Design Of Piston Rings And Expermental Investigation For Tribological Aspect Of Its Material With Mild Steel

Nitin Kharb [1] Vivek Khokhar [2]

Ganga Institute of Technology and Management, Kablana, jhajjar

Department of Mechanical Engineering

Abstract:

The presence of coatings and surface topography play an important role in the tribological performance of sliding components. Depending on the coating used, it is possible to reduce friction and reduce wear. However, although there may be low friction and wear-resistant coatings suitable for use in pistons, some coatings may hinder the tribological performance by changing the lubrication regime or by preventing additives from their intended function through chemical mechanisms. In this work, piston rings segments extracted from a commercial aluminum alloy piston were coated with a chromium coating and were tribologically tested using a wear testing machine against commercial grey cast iron disc, which is similar to the engine cylinder liner segments. This Laboratory tests to evaluate piston ring and cylinder liner materials for their friction and wear behavior in realistic engine oils are described to support the development of new standard test methods. A ring segment was tested against a flat specimen of gray cast iron typical of cylinder liners.

A stepped load procedure was used to evaluate friction behavior using a run-in ring segment. The extent of wear was measured by weight loss, wear volume and wear depth using a geometric model that takes into account compound curvatures before and after testing. Wear volume by weight loss compared well with analytical precision balance. Laboratory test results are compared to engine wear rates.

Introduction

An internal combustion engine is defined as the machine that converts the chemical energy liberated through combustion of a certain fuel, into a mechanical energy that is used to derive a certain vehicle. The definition highlights two important facts about the engines. First, an engine is a machine, hence a mechanism exists. This mechanism can vary and thus we can have more than one mechanism of operation. The two most famous mechanism of operation are two-stroke and four-stroke engines. As clear from its name, the only difference exists in the so called stroke. This leads to different design considerations, and accordingly leads to distinguishable efficiency for each kind. There is a Third design for engines that is called the Rotary Engine.

The second point in the definition is the conversion of chemical energy to mechanical energy; one can distinguish two main types of engines, Diesel engine and Gasoline engines. The first engine is based on thermodynamic cycle called Diesel cycle, while the second is based on the cycle called Otto cycle. Due to the difference in the thermodynamic cycle that is used to burn the used fuel, a certain fuel is selected to suit the process. In Otto cycle engines, gasoline is the fuel. In Diesel cycle engines, diesel oil is the fuel. Further the engines may be classified on the basis of number of cylinders as Single Cylinder Engines & Multi Cylinder Engines.

Parts of the Internal-Combustion Engine and their functions:

The function of the mechanism of any engine is to provide a means whereby the heat energy of the fuel can be efficiently converted into useful mechanical work. A study of its construction and parts is needed in order to become familiar with the engine as a whole and with the terms used in describing it. Some of the principal parts are described below.

The cylinder is usually made of hard, close-grained cast iron and may be arranged horizontally, vertically, or at an angle to the vertical, according to the type of engine. In most aircraft engines the cylinders are made of steel. For reasons already given, the cylinders must be provided with some means of cooling the walls. In small engines this may be accomplished by placing fins, or ribs, on the outer surface of the cylinder to expose a large cooling area to the outside air. The largest engines and the majority of smaller ones are water cooled, the cylinders being cast with outer walls, or jackets, inside of which water is circulated to cool the inner wall.

Pistons are usually made of a good grade of close-grained cast iron or aluminium alloy. In larger engines, cast steel is sometimes used. The pistons are similar to the steam-engine pistons except that they are longer. For single-acting engines the trunk piston is the type generally employed. Usually no special provision is made for the cooling of this type of piston, as the circulation of air within it is sufficient. All pistons are provided with rings to prevent leakage between the piston and the cylinder walls.

The valves of an internal-combustion engine serve the same purpose as the valves of a steam engine. They admit the fresh mixture of air and fuel into the cylinder at the proper time and permit the exhaust gases to escape. In some engines slide valves are used to perform these functions, but poppet, or lift, valves are most commonly used. Valves for small cylinders are made of alloy steel. The valves are worked from an auxiliary, or cam, shaft. In most engines the valves are actuated by cams, while in large engines eccentrics are generally employed.

The force on the piston of the internal-combustion engine is transmitted to the revolving crankshaft through a connecting rod and crank in the same manner as in the steam engine. In single-acting engines there is no piston rod, but the connecting rod is fastened directly to the trunk piston, which also acts as a crosshead. In double-acting engines the arrangement is the same as that of the steam engine, there being a piston rod, cross-head, and connecting rod. These parts are usually made of open-hearth steel.

