37.79 $15,000\frac{lb_m}{hr}$ **of air enters a gas turbine at** $800°F$ **and** $70psia$**. The turbine produces** $300hp$ **of net work and the air exits the turbine at** $14.7psia$**. What is the efficiency of the turbine?**

A. 35%

B. 47%

C. 53%

D. 65%

Consider the high temperature, high pressure air entering the turbine as State 1 and the atmospheric air exiting the turbine as State 2. Find the *ideal* exit temperature by assuming a Constant Entropy Process. Use absolute temperature i.e. Rankine.

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

$$T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\left(\frac{k-1}{k}\right)} = (1260R)\left(\frac{14.7psia}{70psia}\right)^{\frac{1.4-1}{1.4}} = 806.7R = 346.7°F$$

Use the temperatures, the mass flow rate, and the specific heat capacity of air to determine the *ideal* heat input to the turbine. Convert units to hp.

$$\dot{Q}_{in} = \dot{m}c_p\Delta T$$

$$\dot{Q}_{in} = \left(15,000\frac{lb}{hr}\right)\left(0.24\frac{Btu}{lb°F}\right)(800°F - 346.7°F) = 1.63\times 10^6\frac{Btu}{hr}$$

$$\dot{Q}_{in} = \left(1.63\times 10^6\frac{Btu}{hr}\right)\left(\frac{KW}{3412\frac{Btu}{hr}}\right)\left(\frac{hp}{0.7457KW}\right) = 641.4hp$$

The efficiency is the ratio of the work output to the heat input. Calculate the efficiency.

$$\eta = \frac{\dot{W}_{out}}{\dot{Q}_{in}} = \frac{300hp}{641.4hp} = 46.8\%$$

Answer B