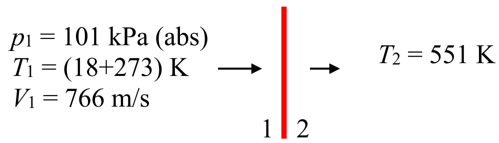
Air approaches a normal shock with $T_1 = 18$ °C, $p_1 = 101$ kPa (abs), and $V_1 = 766$ m/s. The temperature immediately downstream from the shock is $T_2 = 551$ K.

1. Determine the velocity immediately downstream from the shock.
2. Determine the pressure change across the shock.
3. Calculate the corresponding pressure change for a frictionless, shockless deceleration between the same speeds and temperatures.

SOLUTION:



The velocity downstream of the shock may be found from conservation of energy.

$$c_P T_1 + \tfrac{1}{2}V_1^2 = c_P T_2 + \tfrac{1}{2}V_2^2 \quad (1)$$

$$V_2 = \sqrt{V_1^2 + 2c_P\left(T_1 - T_2\right)} \;\Rightarrow\; \boxed{V_2 = 254.3\text{ m/s}} \quad (2)$$

using c_P = 1004 J/(kg·K).

The pressure change across the shock may be found using the normal shock relations.

$$\Delta p = p_2 - p_1 = p_1\left(\frac{p_2}{p_1} - 1\right) \;\Rightarrow\; \boxed{\Delta p = 4.73*10^5\text{ Pa}} \quad (3)$$

where

$$\frac{p_2}{p_1} = \frac{2\gamma}{\gamma+1}\text{Ma}_1^2 - \frac{\gamma-1}{\gamma+1} \;\Rightarrow\; p_2/p_1 = 5.6880 \quad (4)$$

and

$$\text{Ma}_1 = \frac{V_1}{c_1} = \frac{V_1}{\sqrt{\gamma R T_1}} \;\Rightarrow\; \text{Ma}_1 = 2.24 \quad (5)$$

In addition,

$$\text{Ma}_2^2 = \frac{\left(\gamma-1\right)\text{Ma}_1^2 + 2}{2\gamma\text{Ma}_1^2 - \left(\gamma-1\right)} \;\Rightarrow\; \text{Ma}_2 = 0.54 \quad (6)$$

Note that we could have also simply used:

$$\text{Ma}_2 = \frac{V_2}{c_2} = \frac{V_2}{\sqrt{\gamma R T_2}} \;\Rightarrow\; \text{Ma}_2 = 0.54\ \text{(Same result as the previous one!)} \quad (7)$$

The corresponding pressure change for an isentropic deceleration between the same speeds may be found by combining isentropic stagnation pressure ratios,

$$\Delta p = p_2 - p_1 = p_1\left(\frac{p_2}{p_1} - 1\right) \;\Rightarrow\; \boxed{\Delta p_{\text{isentropic}} = 8.41*10^5\text{ Pa}} \quad (8)$$

where,

$$\frac{p_2}{p_1} = \frac{\left(p_2/p_0\right)}{\left(p_1/p_0\right)} = \frac{\left(1 + \frac{\gamma-1}{2}\text{Ma}_2^2\right)^{\frac{\gamma}{1-\gamma}}}{\left(1 + \frac{\gamma-1}{2}\text{Ma}_1^2\right)^{\frac{\gamma}{1-\gamma}}} \;\Rightarrow\; p_2/p_1 = 9.3253 \quad (9)$$