Internal Combustion Engines

Lecture-15

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Supercharging and Turbocharging

- The maximum power generation by an engine is limited by the amount of air it can take in
- If the inducted air is compressed to a higher density than ambient, prior to entry into the cylinder, the maximum power an engine of **fixed** dimensions can deliver will be increased
- The term supercharging refers to increasing the air (or mixture) density by increasing its pressure prior to entering the engine cylinder
- Compressor, if run by the engine power, is called supercharger
- Compressor, if coupled to a turbine run by exhaust, is called turbocharger

P-V Diagram

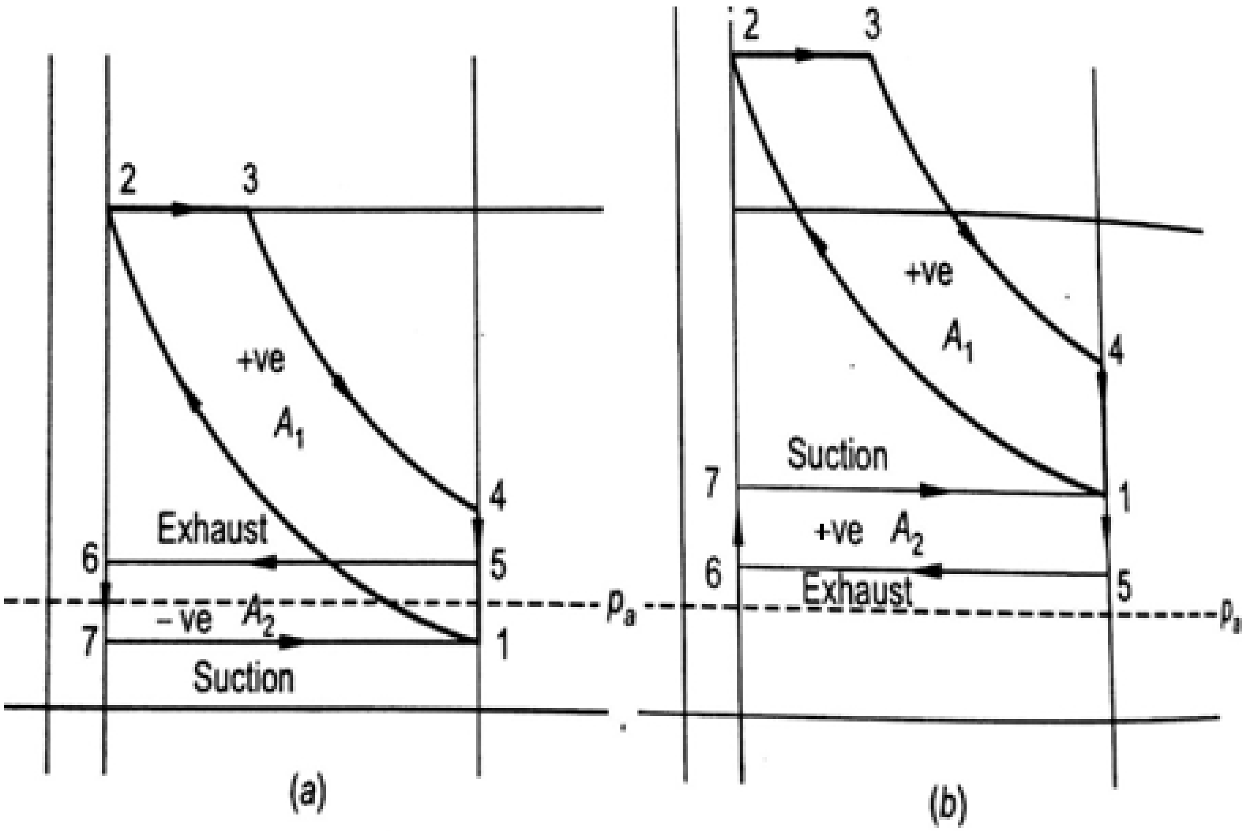
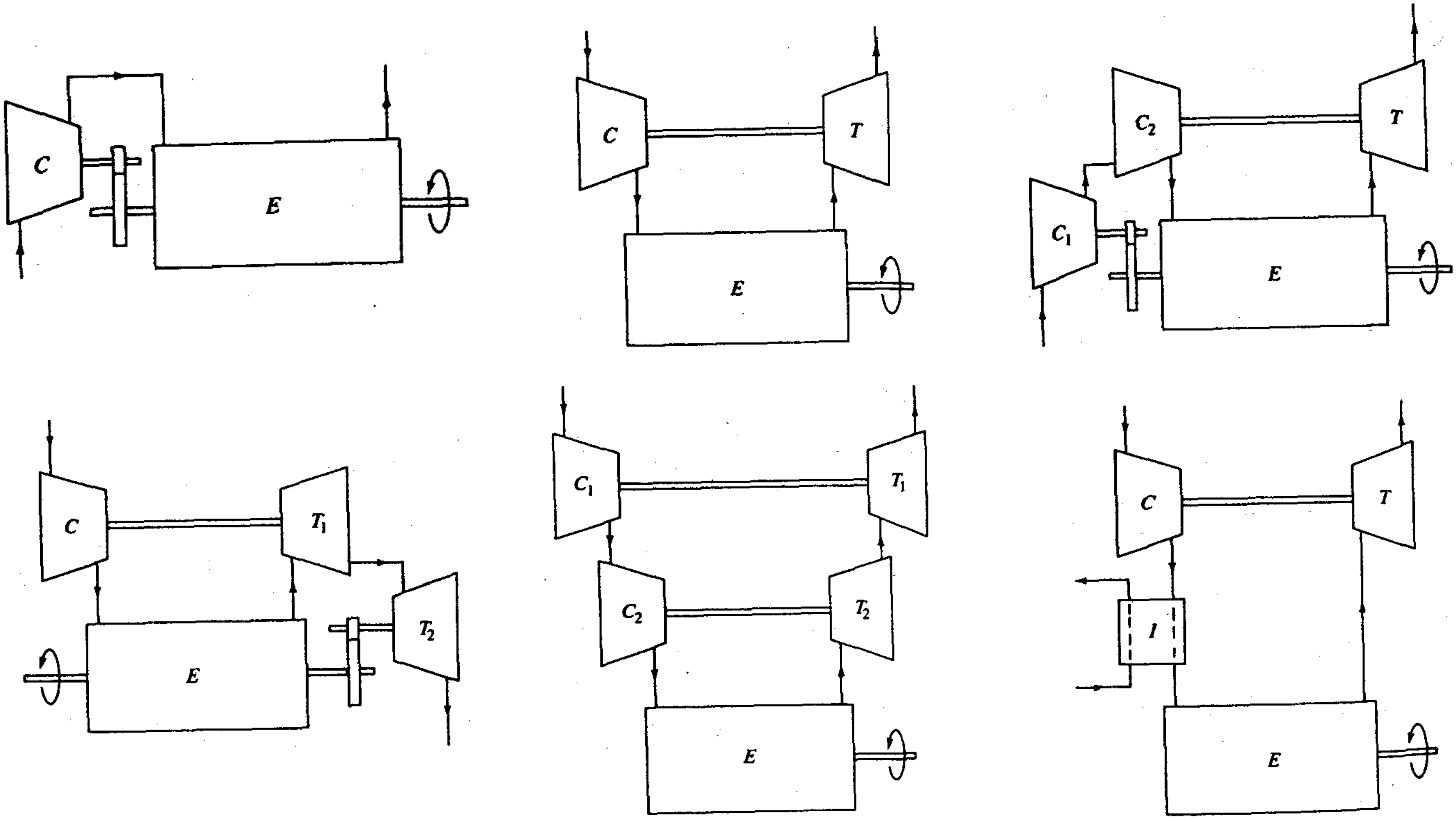


