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Identification and study of tribology parameters in internal combustion engine

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Abstract
This paper presents studies related to engine tribology in internal combustion engine. Friction loss is the main portion around forty nine percent of the energy consumption developed in an engine. Lubricants are used to reduce the friction and wear and fuel consumption, increased power output of the engine, reduced oil consumption, a reduction in exhaust emissions in the engine. From the Analysis of the tribologist this means increasing specific loads, speeds and temperatures for the major frictional components of the engine, namely, the piston assembly, the valve train and the journal bearings, and lower viscosity engine oils with which to lubricate them. The literatures revealed that the most important parameter in the engine is lubricant, speed and load and with help of many different methods like blending the engine oil, remove the compression ring, additives are added to engine oil and analysis of piston ring assembly it can get the control on to the friction and wear and achieve almost all the objective that are concerned.

Keywords: engine, tribology, friction, lubricant, wear

1. Introduction
The motor car is one of the most common machines in use today, and it is no exaggeration to state that it is crucial to the economic success of all the developing and developed nations of the world and to the quality of life of their citizens. The motor car itself consists of thousands of component parts, many of which rely on the interaction of their surfaces to function. There are many hundreds of tribological components, from bearings, pistons, transmissions, clutches, gears, to wiper blades, tires, and electrical contacts. The application of tribological principles is essential for the reliability of the motor vehicle, and mass production of the motor car has led to enormous advances in the field of tribology. For example, many of the developments in lubrication and bearing surface technology have been driven by requirements for increased capacity and durability in the motor industry. For the purpose of classifying the tribological components, one Tribology comes from the Greek word, ―tribos‖, it meaning is ―rubbing‖ or ―to rub‖ And from the suffix, ―ology‖ means ―the study of‖ Therefore, Tribology is the study of rubbing, or ―the study of things that rub‖ [21, 22].

A. Tribology
Tribology is the science and technology of interacting surfaces in relative motion (and the practices related thereto), including the subject of friction, wear and lubrication [23].
This includes the fields of:
- Friction,
- Lubrication
- Wear

B. Friction
When one solid body is slid over another so there is a some resistance to the motion which is called friction. Considering friction as a nuisance, attempts are made to eliminate it or to diminish it to as small a value as possible. No doubt a considerable loss of power is caused by friction (e.g. about 20% in motor cars, 9% in airplane piston engine and (1 ½ -2) % in turbojet engines) but more important aspect is the damage that is done by friction – the wear or seizure of some vital parts of machines. This factor limits the design and shortens the effective working life of the machines [22, 34].

C. Lubrication
It is evident that lubrication is required to minimize sliding friction in complete bearings. An additional function of the lubricant is to act as a protection for the accurately-ground and highly-polished surfaces of the balls, rollers and rings. If free moisture is allowed to contact the bearing elements, corrosion and pitting will follow and the bearing life will be considerably shortened. At the same time, a suitable lubricant should prevent the entry of external contaminating matter in the form of dirt or abrasive dust [25].

D. Wear
Wear is the actual removal of surface material due to the frictional force between two mating surfaces. This can result in a change in component dimension which can lead to looseness and subsequent improper operation. The adhesion mechanism of friction enables us to understand the basic mechanism of metallic wear, when a junction shears during sliding it may shear in one or other of four ways. It produced by the processes of abrasion, adhesion, erosion, tribochemical reaction and metal fatigue [22].

E. Tribological Properties
In characterization of tribology, the friction & the wear can expressed as a function of temperature, additive concentration,

normal load or cycle time separately. Although by plotting the stribeck curves for friction coefficient & wear scar diameter as a function of all rotation speed, viscosity & normal force [21].

F. Tribosystem

Tribosystem consists of six elements .they are two contacting parts (base objects and opponent body), environment condition, intermediate materials, load & motion. Humidity, environmental temperature & pressure are the main environment condition [21].

2. Review of literature

Initially, the dimensionless parameters that characterize the operation of a piston ring and its friction were identified. Next an analytical model describing the dynamics surrounding ring's performance was developed.

Using this model in numerical simulation, the operational behavior of ring was predicted. In cylinder pressure which is one of the inputs for the MATLAB code was simulated using the first law of thermodynamics. Mufti and Priest [1] have measured the piston assembly friction losses under fired condition on a single cylinder Ricardo Hydra Gasoline car engine using the IMEP method and found that piston assembly friction found approximately double during power stroke and compression stroke in comparison to suction and exhaust stroke in an engine cycle at different all speeds. Also, they observed that power loss by first compression ring is always found approximately 33% higher than that of second ring at different operating conditions and piston assembly friction losses by both rings also observed about 30-35% of total power losses at all different operating speeds. Hamatake *et al*. [2] studied the frictional behaviour of piston ring assembly by varying no. of piston rings and concluded that to reduce the friction losses, decrease the number of rings. Hoshi [3] has experimented.

