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The Shirpur Education Society's

R. C. Patel College of Engineering and Polytechnic, Shirpur

Department of Mechanical Engineering

NAME OF COURSE: - Power Engineering (PER)

CODE OF COURSE: - 315371

SEMESTER: - TYME-5K

SUBJECT TEACHER: - Mr. B. S. Patil

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QUESTION BANK

Chapter 4. Air Compressors

Program Name: Mechanical Engineering
Name of Subject & Code : Power Engineering (315371)
Date -07/08/2026

Program Code: ME5k
Semester : Fifth

Q. NO.	QUESTION	DETAIL	MAPPING
1	Define the terms compressor capacity and volumetric efficiency related to air compressor.	W-25 2 M	TLO-4.3R
2	Select a suitable air compressor for the following applications with justification. i) Operating pneumatic tools in automotive workshop. ii) Gas pipeline station iii) Jet Engine iv) CNC actuators and tool changers.	W-25 4 M	TLO-4.4A
3	Compare reciprocating compressors and centrifugal compressors on the basis of the following parameters :– i) Pressure range ii) Mechanical efficiency iii) Capacity control iv) Applications.	W-25 4 M	TLO-4.2A
4	Explain with a neat sketch construction and working of axial flow air compressor.	W-25 4 M	TLO-4.2U
5	A single stage air compressor takes in air at a suction temperature of 25°C and a suction pressure of 1.5 bars. The compressor delivers air at a pressure of 4 bars and the volume of air entering the compressor is 4 m3 /min. The index of compression is 1.35. Calculate power required and isothermal efficiency.	W-25 4 M	TLO-4.3A
6	Give the classification of air compressors.	OTHER- 4M	TLO-4.1R
7	Compare reciprocating and rotary compressor. (any six points)	OTHER- 4M	TLO-4.2A
8	Explain the working of single stage single acting reciprocating air compressor with sketch.	OTHER- 4M	TLO-4.2U
9	A single Cylinder Single acting reciprocating air compressor has Cylinder diameter and stroke of 200 mm and 300 mm resp. The Compressor delivers air at 8 bar while running at 100 rpm. Find – i) Indicated Power ii) Mass of air delivered by compressor per min iii) Temperature of air delivered by compressor The Compression follows the law $PV^{1.25} = C$ Take, R = 287 J/kg°K	OTHER- 6M	TLO-4.3A
10	Explain the different uses of compressed air.	OTHER- 4M	TLO-4.1U
11	Explain the necessity of multistate compression.	OTHER- 4M	TLO-4.3U
12	Draw a P V diagram for working of two stage reciprocating air compressor when intercooling is imperfect and perfect.	OTHER- 6M	TLO-4.3R
13	Explain free air delivery related to air compressor.	OTHER- 4M	TLO-4.3U
14	A single stage, single acting reciprocating air compressor has a bore 300 mm and stroke 400 mm is required to compress air from 1 bar to 5 bar. Find the power require to drive the compressor if compressor runs at 200 rpm, in case the compressor is , 1) adiabatic 2) isothermal.	OTHER- 6M	TLO-4.3A
15	A single stage single acting reciprocating air compressor has a bore 300 mm and stroke 400 mm is required to compress air from 1 bar to 5 bar if compressor runs at 200 rpm. Find the maximum and minimum power required to run the compressor.	OTHER- 6M	TLO-4.3A

Chapter NO. 4

Air compressor

4.1 - function:-

It is a machine which suck low pressure low temperature air from atmosphere & compressed it to high pressure by reciprocating motion of piston or rotory motion of blades in casing."

*** Uses of compressed air:-**

1] for filling the air in the tube of vehicle
2] In automobile service station to clean vehicles.
3] for spray painting in paint industries.
4] To operate air brakes in vehicle.
5] for cleaning workshop machine.
6] for cooling large building.
7] for supercharging of I.C. Engine
8] for operating pneumatic tools/drives.

*** classification of air compressors:**

mainly classified in two groups.

1] Reciprocating air compressor.
2] Rotary air compressor.

Compressors

- 1] Reciprocating [+ve displacement]
  - 1] single stage
    - single acting
    - double acting
  - 2] Multi stage
    - single acting
    - double acting
- 2] Rotary
  - 1] Non +ve displacement
    - centrifugal OR Radial flow
    - Axial flow
  - 2] positive displacement
    - 1] screw type
    - 2] vane type
    - 3] Root blowers

2] again classified as

Compressor

- According to capacity
  - Low capacity [0.15 m^3/sec]
  - Medium capacity [0.15 to 15 m^3/sec]
  - High capacity [above 5 m^3/sec]
- According to pressure
  - Low pressure
  - High pressure
  - medium pressure
- according to driving unit
  - Belt
  - chain
  - Direct

Definition:-

a] Compressor Ratio:-

Ratio of vol^m of air before compression to vol^m of air after compression. denoted by Rc.

$$R_c = \frac{V_s + V_c}{V_c} , \quad V_s = \text{swept vol}^m, \; V_c = \text{clearance vol}^m.$$

b] Compressor capacity:-

Quantity of free air actually delivered by a compressor in m^3/min.

c] Free air delivered [FAD]:-

Volume of air delivered under the conditions of temperature & pressure existing at the compressor intake.

i.e. $P = 1\,atm$ & $T = 15^0C$

d] Swept volume:- [Vs].

Volume swept by piston when it moves between TDC & BDC.

$$V_s = \frac{\pi}{4} d^2 L = \underset{[A_s]}{\text{Area of piston}} \times \underset{[L]}{\text{stroke length}}$$

e] Pressure ratio:-

Ratio of pressure after compression to before compression.