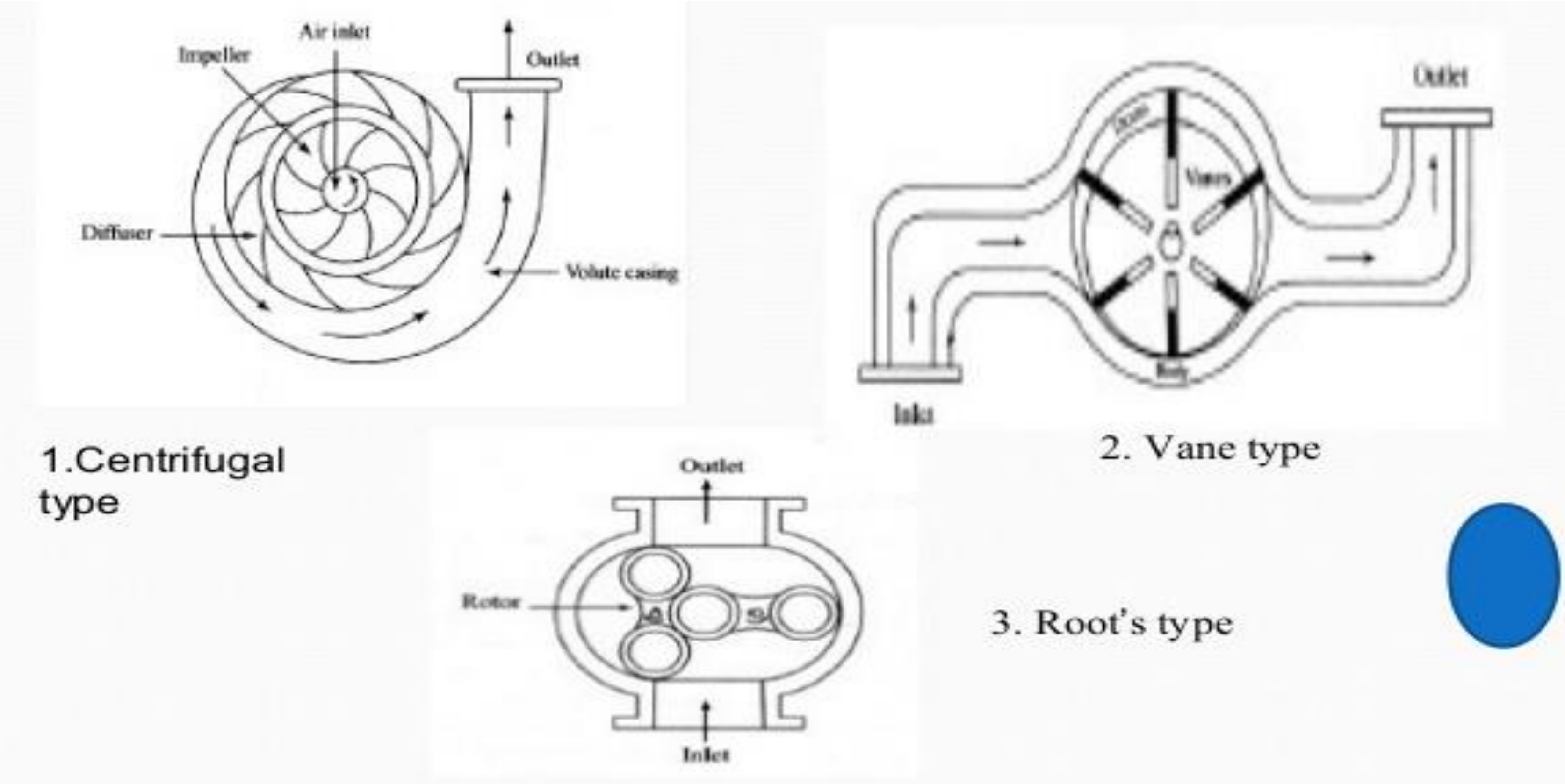
Fig.4.3: effect of supercharging on Diesel cycle.

