International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-2 Issue-1, October 2012

Design and Development of Test Rig for Measurement of Frictional Torque of a Half Engine

Gajanan N. Munishwar, Ashok Pise

Abstract: ***Automobile Industry is the largest industry in the world. Automotive engines need to be reconditioned after certain running. The frictional torque of a half engine (which consists of cylinder block, pistons with rings and gudgeon pins, connecting rods, crankshaft and bearings) is about 75% to 80 % of the total frictional torque of that engine. The components of new engines are manufactured with high degree of automation and accuracy but the same is not available during their reconditioning. Obviously, due to difference in accuracy of CNC machines and GPMs, a newly manufactured half engine has comparatively less frictional torque than a reconditioned one. This results in somewhat poor performance of a reconditioned engine as compared with the new one. The objective of this research work is to design & develop a test rig which could measure the frictional torque of a reconditioned half engine accurately and to bring quality consciousness in engine reconditioning business.***

Keywords: ***Automotive half engine, engine reconditioning, engine performance, frictional torque measurement, measuring test rig.***

I. INTRODUCTION

India is one of the developing countries, where use of automobiles is increasing in geometric progression. After running of certain km (e.g. 1 or 1.5 lakh km), vehicle engines' efficiency is reduced due to normal & abnormal wear and tear of engine components. In developed countries such engines are dumped in the scrap. However, it is difficult to afford the same from economic point of view in developing countries like ours; hence such engines are needed to be reconditioned and used.

Reconditioning is the process of restoring / obtaining the engine performance to the highest possible level. Reconditioning is generally carried out on general purpose machines (GPM) like lathe, grinding machine, boring machine etc. But the production of engine components is carried on CNC / VMC machines having much more accuracy than GPMs. In any assembly where the components have different types of relative movements w. r .t. each other, the amount or magnitude of the friction does not depend merely on dimensions and their tolerance but also their tolerances on the geometrical configuration like co – axiality, perpendicularity, etc.

A reconditioned engine does not possess that much geometrical and dimensional precision and accuracy in static condition (without starting engine) as a newly manufactured engine and this results in increasing the frictional torque. During reconditioning of engine, various processes are carried out on the engine components. In this, boring and honing of cylinder bores, straightening and grinding of crankshaft, straightening & repairing of connecting rod etc. are carried out. There is no standard system available in reconditioning workshops for measurement of the frictional torque of a reconditioned engine or half engine, other than a torque wrench which is generally used to tighten or loosen the fasteners [1, 2]. If any such system is made available with them, reconditioned engines would improve their performance.

Generally during braking of vehicles from moderately high speeds or high speeds, their engines are made use of for absorbing the kinetic energy partially, by virtue of frictional torque, in conjunction with the conventional braking system, for control and safety purpose.

The main objective of this paper is to describe the design and development of a standard system for measurement of a half engine frictional torque, for the technocrats involved in reconditioning business.

II. REVIEW OF LITERATURE & FIELD SURVEY

One way of classifying the torque is based on whether it is measured under static condition or dynamic condition. Whenever torque of any system is measured in its running condition it is known as dynamic torque and where the system is not in running condition and torque is measured, it is accounted as static torque.

Frictional torque in static condition for any assembly or system gives a fair idea about magnitude of friction within it, i.e. internal friction. The mechanical efficiency, in general, of any mechanical assembly or system mainly depends on the freeness of relative motions in between internal parts or in other words on the internal frictional drag. It is very important to obtain maximum freeness among the moving components during reconditioning. It is obvious that for any engine, static and dynamic frictional torques are proportional to each other.

Manuscript published on 30 October 2012.
***** Correspondence Author (s)
Gajanan N. Munishwar*, Head of Mechanical Engineering Department, New Polytechnic, Unchagaon, Kolhapur, India.
Ashok Pise, Head of Mechanical Engineering Department, Government College of Engineering, Karad, India.

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It is a custom for maintenance people to check the magnitude of internal friction or freeness in the assembly after reconditioning to judge the quality of reconditioning [2].

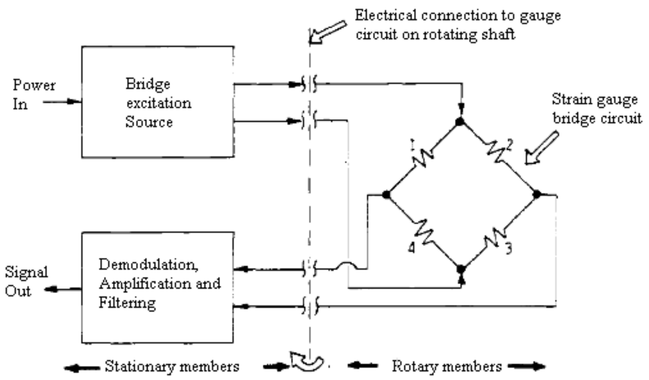
The authors visited more than 25 garages of different sizes i.e. small scale, medium scale and large scale but nowhere they could find any device which could measure frictional torque of engine to the requisite accuracy. Only manual judgment is the deciding factor for the acceptance of the reconditioning work carried out on the engine.

In most reconditioning cases, the vehicles gave 10% to 15 % increased mileage as compared with just before dismantling. However mileage figures hardly reached those of new vehicles [3].

Following are various methods of torque measurement,

A. Strain gauge torque meter

Torque transducers utilizing strain gage sensing elements are used more frequently, since in this case a short shaft length is required than any other type of torque transducer. The bridge arrangement is made such that one pair of gages increases in resistance due to tensile strain while the other pair decrease in resistance due to compressive strain. The two most important aspects of strain gage torque measurement are, assurance that the elastic structure onto which the gages are bonded will deform linearly with applied torque, and assurance that a good mechanical bond is maintained between the gauges and the mounting surface. Fig. 1 shows schematic diagram for strain gauge torquemeter [4].



