TOTAL ENGINE FRICTION

Total engine friction, defined as the difference between indicated horse power and brake horse power, includes the power required to drive the compressor or a scavenging pump and the power required to drive engine auxiliaries such as oil pump, coolant pump and fan, etc.

Total engine friction can be divided into five main components. There are

1. Crankcase mechanical friction.
2. Blow by losses (compression-expansion pumping loss).
3. Exhaust and inlet system throttling losses.
4. Combustion chamber pumping loop losses.
5. Piston mechanical friction.

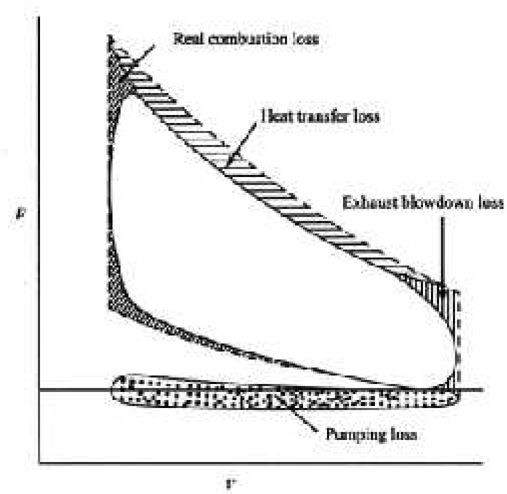
Crankcase Mechanical Friction Crankcase mechanical friction can further be sub-divided into three types as

1. Bearing friction
2. Valve gear friction
3. Pump and miscellaneous friction.

The bearing friction includes the friction due to main bearing, connecting rod bearing and other bearings. Bearing friction is viscous in nature and depends upon the oil viscosity, the speed, size and geometry of the journal. All crankcase friction losses other than bearing and valve gear losses vary roughly in proportion to engine displacement and speed. The bearing losses are affected very little by the loading of the bearing but they rise rapidly with increase in speed because these losses are primarily the result of continuous shear of the oil film in the bearing clearance.

Crankcase mechanical friction is about 15 to 20 percent of total engine friction. Since, there are a number of moving parts, the frictional losses are comparatively higher in reciprocating engines.

Blow by Losses. Blow by is the phenomenon of leakage of combustion products past the piston and piston rings from the cylinder to the crankcase. These losses depend upon the inlet pressure and compression ratio. These losses vary as the square root of inlet pressure, and increase as the compression ratio is increased. Blow by losses are reduced as the engine speed is increased.



Blowby losses

Exhaust and Inlet Throttling Loss. The standard practice for sizing the exhaust valve is to make them a certain percentage smaller than inlet valves. This usually results in an insufficiently sized exhaust valve and hence, results in exhaust pumping loss.

Combustion Chamber Pumping Loop Losses. In the case of pre-combustion chamber engines an additional loss occurs. This is the loss occurring due to the pumping work required to pump gases into and out of the pre-combustion chamber. The exact value of this would depend upon the orifice size connecting the pre-combustion chamber and the main chamber, and the speed. Higher the speed greater is the loss and smaller the orifice size greater is the loss.

Piston Mechanical Friction. Piston Mechanical Friction sub-divided into two types.

1. Viscous friction
2. Non-viscous friction

Non-viscous friction further divided into (a) Friction due to ring tension, (b) Friction due to gas pressure forces behind the ring. The viscous friction depends upon the viscosity of the oil and the temperature of the various parts of the piston. The degree to which the upper part of the piston can be lubricated also affects the viscous friction. The oil film thickness between piston and the cylinder is also affected by the piston side thrust and the resulting vibrations. The cylinder gas pressure behind the top rings. Because of the ring tension the ring presses against the cylinder wall and results in frictional losses. In addition to the ring tension, the gas pressure behind the ring also causes friction losses. The pressure behind the top piston ring is as high as the pressure of the combustion chamber. For other piston rings it is much lower.

EFFECT OF ENGINE VARIABLES ON ENGINE FRICTION

Effect of stroke to bore ratio.The effect of stroke to bore ratio on engine friction and economy is very small. High stroke to bore ratio engines have equally good friction me p values as that for low stroke to bore ratio engine. At high speeds the higher stroke to bore ratio engine may have some disadvantages.

Effect of cylinder size and number of cylinders The friction and economy improves as a smaller number of larger cylinders are used. This is because the proportion between the working piston area and its friction producing area, i.e. circumference, is reduced. Thus, there seems to be some justification for the layman's notion that four and six-cylinder engines are more efficient than eight cylinders.

Effect of number of piston rings The effect of number of piston ring is not very critical and this number is usually chosen on the basis of cost, size and other requirements rather than on the basis of their effect on friction.

Effect of compression ratio Friction mean effective pressure increases as the compression ratio is increased. But the mechanical efficiency either remains constant or improves as the compression ratio is increased. If the displacement is varied to keep the maximum engine torque constant, this results in better part load friction characteristics.

Effect of engine speed Engine friction increases rapidly as the speed increases. The best way to improve mechanical efficiency at high speed is to increase the number of cylinders.

Effect of oil viscosity Higher the oil viscosity greater is the friction loss. The temperature of the oil in the crankcase significantly affects the friction losses, wear and service life of an engine. As the oil temperature increases, the viscosity decreases and friction losses are reduced during a certain temperature range. If the temperature goes higher than at a certain value the local oil film is destroyed resulting in metal to metal contact.

Effect of cooling water temperature A rise in cooling water temperature reduces engine friction through its effect on oil viscosity. During starting operation the temperature of both the oil and the water is low. Hence, the viscosity is high. This results in high starting friction losses and rapid engine wear.

Effect of engine load As the load increases the maximum pressure in the cylinder has a tendency to increase slightly. This results in slightly higher friction values. However, this increase in friction loss is more than compensated by the decrease in oil viscosity due to higher temperatures resulting from increased load. Further in case of petrol engines the throttling losses reduce as the throttle is opened more and more to supply more fuel for allowing an increase in engine load. Both these effects combine to reduce frictional losses of a petrol engine as engine load is increased. However, for diesel engines the frictional losses are more or less independent of engine load.