- The supercharged cycle shifts upward
- The bottom loop has been turned to a positive loop
- The work done by the cycle should be addition of these two loop areas
- Compressor work should be subtracted to get the work done by the device

Configurations



Types of Superchargers



- Mainly two types – Centrifugal and positive displacement
- Vane type and Root's type are positive displacement superchargers

Example: A 3-litre 4-stroke diesel engine develops 12 kW/m^3 of free air inducted per minute. The volumetric efficiency is 82% at 3600 rpm referred to atmospheric condition of 1 bar and 27^{o}C.

A rotary compressor, mechanically couple to the engine, is used for supercharging. The pressure ratio and isentropic efficiency are 1.6 and 70% respectively. Calculate the percentage increase in brake power for supercharging.

Assume mechanical efficiency of the engine to be 85% and air intake to the cylinder to be at the pressure equal to delivery pressure from compressor and temperature equal to 5.6^{o}C less than the delivery temperature of the compressor. Also assume that cylinder contains volume of charge equal to swept volume.

Solution: Swept volume = V_S = (3/1000)X(3600/2) = 5.4 m^3/min

Actual volume of air inducted = $V_a = V_s$ X η_v = 5.4 X 0.82 = 4.428 m^3/min

Power developed = 4.428 X 12 = 53.136 kW

Delivery pressure from compressor = p_d =1 X 1.6 1.6 bar

Delivery temp from compressor = $T_d = T_a(p_d)^{(\gamma-1)/\gamma}$ = 343.12 K

The actual delivery temperature = T_{ac} [With non isentropic flow]

Now, compressor efficiency = η_c = 0.7 = (343.12 – 300)/(T_{ac} – 300)

So, T_{ac} = 361.6 K and engine intake temp = (361.6 – 5.6) = 356 K

Actual volume of air inducted corresponding to swept volume at atmospheric condition = (5.4X1.6X300)/(1X356) = 7.281 m^3/min

So, increase in ip due to supercharging = (7.281 – 4.428)X12 = 34.236 kW

Increase in ip due to increase in intake pressure

= (Δp X V_s)/(60 X 1000) kW = (1.6 -1) X 10^5 X 5.4/60000 = 5.4 kW

Total increase in ip = 34.236 + 5.4 = 39.636 kW

Mass of air delivered by the compressor/min = (1.6X10^5X5.4)/(300X356)

= 8.09 kg/min

Power to run the compressor = (8.09/60)X1.005X(361.6 – 300) = 8.35 kW

So, net increase in power = 39.636 – 8.35 = 31.286 kW

Percentage increase = (31.286/53.136)X100 = 58.88%

Thank You