On 1300CC 4-cylinder petrol engine at speeds 2000 rpm without load and at 5000rpm with full load by using lubricating oil as SAE 10W30 at constant temperature of 800 0C and concluded that by changing the piston shape and reducing cross section, friction losses in piston assembly system were reduced by 23% that amounted to 9-11.5% of total friction losses. 3% of total frictional losses reduced by reducing slightly diameters and width of bearing on crankshaft and connecting rod. Estimated total % frictional losses were observed at 2000rpm and at 5000 rpm were 21%and 17% respectively. Tateishi [4] has experimented to reduce piston ring friction losses by applying two-ring package instead of the standard three ring packages and by developing low viscosity engine oil, reduction in piston mass, piston ring width and piston ring tension. Reduction of piston ring tension and using two ring packages are effective in reducing piston ring friction and reduction of piston ring friction can contribute to reducing the fuel consumption by several percentages. Wong [5] have done experiments and found that the PRA friction force was found to increase linearly with piston speed, decrease with increasing oil film temperature and slightly increase with gas pressure. Bolander *et al.*, [6] have developed the numerical model to investigate the effects of surface modifications on the lubrication condition and frictional loss at the interface between a piston ring and cylinder liner and observed that the modified cylinder liner was shown to reduce the cycle-average friction coefficient by 55-65%, while total energy loss per cycle was reduced by 20-40%. Taylor [7] Suggested a procedure to calculate PRA friction loss by solving Reynolds equation. The calculation of oil film thickness under the piston rings involves solving Reynolds equation, using the appropriate piston ring profile and taking into account the variable speed of the piston ring as the piston moves from BDC to TDC. It is also necessary to know the gas pressure on either side of the piston ring, the piston ring temperature and the liner temperature at the piston ring position. If all these parameters are known, then the oil film thickness and friction force of the piston ring may be calculated. Noorman [8] measured friction by motoring of an engine by an electric dynamometer and found that motoring friction was found to increase with speed. Ting [9] have used test bench for measurements and showed that PRA friction force was found to increase linearly with the piston speed and found that use of low viscosity oil cause sudden increase in wear at TDC and BDC. Bhatt and Mistry [10] Have experimented on 150CC motorized test rig by using different lubricants and operating the system for speed ranges from 500 to 2000rpm and observed that ring geometry played important role to reduce piston ring assembly friction. Nautiyal *et al.*, [11] have studied friction and wear process in piston rings and friction co-efficient were investigated on a modified Bowden-Leben machine using actual segments of piston ring and cylinder liner and found that co-efficient of friction remains more or less constant with increase in oil temperature and large part of top piston ring wear takes place during boundary lubrication around TDC position. Sharma [12] has experimentally studied the various parameters of the engine tribology and experimented with various application of the piston ring geometry at low profile at the piston ring edge and offered a co-relation in the form of equations with a different constant of system.

3. Importance of engine tribology

To reduce friction and wear, the engine tribologist is required to achieve effective lubrication of all moving engine components, with minimum adverse impact on the environment. This task is particularly difficult given the wide range of operating conditions of load, speed, temperature, and chemical reactivity experienced in an engine [5].

Improvements in the tribological performance of engines can yield:

- Reduced fuel consumption
- Reduced oil consumption Increased engine power output
- A reduction in harmful exhaust emissions
- Improved reliability, durability, and engine life
- Reduced maintenance requirements and longer service intervals