* Working of single stage, single acting Reciprocating air compressor:-

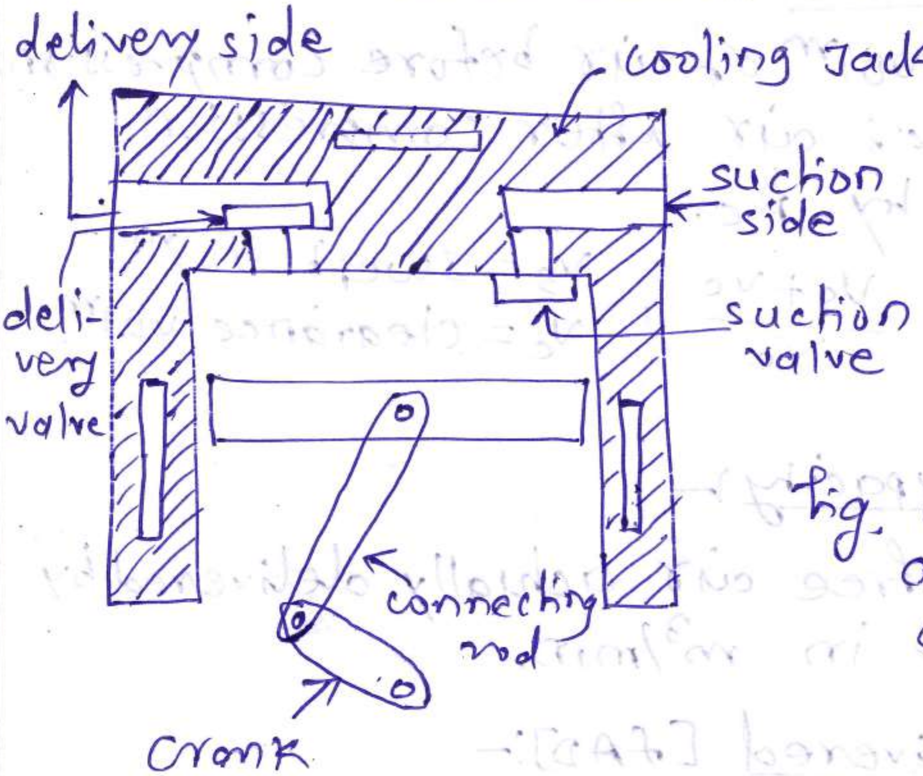


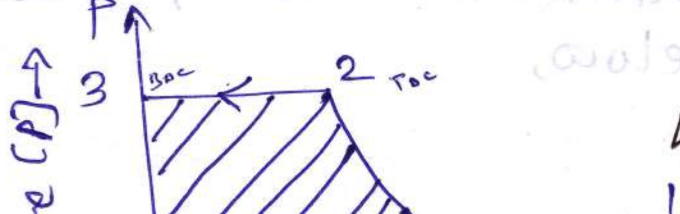
fig. single stage single acting Reciprocating air compressor.

* figure shows sectional view of an air cooled single stage single acting Reciprocating air compressor. Both suction & delivery valves are disc type & are operated automatically
* They are open & closed by difference in the air pressure acting on their two sides & are kept closed by light springs.
* During downward motion of piston, the pressure inside the cylinder falls below atmospheric, thus the suction valve opens & atmospheric air enters in cylinder.
* During upward motion of piston, the air inside the cylinder is compressed which increases pressure than receiver pressure, as a result of which delivery valve opens

& discharge takes place from cylinder to the receiver.

* compressor is driven by external source [electric motor or prime mover]

* <u>Indicator</u> <u>diagram</u>:- <u>without</u> <u>clearance vol^m</u>



Process:-

4→1 ⇒ suction

1→2 ⇒ compression

inlet valve opens at (TDC) 4 & closes at 1. (BDC)

outlet valve opens at (TDC) 2 & closes at 3 (BDC)

shaded area is a work done.

process 1→2 is a compression process.

it may be, ① isothermal. process $pv = const$

② isentropic process $pv^{\gamma} = const$

③ polytropic process. $pv^{n} = const.$

all three processes are drawn in following fig.

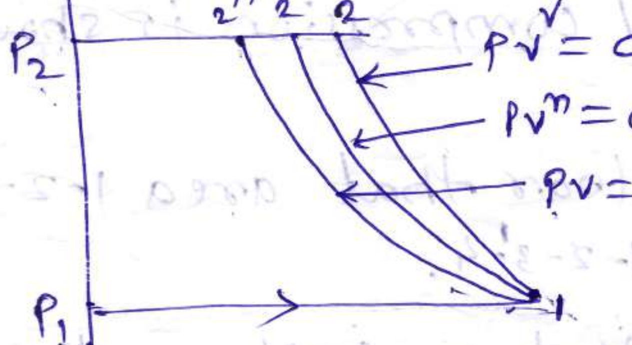


fig. indicator diagram with all three processes.

[Imp]

Q:- Why work of isothermal compression is less than work of isentropic compression in Reciprocating air compressor.

→ As we know, the area under the indicator diagram is work required for compressor.

