EXPERIMENT INVESTIGATION OF LASER SURFACE TEXTURING ON PISTON RINGS TO REDUCE FRICTION, WEAR, OIL CONSUMPTION, AND HARMFUL EMISSION

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ABSTRACT

In IC engine piston ring friction losses account for approximately 20% of total mechanical losses. A reduction in piston ring friction would ergo result in higher efficiency, lower fuel consumption and reduced emissions. To reduce these losses, sundry parametric approaches are made concretely at design stage and experimental level. The goal of this study was develop piston ring designs to amend engine efficiency, without adversely affecting oil consumption, blow by, wear and cost. Thus it provides characterization of a pressure balance in terms of efficacious area and distortion coefficient of the piston and cylinder. The variable parameters are piston velocity, engine haste, oil viscosity, gas pressure, crank angle film thickness and coefficient of friction. Non variable parameter are system constant, bore diameter, ring tension, ring width, compression ratio, reciprocating mass, piston ring area and piston ring profile. The major posits for developing models are either hydrodynamic lubrication theory or commixed lubrication theory of Reynolds equation.

Keywords:- Engine Speed, laser surface texturing, LST, Oil viscosity, Oil film Thickness , Piston Velocity, etc

I. INTRODUCTION

Ecumenical environmental concern is leading internal combustion engines designs. International legislation is establishing milestones to achieve conveyance emission goals. To meet emission targets, main development directions are incipient exhaust gas after treatment, systems, combustion strategies and amelioration of engine mechanical efficiency. When it comes to reduce engine friction power losses, the potency cell unit, especially the piston rings pack, presents great potential. It is already prominent that the cylinder-piston-piston rings assembly accounts for 37% of the engine friction loss; its idealizing could lead to a reduction of fuel consumption up to 5%.

The challenge to develop future power cell unit mainly consists of reducing friction power losses and weight while maintaining functionality of gas sealing, oil control and durability. This might require some compromise in component design and only a system approach (involving tribology, material science, simulation, testing, and manufacturing) together with a full understanding of interactions in the engine will lead to best decisions.Many of the present and future intended major engine technological evolutions influence significantly the operating conditions of the potency cell unit and have to be considered as adscititious constrains in the perpetual efforts to reduce the friction power losses within the ring pack. Engine downsizing and incremented power density engender more preponderant thermal and mechanical loads that require higher ring material and coating durability to stand incrementing cylinder pressure. Higher thermal and mechanical loading betokens higher deformations of piston grooves and lands (especially on lightweight designs), as well as more consequential deformations of the cylinder bores (concretely of lightweight blocks with circumscribed cooling capacities) needing better ring conformability. Thus concrete ring features are needed to assure the optimum management of gas and oil in the ring belt area to amend engine blow-by, reduce oil and fuel consumption, deleterious emission, and ascertain incremented durability.

II. CASE STUDY

We have taken research work done by G.Ryk & I.Etsion [1] as a Case study. They tested piston rings with partial surface texturing. In this study friction tests were carried out with several values of the mundane load Fe corresponding to a nominal contact pressure range from 0.1 to 0.3MPa. A special test rig was designed to provide linear reciprocating sliding kineticism simulating the case of piston ring and cylinder liner. The main structural features of the test rig are shown in Fig. An electric motor 1 drives the crank mechanism 2 thatensures reciprocal kineticism of a cylinder liner segment along the two linear bearing guides 9, fine-tuned on a mundane substructure and isolated from the laboratory floor by special damping pads. A self-alignment holder mechanism 4 ascertains alignment of two piston ring segments with reverence to the obverse cylinder liner segment. It additionally sanctions the application of a mundane load Fe as well as alimenting of lubricant to the contact zone and leading out wires of thermocouples that are embedded in the piston ring specimens to quantify their face temperature. A special contrivance consisting of two elastic beams 11 was designed to quantify the friction force. These beams sanction the displacement of an arm 13, which deflects due to the friction force acting between the rubbing surfaces. Strain gauges annexed to the elastic beams register the time variations of this deflection corresponding to variations in the friction force between piston rings and cylinder liner. The reciprocating speed quantification is realized with an optical gauge 14. A schematic of the test is presented in Fig.1 exhibiting two engenderment piston ring segments 6 and an engenderment cylinder liner segment 7. The angular extent of the contact between ring segments and cylinder liner surfaces is 40 degrees. The ring segments are liberatingly mounted in special grooves in the holder to simulate authentic piston ring possible tilt during reciprocation. The operating mundane load Fe is applied to the self aligned specimens' holder by betokens of precise weights. Plenarily formulated engine oil SAE 40 is supplied from a reservoir 1 through a metering system for lubricant flow rate control by drip lubrication. The alimenting oil system is utilized to simulate genuine oil.