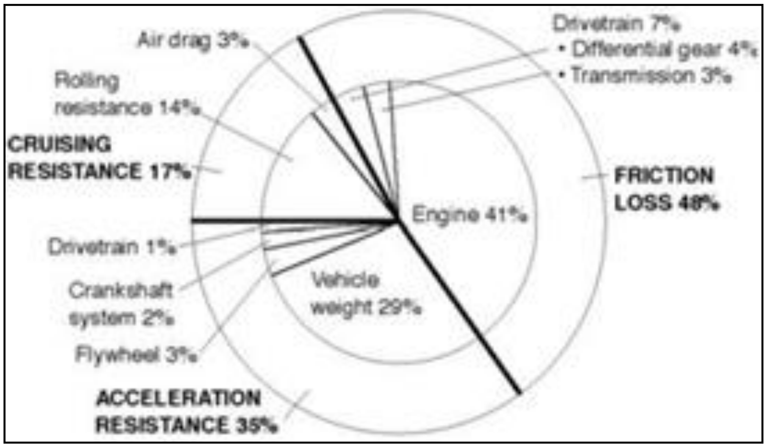

Fig 1: Energy consumption developed in an engine

It is interesting to consider where the energy derived from combustion of the fuel is apportioned in an engine. In a published paper, Anderson (1991) showed the distribution of fuel energy for a medium size passenger car during an urban cycle. Only 12% of the available energy in the fuel is available to drive the wheels, with some 15% being dissipated as mechanical, mainly frictional, losses. Based on the fuel consumption data in Anderson's publication, a 10% reduction in mechanical losses would lead to a 1.5% reduction in fuel consumption. The worldwide economic implications of this are startling in both resource and financial terms and the prospect for significant improvement in efficiency by modest reductions in friction is clear. [21] Concerning energy consumption within the engine as shown in Fig 1 friction loss is the main portion (48%) of the energy consumption developed in an engine. The acceleration resistance (35%) and the cruising resistance (17%) are the other portions. If one looks into the entire friction loss portion, engine friction loss is 41% and the transmission and gears are approximately 7%. Concerning engine friction loss only, sliding of the piston rings and piston skirt against the cylinder wall is undoubtedly the largest contribution to friction in the engine.

Frictional losses arising from the rotating engine bearings (notably the crankshaft and camshaft journal bearings) are the next most significant, followed by the valve train (principally at the cam and follower interface), and the auxiliaries such as the oil pump, water pump, and alternator. The relative proportions of these losses, and their total, vary with engine type, component design, operating conditions, choice of engine lubricant, and the service history of the vehicle (i.e., worn condition of the components). Auxiliaries should not be overlooked, as they can account for 20% or more of the mechanical friction losses. For example, an oil pump in a modern 1600 cc gasoline engine can absorb 2 to 3 kW of power at full engine speed, while for a racing car this can rise to some 20 kW [17, 21].

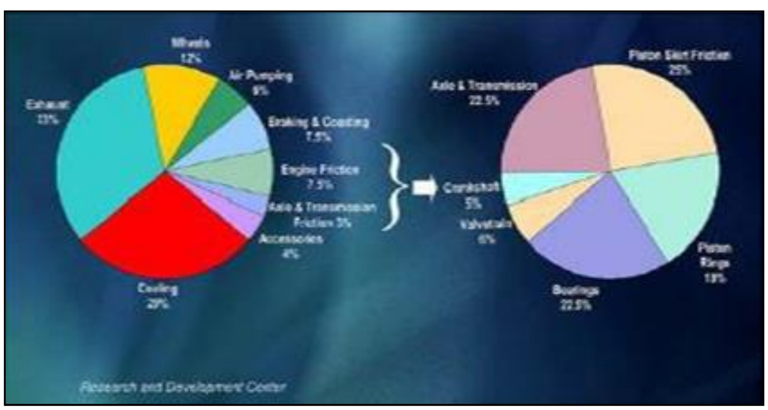

Fig 2: Distribution of energy consumption in a light-duty

4. Conclusion

A broad literature survey is carried out in the research area of engine tribology and in some research paper researchers conclude that in the area of piston compression ring to know about the simulation and experimental methods developed to study its performance. Many no. of experimental methods in compression ring is there in tribology. In other research paper researches revealed that the temperature is increase and the viscosity of oil is decreases if the blend ratio of oil increases. It is found that 10 % blend oil shows the characteristic at higher load, while other oils of different percentage of blending oils are not shown good characteristics at higher load from the analysis of oil at both loads at 15 and 40 kg. It can be concluded that tribological performance is good in 10 % blend oil at 40 kg load. Initially the power consumption is reduces till 900 rpm but then it increases with increase in speed of the engine. Same specified lubricants under different brand offers variation in PRA friction. Referring the other research papers it can be conclude that Nature of curve of power consumption of PRA system with is in line with Stribeck curve nature, which means initially the system operates in boundary at 600 rpm or mixed lubrication condition at 900 rpm and later on after 900 rpm is mixed to hydrodynamic lubrication condition. From other paper it can be conclude that if some additives like tio2 and P25 are include in the oil than the coefficient of friction is slightly reduced because of the nanoTiO2 particles but most importantly it stabilized it .It is might be due to its uniform film formation on the sliding surface.P25 increased coefficient of friction slightly and was higher than base for all the compositions. 0.25 wt% addition of TiO2 to base oil. From all this paper finally concludes that all the main reason of engine performance is depend on the wear and friction of the engine components so if lubrication is good than almost many problems is solved so lubrication is very important parameter in engine tribology.

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