



Engine Friction and Lubrication

Engine friction

- terminology
- Pumping loss
- Rubbing friction loss

Engine Friction: terminology

- Pumping work: W_p
 - Work per cycle to move the working fluid through the engine
- Rubbing friction work: W_{rf}
- Accessory work: W_a

Total Friction work: $W_{tf} = W_p + W_{rf} + W_a$

Normalized by cylinder displacement → MEP

- $tfmep = pmep + rfmep + amep$

Net output of engine

- $bmep = imep(g) - tfmep$

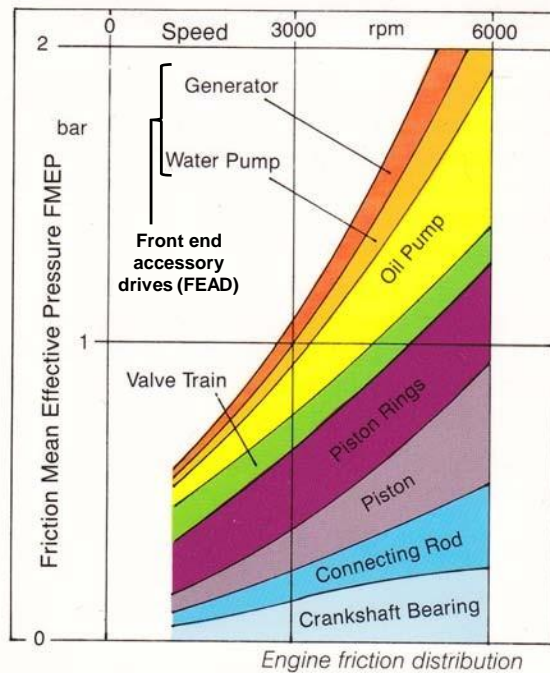
Mechanical efficiency

- $\eta_m = bmep / imep(g)$

Friction components

1. Crankshaft friction
 - Main bearings, front and rear bearing oil seals
2. Reciprocating friction
 - Connecting rod bearings, piston assembly
3. Valve train
 - Camshafts, cam followers, valve actuation mechanisms
4. Auxiliary components
 - Oil, water and fuel pumps, alternator
5. Pumping loss
 - Gas exchange system (air filter, intake, throttle, valves, exhaust pipes, after-treatment device, muffler)
 - Engine fluid flow* (coolant, oil)

*Have to be careful to avoid double-counting. The engine coolant and oil flow losses are provided for by the oil and water pump. The nature of the loss is a pumping loss though.



SI engine friction

(excluding pumping loss)

Source: FEV Brochure

Engine Friction

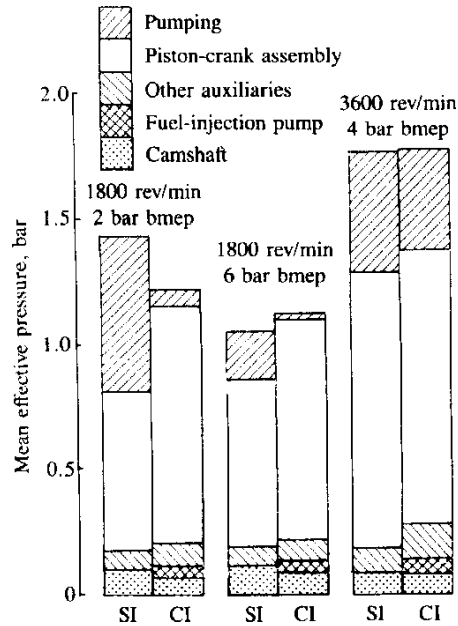


Fig. 13-1
Comparison of major categories of friction losses: fmep at different loads and speeds for 1.6 L four-cylinder overhead-cam automotive Spark Ignition (SI) and Compression-Ignition (CI) engines.

