Question#78605

Air is compresses in a two-stage vane-type compressor from 1.013 bar to. 8.75 bar Using the data below, and assuming equal pressure ratios in each stage, that compression is complete in each stage that the machine operates in an ideal manner and is uncooled apart from the intercooler,

calculate:

(i) the power required.

(ii) The volume flow rate measured at the delivery pressure.

Solution

Since we do not have heat exchange, we consider only adiabatic compression work.

Gas constant:

$$R = 286.6 \frac{J}{kg*K}$$

Or

$$R_m = 8.3144598 \frac{J}{mol*K}$$

Molar mass of dry air

$$M = 29 \frac{gm}{mol}$$

We take the air temperature in 25 degrees Celsius

$$T_0 = 273 + 25 = 298K$$

The adiabatic index for air at a temperature of 25 degrees Celsius

$$k = 1.4$$

Compressor inlet pressure

$$P_0 = 1.013bar = 101300Pa$$

Compressor outlet pressure

$$P_2 = 8.75bar = 875000Pa$$

To compress one cubic meter of air, we need

$$A = \frac{k}{k-1} * R * T_0 * ((\frac{P_2}{P_0})^{\frac{k-1}{k}} - 1) = 2.546 * 10^5 \frac{m^2}{s^2} \quad (1)$$

For vane-type compressor the efficiency of each stage is about 0.7

$$\eta_1 = 0.7$$
$$\eta_2 = 0.7$$

Density of dry air at 25 degrees Celsius

$$\rho_0 = \frac{P_0 * M}{R_m * T_0} = 1.186 \tfrac{kg}{m^3} \qquad (2)$$

Air consumption in the volume of one cubic meter per minute

$$Q = 1 \tfrac{m^3}{\min} = 0.017 \tfrac{m^3}{s}$$

$$G = Q * \rho_0 = 0.019755 \tfrac{kg}{s} \qquad (3)$$

Coefficient of unaccounted calculations for compressor machines

$$K = 1.1...1.3$$

The required engine power for compressor

$$P = K * \frac{G * A}{\eta_1 * \eta_2} = 1.129 * 10^4 W = 11.29 kW \qquad (4)$$

Answer:

The required engine power for a vane-type compressor that would compress the dry air in the volume of one cubic meter per minute - 11.29kW