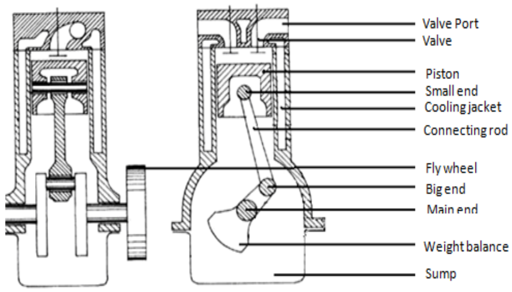


Fig.1 Insight of a typical single cylinder engine (Courtesy: spr ltd)

Performance parameters:

The parameters on the basis of which the performance of an I. engine is judged are known as performance parameters.

Some of them are:

1. **Torque**: - It is the tendency of a force to rotation object about an axis torque is considered as a twist to an object. Torque is defined as the cross product of lever arm distance vector and force vector, which tends to produce rotation .and its SI unit is Newton meter (Nm)

   T = R x F

   Where,

   T = torque vector

   R = displacement vector

   F = force vector

2. **Brake power:** - It is defined as the power available in crankshaft, the brake power of an IC engine is, usually measured by means of brake mechanism (pony brake or rope brake).

   $$B.P = \frac{(W-S)\,\pi\, D\, N}{60}$$

   Where,

   W = dead load in N

   S = spring balance reading in N

   D = diameter of the brake drum in m

   N = speed of the engine

3. **Indicated power** :- The indicated power is the power actually developed by engine cylinder

$$I.P = \frac{100\ k\ Pm\ L\ A\ N}{60}$$

Where,

K = no. of the cylinder

Pm = actual mean effective pressure in bar

L = length of stroke in meter

A = area of the piston

N = no. of working strokes in per min.

4. **Indicated mean effective pressure**: - Indicated mean effective pressure of an engine is obtained from indicator diagram drawn with the help of engine indicator. Mathematically ,mean effective pressure(in bar) It may be noted that the mean effective pressure calculated on the basis of theoretical indicator diagram , it is known as theoretical mean effective pressure . If it is based on the actual indicator diagram, then it I called actual mean effective pressure.

$$IMEP = \frac{\text{area of indicator card x scale of indicator spring}}{\text{Length of the indicator card}}$$

5. **Mechanically efficiency**: - It may be defined as the brake power (B.P) to the indicated power (I.P).

$$Efficiency = \frac{B.P}{I.P}$$

6. **Indicated thermal power efficiency**: - It is defined as the ratio of heat equivalent to one KW hour to the heat in the fuel per I.P

$$ITPE = \frac{I.P \times 3600}{m\ f \times C}$$

7. **Brake thermal power efficiency**: - It is the ratio of the heat equivalent to one kw hour to the heat In the fuel per B.P. hour.

$$BTPE = \frac{B.P \times 3600}{m\ f \times C}$$

8. **Volumetric efficiency**: - It is the ratio of the actual volume of charge admitted during suction strokes at the N.T.P. to the swept volume of piston.

9. **Specific fuel consumption**: - It is defined as the amount of fuel burns to produce one kw amount of energy.

Modern era engines:

Automotive engineering has seen a spate of innovations in the past decade, MV's (Multiple valves), DOHC's (Double overhead cams), MPFI (Multi-port fuel injection) which, when combined with stronger and lighter carbon composites and metal alloys, are bringing the internal combustion engine technology to its full potential**.**

These modern innovations have resulted in such a better fuel economy, more power & cleaner engine. But the irony is that all these inventions have increased the efficiency merely by 5% with an overall efficiency of less than 25 %. This is because the I.C. engine looses 42% of its energy to exhaust and 28% of its energy to the cooling system. However in order to reduce the energy losses it is proposed to use the exhaust gases to run a turbine which in turn can run the auxiliary devices which are at present powered by the main engine such as turbo charger.

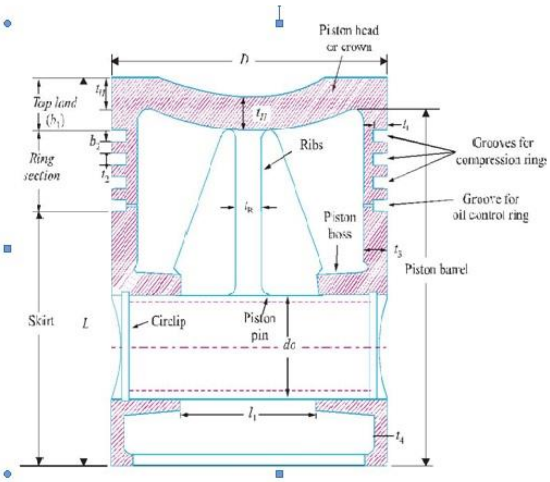
Various methods that may be implemented for improving the engine efficiency are as follows:

1. Run the engine at lean fuel i.e. use sotcheometric air fuel ratio.
2. High compression ratio with high octane/cetane number.
3. Run the engine at optimum conditions, meaning low friction (modest engine speed) and low pumping work (air throttle more open).

