end bearing increased clearance, piston and piston pin increased clearance.

An instrumentation set-up was used to measure the vibration signals produced by the engine and consists of an

accelerometer, charge amplifier, fast fourier transform analyser and X-Y recorder and a once per cycle trigger was obtained from the camshaft sprocket by means of an infrared photo electric pick-up in conjunction with a phase indicator.

The tests were made at different speeds with no load as to use the results on any engine while being in the car as it is runned at no load.

The theoretical analysis carried out concerns the parts where faults were investigated. Forces acting on the piston and crank mechanisms were calculated, and the valves timing and duration period were obtained.

The analysis made to the measured results in conjunction with the theoretical bases concluded the following:

1- Positioning accelerometer:

Optimum positioning of the vibration accelerometer in relation to the event to be measured is one of the major steps taken care of in engine's faults diagnosis. It is important to locate the accelerometer on machine member that will transmit the pertinent vibrations to it, any variation could lead to confusion and missing events.

2- Tracing valves'events:

Vibration signals from reciprocating machines are typically coming from events which happen at different times in the machine cycle but repeats for each cycle. Valve opening and closing events were traced by vibration measurement as a guide to any event which occur during the cycle, it showed up as an increase in amplitude at the timing of the defective valve and accelerometer placed at tappet housing bolt.

3- Connecting-rod big end diametral clearance:

The increase in the bearing diametral clearance was noticed by the high rise in amplitude at the instant of firing where the load is changing its direction and accelerometer placed at crankcase.

4- Piston diametral clearance:

The defective piston gives an increase in the amplitude observed at the change in direction of the side-thrust force and where the change in direction of motion and accelerometer placed at cylinder block.

5- Piston-pin diametral clearance:

The increased clearance pin gave a rise in amplitude at the change in direction of motion and also the change in direction of the resultant force acting on the piston and accelerometer placed at cylinder block.

CHAPTER 1

1.1 Introduction and Review of the Previous Work

Since the mid 1950's many researchers have studied the behaviour of reciprocating machines in relation to the generation of vibration energy and hence the radiation of noise.

In their studies these researchers have distinguished between "mechanical noise" due to mechanical process Simmons(1)* and other noise generated by such sources as inlet and exhaust gas flows.

The relevance of this work to fault diagnosis is that radiated engine noise is the direct result of engine surface vibration, which in turn is generated by mechanical sources within the engine.

A wide variety of techniques are applied to the condition monitoring of diesel engines. The ones considered below related to the measurement of dynamic parameters such as pressure and vibration.

A comparison between noise and vibration measurement is made and a recommendation to the method used in this research is given.

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* Superscript numbers refer to the list of refernces in pages 59, 60, 61, 62, 63.

1.1.1. Noise Measurement and Analysis:

Research into mechanical noise has, broadly, divided into two schools of thought. Priede & Austen (2,3) have been concerned with the relation between generated noise and the cylinder pressure time history. This school has ascribed the dominant engine excitation force to be that of combustion.

Fig (1) illustrates how the further that a periodic function deviates from a pure sinusoid, the higher will be the level of the harmonics (multiples of fundamental frequency). In a diesel engine there is a major discontinuity in the cylinder pressure/ crank angle curve at the onset of combustion (circled in Fig (2a) which results in a rich harmonic content in the excited vibration signal. This explains why an engine operating at 1500 RPM (25 Hz) generates significant vibration & noise up to several thousand Hz . The theory also explain why a petrol engine with a much "smoother" pressure/ crank angle curve Fig (2b) produces less high frequency energy Fig (3).

The actual reported changes in engine vibration with operating conditions vary considerably between researchers.

The consensus, however, is that the low frequency (<400Hz) and high frequency (> 5 KHz) parts of the spectrum are those least affected by changes in load, timing fuel