



## 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

–  $bmep = imep(g) - tfmep$

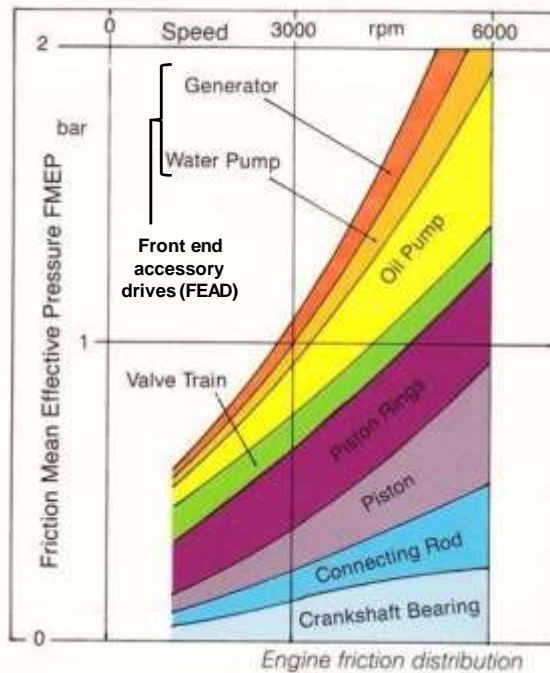
Mechanical efficiency

–  $\eta_m = bmep / imep(g)$

## 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

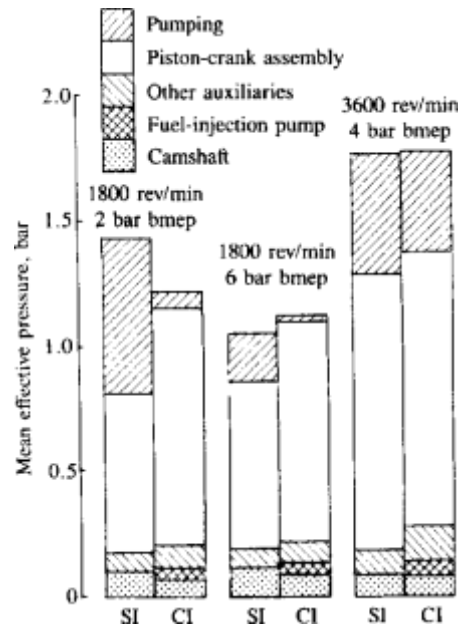


Fig. 13-1

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.

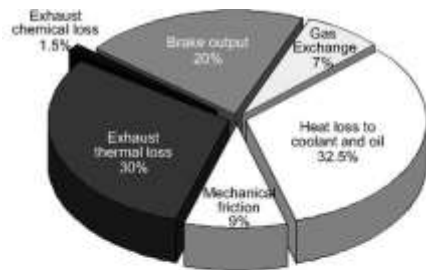


Figure 1. Typical engine losses at part load

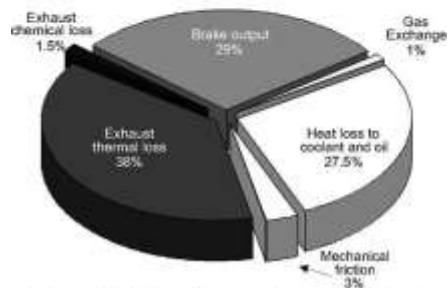
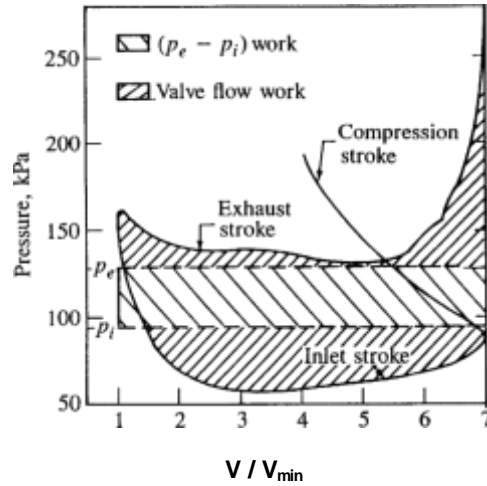


Figure 2. Typical engine losses at full load

## Fuel energy accounting for SI engine

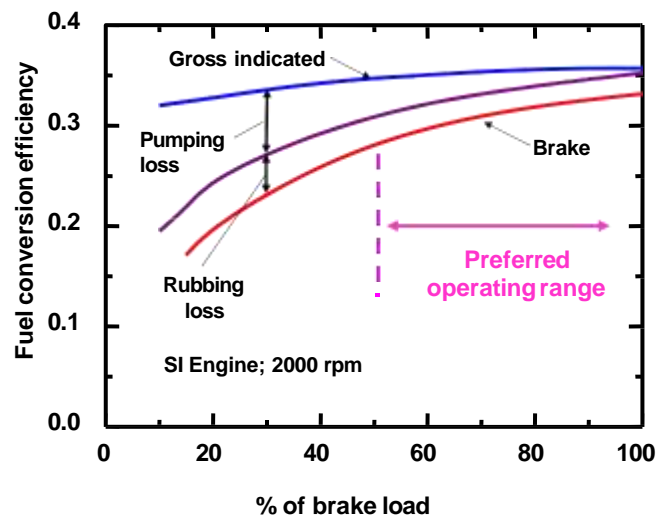
SAE Paper 2000-01-2902

## Pumping loss

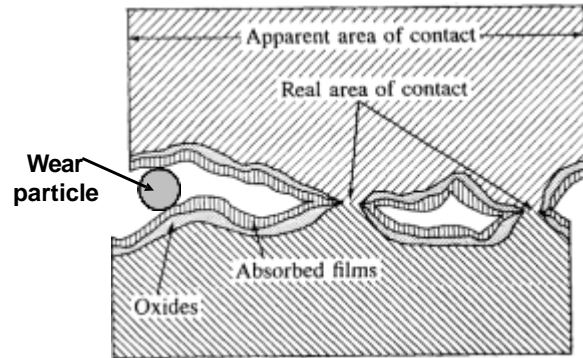


**Fig. 13-15 Pumping loop diagram for SI engine under firing conditions, showing throttling work  $V_d(p_e - p_i)$ , and valve flow work**

## SI Engine losses



## Sliding friction mechanism



Energy dissipation processes:

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

## Bearing Lubrication

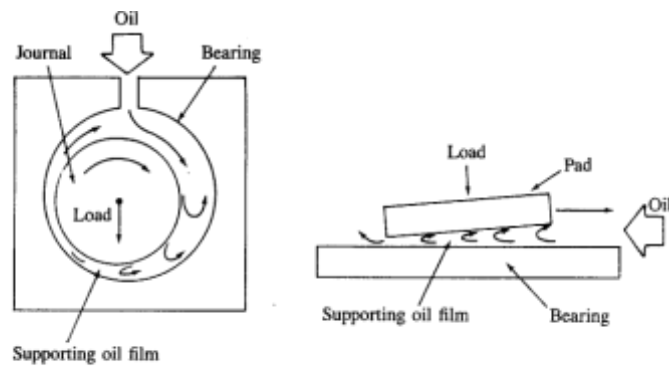


FIGURE 13-2  
Schematic of a lubricated journal and a slider bearing.

