Turbine Thrust Data

200.A.08 *(Effective June 1, 2006)*

CALCULATING AXIAL THRUST

Axial thrust is a force caused mainly by the differences in pressure that exist between the suction side and discharge side of an impeller. Axial thrust can be very small for double suction type impellers where flow enters both sides of the impeller. Axial thrust for the vertical turbines can be quite large depending upon the impeller design, the generated differential head, the pump length and several other factors.

Under normal circumstances vertical turbine Pump has a thrust load acting parallel to the pump shaft and in a downward direction. The load is due to unbalanced pressures, dead weight and liquid direction change. Optimum selection of the motor bearing and correct determination of the required bowl lateral for deep setting pumps require accurate knowledge of the magnitude and direction of these forces. In addition, but with a less significant role, thrust influences shaft horsepower rating and shaft critical speeds.

The components of the axial thrust are:

1. Hydraulic thrust (usually down)
2. Dead weight (always down)
3. Shaft thrust (usually up)
4. Sleeve thrust (always up)

We will discuss each of these components separately.

HYDRAULIC THRUST

The largest component of the axial thrust is usually the hydraulic thrust produced by the impeller. Most of time the hydraulic thrust of an impeller is in the downward direction is due to the unbalanced pressure acting on the surfaces of the impeller (See the picture below).
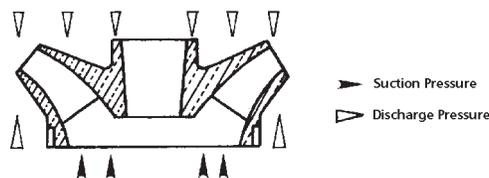
The higher discharge pressure pushes down on the top side of the impeller while lower pressure pushes up on the suction. The result of these two forces is always thrust toward the suction side of the impeller (downward direction for the vertical turbines).

We obtain hydraulic thrust by multiplying the thrust factor (K-factor) by the pressure differential across the impeller measured in feet (total dynamic head of the pump) and times the specific gravity of the liquid being pumped. The K-factor is shown on each performance curve. It is either estimated by analyzing the geometry of the impeller or determined by test.

Hydraulic Thrust = K x TDH x S.G.

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DEAD WEIGHT

In addition to the hydraulic thrust produced by the impeller, the dead weight of the impellers and the entire shaft assembly weight are acts downward. The shaft assembly weight is calculated by multiplying the length of the column assembly times the weight of the shaft per foot from table on page 200.B2. The bowl assembly shaft and the head shaft weights are usually insignificant. The total impeller weight equals impeller weight from impeller data page (page 10 of this Section.) times the number of stages.

SHAFT THRUST

Shaft thrust occurs because different pressures act on the different places on the shaft assembly. Suction pressure pushes up on the bottom of the bowl assembly shaft. Discharge pressure pushes down on the bowl assembly shaft where it is turned down to couple to the lineshaft. Since the top of the shaft assembly is pushed down only by the atmospheric pressure, up-thrust can occur where high suction pressure exists. The shaft up-thrust can be calculated as shown below:

Shaft Up-thrust   = Pump-Shaft Cross-Section Area X Suction Pressure
– Shaft Step Area X Discharge pressure

SLEEVE THRUST

Finally, there can be an upward force across a head shaft sleeve or mechanical seal sleeve. For most applications, these forces are small; however, when there is a danger of up-thrust or high suction pressure, these forces can be significant.

The sleeve up-thrust can be calculated by multiplying the sleeve area in square inches times the pressure differential across the sleeve.

Sleeve Up-thrust = Sleeve Area X Discharge Pressure

TOTAL PUMP THRUST

Total pump thrust is the sum of the component we discussed above:

Total Thrust = Hydraulic thrust (down)
+ Dead weight (down)
– Shaft thrust (up)
– Sleeve thrust (up)

Note that if total thrust is negative or in the up direction, the pump will not operate properly. Vertical turbine pump shaft will not run straight under compression. Something must be done to prevent operation at any point where up-thrust exist. A simple solution is to restrict the operation of the pump to flows where no up-thrust occur. Alternate solutions are to eliminate the shaft sleeve or try to reduce the pressure on the bottom of the shaft.

NOTE: If you are using a low NPSHR first stage, the impeller K-factor for the first stage will be different from the upper stages. You will need to do separate calculations for the first stage and add to the calculation for the additional stages.

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