Automotive Vehicles
AEL ZC441

BITS Pilani
Pilani Campus

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Lecture 1 - Recap

- Introduction to Automobile
- Development of Automobile (1769 to 2005)
- General Classification (Type I & II)
- Basic Structure &
- Components of Automobile (Basic Structure, Power Plant, Transmission System, Auxiliaries, Controls, Superstructure)

Lecture 2 - Recap

- Chassis & Body
- Classification
- Conventional Construction
- Sub frames
- Frameless Constructions
- Classifications of Body

Lecture 3 - Recap

- Cylinder Block and crank case
- Cylinder Head
- Sump or oil pan
- Intake and Exhaust Manifolds
- Gaskets
- Cylinder Liners
- Piston
- Piston Rings
- Connecting Rods
- Piston Pins
- Crankshaft
- Main bearings
- Valves and Valve actuating mechanisms
- Mufflers

Today's Topic

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Lect No.	Learning Objectives	Topics to be covered	Reference to Text
1	An introduction to automobiles	Overview of the course and evaluation scheme Development of automobiles, General classification, Basic structure and components of automobile	1TB1,1TB2
2	The chassis Construction and Body	Classification, Conventional construction, Sub frames, Frame less constructions, Classification of body, Numerical problems on chassis member bending.	11TB1, 1 TB2
3	Reciprocating Engine Construction and basics	Constructional details, Calculation of displacement velocity and acceleration of piston and connecting rod, Working of 2and 4 stroke engines. Numerical problems on the above topics	3TB1
4	Cooling systems	Need. Variation of gas temperature. Piston temperature distribution. Theory of engine heat transfer and correlation. Parameters affecting engine heat transfer. Air-cooled systems.	8TB1, 12RBa
5	Cooling systems	Types of water-cooling systems. Radiators. Fans. Correlation for the power required for engine cooling. Numerical problems on the above topics	8TB1, 12RBa
6	Lubrication systems	Causes of engine friction. Function of lubrication. Mechanism of lubrication. Journal bearing lubrication.	7TB1, 11RBa
	Lubrication systems	Types of lubrication systems. Lubrication of engine components.	7TB1, 11RBa
7	Clutch	Definition of clutch, requirements, classification, principle of working of friction clutches, Driving system and Plate clutch (uniform pressure and uniform wear).	14TB1, 3TB2

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Automotive Vehicles
Lecture 3

Cooling System

- Need of Cooling system
- Variation of Gas temperature
- Theory of Engine heat transfer and co-relation
- Parameters affecting Heat transfer
- Air cooled Systems

Need of Cooling system

- Cooling system prevents the development of High temperatures in the combustion chambers saving damage of Pistons, cylinders, valve and other components
- Cooling system maintains the operating temperature at a safe level over a wide range of speeds, different loads and ambient temperatures
- It helps warming up the engine to the required operating temperature and maintains the same irrespective of outside temperature
- It helps proper carburation

Variation of Gas temperature

Transfer of heat takes place due to difference in temperature as Heat flows from hotter to colder substance may be Solid, Liquid and Gas.

Three Modes of Heat transfer:

- Conduction
- Convection
- Radiation

Types of Cooling System : Air cooling & Water cooling

Variation of Gas temperature – Modes of Heat Transfer

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Conduction

- Heat is transferred from particle to particle throughout a body without any visible sign of movement.
- This heat flow is most effective in Solids and occur at lower rate in Liquids

The basic heat conduction equation is

$$q = \frac{dQ}{dt} = -kA\frac{dT}{dx},$$

Where dQ = Quantity of heat conducted in time, J

q = rate of Heat transfer by conduction , W or J/s

t = time, s

Q = quantity of heat, J

A = unit area normal to heat flow path, m^2

dT/dx = temperature gradient K/m

k = thermal conductivity , W/mK

Variation of Gas temperature – Modes of Heat Transfer

Conduction Equation of Slab:

The equation of heat transfer through a uniform slab is, $q = -\frac{k}{A}\frac{\Delta T}{\Delta x}$,

where $\Delta x = x_2 - x_1$ = Thickness of slab , m

$\Delta T = T_2 - T_1$ = temperature difference b/w two surfaces , K

Conduction Equation of Tube:

The equation of heat transfer through walls of tube is, $q = \frac{2\pi k l (t_1 - t_2)}{\ln (r_2/r_1)}$,

Where l = length of the tube, m

t_1 = inner wall temperature, K

t_2 = outer wall temperature, K

r_1 = inner radius of tube, m

r_2 = outer radius of tube, m

Variation of Gas temperature – Modes of Heat Transfer

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Convection :

- Heat is carried by circulating currents of moving particles in liquid or gas
- Natural or free convection are created due to difference in temperature at various levels in the liquid
- Forced convection is achieved by Pump or fan

