Compressible Flow TME085

Quasi-One-Dimensional Flow

Choked Massflow

Division of Fluid Dynamics
Department of Mechanics and Maritime Sciences
Chalmers University of Technology

For steady-state nozzle flow, the massflow is obtained as

$$\dot{m} = \rho u A = const \tag{1}$$

Eqn. 1 can be evaluated at any location inside the nozzle and if evaluated at sonic conditions we get

$$\dot{m} = \rho^* u^* A^* \tag{2}$$

By definition $u^* = a^*$ and thus

$$\dot{m} = \rho^* a^* A^* \tag{3}$$

ρ^* and a^* can be obtained using the ratios ρ^*/ρ_o and a^*/a_o

$$\rho^* = \left(\frac{\rho^*}{\rho_o}\right)\rho_o = \frac{p_o}{RT_o}\left(\frac{2}{\gamma+1}\right)^{1/(\gamma-1)} \tag{4}$$

$$a^* = \left(\frac{a^*}{a_o}\right)a_o = a_o\left(\frac{2}{\gamma+1}\right)^{1/2} = \sqrt{\gamma RT_o}\left(\frac{2}{\gamma+1}\right)^{1/2} \tag{5}$$

Eqns. 5 and 4 in Eqn. 3 gives

$$\dot{m} = \frac{p_o}{RT_o}\left(\frac{2}{\gamma+1}\right)^{1/(\gamma-1)}\sqrt{\gamma RT_o}\left(\frac{2}{\gamma+1}\right)^{1/2} A^* \tag{6}$$

which can be rewritten as

$$\dot{m} = \frac{p_o A^*}{\sqrt{T_o}}\sqrt{\frac{\gamma}{R}\left(\frac{2}{\gamma+1}\right)^{(\gamma+1)/(\gamma-1)}} \tag{7}$$

Eqn. 7 valid for:

- quasi-one-dimensional flow
- steady state
- inviscid flow
- calorically perfect gas

It should be noted that the choked massflow can be calculated using Eqn. 7 even for cases with shocks downstream of the throat.