Indicated diagram with both processes are shown below,

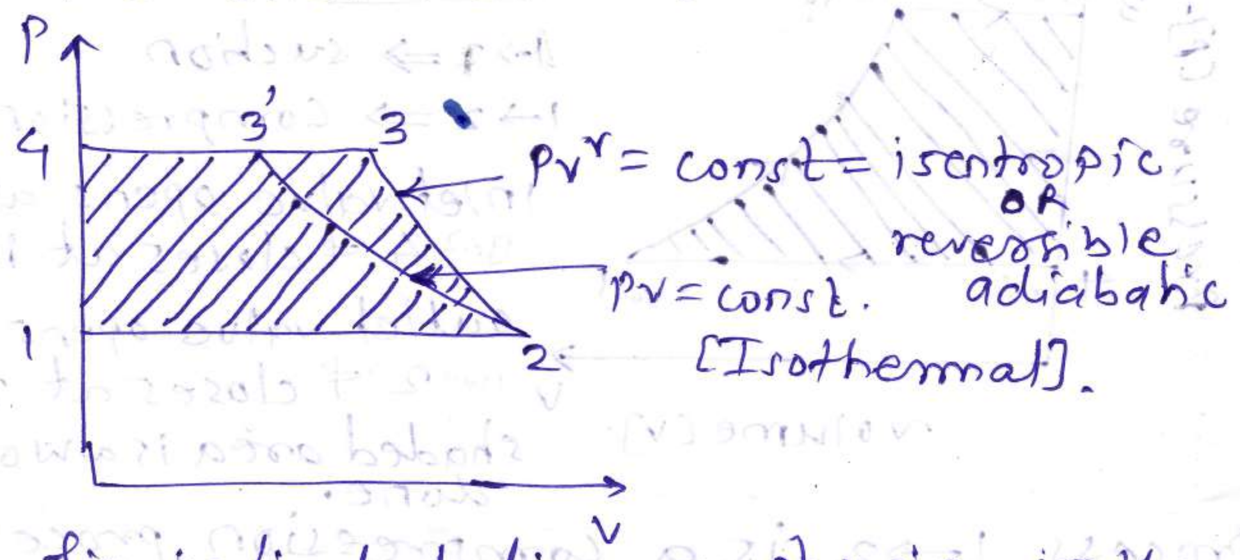


fig. indicated diagram showing isothermal & polytropic process.

The isentropic curve is steeper than isothermal process/curve.

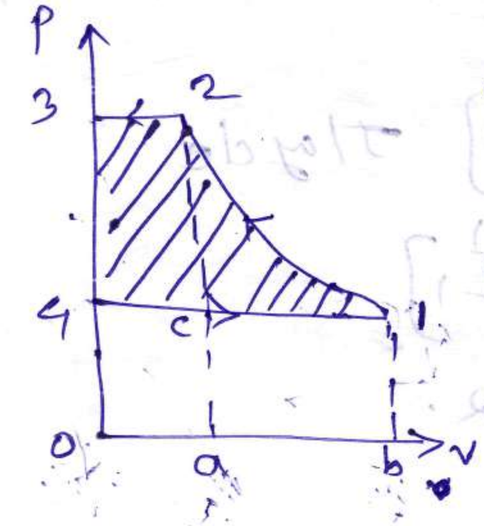
The work required per cycle on air during isentropic compression is shown by 1-2-3-4 & during isothermal compression is shown by 1-2-3'-4.

From figure it is clear that area 1-2-3-4 is greater than 1-2-3'-4.

therefore it follows that an isothermal compression is economical & more efficient. since, less work is required per cycle on air to carry out, while isentropic compression require more.

* Work required per cycle during polytropic compression [$PV^n = c$].

→



area 1234 = area 0a23 + area ab12a − area 0b14

$$= P_2V_2 + \frac{P_2V_2 - P_1V_1}{n-1} - P_1V_1$$

$$= \frac{n}{n-1}\left[P_2V_2 - P_1V_1\right] \text{ J/cycle}$$

But $P_2V_2 = mRT_2$ & $P_1V_1 = mRT_1$ — ①

$$\therefore \; W = \frac{n}{n-1} mR\left[T_2 - T_1\right] \quad — ②$$

also from eqⁿ ①

$$W = \frac{n}{n-1} P_1V_1\left[\frac{P_2V_2}{P_1V_1} - 1\right] \quad \boxed{BME}$$

but $\frac{V_2}{V_1} = \left(\frac{P_2}{P_1}\right)^{-\frac{1}{n}}$

$$\therefore \; W = \frac{n}{n-1} P_1V_1\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right] \quad \text{OR} \quad — ③$$

$$W = \frac{n}{n-1} mRT_1\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right]. \quad — ④$$

only formulas & not a derivations are in syllabus. [1, 2, 3 & 4]

Indicated work / total work $= \frac{W \times N}{60}$ watt

where N = rpm.

* if compression is isentropic $PV^\gamma = C$
n is replaced by γ in equation 1,2,3 & 4
as.

$$W = \frac{\gamma}{\gamma-1} P_1 V_1 \left[\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} - 1 \right] \text{ J/cycle}$$

$$= \frac{\gamma}{\gamma-1} m R T_1 \left[\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} - 1 \right]$$

$$= \frac{\gamma}{\gamma-1} \left[T_2 - T_1\right] \cdot mR.$$

* if compression is isothermal [$PV = C$]
then,

$$W = \text{area}[1234]$$

$$= \text{area}[0923] + \text{area}[ab12a] - \text{area}[ob14]$$

$$= P_2 V_2 + P_1 V_1 \log\left[\frac{V_1}{V_2}\right] - P_1 V_1$$

$$= P_1 V_1 \ln\left[\frac{V_1}{V_2}\right] \quad (1) \qquad \text{as } PV = C, \; P_1 V_1 = P_2 V_2$$

$$= P_1 V_1 \ln\left[\frac{P_2}{P_1}\right] \quad (2)$$

$$= m R T_1 \ln\left[\frac{P_2}{P_1}\right] \quad (3)$$

4.2

* Need of multistaging in air compressor
"OR"
Method to improve ~~multistaging~~ efficiency

→ In single stage compression, the air is compressed to high pressure, it gives the high compression ratio & high discharge temperature which produce adverse effects on the efficiency, work done & power &

performance of the system because less time is available for the rejection of heat from the air. Hence there may be a chance to heat cylinder head & burn lubricating oil.

In such applications following methods are used to improove efficiency of air compressor

1] multi-staging:-

Instead of compressing air in single cylinder compression is carried out in more than one cylinder.

2] providing cooling Jackets:-

It makes a compression process near about isothermal, as it requires less work.

3] multi-stagging with intercooler:-

between two stages, air is passed through intercooler, which cools the air to original temperature. & makes the compression process isothermal.

advantages of multistagging:-

1] air can be cooled between stages
2] Mechanical balanced is good.
3] Reduced leakage losses
4] High pressure ratio
5] power required is less
6] More volumetric efficiency.

