ENE 327 – Pumps and Compressors

WEEK 4: EULER –n EQUATIONS

<u>FUNDAMENTAL RELATIONS FOR THE FLOW THROUGH AN ARBITRARY TURBOMACHINE</u>

The Euler -n Equation (Forces and Momentum normal to a streamline) [1]

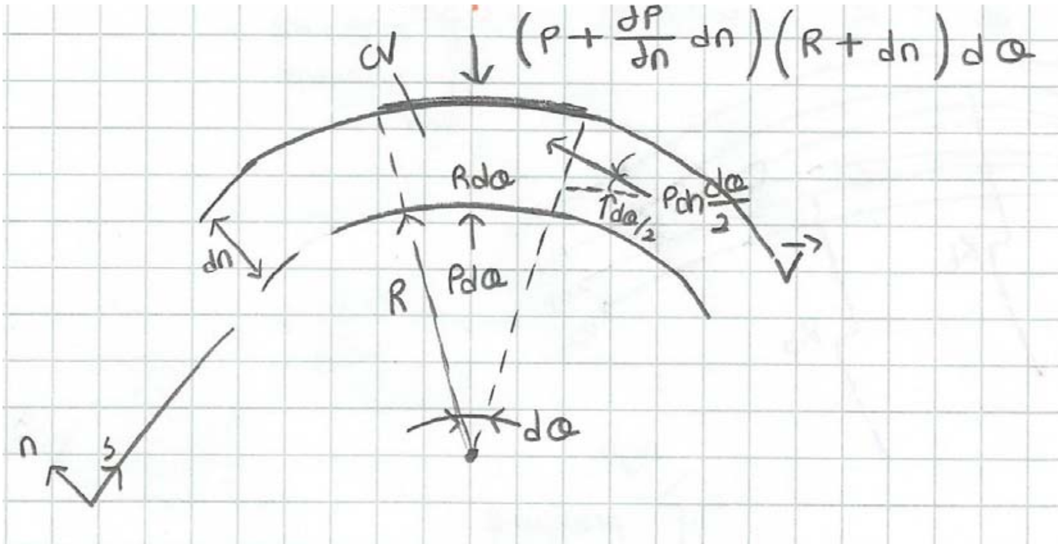

Figure 1: Pressure forces normal to the streamlines

The mass of the fluid element is $\rho.R.dQ.dn$

The centripetal acceleration of this mass will be towards the center of streamline curvature of magnitude $\frac{\rho.V^2}{R}$. Thus for an inviscid fluid in equilibrium in the absence of any significant body forces.

$$\left[P + \frac{\partial P}{\partial n}dn\right].(R+dn).dQ - P.R.dQ - 2\left(P.dn.\frac{dQ}{2}\right) = \rho.R.dQ.\frac{dn.V^2}{R}$$

which simplifies to:

$$\frac{\partial P}{\partial n} = \rho . \frac{V^2}{R}$$

This is extremely important and very frequently misunderstood principle in fluid mechanics: that should be grasped by every fluid machinery engineer.

It gives the fundamental insight as to why an airfoil develops lift, how a secondary flow develops in the passage of a turbomachinery blade row or in a river bed and the level of forces to be expected around an simple bend.

The net force acting in the normal direction must be balanced by the centripetal acceleration of a fluid particle.

To appreciate these point further consider the following samples.

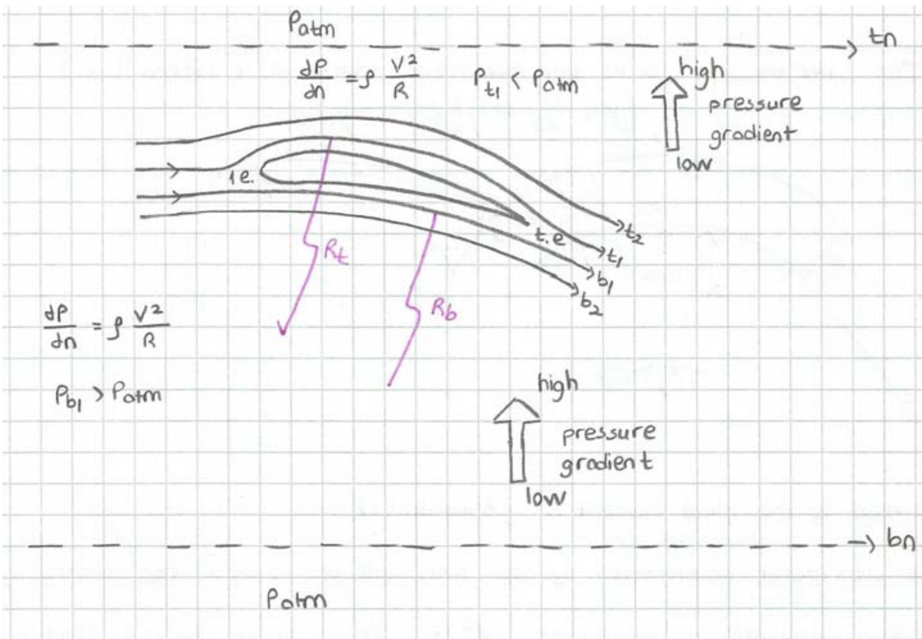

Figure 2. Streamline body

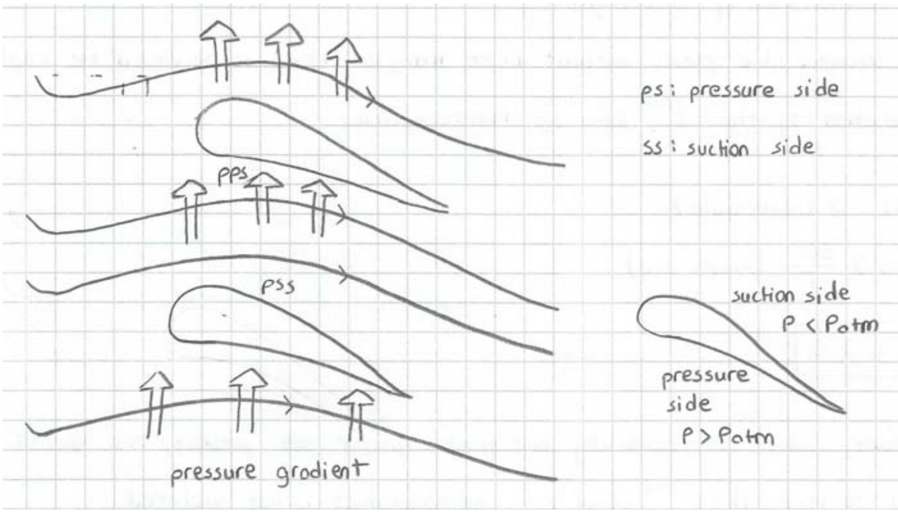

Figure 3. Lift form on a turbine blade

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.