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A Study of Air Cooled Eddy Current Dynamometer Engine Test Rig

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ABSTRACT

In this paper a study of test rig is done which consist of number of parts like cardan shaft, Plummer block, test bed etc. for testing of engine, by considering various important parameters of engine such as Power produced by the engine, Engine speed and Fuel consumption. The whole world is trying to reduce engine consumption and its pollutant emission and this requires testing of engine on test rig to determine parameters. These problems bring engine test bed to become measuring systems more and more powerful and versatile.

There is a growing demand for engine in every aspect of our daily life, thus importance of engine is gigantic as we know engine is the heart of power plant, automobile industry, agricultural sector etc. It is therefore necessary to develop efficient and reliable engine, reduce the cost and improve power output of engine. At initial stage of design and development an engineer consider certain objectives in mind, this may include specific fuel consumption, brake power, cooling engine etc. While developing engine it is required to take in consideration all the parameters affecting the engines design and performance. There are numbers of parameters so it becomes difficult to account them while designing an engine. So it becomes necessary to conduct tests on the engine and determine the measures to be taken to improve the engines performance.

***Keywords*— Air Cooled Eddy Current Dynamometer, Engine Test Rig, Engine Testing.**

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I. INTRODUCTION

In this paper different aspects of engine test rig are explained in details. The topics that will cover in this paper will include: what is engine test rig is, its importance, how it is operated, its modeling and design and development of some other parts of engine test rig.

At a design and development stage an engineer would design an engine with certain aims in his mind. The aims may include the variables like indicated power, brake power, brake specific fuel consumption, cooling of engine etc. The other task of the development engineer is to reduce the cost and improve power output and reliability of an engine. In trying to achieve these goals he has to try various design concepts. After the design the parts of the engine are manufactured for the dimensions and surface finish and may be with certain tolerances. In order verify the designed and developed engine one has to go for testing and performance evaluation of the engines.

Eddy current dynamometers are electromagnetic load devices. The engine being tested spins a disk in the dynamometer. Electrical current passes through coils surrounding the disk, and induce a magnetic resistance to the motion of the disk. Varying the current varies the load on the engine. The engine testing is required to be carried out to check the actual performance with the design performance. A dynamometer is a general term for any device that can apply a resistance load and measure that load and loaded speed to determine the power output. Dynamometer can measure wide range of power for different system but a specific type of dynamometer must be selected or designed for different systems. A Test Rig is flexible combination of hardware, software, data, and interconnectivity that can be configured by the Test Team to simulate a variety of different Live Environments on which an AUT can be delivered. It is an apparatus used for assessing the performance of a piece of mechanical or electrical equipment.

The nature and the type of the tests to be conducted depend upon various factors, some of which are the degree of development of the particular design, the accuracy required, the funds available, the nature of the manufacturing company, and its design strategy. In this project only certain basic tests and measurements will be considered.

A. Dynamometer

A dynamometer is a load device which is generally used for measuring the power output of an engine. Several kinds of dynamometers are common, some of them being referred to as “breaks” or “break dynamometers”: dry friction break dynamometers, hydraulic or water break dynamometers and eddy current dynamometers. Dry friction dynamometers are the oldest kind, and consist of some sort of mechanical breaking device, often a belt or frictional “shoe” which rubs a rotating hub or shaft. The hub or shaft is spun by the engine. Increasing tension in the belt, or force of the shoe against the hub increases the load on the engine. Hydraulic dynamometers are basically hydraulic pumps where the impeller is spun by the engine. Load on the engine is varied by opening or closing a valve, which changes back pressure on the hydraulic pump. Eddy current dynamometers are electromagnetic load devices. The engine being tested spins a disk in the dynamometer. Electrical current passes through coils surrounding the disk, and induce a magnetic resistance to the motion of the disk. Varying the current varies the load on the engine. The dynamometer applies a resistance to the rotation of the engine. If the dynamometer is connected to the engine’s output shaft it is referred to as an Engine Dynamometer. When the dynamometer is connected to the vehicles drive wheels it is called a Chassis Dynamometer. The force exerted on the dynamometer housing is resisted by a strain measuring device (for example a strain gage).