Disadvantages:→ ① Unit construction is more complicated.

(BRCE)

* Two-stage Reciprocating air compressor with intercooler.

Two stage air compressor with intercooler is shown in following figure with indicated diagram.

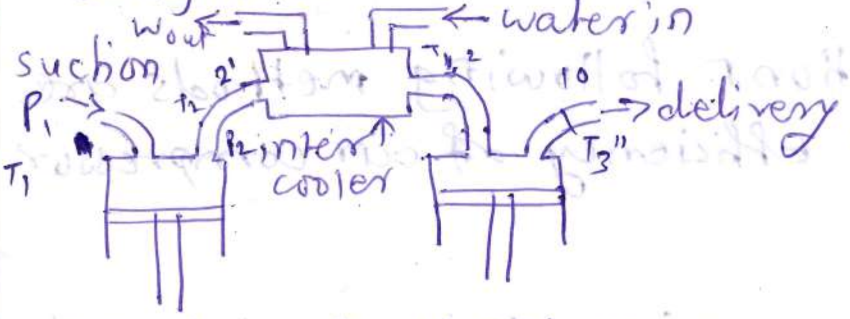


fig. two stage air compressor with intercooler

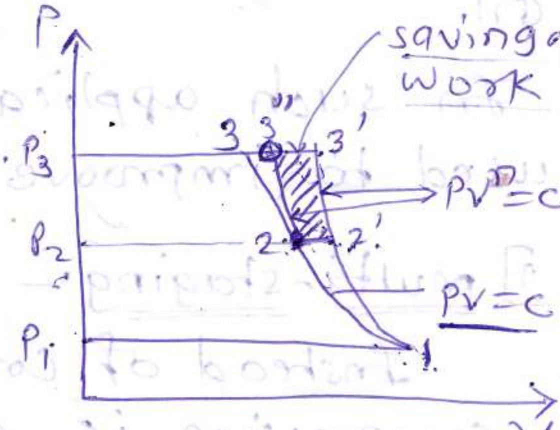


fig. indicater diagram

In multistage air compression process, part of air ~~is~~ compressed in L.P. cylinder & part ~~of~~ air in H.P. cylinder.

Intercooler is installed between two stages.

The size of H.P. cylinder is smaller than L.P. cylinder.

The air from atmosphere is sucked in the low pressure [L.P] cylinder at P_1 then is compressed poly- ~~technical~~ tropically to pressure P_2. (1-2')

The L.P cylinder discharges into the intercooler along line 2'-P where air is cooled at constant pressure P_2 to its original temperature corresponding to point 1 by circulating cold water.

after intercooler, air is discharges into a H.P. cylinder & compressed to pressure P_3.

The shaded area 2'-2-3''-3' shows a save in work input to a compressor.

(B110)

~~Real feral~~ Perfect intercooling:-

The intercooler which reduces the temperature of air to original temperature are called perfect intercooling.

Imperfect intercooling:-

The outlet temperature of air which is not equal to initial inlet temperature of air is called imperfect intercooling.

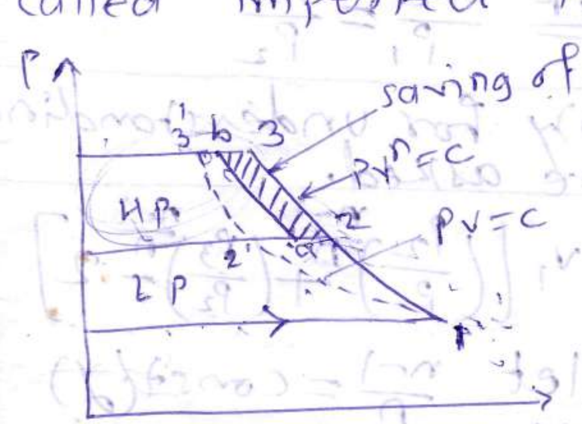


fig. indicator diagram with Imperfect intercooler

* Work done with Imperfect intercooler:→

$$(W_{LP}) = \frac{n}{n-1} P_1V_1\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right]$$

$$(W_{HP}) = \frac{n}{n-1} P_2V_2\left[\left(\frac{P_3}{P_2}\right)^{\frac{n-1}{n}} - 1\right]$$

total work done = $W_{LP} + W_{HP}$

$$W_T = \frac{n}{n-1}\left\{P_1V_1\left(\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right] + P_2V_2\left[(P_3/P_2)^{\frac{n-1}{n}} - 1\right]\right\} \text{ J/cycle} \quad — (1)$$

Put $P_1V_1 = mRT_1$

* Work done Required for perfect intercooler:-

For perfect intercooling $P_2V_2 = P_1V_1$

$$\therefore W_T = \frac{n}{n-1} P_1V_1\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} + \left(\frac{P_3}{P_2}\right)^{\frac{n-1}{n}} - 2\right] \text{ J/cycle} \quad — (2)$$

Condition for Minimum work done during Perfect Intercooling:-

The intermidiate pressure P_2 is a ~~algebraic~~ geometrical mean of initial or final pressure.

