School of Engineering Technology

METE123 THERMODYNAMICS
AIR COMPRESSOR EXPERIMENT

OBJECTIVE: Evaluate the performance of a typical two-stage air compressor.

PROCEDURE

The compressor used in this experiment is an Integersol-Rand type 30 two-stage air compressor. After the engine is running for a sufficient time (approx. 10 minutes), the following reading should be taken:

1. Low pressure cylinder inlet and discharge pressures (P_I and P_2).
2. Intercooler pressure drop (P_3 - P_2).
3. High pressure cylinder discharge pressure P_4 (Tank pressure).
4. Orifice pressure drop (P_5 - P_8).
5. Pressure after the orifice.
6. Low pressure cylinder inlet and discharge temperatures. (T_I and T_2).
7. High pressure cylinder inlet and discharge temperatures (T_3 and T_4).
8. Temperature before and after orifice (T_5 and T_8).
9. Compressor speed.
10. Electric power input.

The high pressure cylinder discharge pressure P_4 starts from 100 psig, and several runs are made by decreasing the tank pressure for each time.

RESULTS & QUESTIONS

1. Calculate the following:

   (a) Air flow rate *m*
   (b) Electric input power We
   (c) Isentropic air work Wa
   (d) Isothermal air work Wi
   (e) Isothermal compressor efficiency (η_i), volumetric efficiency (η_m), and over all mechanical efficiency (η_v)

2. Plot and discuss the following:

   (a) Plot We, Wa, Wi, η_i and η_m vs. *P4*
   (b) Discuss the characteristic of these curves
   (c) discuss the errors which are concerned in this experiment.

THEORY

1) Air mass flow rate (m), by applying Bernoulli's equation, the air mass flow rate can be determined by:

$$m = 144 A_o \left(\frac{2g \Delta P_{58} P_5}{RT_5} \right)^{1/2} 60 C_d$$

where:

m = air mass flow rate (lbm/min)
A_o = Oriface area (ft^2), the inside diameter of the orifice is .5 in.
g = 32.2 ft/s^2
ΔP_{58} = pressure drop across orifice (psi),
P_5 = pressure ahead of orifice (psia)
R = Specific gas constant of air, 53.3 ft-lbf/lbmR
T_5 = temperature ahead of orifice (R)
C_d = Discharge coefficient, 0.6

2) Electric input power, We (BTU/Min)

We =KW(3413)/60

Where KW = kilowatt usage of compressor.(1KW = 3413 BTU/hr)

3) Air isentropic work, Wa (BTU / min)

Wa = mCp(T2-T1 +T4-T3)

Where:

Cp = specific heat (.24 BTU/lbmF)
T1 = low pressure cylinder inlet temperature
T2 = low pressure cylinder outlet temperature
T3 = high pressure cylinder inlet temperature
T4 = high pressure cylinder outlet temperature

4. Air Isothermal Work, Wi (BTU/min)

$$Wi = \frac{mRT_1}{776} \ln \frac{P_4}{P_1}$$

Where:

P1 = low pressure cylinder inlet pressure (psia)
P4 = high pressure cylinder outlet pressure (psia)

5. Isothermal compressor efficiency *(η_i)*.

$$\eta_i = Wi / Wa\ (100)$$

5. Overall mechanical efficiency *(η_m)*.

$$\eta_m = Wa / We\ (100)$$

Volumetric efficiency of the low pressure cylinder (η_v).

