SIMPLE THRUST CALCULATION FOR CENTRIFUGAL COMPRESSOR IMPELLERS

By Eric Dunlap

When designing a new centrifugal compressor stage for a rerate application it is critical to consider how the new impeller will change the thrust load acting on the rotor and whether the existing thrust bearing is adequate for the new load. Impeller geometry, inlet pressure, and discharge pressure each play a major factor in the thrust load exerted on the impeller.

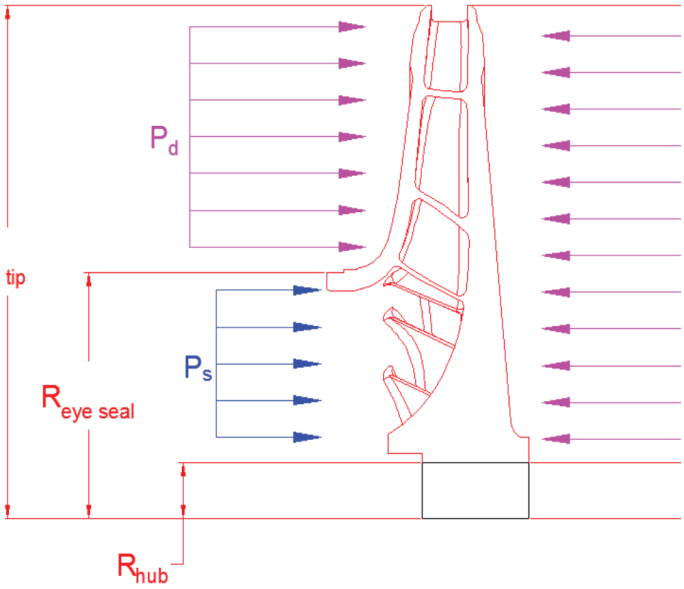

Figure 1

The figure on the right shows an illustration of the pressures acting on an impeller. The pressure on the discharge side of the impeller can be assumed to be equal to the impeller discharge pressure, Pd. The pressure on the suction side of the impeller, above the eye seal, can also be assumed equal to the impeller discharge pressure. Below the eye seal, the pressure is equal to the impeller suction pressure, Ps. By multiplying these pressures by the cross sectional area on which they act on the impeller one can calculate the thrust force acting in each region. The sum of these thrust forces is the net thrust force acting on the impeller due to the pressure differential.

$$Thrust = \left[P_d * \pi * \left(R_{tip}^2 - R_{hub}^2\right)\right] - \left[P_d * \pi * \left(R_{tip}^2 - R_{eye}^2\right)\right] - \left[P_s * \pi * \left(R_{eye}^2 - R_{hub}^2\right)\right]$$

This equation can be simplified to:

$$Thrust = (P_d - P_s) * \pi * \left(R_{eye}^2 - R_{hub}^2\right)$$

The figure and equations show that the net thrust force will push the impeller towards the suction end of the machine and is dependent on the difference between the discharge and suction pressures and the eye and hub seal diameters. Larger pressure ratios will result in larger thrust loads acting on the impeller and will increase the required capacity of the thrust bearing. In scenarios where the thrust load is increased beyond the capacity of the existing thrust bearing it will need to be upsized when the rerate components are installed.

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