The fundamental convection equation is $q = hA\,\Delta T$

Where q = average rate of heat transfer by convection W or J/s

A = heat transfer area, m^2

ΔT = difference b/w the temperature of the surface and that of fluid, K

h = an average value of proportionality constant , W/m^2K

Variation of Gas temperature – Modes of Heat Transfer

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Convection :

Forced convection co-relation is given by

$$hL/k_f = C\,(GL/\mu)^n (C_p\,\mu/k_f)^m,$$

Where h = Coefficient of heat transfer

L = dimension of passage

K_f = thermal conductivity of fluid

C = proportional constant

G = mass of fluid / area,

m = mass flow rate

A = cross sectional area

V_m = mean fluid velocity

μ = fluid dynamic viscosity

Cp = specific heat of fluid at constant pressure

hL/K_f = Nusselt Number

GL/μ = Reynolds Number

$Cp\,\mu/K_f$ = Prandtl Number

Variation of Gas temperature – Modes of Heat Transfer

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Radiation :

- All solid, liquid, gas emit energy by wave motion which radiates in all directions
- Doesn't require any material medium to transfer heat
- Emissive power is directly proportional to Forth power of its absolute Temperature

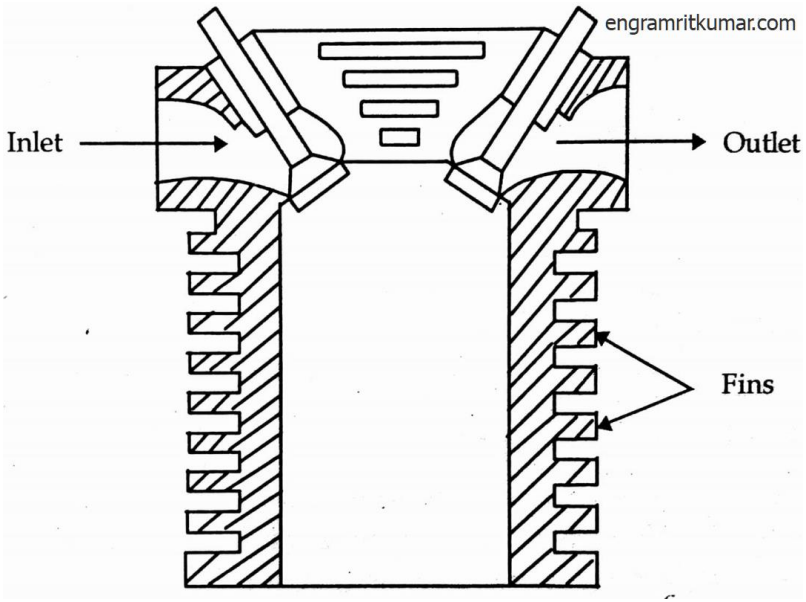
Stefan Boltzmann's law of exchange of heat by radiation given by $q = \delta A T^4$,

$$q = \delta A_1 (T_1^4 - T_2^4).$$

$$q = \delta A_1 \varepsilon_1 F_{12} (T_1^4 - T_2^4)$$

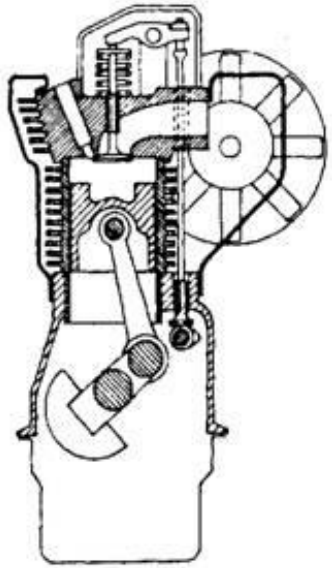
Air cooling system

- Current of air flowing continuously over the heated surface from where heat is to be removed
- Heat dissipated depends on Surface are, Mass flow rate, Temperature difference, Conductivity
- For effective cooling, Fins & Baffles are used
- Fins are integral part or inserted over cylindrical barrels

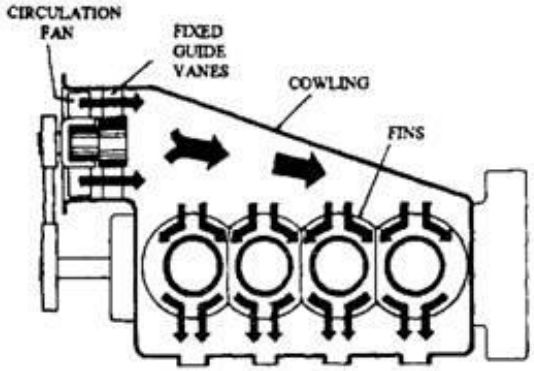


Air cooling system

- Higher upper cylinder temperature, more heat goes through Piston and cylinder to oil
- Air cooled Engines uses oil coolers (with high viscous oil) to assist excess removal of heat
- Fan / blowers are used

