



PRIFYSGOL CYMRU

Y Drindod Dewi Sant

UNIVERSITY OF WALES

Trinity Saint David

Vehicle Technology

Engine Performance

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PRIFYSGOL CYMRU

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- Specific Fuel Consumption
- Mechanical Efficiency
- Thermal Efficiency
- Volumetric Efficiency

Vehicle Technology

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Vehicle Technology Contents

Specific Fuel Consumption

- Specific Fuel Consumption (SFC) is measured in **kilograms of fuel used per kilowatt hour**
- It is a measure of how efficient the engine is at turning chemical energy into actual useful power
- Determination of best operating conditions for engine
- Estimate running costs
- Particularly used by truck and HGV engineers since cost of carrying a given load is essential



Specific Fuel Consumption

- Definition

$$SFC = \frac{M'}{P}$$

- M' = mass of fuel used per hour (kg/hr)
- P = Power (kW)
- To obtain SFC, engine torque T (Nm) is measured
- Fuel consumption apparatus is used to measure time taken (t sec) for a given volume of fuel (v cc) to be used

Specific Fuel Consumption

- Calculate power in kW (P) using

$$P = \frac{2\pi NT}{60000}$$

- Calculate SFC (kg/kWh) from

$$SFC = \frac{v \times 0.75 \times 3600}{1000 \times t \times P}$$

- v = volume of fuel used (cc)
- t = time to use fuel (s)
- 0.75 is specific gravity of fuel (converts volume to mass)



Specific Fuel Consumption

- Typical value is 0.3 to 0.5 kg/kWh
- If a fuel injection system is used, rate of fuel usage (M'' , kg/cycle) can be found from injection pulse width

$$M'' = \frac{m' t n'}{60 \times 1000 \times 1000}$$

- m' = injector flow rate (g/min)
- t = injector pulse width (ms)
- n' = number of injections per rev





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Mechanical Efficiency

- This is a measure of the frictional losses in an engine, from piston ring friction, bearings, windage etc.

$$\eta_m = \frac{\textit{Brake Power}}{\textit{Indicated Power}} = \frac{\textit{BMEP}}{\textit{IMEP}}$$

- So it's the ratio of the useful work done by the engine to the actual work done by the burning fuel/air mixture
- Typical value 80%



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Thermal Efficiency

- This measures the overall ability of the engine to convert fuel energy into mechanical energy
- Engines don't convert all of the heat energy stored within fuel into useful work
 - Roughly $\frac{1}{3}$ of the heat energy goes into doing useful work
 - $\frac{2}{3}$ is lost in exhaust gases, cooling system and as radiated losses to surrounding areas
 - So the thermal efficiency is the proportion of the total heat energy available from the fuel which is converted into useful work

Thermal Efficiency

- Definition

$$\eta_t = \frac{P}{M' \times CV}$$

- P = power (kW)
- M' = mass of fuel used per second (kg/s)
- CV = calorific value of fuel (43500 kJ/kg for petrol)
- Use BP to get η_{tb} or IP to get η_{ti}

$$\eta_{tb} = \eta_{ti} \times \eta_m$$



Thermal Efficiency

- Thermal efficiency is dependent on:
 - *Mixture strength*
 - *Compression ratio*
 - *Engine Speed*
 - *Throttle position*
 - *Valve timing*
 - *Ignition timing*
 - *Fuel type*
 - *Engine dimensions*
 - *Combustion chamber design*
 - *Inlet charge temperature*
 - *Cylinder temperature*