PISTON:

A piston is a component of a reciprocating engine, pumps and gas compressors. It is located in a cylinder and is made gas tight by piston rings. In. an engine, its purpose is to transfer force from expanding gas in the cylinder to the crankshaft by a piston rod or a crank rod. A piston is a cylindrical engine component that slides back and forth in the cylinder bore by forces produced using the combustion process. The piston acts as a movable end of the combustion chamber. The stationary end of the combustion chamber is the cylinder head.

Pistons are commonly made of a cast aluminium alloy for excellent and lightweight thermal conductivity. Thermal conductivity is the ability of a material to conduct and transfer heat. Aluminium expands when heated and proper clearance must be provided to maintain free piston movement in the cylinder bore. Insufficient clearance can cause the piston to seize in the cylinder. Excessive clearance can cause a loss of compression and an increase in piston noise. The piston acts as the movable end of the combustion chamber and must withstand pressure fluctuations, thermal stress, and mechanical load. Piston material and design contribute to the overall durability and performance of an engine. Most pistons are made from die- or gravity-cast aluminium alloy. Cast aluminium alloy is lightweight and has good structural integrity and low manufacturing costs. The light weight of aluminium reduces the overall mass and force necessary to initiate and maintain acceleration of the piston. This allows the piston to utilize more of the force produced by combustion to power the application. Piston designs are based on benefits and compromises for optimum overall engine performance.



Piston profile:

The piston which seems to be cylindrical in shape is actually having a linear as well as polar profile on it. The upper and lower end of the piston is curved inwards and has maximum diameter (nominal diameter) at the skirt at a particular height. This curved profile provided along the length of the piston is known as linear profile. Similarly when seen from the top, the geometry appears to be a circle which is not the case. In actual it is oval in shape having its minor axis along the pin bore axis and major axis perpendicular the minor axis. This type of profile provided on the piston outer diameter is known as Polar profile. The profile is provided in order to compensate the thermal expansion of the piston inside the cylinder. Once the engine starts operating, the inside temperature begins to rise resulting in the thermal expansion of the piston. The portions equipped with more material tend to expand more than those having lesser material. Accordingly the profile has been given to the piston so as to compensate the thermal expansion and finally it achieves a cylindrical shape inside the cylinder.

Types of cylinder piston fitments:

The cylinder/piston fit is one of the most important factors governing the success of an engine. Material selection wise, there are many choices out of which the best suited one is selected as per the necessity and engine requirements. Each has their own characteristics, advantages, and disadvantages. The most common choices, in ascending order of preferences are:

1. Steel liner, Cast Iron piston
2. Cast Iron liner, Cast Iron piston
3. Steel liner, Steel piston
4. Steel liner, Aluminium piston, and Cast Iron ring(s)

Piston Nomenclature:

Broadly a piston can be classified into two zones namely ring zone & Skirt zone. The ring zone comprises of ring grooves and ring lands. The upper most rings is the compression ring which solely bears all the pressure during power stroke and transmits a large amount of heat generated to the surrounding through the cylinder. Thus keeps the internal temperature under control. Below this there are intermediate rings and oil rings. The oil ring contains oil holes through which oil passes over the piston skirt and form a layer of oil between cylinder liner and the piston.

The number of grooves depends on the size of the piston & requirement of the engine. There may be 2,3,5 or 7 rings in a piston. The skirt portion is having feed lines on its surface that helps in holding the layer of oil on it. On the minor axis of the piston there are two bores in the piston known as pin bore that holds the gudgeon pin in it with the help of circlips. The circlips stops the sideways movement of the gudgeon pin when in operation. The top of the piston is known as crown. It contains cavity which is used as a combustion chamber where the mixture of air and fuel burns to produce hot gases.

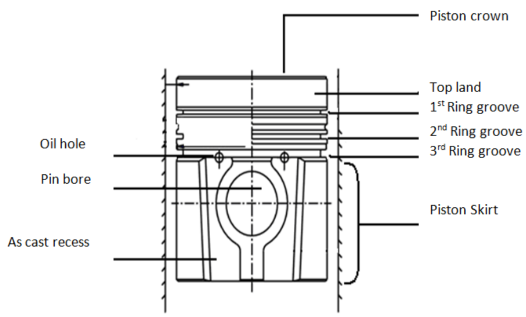


Fig. piston nomenclature

Composition of piston:

An Aluminium piston contains many alloying elements in its composition such as Silicon, Manganese, Zinc, Tin, Iron, Titanium, Copper, Magnesium and Lead etc. According to the composition each type of the piston material has been assigned with a code. Some of them are given below. The prime objective of adding these alloying elements is to improve the physical and thermal properties of the Aluminium. They impart hardness, toughness and durability to the piston. Elements like Magnesium improve the machinability of the metal whereas Silicon makes it more hard and wear resistant. These alloying elements also lower the coefficient of thermal expansion of the Aluminium to match up with the coefficient of thermal expansion of C.I. ring.