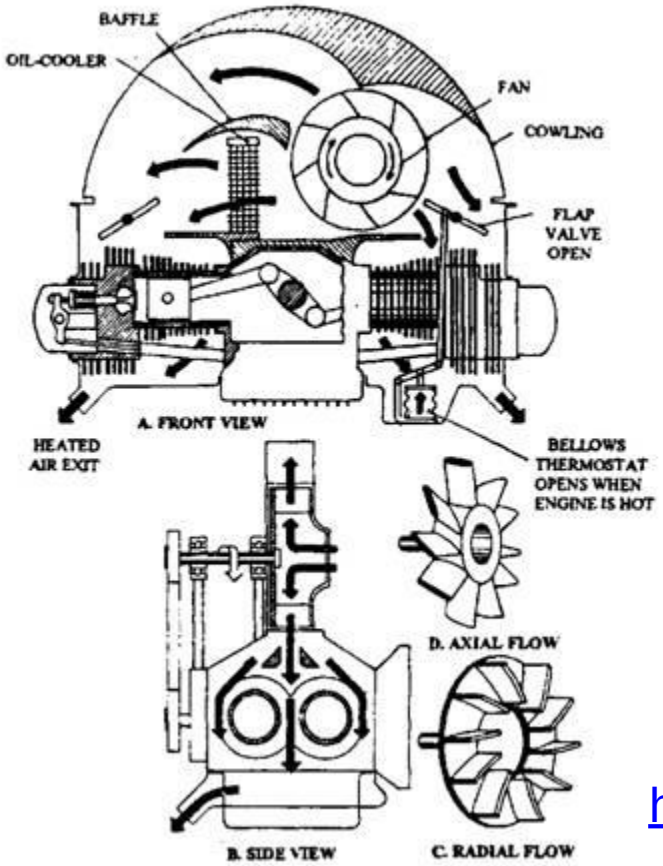


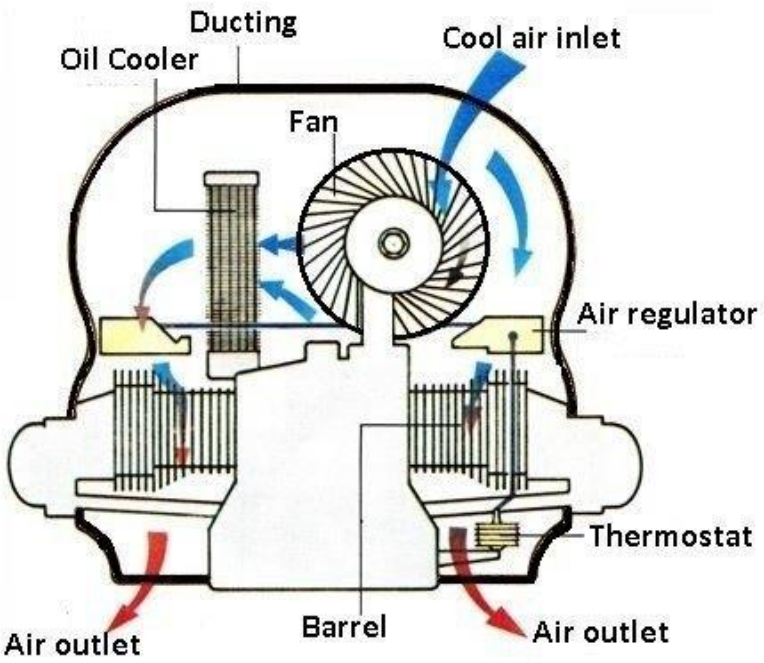
A. FRONT VIEW



B. PLAN VIEW

Air Cooling System





https://www.youtube.com/watch?v=Ikdz3wx9iPc

Air cooling system

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Advantages :

- Lighter
- No radiator, Cooling jackets and additional components are required
- Can be operated in extreme climates while Water freezes
- When there is scarcity of water, Air cooled Engines can be used
- Maintenance is easier as No leakages
- Air cooled engines warm up earlier than Water cooled Engines
- Problems caused by boiling, Freezing or corrosion are absent

Disadvantages :

- Not easy to maintain uniform cooling and hence distortion takes place
- Use of Fins increases Overall Engine length
- Fan is bulky and absorbs more Engine power
- More Noisy as sound insulator (Water) is not available
- Some components are inaccessible due to baffles /fins
- Cooling fins may vibrate causing more noise.

Water Cooling system