An insulated rigid tank is initially evacuated. A valve is opened in order that air at 1 MPa and 298K can flow slowly enough into the tank until the pressure inside the tank also reaches 1 MPa. Then at this moment the valve is closed again. Determine the final temperature of the air in the tank. Assume here that air is perfect gas and its specific heat capacities are constant.

The specific heat capacity at constant pressure is c_p=1.004 kJ/kg

The specific heat capacity at constant volume is c_V=0.717 kJ/kg

Solution:

The 1st law of thermodynamics:

$$\sum_i \dot{Q}_i + \sum_j \dot{W}_j + \sum_k \dot{m}_k \cdot \left(h + \frac{c^2}{2} + g \cdot z\right)_k = \frac{d}{d\tau}(\sum_l m_l \cdot (\overline{u} + \overline{e}_{kin} + \overline{e}_{pot})_l)$$

ΣQ=ΣW=0

The kinetic energy of the air flowing into the tank can be neglected since the speed is slow enough.

Since this process is not stationary, the equation can be rewritten as:

$$h_{in}=u_2$$

here h_{in} means the specific enthalpy of the air flowing into tank.

u_2 means the specific internal energy inside the tank after air inflow.

$$h_{in}=c_p \cdot T_{in} \text{ and } u_2=c_V \cdot T_2$$

$$T_2 = T_{in} \cdot \left(\frac{c_p}{c_v}\right) = 298K \cdot \left(\frac{1.004}{0.717}\right) = 417.28K$$