"OR"

Pressure ratio in each stage is same.

i.e. $P_2 = \sqrt{P_1 P_3}$ or $\frac{P_2}{P_1} = \frac{P_3}{P_2}$

Prof:-> Not in syllabus, only for understanding but may be asked.

we know, $W_T = \frac{n}{n-1} P_1 V_1 \left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} + \left(\frac{P_3}{P_2}\right)^{\frac{n-1}{n}} - 2 \right]$

as, P_1 & P_3 are fixed & let $\frac{n-1}{n} = const (\gamma)$

$\therefore$ $W_T = const \cdot \left[\left(\frac{P_2}{P_1}\right)^{\gamma} + \left(\frac{P_3}{P_2}\right)^{\gamma} - 2 \right]$

differentiate w.r.t. P_2

$$\frac{dW_T}{dP_2} = \left[\frac{\gamma (P_2)^{\gamma - 1}}{(P_1)^{\gamma}} + \frac{(-\gamma)(P_3)^{\gamma}}{(P_2)^{\gamma + 1}} \right] = 0$$

$$\therefore \frac{\gamma [P_2]^{\gamma - 1}}{(P_1)^{\gamma}} = \frac{\gamma [P_3]^{\gamma}}{(P_2)^{\gamma + 1}}$$

$$\therefore [P_2]^{2\gamma} = (P_1 P_3)^{\gamma}$$

$$\therefore \boxed{P_2 = \sqrt{P_1 P_3}}$$

Minimum work required during perfect Intercooling :-

$$W_{min} = \frac{2n}{n-1}\left[\left(\frac{P_3}{P_1}\right)^{\frac{n-1}{2n}} - 1\right] \text{ Joules/cycle.}$$

Total indicated power $= W_{min} \times \frac{N}{60}$ J/s or W

Proof not in syllabus, but may be asked.

---

we know, $W_T = \frac{n}{n-1} P_1V_1\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} + \left(\frac{P_3}{P_2}\right)^{\frac{n-1}{n}} - 2\right]$

Put $\frac{P_2}{P_1} = \frac{P_3}{P_2}$

$$\therefore W_T = \frac{n}{n-1} P_1V_1\left[2\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 2\right]$$

$$= \frac{2n}{n-1} P_1V_1\left[\left(\frac{\sqrt{P_1P_3}}{\sqrt{P_1}\sqrt{P_1}}\right)^{\frac{n-1}{n}} - 1\right]$$

$$= \frac{2n}{n-1} P_1V_1\left[\left[\left(\frac{P_3}{P_1}\right)^{\frac{1}{2}}\right]^{\frac{n-1}{n}} - 1\right]$$

$$= \frac{2n}{n-1} P_1V_1\left[\left(\frac{P_3}{P_1}\right)^{\frac{n-1}{2n}} - 1\right].$$

3-stage with perfect & Imperfect intercooling

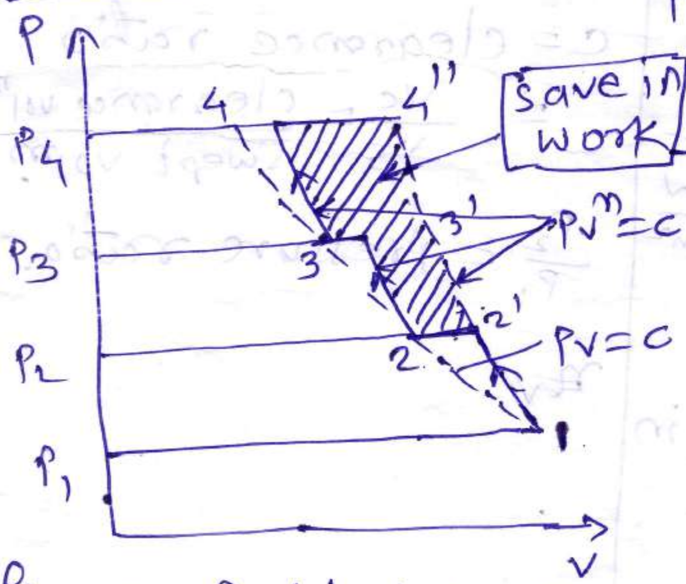


fig. perfect intercooling

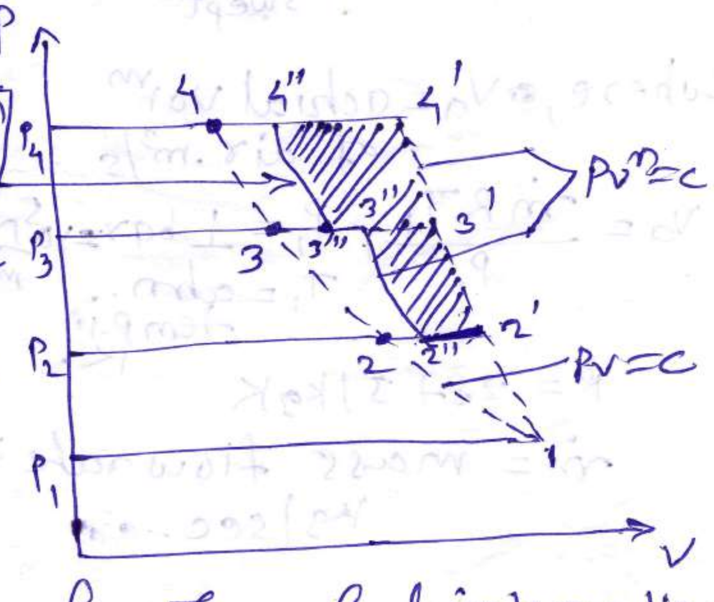


fig. Imperfect intercooling.

function of aftercooler:→

aftercooler is a Heat exchanger like shell & tube type, which cools the air after compression in cylinder, below the dew point of water. As a result of which moisture present in compressed air is condensed & seperated by centrifugal action of moisture seperator & drain valve.

4.3 Efficiency IMP definitions 2M

① **volumetric efficiency :- (η_v)**

It is a ratio of actual volume of the free air delivered at constant atmospheric condition discharge in one delivery stroke to the swept volume by the piston during the stroke.

η_v lies between 70 to 85%

$$\eta_v = \frac{V_a}{V_{swept}}$$

where, V_a = actual vol^m of air. m^3/s.

$V_a = \frac{\dot{m} R T_1}{P_1}$, $P_1 = 1\ bar = 10^5 \frac{N}{m^2}$

T_1 = atm. temp. in K.

