An airflow of 5 g/s is throttled adiabatically to ambient pressure (p_a=1bar). The air enters the throttling at the pressure p_1. The flowing of exergy loss due to the throttling is 160 W. Determine the pressure p_1 before the throttling.

The ambient temperature is T_a=298K. The changes of kinetic und potential energies can also be neglected. Air is assumed to be perfect gas.

The specific gas constant for air is R_{air}=0.287 J/g·K and the specific heat capacity at constant pressure c_p=1 J/g·K

Solution:

In order to calculate the exergy loss, we also need to determine the production of entropy during this process:

$$s_{prod} = c_p \cdot ln\frac{T_2}{T_1} - R_{air} \cdot ln\frac{p_2}{p_1}$$

The general expression for the exergy loss is:

$$\varepsilon = \dot{m}_{air} \cdot T_a \cdot s_{prod} = \dot{m}_{air} \cdot T_a \cdot (c_p \cdot ln\frac{T_2}{T_1} - R_{air} \cdot ln\frac{p_2}{p_1})$$

Considering the throttling process, we can reduce the conservation of energy equation to:

$$h_1 = h_2$$

That means, enthalpy values at the inlet and outlet are the same.

$$h_1 = h_2 \rightarrow c_p \cdot T_1 = c_p \cdot T_2 \rightarrow T_1 = T_2$$

Therefore the equation of exergy loss is reduced to:

$$\varepsilon = \dot{m}_{air} \cdot T_a \cdot \left(-R_{air} \cdot ln\frac{p_2}{p_1}\right)$$

$$\Longrightarrow p_1 = p_2 \cdot \exp\left(\frac{\varepsilon}{\dot{m}_{air} \cdot T_a \cdot R_{air}}\right) = 1bar \cdot \exp\left(\frac{160W}{5g/s \cdot 298K \cdot 0.287J/g \cdot K}\right) = 1.45\ bar$$