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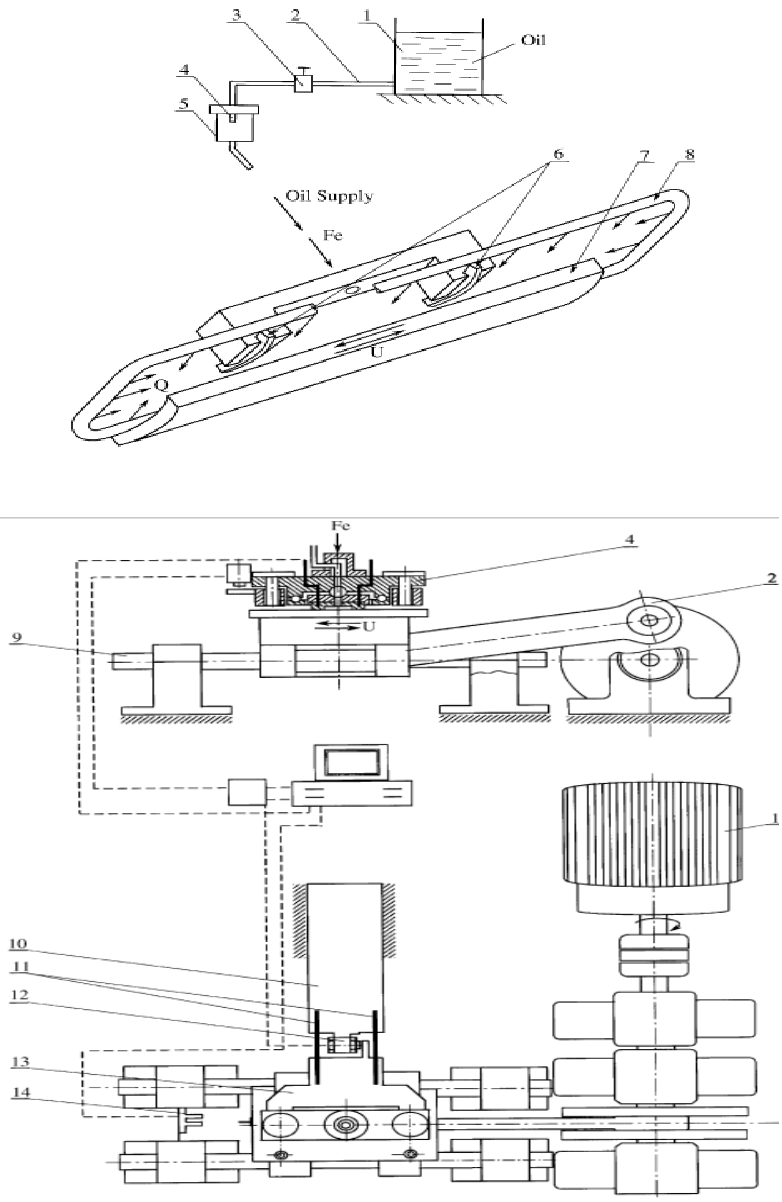

FIG.1:- Layout of Experimental Setup

III. TEST PROCEDURE

The parameters that could be varied in the present study are:-

- operating mundane load Fe,
- sliding speed U,
- Ambient temperature,
- Oil victualing rate,
- Parameters of the laser texturing.

The friction tests were carried out with several values of the mundane load Fe corresponding to a nominal contact pressure range from 0.1 to 0.3MPa. The lower contact pressure represents typical values caused by the ring's own elasticity in an authentic engine. The higher contact pressure represents the supplemental average gas pressure acting on the back of the ring, which for a medium power gasoline engine is about 0.2MPa. It is paramount to accentuate that the genuine external mundane load Fe acting on the piston ring varies with time (crank shaft angle) along with the gas pressure transmutation in the combustion chamber. However, since the average friction force is only marginally affected (less than 15%) by the combustion pressure spike, the external mundane load in the present experiments was maintained constant during the reciprocation of the specimens.