$R = 287\ J/kgK$

$\dot{m}$ = mass flow rate in kg/sec.

$$\eta_v = 1 - c\left[\left(\frac{P_2}{P_1}\right)^{\frac{1}{n}} - 1\right]$$

c = clearance ratio

$= \frac{V_c}{V_s} = \frac{\text{clearance vol}^m}{\text{swept vol}^m}$

$\frac{P_2}{P_1}$ = pressure ratio.

Factors affecting on volumetric efficiency of air compressor:-

1] As pressure ratio (P_2/P_1) & clearance ratio ($\frac{V_c}{V_s}$) increases, volumetric efficiency decreases.

2] Valve leakages, specially at inlet valve.

3] Piston ring leakage which allow air to pass from one side of the cylinder to other.

4) very high speed of rotation.

2] Isothermal efficiency:-

"Ratio of isothermal power in watts to the indicated or actual power in watts."

$$\eta_{iso} = \frac{\text{isothermal power in watt}}{\text{indicated power in watt}}$$

$$\text{isothermal power} = P_1 V_1 \ln\left(\frac{P_2}{P_1}\right) \text{ or } mRT_1 \ln\left(\frac{P_2}{P_1}\right)$$

$$= P_1 V_1 \ln\left(\frac{V_1}{V_2}\right) \text{ or } mRT_1 \ln\left(V_1/V_2\right)$$

$$\text{indicated power} = \frac{n}{n-1} P_1 V_1 \left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right] \text{ or}$$

$$= \frac{n}{n-1} mRT_1 \left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right]$$

3] Mechanical efficiency:- (η_m)

"Ratio of indicated power to the Brake or shaft power."

$$\eta_m = \frac{I.P}{S.P} \times 100\%$$

$$\boxed{\text{Shaft/Brake power} = I.P - F.P.}$$

Numericals

Q.1] A single stage air compressor deliver air at 5 bar. The suction temperature & pressure is 20°C & 1 bar. Volume of air entering the compressor is 2 m³/min. The index of compression is 1.2. Calculate isothermal efficiency of the compressor. — 4M

→ We know, $\eta_{iso} = \dfrac{\text{isothermal power}}{\text{indicated power}}$

$$\text{isothermal power} = mRT_1 \ln(P_2/P_1)$$
$$= P_1 V_1 \ln(P_2/P_1)$$

where, $P_1 = 1\times10^5\ N/m^2$, $V_1 = 2\ m^3/min = \frac{2}{60}\ m^3/sec$

$P_2 = 5\ bar = 5\times10^5\ N/m^2$, $n = 1.2$

$$\text{Isothermal power} = 1\times10^5 \times \frac{2}{60} \ln\left(\frac{5}{1}\right)$$
$$= 5364.79\ W$$

$$\text{Indicated power} = \frac{n}{n-1} P_1 V_1 \left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right]$$
$$= \frac{1.2}{1.2-1} \times 10^5 \times \frac{2}{60}\left[\left(\frac{5}{1}\right)^{\frac{1.2-1}{1.2}} - 1\right]$$
$$= 6153.181\ \text{watt}$$

$$\therefore \eta_{iso} = \frac{5364.79}{6153.181} = 87.18\%$$

Q.2] In a single stage single acting reciprocating compressor initial pressure is 1 bar, volume 0.0133 m³ & delivers at 15 bar of the compression follows the law $PV^{1.3} = C$. Find the power required to drive the compressor. If compressor speed is 350 rpm. Neglect the clearance.

→ $$\text{power} = \frac{n}{n-1} P_1 V_1 \left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right] \times N/60$$
$$= \frac{1.3}{1.3-1} \times 10^5 \times 0.01333 \times \left[\left(\frac{15}{1}\right)^{\frac{0.3}{1.3}} - 1\right] = 29.18\ kW$$

5.014 kW

if clearance volume in above eqn is 5% of swept vol^m the find, η_{vol^m}.

→ we know,

$$\eta_{vol^m} = 1 - C\left[\left(\frac{P_2}{P_1}\right)^{1/n} - 1\right]$$

$$= 1 - \frac{V_c}{V_s}\left[\left(\frac{P_2}{P_1}\right)^{1/n} - 1\right]$$ where, $c = \frac{V_c}{V_s}$

& $V_c = 0.05 V_s$

$$= 1 - 0.05\left[\left(\frac{15}{1}\right)^{\frac{1}{1.3}} - 1\right] \quad \therefore \boxed{\frac{V_c}{V_s} = 0.05}$$

$$\boxed{\eta_{vol^m} = 64.85 \times 100\%}$$

2] During a test on single stage reciprocating compressor of a 14×10 cm bore & stroke having 3 percent clearance.

Barometer reading = P_0 = 1.028 bar

suction pressure = P_1 = 1.0465 bar

Discharge pressure = P_2 = 5.0965 bar

suction temperature = T_1 = 22° + 273 = 295°K

Discharge — " — T_2 = 174 + 273 = 447°K

Speed of shaft = 1160 rpm

Shaft power = 7.5 Kw

mass of air delivered/min = 1.75 Kg

Determine,

1. actual vol^m efficiency
2. Indicated power
3. Isothermal efficiency
4. Mechanical efficiency

→ $\eta_v = \frac{\text{actual vol}^m/\text{stroke}}{\text{swept vol}^m/\text{stroke}} = \frac{V_a}{V_s}$

$$v_a = \frac{mRT_1}{P_b} = \frac{1.75 \times 287 \times 295}{1.026 \times 10^5}$$ [min m^3/min]

$v_a = \underline{1.453}\ m^3/min$

piston displacement $(V_s) = \frac{\pi}{4} d^2 L \times N$

$= \frac{\pi}{4} \left[\frac{14}{100}\right]^2 \times \frac{10}{100} \times 1160$

$= 1.787 m^3/min$.