II. LITERATURE REVIEW

F. Perez, P. Moulin, A. Del Mastro[3] describes that the race for engine consumption and pollutant emission reduction requires engines development time reduction and optimisation. These problems bring engine test bed to become measuring systems more and more powerful and versatile. C. Y. Liu, K. J. Jiang, Y. Zhang[1], explain the structure and working principles of an eddy current retarder acting as an auxiliary brake set. Based on the principle of energy conservation. According to the characteristics of the eddy current retarder, an exclusive test bed was developed and used for brake performance measurements. According to Gaurav Malhotra, Freedon Daniel and Virender Singh[4]. There are enormous parameters so it becomes difficult to account them while designing an engine. So it becomes necessary to conduct tests on the engine and determine the measures to be taken to improve the engines performance. In paper of Robert R. Raine, Keri Moyle and Gordon Otte[2] they also presents some results from an project that demonstrate the capabilities of the equipment.

III.STEPS OF DESIGN PROCEDURE

Selection of the type of engine which we have to test with their power and torque produce capacity. This information is collected from specifications given by manufacturer.

The type of retarder is selected according to our purpose as many choices are available such as air cooled Eddy Current dynamometer, water cooled Eddy Current dynamometer, Hydraulic dynamometer etc. In this project air cooled eddy current retarder is selected.

Selection of power absorption unit based on the torque/ power requirement.

Designing the test bed platform. Designing of casing for engine test rig, Designing of fuel tank according to type of engine (petrol engine, diesel engine) means fuel use in engine to run it.

I. DIFFERENT PARTS OF THE SYSTEM

A. Eddy Current Dynamometer

The machine makes use of the principle of electro-magnetic induction to develop torque & dissipate power. When the coils housed in both the casings carry d c current, they are surrounded by magnetic lines of force – flux lines. This field is parallel to the machine axis. Toothed rotor of high permeability steel mounted on shaft rotates with a fine clearance between water cooled loss plates. Motion of rotor gives rise to changes in the distribution of magnetic flux in the loss plates ($d\Phi/dt$). Change in flux is due to passing of steel tooth & air gap between two teeth between magnetic lines of force. This changing magnetic flux linked with loss plates, in turn give rise to circulating Eddy Currents in loss plates. Casings try to rotate in the same direction as that of rotor. Eddy currents generated in loss plates generate heat due to power absorption. This heat is transferred to water circulating in the water passages of the loss plates. Some cooling is also achieved by radial flow of air in the gaps between rotor & loss plate. This hot air passes out through the slots on the outer periphery of casings.

Fig 1: Isometric view of retarder

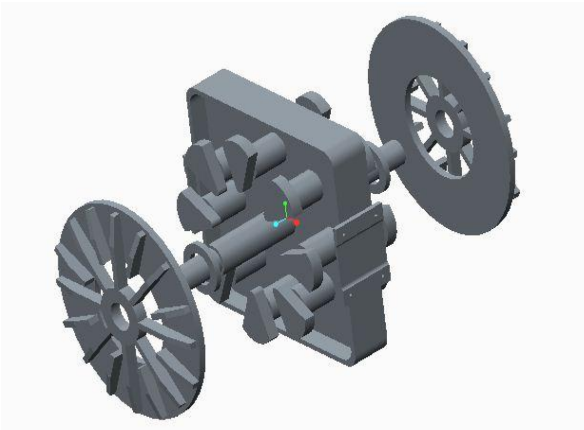

Fig 2: Expanded view of power absorber unit

B. Cardan Shaft

Also known as propeller shaft or cardan shaft & used for mechanical power transmission from engine to dynamometer.

- Do not use a carden shaft whichever is available at site
- Data required for calculation to select a suitable shaft is –
  - Speed range & torque characteristic of engine to be tested
  - Rotational inertia of engine
  - Load factor with reference to nominal rating of shaft
  - Maximum engine torque
  - Whirling of shaft
  - Degree of misalignment of engine & dynamometer
- Cardan shaft selection is done with all data available
- However, the responsibility of supplying cardan shaft of correct size & specifications lies entirely on the shaft manufacturer.