Table 1 : Material: [P -AL-003] { (LM- 6) (2285) (IS-7793-1975):

ELEMENTS		REQUIRED	ELEMENTS		REQUIRED
SILICON	Si	0.6 Max.	COPPER	Cu	3.5 ~ 4.5.
MANGANESE	Mn	1.2 ~ 1.8	MAGNESIUM	Mg	1.2 ~ 1.8
ZINC	Zn	0.2 Max.	NICKEL	Ni	1.7 ~ 2.3
TIN	Sn	0.05 Max.	TITANIUM	Ti	0.2 Max.
IRON	Fe	0.7 Max.	LEAD	Pb	0.05 Max
			ALUMINIUM	Al	Remainder

Cylinder liner:

A cylinder liner is a cylindrical part to be fitted into an engine block to form a cylinder. It is one of the most important functional parts to make up the interior of an engine. The cylinder liner, serving as the inner wall of a cylinder, forms a sliding surface for the piston rings while retaining the lubricant within. The most important function of cylinder liners is the excellent characteristic as sliding surface and these four necessary points.

1. High anti-galling properties
2. Less wear on the cylinder liner itself

3. Less wear on the partner piston ring
4. Less consumption of lubricant

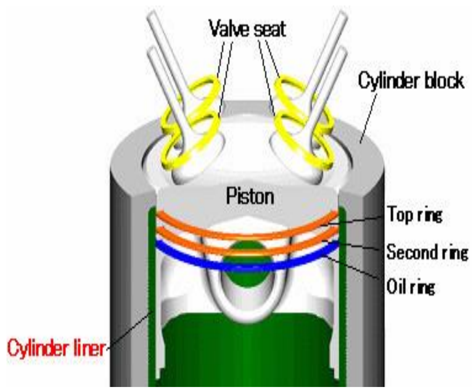


Fig : cylinder liner in engine

The cylinder liner receives combustion heat through the piston and piston rings and transmits the heat to the coolant. The cylinder liner prevents the compressed gas and combustion gas from escaping outside. It is necessary that a cylinder liner which is hard to transform by high pressure and high temperature in the cylinder. A cylinder wall in an engine is under high temperature and high pressure, with the piston and piston rings sliding at high speeds. In particular, since longer service life is required of engines for trucks and buses, cast iron cylinders that have excellent wear-resistant properties are only used for cylinder parts. Also, with the recent trend of lighter engines, materials for engine blocks have been shifting from cast iron to aluminum alloys. However, as the sliding surface for the inner cylinder, the direct sliding motion of aluminum alloys has drawbacks in deformation during operation and wear-resistance. For that reason, cast iron cylinder liners are used in most cases.

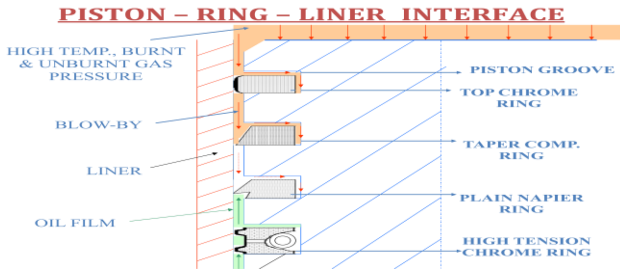
Piston Ring:

The piston ring is a split band that fits into a groove on the outer diameter of the piston in a reciprocating engine pressed against the wall of the cylinder by springs mounted in the inner “junk ring”. The Tongue maintains the seal as the ring expands and split apart.

Fig: Piston ring Courtesy: (spr ltd.)

A ring groove is a recessed area located around the perimeter of the piston that is used to retain a piston ring. Ring lands are the two parallel surfaces of the ring groove which function as the sealing surface for the piston ring. A piston ring is an expandable split ring used to provide a seal between the piston and the cylinder wall. Piston rings are commonly made from cast iron. Cast iron retains the integrity of its original shape under heat, load, and other dynamic forces. Piston rings seal the combustion chamber, conduct heat from the piston to the cylinder wall, and return oil to the crankcase. Piston ring size and configuration vary depending on engine design and cylinder material.