$\eta_{vol,m} = \frac{1.45}{1.787} \times 100\% = \underline{81.35\%}$

2] Isothermal efficiency $(\eta_{iso}) = \frac{\text{isothermal power}}{\text{indicated power}}$

Isothermal power $= \dot{m} R T_1 \ln(P_2/P_1)$

$= \frac{1.75}{60} \times 287 \times 295 \ln\left[\frac{5.09}{1.04}\right]$

$= 3931.62\ W$ ~~392~~ 3921.03^{W}

$\boxed{\text{Iso Power} = 3.931\ kW}$

Indicated power [I.P.] $= \frac{n}{n-1} \dot{m} R [T_2 - T_1]$

Here, value of n is not given. so find it by

$$\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} = (T_2/T_1)$$

$$\left[\frac{5.09}{1.04}\right]^{\frac{n-1}{n}} = \left[\frac{447}{295}\right]$$

$$\left(\frac{n-1}{n}\right) \ln[4.87] = \ln\left[\frac{447}{295}\right]$$

solve

$\boxed{n = 1.35}$

$\therefore\ I.P = \frac{1.35}{1.35-1} \times \frac{1.75}{60} \times 287\ (447-295)$

$= 4907.7\ W = 4.9077\ kW$

$\therefore\ \eta_{iso} = \frac{3.931}{4.9077} \times 100\% = \underline{80.11\%}$ — $\left\{ \because \eta_{iso} = \frac{\text{Iso Power in kW}}{\text{I.P. in kW}} \right.$

$$\eta_{mech} = \frac{4.9077}{7.5} = \underline{65.43\%} \Rightarrow \eta_{mech} = \frac{I.P}{S.P} \times 100$$

overall efficiency $= \eta_{iso} \times \eta_{mech}$

$= 0.8011 \times 0.6543$

$= 0.5242$

$$\boxed{\eta_{oo} = 52.42\%}$$

---

* Rough work *

$R = \frac{J}{kg.K}$ $\therefore J = N.m$

$m = \frac{kg}{min}$

$T = K$

$P = N/m^2$

$V_a = \frac{mRT}{P}$

$= \frac{\cancel{kg}}{min} \times \frac{N.m\,\cancel{K}}{\cancel{kg}.\cancel{K}}$

$= \frac{\frac{\cancel{N}.m}{min\,\cancel{N}}}{m^2}$

$$\boxed{V_a = \frac{m^3}{min}}$$

$\frac{kg}{min}$

$\frac{kg\,m^2}{sec^2} = \frac{kg\,m\,m^2}{sec\times sec^2}$ N.

N.

$R \cdot 5\,\frac{kg}{K} = \frac{\frac{J\,K}{kg} \times \frac{kg\,K}{min}}{N/m^2}$

$= \frac{\frac{N.m\,K\,\cancel{kg}\,K}{\cancel{K}\,\cancel{kg}\,min}}{N}$

$= \frac{N\,K.K}{m.\,min}$

$= \frac{N \times N.m\,K^2}{min \times m^2}$

$= \frac{J\,\cancel{K} \times \cancel{kg} \times K\,m^2}{N \times \cancel{kg} \times min\,\cancel{K}}$

$= \frac{\cancel{N}.m\,\cancel{K}.\cancel{K}.m^2}{\cancel{N} \times min\,\cancel{K}} = \frac{m^3}{min}$

$\frac{kg\,m^2}{sec^2}$

$1\,N = \frac{kg \times m}{sec^2}$

$\frac{n-1}{n} = 0.261$

$n = 0.261n + 1$

$0.739n = 1$ $\therefore n = \underline{1.35}$

4.1 Continue.

* Rotary compressors :-

- used for supplying large volume of air upto $3000 m^3/min$ at very low pressure which raises upto 10 bar.
- The running speed of compressor are upto 40000rpm, which is very high.

1] Screw compressor :-

It consists of Helical grooved rotors which are mesh with each other in a housing. An electric motor drives a male rotor shaft + female follows it ~~but in some design~~

male part is known as lobe

Female part is known as flutes/antilobe.

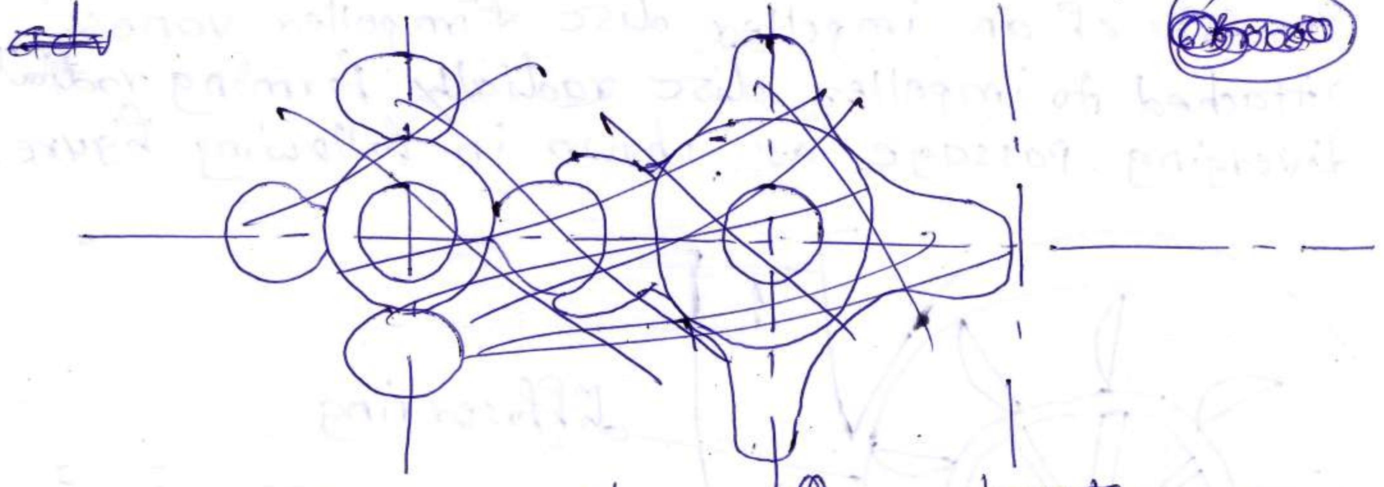
Compression process :-

1] As the rotors begin to unmesh, a void is created on both male & female side & gas is drawn in through the inlet port.