The average friction force over one reciprocating cycle was evaluated by on-line integration of the absolute values of the instantaneous quantified friction force. The resolution of these quantifications was 0.1N and the precision was 5%. The average friction force was acclimated to evaluate the efficiency of the partial LST. All tests commenced at 500 rpm followed by step increments of 100 rpm each, up to the maximum speed of 1200 rpm. It took between 3 and 5 min for the surface temperature to stabilize at each speed level. After reaching the stable temperature, friction quantification was taken at each speed level. A personal computer accomplished data acquisition and processing thus enabling online calculation of the average friction force over one cycle of revolution at every crank haste. The technical designations of the engine were presented in Table 3.1.

TABLE 1:- Specifications Of The Engine

Type	Vertical [TRB]
KW/H.P.	5.9 / 8 H.P.
RPM	850
S.F.C.	268 gm/kwh
Governing class	B1
Lubrication Oil	SAE 30
Fuel	HSD
Engine No.	9835

IV. RESULTS AND DISCUSSION

Two series of tests were carried out to study the benefit of Partial LST in friction reduction of textured piston rings. The first consisted of the non textured barrel shape face rings to establish a reference, and the second was performed with partial LST cylindrical face rings. Typical results for a representative case with a nominal contact pressure of 0.2MPa. The average friction force is presented versus crank rotational velocity for the reference non textured barrel shape rings and for the partial LST cylindrical face rings. As can be optically discerned the average friction increases with speed and load in both cases as would be expected in a hydrodynamic lubrication regime. Limpidly the LST has a substantial effect on friction reduction compared to the non textured reference rings. The average friction obtained with the partial LST cylindrical face rings is about 20– 25% lower than in the reference barrel face rings over the entire speed range from 500 to 1200 rpm. Only the friction level was remotely shifted up or down for higher (0.3MPa) or lower (0.1MPa) nominal contact pressure, respectively. The percentage distinction between the average friction in the non-textured and partial LST rings was virtually independent of the nominal contact pressure, and scarcely decremented with incrementing rotational velocity. It should be noted that above 900 rpm the vibrations level of the test rig commences to increment and above 1200 rpm.

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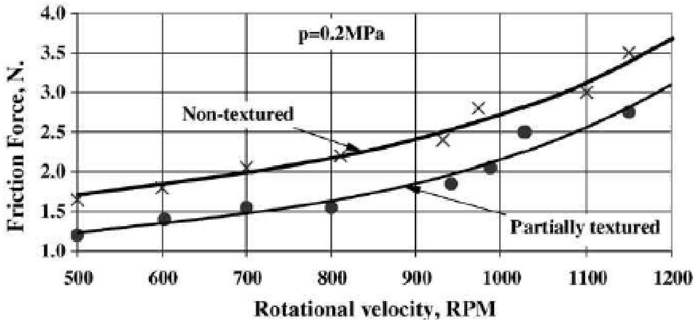

FIG.2:-Time Average Friction Force Vs. Crank Rotational Velocity For External Normal Pressures Of 0.2mpa

It reaches such a caliber that enjoined testing in this speed range. Hence, the friction quantifications at 1200 rpm can be considered less reliable than at the 500–900 rpm range. Conclusively, some authentic engine tests were performed with partial LST barrel shape rings exhibiting very little friction reduction at low speeds below 2000 rpm. Above 2000 rpm this little benefit of the partial LST vanished thoroughly. It seems that the barrel shape, which presumably was arrived at by tribulation and error experience over many years, is not a good candidate for partial LST. The crowning of the ring face by itself provides vigorous hydrodynamic effect that masks the more impotent hydrodynamic effect of the surface texturing especially at high speeds. Hence, in the future a more congruous comparison with firing engine test should be made, kindred to the present rig test, between the performance of optimum non-textured barrel shape and optimum partial LST cylindrical shape rings.

V. CONCLUSION

Friction reduction with partial laser surface texturing (LST) cylindrical face piston rings was evaluated on a reciprocating test rig by measuring the friction force between piston rings and cylinder liner segments. The results were compared with a reference non-textured barrel face piston ring. It was found that, within the speed limitation of the test rig, a friction reduction of up to about 25% can be obtained with partial LST cylindrical face rings. Some preliminary real engine tests, with production (barrel shaped) piston rings and cylinder liners did not show the same amount of friction reduction. Further investigation is required with a firing engine using optimum partial LST cylindrical face rings.

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