Piston Ring assembly:



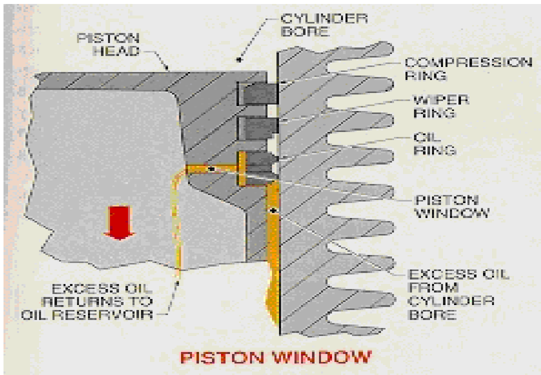


Fig : Piston rings arrangement

DESIGN OF PISTON RING:

The piston rings are used to impart the necessary radial pressure to maintain the seal between the piston and the cylinder bore. These are usually made of grey cast iron or alloy cast iron because of their good wearing properties and also they retain spring characteristics even at high temperatures.

The piston rings are of the following two types:

1. Compressor rings
2. Oil control rings

The compression rings or pressure rings are inserted in the grooves at the top portion of the piston and may be three to seven in number. These rings also transfer heat from the piston to the cylinder liner and absorb some part of the piston fluctuation due to the side thrust. The oil control rings or oil scrapers are provided below the compression rings. These rings provide proper lubrication to the liner by allowing sufficient oil to move up during upward stroke and at the same time scrap the lubricating oil from the surface of the liner in order to minimize the flow of the oil to the combustion chamber. The compression rings are usually made of rectangular cross-section and the diameter of the ring is slightly larger than the cylinder bore. A part of the ring is cut- off in order to permit it to go into the cylinder against the liner wall. The diagonal cut or step cut ends may be used. The gap between the ends should be sufficiently large when the ring is put cold so that even at the highest temperature, the ends do not touch each other when the ring expands, otherwise there might be buckling of the ring.

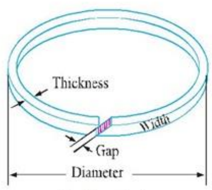


Fig :Diagonal cut

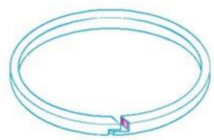


Fig : Step cut

The radial thickness (T_1) of the ring may be obtained by considering the radial pressure between the cylinder wall and the ring. From bending stress consideration in the ring, the radial thickness is given by

$$T_1 = D \sqrt{\frac{3 P_w}{\sigma t}}$$

Where,

D = diameter of the bore.

Pw = Pressure of gas on the cylinder wall in N/mm^2. Its value is limited from 0.025 N/mm^2 to 0.042 N/mm^2.

σ t = Allowable bending (tensile) stress in MPa. Its value may be taken from 85 MPa to 110 MPa for cast iron rings.

The minimum axial thickness (T_2) may also be obtained from the following empirical relation:

$$T_2 = \frac{D}{10\, n_R}$$

Where,

n_R = number of rings

The width of the top land is made larger than other ring lands to protect the top ring from high temperature conditions existing at the top of the piston,

Width of top land,

$B_1 = t_H$ to $1.2\, t_H$

The width of other ring lands in the piston may be made equal to or slightly less than the axial thickness of the ring

Width of other ring,

$B_2 = 0.75\, T_2$ to T_2

The depth of the ring grooves should be more than the depth of the ring so that the ring does not take any piston side thrust.

Based on the design study, better heat treatment based alloy for different parts of power producing unit of an I C Engine may be designed. Also profile of piston ring may be considered for better lubrication, smooth functioning and efficient capable engine.

CALCULATION OF RESULTS AND DISCUSSIONS

Wear rate with cast iron pin without coated condition:

The cast iron pin taken for experiment has a dimension of diameter of 10 mm and length is about is 30 mm. The initial mass of pin was 19.5102 gm. The projected length beyond gripping in the clamp of the test rig is 4 mm. The cast iron disc of diameter 165 mm is taken for testing. The experiment carried shows the variables and the result obtained during pin on disc testing table.. Column 1 shows velocities (m/s) for different loads (kg). Column 2 shows the load applied during each run. The mean value of friction force for each run is taken from the graph showing on computer monitor attached with the wear testing machine and then coefficient of friction is obtained .coefficient of friction is shown in column 3. Disc rpm is shown in column 5. Tracking distance is taken in decreasing order from 120 to 60. Sliding distance is taken 2000 m. Time recorded in each run is shown in column 8. Column 9 shows mass after wear of pin by weighing in weighing machine. Last column shows specific wear rate.