2] further rotation starts the meshing of another male lobe with another female inter lobe space on the suction end & progressively compresses the air in axial direction of the discharge port.

3] Thus the volume of the trapped air within the inter lobe space is decreased & air pressure consequently increased.

4] when a discharge port is uncovered, the compressed air is discharge to air tank.



advantages :- ① less maintenance due to few moving part.

② smaller size, lighter weight.

③ less starting torque.

disadvantages :-

Performance affected by moisture in suction air.

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* applications of Reciprocating compressor.

① service station for cleaning vehicle

② In spray painting ③ filling air in tubes of vehicle.

④ in workshop, cleaning m/cs.

* appln of Rotary compressor :-

① oil refinery ② petrochemical plant.

③ Refrigeration plant ④ supercharging of CI & SI Engine.

Centrifugal ~~pump~~. compressor.

- it consists of impeller & diffuser. The diffuser consists of an impeller disc & impeller vanes, attached to impeller disc radially forming radial diverging passage as shown in following figure.

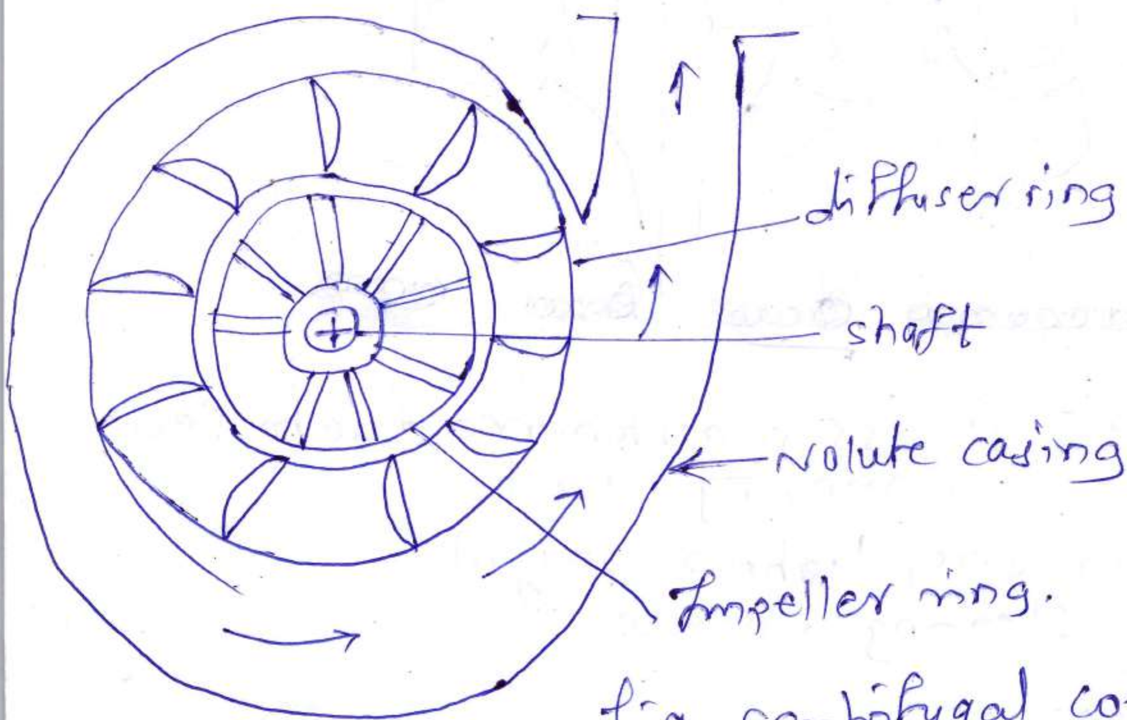

fig. centrifugal compressor.

air is drawn into compressor in axial direction, when shaft Rotates. The air is flown radially outwards through Impeller passage due to centrifugal forces & K.E. is imported to the air with some static pressure rise ~~shown~~.

The air leaves impeller tip with high velocity & enters the diffuser, which further converts the K.E. of air in pressure energy.

The flow from the diffuser is collected in a spiral passage from which it is discharged from the compressor.

* application of Reciprocating Compressor.
1] for cleaning m/cs in workshop.
2] for filling air in tube in repair shop.
3] creating blast in blast furnace.
4] automobile service station to clean vehicle.
5] In spray painting shop.

* Application of Rotary compressor:-
1] oil Refinery 2] petro chemical plant.
3] Refrigeration plant 4] supercharging of S.I & C.I Engine.

* difference between Reciprocating air compressor & Rotary air compressor. IMP

Reciprocating A/comp	Rotary air compressor
1] Delivery of air intermittent	1] delivery of air is continuous.
2] Low flow rate of air	2] high flow rate of air
3] applicable for high pressure ratio	3] used for low pressure ratio
4] can not be directly coupled to prime-mover	4] can be directly coupled to prime mover.
5] used for small quantity of air at high pressure	5] used for large quantity of air at lower ~~pressure~~ pressure
6] more starting torque required.	6] less starting torque required.

ethods to Reduce power consumption in air compressor:→

1] Interstage cooling:-

The compression process is devided into two to Three or more stage. The compressed air is in first stage is passass through intercooler before passing through second stage.

- In intercooler air is cooled to original temp.

2] Water Jacketing:-

Water is circulated arround the compressor & air is cooled.

3) Another methods:-

a) Use multistage compression as it consumes less power for the same output than a single stage compressor.

b) Reduce compressor delivery pressure whenever possible to save energy.

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