Schematic diagram for strain gauge torquemeter [4]

B. Torsional twist torquemeter

An indication of the torque transmitted by a shaft can be obtained by measurement of twist angle, i.e., the torsional strain in the shaft. The twist angle due to applied torque in an automotive driveshaft is, however, quite small. Typically, at full-scale applied torque, the twist angle is no larger than one or two degrees.

C. Load Cell

When load-cell force sensors are installed in engine mounts, the torque reaction forces of the engine/ transmission assembly are measured. The reaction forces are proportional to driveline torque. To isolate interfering shear forces from reaction forces which are related to driveline torque, special engine mounts are used [4].

Frictional torque in the half engine assembly:

The magnitude of torque required to just initiate the rotation of crankshaft of half engine is the result of addition of friction occurring at different mating components. This friction of parts plays a crucial role in the running and performance of engines. Increased friction not only reduces the engines' overall efficiency but also reduces engine components life thereby increasing the maintenance and its cost. Increased friction also reduces the mileage of the vehicle [5, 6].

The areas contribute to increase the frictional torque are friction between piston rings and cylinder walls, friction between small end bush and gudgeon pin, friction between big end bearing and crank pin, friction between journal and main bearing.

Data collected in field survey:

In any research work in mechanical engineering data collected from field experts, technocrats and industries plays a vital role. One may use this data as a base or a guideline for his future work. In the present research work also such data is collected .

a. Original dimensions, geometry and dimensional and geometrical tolerances of the parts of the half engine assembly like cylinder bore diameter, crankshaft diameter, bearing clearances etc.
b. Dimensions after dismantling of engine before reconditioning.
c. Difference between a and b for respective dimensions from which we come to know the amount and pattern of wear.
d. Recommended dimensions / geometry after reconditioning.
e. Actual dimensions / geometry after reconditioning.
f. Difference between d and e which leads to increased torque [5, 6].

In many cases, only dimensional or only geometrical accuracy is obtained which leads to problems. A typical data from workshop manual of TATA 1210 truck pertaining to cylinder block reconditioning is given in table 1.

I: Dimensions of TATA 1210 Truck cylinder bore [7].

Original cylinder bore diameter	92 mm
Max. dia. of worn cylinder bore	92.26 mm
Next piston size available	92.39 mm
Finished bore size required	92.39 mm + 0.11 mm i.e. 92.50 mm
Bore cylinder to size	92.50 mm less 0.07mm = 92.43 mm
	92.50 mm less 0.05 mm = 92.45 mm
Hone cylinder in the first stage to size	92.50 mm less 0.01 = 92.49 mm
Hone cylinder in the second stage to size	92.50 mm
Max. permissible taper or ovality of finished bore	0.015 mm

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The above data indicates that machines having moderately high accuracy should be used for reconditioning [7].

III. Design and Development

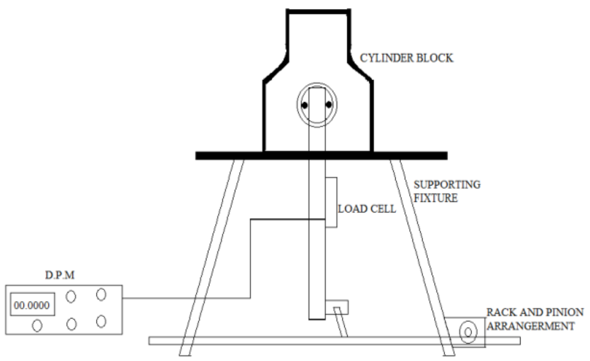
An ergonomically heighted stable frame is used to mount the half engine of Maruti 800 with proper locations and clamps. The desired initiating angular motion of crankshaft is selected as 20° and that too near the vertical position of rotating arm keyed to crankshaft i.e. 10° on either side of vertical position. The rack and pinion with intermediate link mechanism is used to oscillate the arm through approximately 20°. The speed of the stepper motor is so adjusted to have one reading for duration of about 6 sec. Refer to figure 2.

For manufacturing of test rig following components were designed for their material and configuration including dimensions and geometry.

1. Supporting frame
2. Hollow rectangular section bar
3. Rack and pinion
4. Stepper motor
5. Load cell
6. Locators and fasteners.

A stepper motor of 2 kg_f cm torque capacity was selected according to requisite calculations for initiating the rotation of crankshaft through linkages and a mechanism.

Besides the electronic circuit was also designed and optimized to suit the entire configuration mentioned above.



Set up of test rig

IV. Calibration

In order that the inertia as well as the friction of rack pinion mechanism be deleted from the readings obtained for the engine with this mechanism, a dummy stub shaft was mounted on a 6205ZZ bearing and readings were taken for the torque. These readings were subtracted subsequently from those taken for the half engine to obtain the net frictional torque of the half engine. The load cell is checked for its calibration prior to its mounting in the assembly.

5. Results:

For analysis purpose, frictional torque was measured at various piston positions and average of the same was taken for a Maruti 800 engine.

II: Readings of torque for different engine conditions

Title	New engine	Engine w/o reconditioning	Engine after reconditioning
Average of measured torque	5.4 Nm	7.3 Nm	5.9 Nm

6. Interpretation of results and Conclusions:

Based on the research work performed it is concluded that,

a. More quality consciousness should be brought in engine reconditioning process.

b. The test rig developed by the authors is found to be a proper solution for measurement of frictional torque of a half engine.

c. In many cases it is observed that after reconditioning, vehicles' mileage is increased up to 10% to 15%.

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