Table : variables and result obtained in uncoated condition with cast iron pin

velocity (m/sec)	load (kg)	coeff. of friction	frictional force (N)	disc rpm	tracking distance	sliding distance (km)	time (sec)	mass after wear (gm)	mass loss (gm)	specific wear
3.14	2	.08154	1.6	1000	120	2	318	19.5095	0.0007	4.57
4.186	3	0.0645	1.8	1000	100	2	382.2	19.5089	0.0013	7.64
5.23	4	0.0739	2.9	1000	80	2	477.7	19.5082	0.002	10.69
6.28	5	.0672	3.3	1000	60	2	637	19.5077	0.0025	8.16

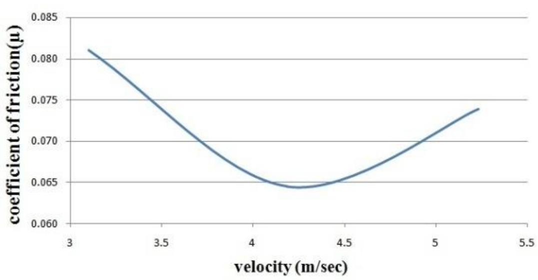


Fig | Coefficient of friction vs. Velocity

The variation of coefficient of friction with the velocity is shown in figure. above this figure has 3 zones. First zone is boundary or mixed zone. In first zone, the coefficient of friction decreases with velocity. In second zone, coefficient of friction decreases up to its minimum value of 0.0645 at 5.23 m/sec velocity of disc. In the third zone coefficient of friction increases rapidly due to debris present between pin and disc. Slope of curve in velocity range of 3.1 to 5.1 m/sec .should be continuously increasing but due to insufficient lubrication and debris sticking in wear area. It is not continuously increasing. Maximum value of coefficient of friction is 0.08154.

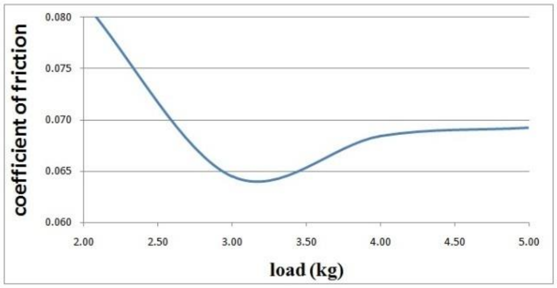


Fig . Coefficient of friction vs. Load

The variation of coefficient of friction with the load is shown in fig. above it has 3 zones also. First zone is boundary or mixed zone. In first zone, coefficient of friction decreases continuously with load. In second zone, the coefficient of friction attains its lowest value of 0.0645 at 3 kg. In third zone, the coefficient of friction increases slowly compare to zone 2 due to less debris present in wear area. Maximum value of coefficient of friction is 0.08154.

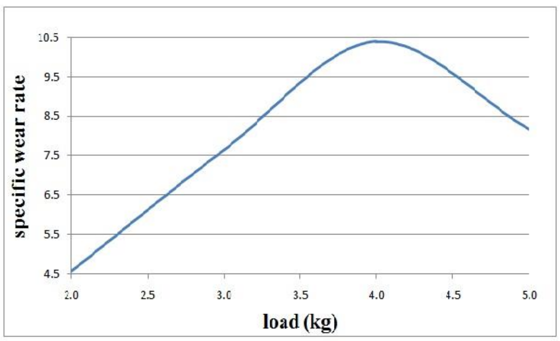


Fig Specific wear rate vs. Load

The variation of specific wear rate with load is shown in fig. above and it shows a 2 zones. In first zone, specific wear rate is continuously increases and obtained its maximum value of 10.69 at the load of 4 kg .in zone 2 specific wear rate decreases up to 8.16 due to insufficient debris present between pin and disc.

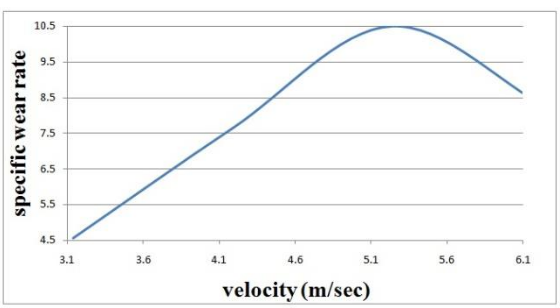


Fig .Specific wear rate vs. velocity

The variation of specific wear rate with velocity is shown in fig. above and it shows specific wear rate is increasing up to velocity 5.3 m/sec in the first zone and attains the maximum value 10.69. In zone 2 specific wear rate decreases because of the formation of the debris. Specific wear rate is decrease up to 8.16.

Wear rate with cast iron pin with coated condition:

The coated cast iron pin has same dimensions before take 10 mm dia. and 30 mm about its length. And it's coated with chromium with help of electroplating. And its initial mass of pin was 20.7986 gm. The projected length beyond gripping in the clamp of the test rig is 4 mm. The experiment carried shows the variables and the result obtained during pin on disc testing table below. Column 1 shows velocities (m/s) for different loads (kg). Column 2 shows the load applied during each run. The mean value of friction force for each run is taken from the graph showing on computer monitor attached with the wear testing machine and then coefficient of friction is obtained .coefficient of friction is shown in column 3. Disc rpm is shown in column 5. Tracking distance is taken in decreasing order from 120 to 60. Sliding distance is taken 2000 m. Time recorded in each run is shown in column 8. Column 9 shows mass after wear of pin by weighing in weighing machine. Last column shows specific wear rate.