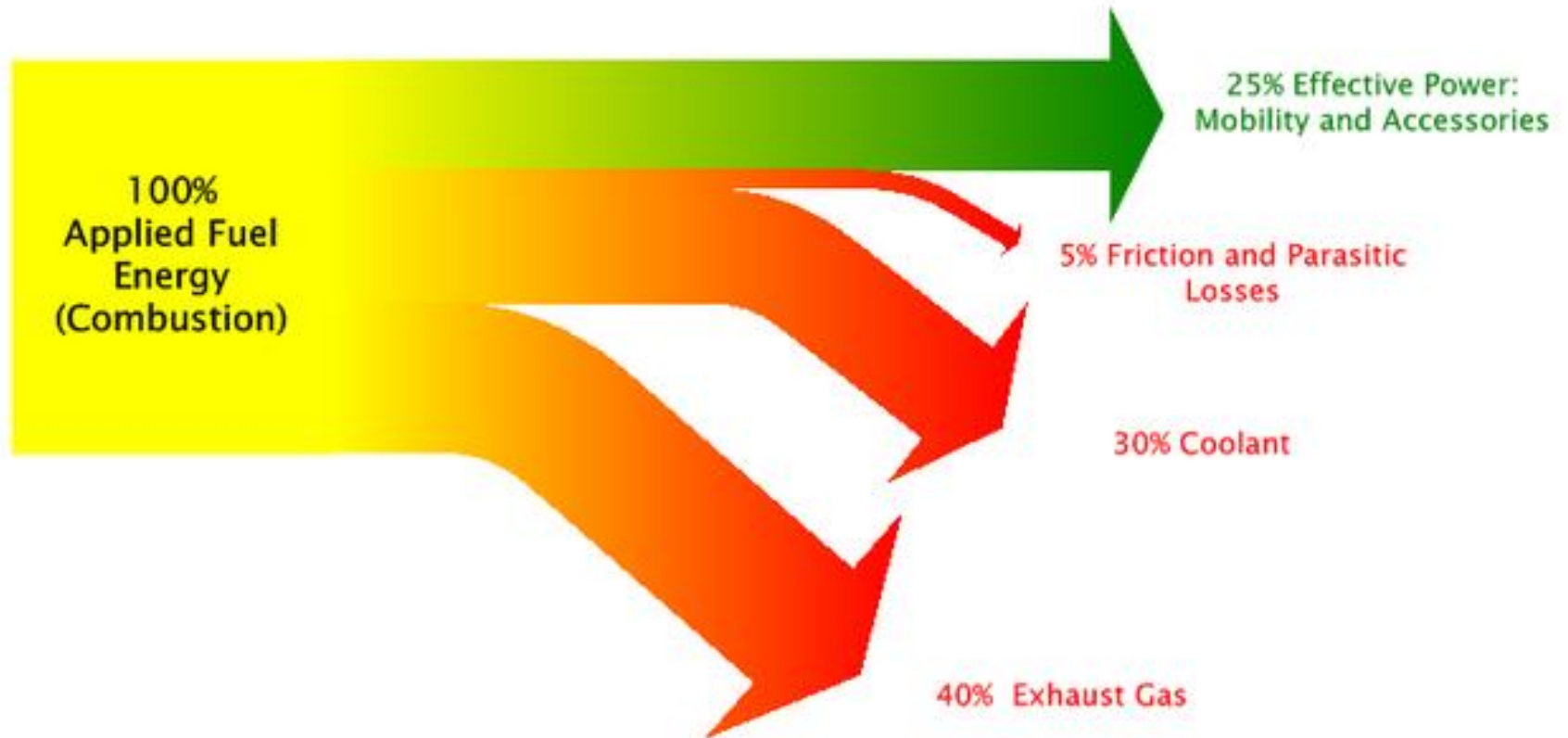
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Typical Energy Split in Gasoline Internal Combustion Engines





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Volumetric Efficiency

- Effectiveness of induction and exhaust system in filling / emptying cylinder
- i.e. The ratio of the actual volume of air charge at standard temperature and pressure to the swept volume of the cylinder
- So a volumetric efficiency of 100% means that the cylinder is completely filled with atmospheric air during the induction stroke