$$\eta_v = m\gamma / PD_1\ (100)$$

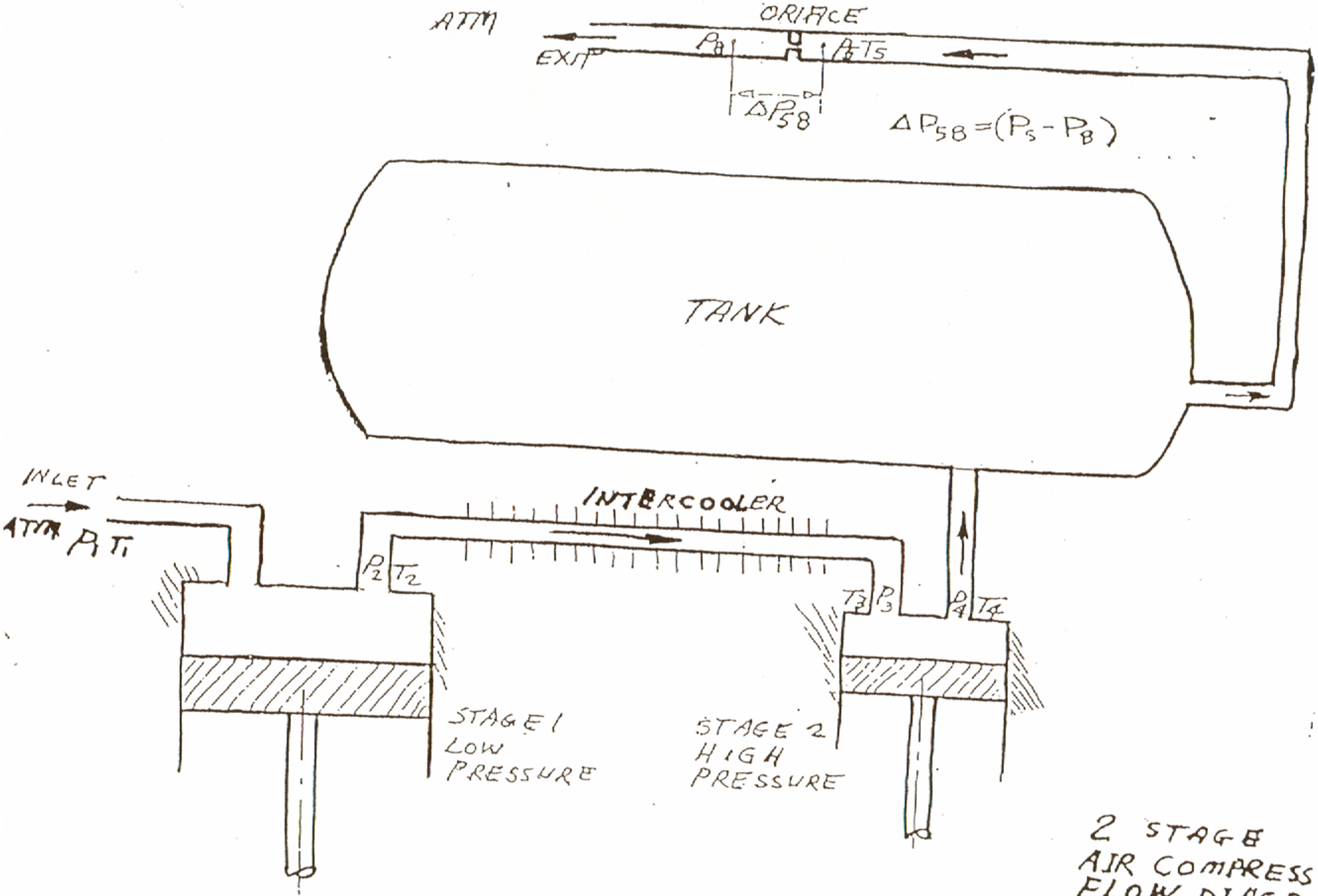
where:

γ = Specific volume of air ahead of low pressure cylinder.

$$\gamma = RT_1 / 144P_1$$

PD_1 in $ft^3/min = \pi d_1^2 LN / 4$

and d_1 is the diameter of the low pressure cylinder (ft) d_1 = 6 in., L is stroke of the piston (ft) L = 4 in. and N is compressor speed in RPM.



FIGURE

2 STAGE
AIR COMPRESS
FLOW DIAGR