Table : variables and result obtained in coated condition with cast iron pin

velocity (m/sec)	load (kg)	coeff. of friction	frictional force (N)	disc rpm	tracking distance	sliding distance (km)	time (sec)	mass after wear (gm)	mass loss (gm)	specific wear
3.14	2	.0387	1.6	1000	120	2	318	20.7985	0.0001	3.98
4.186	3	.0280	1.8	1000	100	2	382.2	20.7984	0.0002	7.07
5.234	4	.0339	2.9	1000	80	2	477.7	20.7983	0.0003	6.58
6.28	5	.04587	3.3	1000	60	2	636.4	20.7982	0.0004	7.72

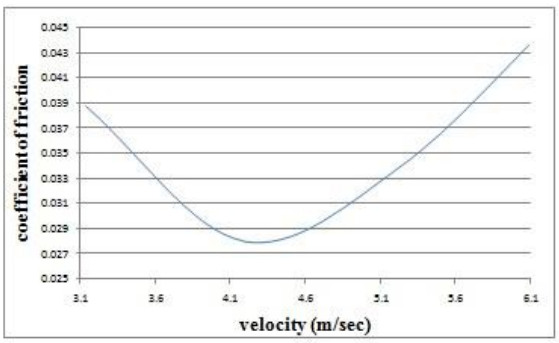


Fig. Coefficient of friction vs. Velocity

The variation of coefficient of friction with the velocity is shown in figure above. Figure has 3 zones. First zone is boundary or mixed zone. In first zone, the coefficient of friction decreases with velocity. In second zone, coefficient of friction decreases up to its minimum value of 0.0280 at 4.186 m/sec velocity of disc. In the third zone coefficient of friction increases up to 0.04587.the reason for increasing the coefficient of the friction due to debris present between pin and disc. Curve is uniform and shows actual stribeck curve.

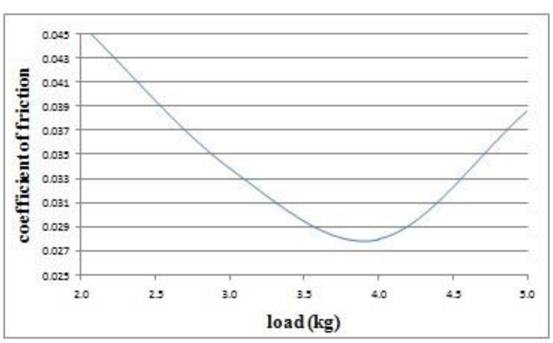


Fig.Coefficient of friction vs. Load

The variation of coefficient of friction with the load is shown in fig above.it has 3 zones also. First zone is boundary or mixed zone. In first zone, coefficient of friction decreases with load. In second zone, the coefficient of friction attains its lowest value of 0.0280 at 4 kg. In third zone, the coefficient of friction increases and attained its maximum value of 0.04587. In zone 3, coefficient of friction is increasingly because debris is presence between pin and disc.

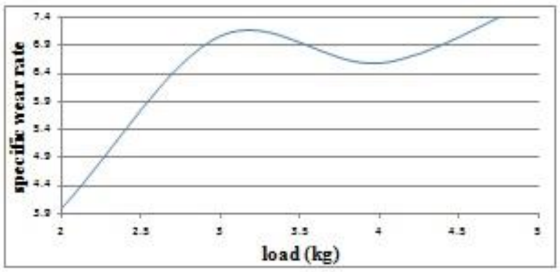


Fig.Specific wear rate vs. Load

The variation of specific wear rate with load is shown in fig above. this figure show tha6t specific wear rate is increased up to the load 3 kg attains the value of 7.07 and then decreases beyond this load. This may be due to the presence of the debris in the cast iron pin which reduces the area of contact between pin and disc and finally the wear rate again increases beyond 4 kg load. Maximum value of the specific wear rate is 7.72 obtained at 5 kg load.

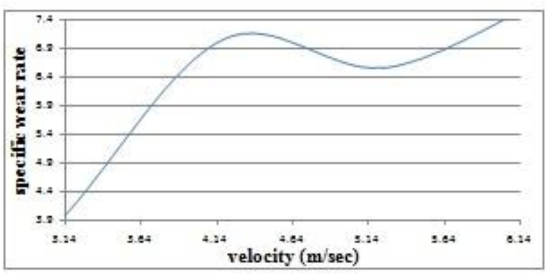


Fig.Specific wear rate vs. Velocity

The variation of specific wear rate with velocity is shown in fig. aboveit has 3 zones .in first zone specific wear rate is increasing with velocity. It attains value of 7.07 at 4.186 m/sec .because of the formation of the thick film lubricant between the pin and disc. In zone 2 specific wear rate decreases up to 6.58 at velocity 5.234 m/sec. in zone 3 specific wear rate increase up to 7.72.

