Steam Nozzles

The steam nozzle is a passage of varying cross section by means of which the thermal energy of steam is converted into kinetic energy. The shape of the nozzle is designed such that it will perform this conversion of energy with minimum losses. Continuity equation is used for designing to produce a jet of steam of high velocity for the purpose of driving steam turbine. When steam flows through a nozzle, expansion processes take place. As the steam expands, there is a drop in pressure and enthalpy of steam, and consequently, its velocity and specific volume both increase. The smalls section of the nozzle is known as throat.

Types of nozzles:

There are two types:

1-Convergent nozzle. (fig.(1))

2-Convergent-Divergent nozzle. (fig.(2))

Variation of specific volume, area, and velocity:

1-Velocity: except for the first part of the nozzle, the velocity increases at almost constant rate.

2-Specific volume: for a considerable part of expansion, the specific volume increases gradually. However, during the latter part of the expansion, the specific volume increases very rapidly.

3-Area:
a) when a specific volume increases less rapidly (low rate) than the velocity the area increases

b) when a specific volume increases more rapidly than the velocity the area increases

**Nozzle efficiency:**

\[
\eta_{\text{nozzle}} = \frac{\text{actual heat drop}}{\text{isentropic heat drop}}
\]

\[
\eta_n = \frac{H_1 - H_2'}{H_1 - H_2}
\]
Velocity coefficient:

\[ C_v = \frac{Actual \, velocity}{Isentropic \, velocity} = \sqrt{Nozzle \, efficiency} \]

\[ H_1 - H_2 = \frac{V_2^2 - V_1^2}{2} \]

\[ V_1^2 = 0.0 \]
\[ V_2^2 = 2(H_1 - H_2) \]

\[ V_v = \frac{V_2}{V_2} = \sqrt{\frac{2(H_1 - H_2)}{2(H_1 - H_2)}} = \sqrt{\eta n} \]

**THE REHEAT FACTOR:**

Consider a multi-stage turbine as shown by the Mollier diagram, Figure 1.

The reheat factor is defined by:

Example (1): Dry saturated steam at 2 MPa enters a steam nozzle and leaves at 0.2 MPa. Find the exit velocity of the steam and dryness fraction. Assume isentropic expansion and neglect inlet velocity.