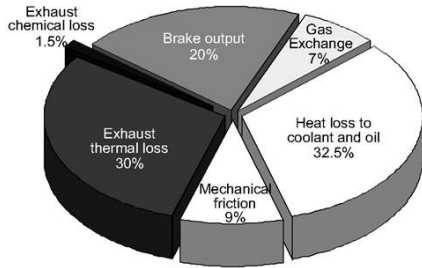


Figure 1. Typical engine losses at part load

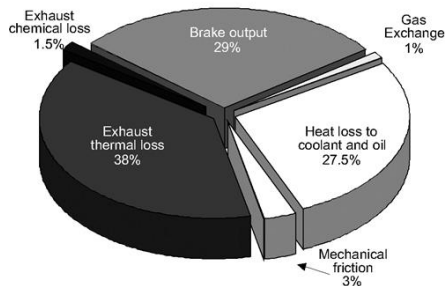


Figure 2. Typical engine losses at full load

Fuel energy accounting for SI engine

SAE Paper 2000-01-2902

Pumping loss

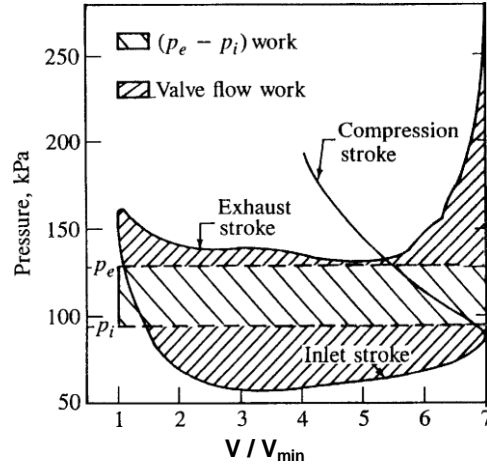
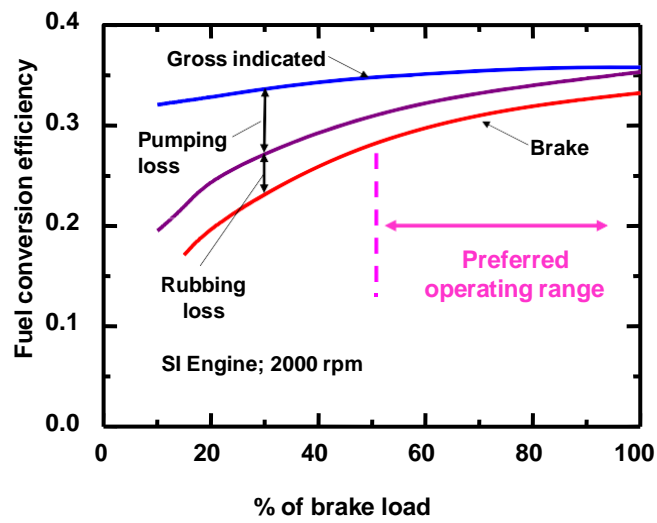
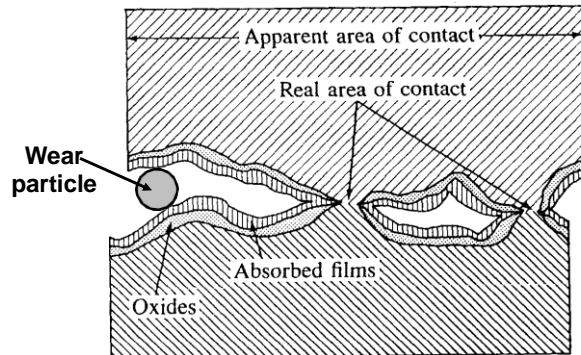


Fig. 13-15 Pumping loop diagram for SI engine under firing conditions, showing throttling work $V_d(p_e - p_i)$, and valve flow work

SI Engine losses



Sliding friction mechanism



Energy dissipation processes:

- Detaching chemical binding between surfaces
- Breakage of mechanical interference (wear)

Bearing Lubrication

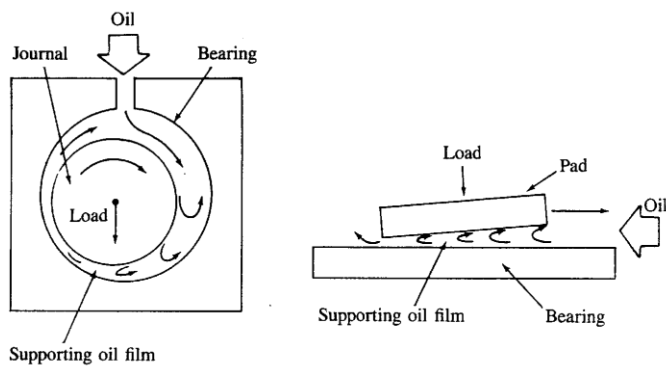


FIGURE 13-2
Schematic of a lubricated journal and a slider bearing.