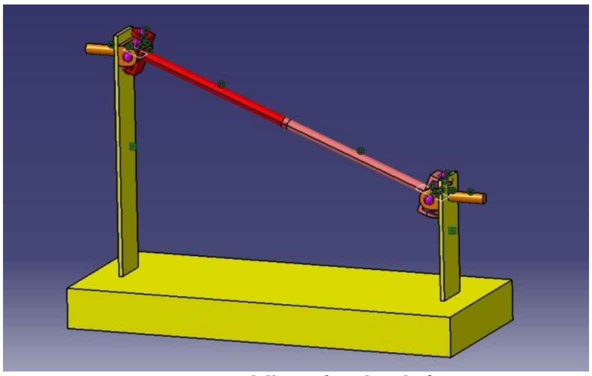

Fig 4: Modelling of cardan shaft

C. Wrong selection of Cardan Shaft

- Wrong choice of cardan shaft may give rise to following problems
  - Torsional oscillations
  - Vibration of engine or dynamometer
  - Whirling of shaft
  - Imposition of axial load on bearings of engine or dynamometer
  - Catastrophic failure
- Never make any alteration in the original shaft
- Never re-weld the cardan shaft.

D. Trunion & Trunion Bearings

- The casing assembly rests on & is cradled in trunion bearings.
- Both the Trunions form a matching pair & not interchangeable.
- They are line bored after firmly secured on the bed plate.
- Deep groove ball bearings provide the most precise method of carcase mounting & are virtually free from friction.
- Bearings are free from resonance problem.
- Bearing selection ensures extended life.
- Only periodical cleaning & oiling is required for trunion bearings

E. Bed Plate

- Bed plate is made of cast iron for all models.
- It is accurately machined at trunion mounting faces & on foundation areas.
- Provision is also made on bed plate for mounting stop screws.
- Pre-load tension spring for load cell is attached to bed plate.
- Terminal box, pressure switch / flow switch are mounted on bed plate only.

IV. MEASUREMENT GROUP

A. Torque and Power

In all cases, a torque arm is attached to the absorption unit, at a fixed distance from its centre. The load cell at the end of the torque arm experiences the force due to the reaction on the casing of the unit.

- Torque can be measured by :

  Torque = Force x Distance

- Knowing the speed of the vehicle, H P can be found by the relationship

  H P = (torque x rpm) / Dyno constant.

The brake power is among the most important parameter in testing the performance of an engine. The power developed by the engine was measured with the help of an electric alternator. The alternator was coupled to the engine with the help of a flexible coupling. The output lead of this mechanically coupled alternator was connected to the control panel along with an ammeter and voltmeter of required range in series and thus by measuring voltage and current, the power developed by the electric generator was known as Brake Power.

B. Fuel Flow Measuring System

The fuel consumption of an engine is measured by determining the time required for consumption of a given volume of fuel. The mass of fuel consumed can be determined by multiplication of the volumetric fuel consumption to its density. In the present set up volumetric fuel consumption was measured using a glass burette. The time taken by the engine to consume a fixed volume was measured using a stopwatch. The volume divided by the time taken for fuel consumption gives the volumetric flow rate. Brake Specific fuel consumption was calculated by using the relationship given below:

$$Bsfc = (Vcc \times \ell \times 3600) / (hp \times t)$$

Where,
Bsfc = Brake specific fuel consumption, g/kW-h
Vcc = Volume of fuel consumed, cc
ℓ = Density of fuel, g/cc
hp = Brake horsepower, kW
t = Time taken to consume, cc of fuel, sec.

C. Speed of the Engine

A tachometer is used for measurement of engine speed. A tachometer is a gauge that measures mechanical rotation, and typically reads out in "RPM" or revolutions per minute. Such a gauge can be used anywhere where a measurement of speed of rotation is needed, but the most common use is to measure how many times in a minute the crankshaft engine turns. Tachometers can be contact based or non-contact ones. In this project contact tachometer is used to calculation of engine speed in rpm and is done by calculating time taken for one rotation. The instrument is capable of measuring RPM over 20k.

V.CONCLUSION

This paper presented a study which allows us to test and validate several developments to acquire a high dynamic engine test rig able to represent the engine behaviour.

Many performance parameters of the engine like Power produced by the engine, Engine speed and Fuel consumption could be measured on air cooled eddy current retarder engine test rig, and the test rig that was developed is based on design optimization of an air cooled eddy current retarder.

The system is suitable for use in a wide range of experiments and projects related to internal combustion engine performance.

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