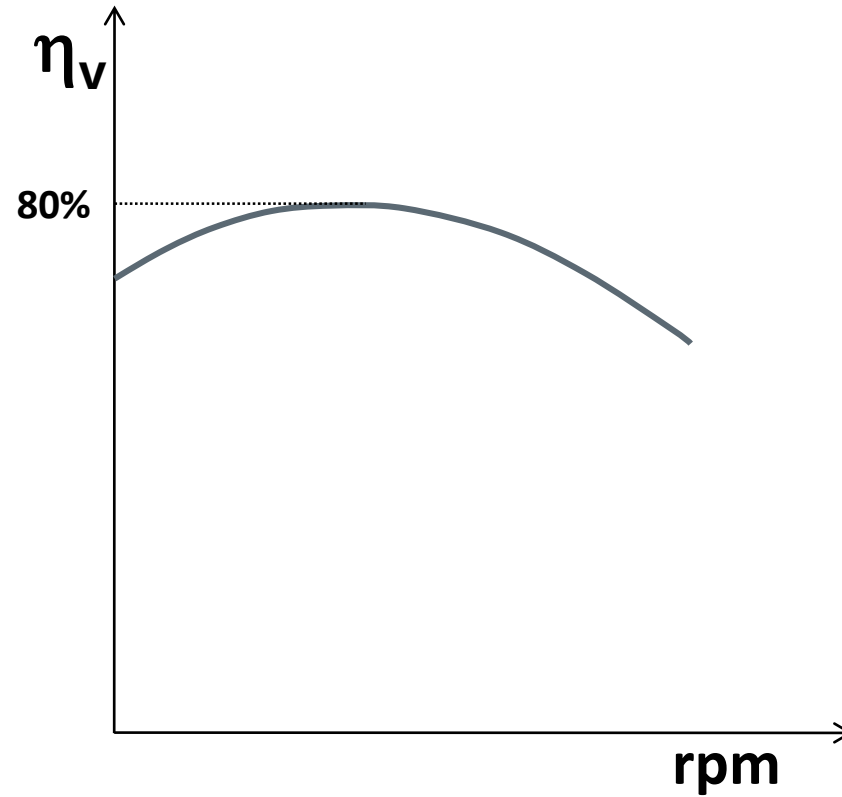
$$\eta_v = \frac{\text{airflow into engine per second}}{\text{swept volume per second}}$$

Volumetric Efficiency

- Rarely exceeds 90% for naturally aspirated engines
- Volumetric efficiency directly affects power (mass of air available limits the amount of fuel which can be burnt)
- Factors:
 - Engine speed
 - Compression ratio
 - Inlet charge temperature
 - Mixture strength
 - Inlet and exhaust design
 - Valve area
 - Valve timing
 - Throttle opening
 - Cylinder temperature

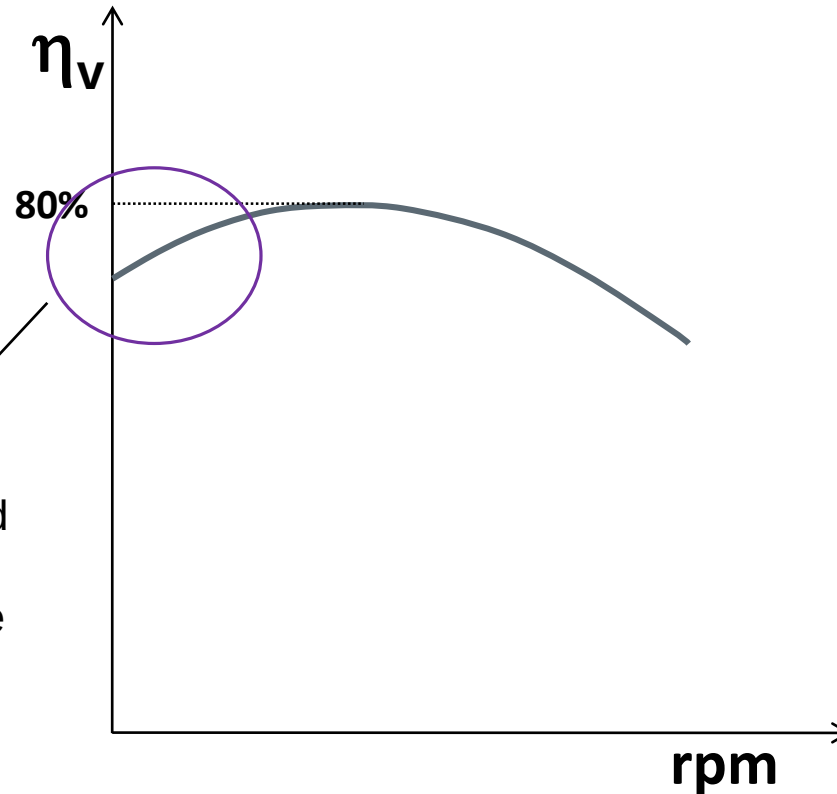


Volumetric Efficiency





Volumetric Efficiency



Low RPM

Efficiency reduced from maximum value due to valve timing being optimised for higher rpm's



Volumetric Efficiency

