ENE 327 – Pumps and Compressors

WEEK 11: CAVITATION

CAVITATION [1]

Cavitation is the local vaporization of a liquid when the absolute pressure falls to a value equal to or lower than the vapor pressure of the liquid at the local temperature. In this case, small bubbles of vapor are formed and boiling starts, while the dissolved air in the liquid is released. The combination of boiling and air release is referred to as the cavitation

In practice, cavitation starts when the pressure is slightly lower than the vapor pressure of the liquid. Although the actual mechanism that causes the cavitation is not yet understood, it seems to be related to the presence of microscopic gas nuclei. These gas nuclei give rise to the formation of bubbles during cavitation inception.

During a flow, as the velocity increases, the pressure decreases and if it falls sufficiently low level, cavitation occurs with the formation of bubbles. These bubbles first grow and then flow with the fluid to the regions of higher pressure where they collapse producing pressure waves. As a result of these pressure waves, the local pressure may be as high as 4 MPa which is accompanied by an increase in the local temperature by as much as $750℃$.

There are two important consequences of cavitation. These are as follows:

1) The pressure waves, which originate during the collapse of bubbles, may damage surrounding structure.
2) The vigorous mixing in the cavitation region dissipates energy and decreases the total pressure.

In turbomachines, cavitation may occur in regions where pressure is minimum. In this case of pumps, the minimum pressure occurs at the suction side or the inlet of pumps. However, it is the outlet side or the suction side for turbines.

Net positive suction head, NPSH, represents the difference between the total head at the suction side of pumps or turbines and the head corresponding to the vapor pressure.

Therefore,

$$NPSH = \frac{p_s}{\rho g} + \frac{V_s^2}{2g} - \frac{p_v}{\rho g}$$

Where p_s is the suction side pressure, V_s is suction side velocity and p_v isthe vapor pressure at the suction temperature.

The NPSH can be nondimensionalized as

$$\sigma = \frac{NPSH}{h}$$

Where σ is the Thoma cavitation coefficient. This factor is constant for similar flows in siöilar turbomachines.

At the point where the cavitation starts, that is at the cavitation inception point

$$\sigma = \sigma_c$$

Where σ_c is the critical Thoma cavitation factor. Therefore, to prevent cavitation required condition is $\sigma > \sigma_c$.

Similar to the specific speed, suction specific speed, S, can be defined as

$$S = \frac{\omega . Q^{1/2}}{(g . NPSH)^{3/4}}$$

Cavitation can be prevented when the suction speed is less than its critical value.

The relation between the Thoma cavitation coefficient, suction specific speed and specific speed can be obtained by combining equations:

$$N_s = S . \sigma^{3/4}$$

REFERENCES

1. Aksel, M.H., 2016, “Notes on Fluids Mechanics”, Vol. 1, METU Publications
2. DOUGLAS, J. F., GASIOREK, J. M. and SWAFFIELD, J. A., *Fluid Mechanics,* 3rd ed., Prentice Hall, Inc., New Jersey, 2003.
3. FOX, R. W. and MCDONALD, A. T., *Introduction to Fluid Mechanics,* 6th ed., John Wiley and Sons, Inc., New York, 2005.
4. ÜÇER, A. Ş., *Turbomachinery,* Middle East Technical University, Ankara,Turkey, 1982.