CONCLUSIONS

This pin and disc test results showed that cast iron piston rings and cylinder liners have insufficient wear characteristics for objective "future" engine. Also cast iron cylinder liner has insufficient strength. On the other hand, developed piston rings and cylinder liners, coated with chromium plating composite by the electroplating and by the means of other method, proved excellent results on the wear resistant characteristics. Moreover the process developed in this study makes possible to apply stronger materials for cylinder liners.

And with this coating surfaces piston rings and piston life is doubled as compared to the uncoated piston rings and piston. Its appearance becomes good. This enables periodic inspection every 4 years instead of every 2 years, consequently reducing the maintel. Lance cost for overhauling. And mean effective pressure, mean piston speed, mean cylindrical pressure is also improved and increased. Due to this frictional force is decreased.

Refrences:

[1] *Nicholas G. Demas , Robert A. Erck , Oyelayo O. Ajayi and George R. Fenske, Tribological studies of coated pistons sliding against cylinder liners under laboratory test conditions. Lubrication science, in 2012.*

[2] John J. truhan, Jun Qu , Peter blau A rig test to measure friction and wear of heavy duty diesel engine piston rings and cylinder liners using realistic lubricants. Tribology International 38 (2005) 211–218.

[3] Kwang-soo Kim, Paras Shah, Masaaki Takiguchi, Shuma Aoki A Study of Friction and Lubrication Behavior for Gasoline Piston Skirt Profile Concepts. In 2009

[4] Ondrej chocholaty, jin HAZEK , Antonin KRIZ, Jan VICEK , comparison of wear resistance of chromium coatings for piston rings using pin on disc test and engine test. EU in 2012.

[5] E. Abu-Nada, I. Al-Hinti, A. Al-Sarkhi, B. Akash, Effect of Piston Friction on the Performance of SI Engine: A New Thermodynamic Approach.
Zarqa 13115 in 2012.

[6] H. Abdullah Tasdemir, Masaharu Wakayama, akayuki Tokoroyama, Hiroyuki Kousaka, Noritsugu Umehara, Yutaka Mabuchi, Tsuyoshi Higuchi.
Wear behaviour of tetrahedral amorphous diamond-like carbon (ta-C DLC) in additive containing lubricants. Wear 307 (1-9) in 2013.

[7] M. Uchidate , H.Liu , K.Yamamoto , A.Iwabuchi . Effects of hard water on tribological properties of DLC rubbed against stainless steel and brass. Wear 307 (79-85) in 2013.

[8] Y. Mabuchi, T.Higuchi, Y.Inagaki, H.Kousaka, N.Umehara (2012) Wear analysis of hydrogen-free diamond-like carbon coatings under a lubricated condition . Wear 307 (48-56) in 2013.

[9] Fenghua Su, Cansen Liu, Ping Huang. Friction and wear of nanocrystalline Co and Co–W alloy coatings produced by pulse reverse electrodeposition.
Wear 307 (114-125) in 2013.

[10] V. Chaudhr, Satish V. Kailas. Damage quantification under sliding and seizure condition using first-of-a-kind fretting machine. Wear 307 (114-125) in 2013.

[11] Felix W¨ahlisch, Judith Hoth, Christian Held, Thomas Seyller, Roland Bennewitz. Friction and atomic-layer-scale wear of graphitic lubricants on SiC (0001) in dry sliding. Wear 307 (78-81) in 2013.

[12] Idris cesur, Vezir AYHAN, Adnan PARLAK, Omer SAVAS. The effect of different fuel on wear between piston ring and cylinder in 2013.

[13] Peter Andersson, Jaana Tamminen, Carl-Erik Sandstrom. Piston ring tribology in 2002.

[14] Tto Sugimoto, Fumiaki Honda, Kenichi Inoue. Analysis of wear behaviour and graphitization of hydrogenated DLC under boundary lubricant with MoDTC. Wear 305 (124-128) in 2013.

[15] H. Sarmadi, A.H. Kokabi, S.M. Seyed Reihani. Friction and wear performance of copper–graphite surface composites fabricated by friction stir processing (FSP). Wear 304 (1-12) in 2013.

[16] R. Priya, C. Mallika, U. Kamachi Mudali. Wear and tribocorrosion behaviour of 304L SS, Zr-702, Zircaloy-4 and Ti-grade 2. Wear 310 (90-100s) in 2014