Run Times
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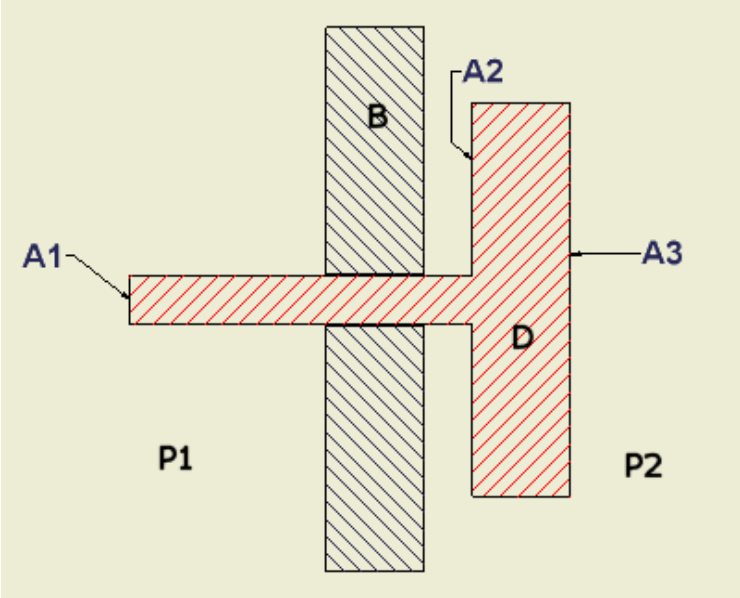
Centrifugal pumps experience axial loads that result from unbalanced hydraulic forces acting on the impeller. The severity of the axial load is largely dependent on suction pressure, mechanical configuration and the pressure differential present in the stage.

Dale B. Andrews



The sketch at left depicts a simple disc and shaft(D) that penetrates a pressure boundary(B) that separates two different pressures P1 and P2 acting on areas A1, A2 and A3. The axial thrust acting on disk (D) will be the sum of the opposing forces (F_A) where:

$$F_A = (P1 \times A1) + (P2 \times A2) - (P2 \times A3).$$

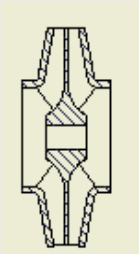
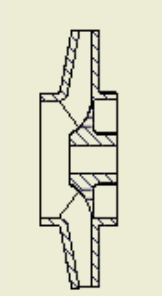
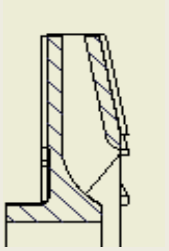
If P1 is at atmospheric pressure, use of gage pressure at P2 will negate the effect of P1, dropping out that term, and the equation becomes:

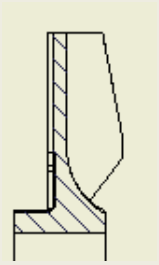
$$F_A - (P2 \times A2) - (P2 \times A3) \quad \text{or}$$
$$P2 \times (A2 - A3)$$

Of course, impellers have a more complex geometry than a simple disc. They have many exposed surfaces, subject to many different localized pressures that are not easy to measure. With impellers, axial thrust is not only a function of static pressure as shown in the example above, but also the hydraulic pressure differential generated by the impeller itself.

Selecting the appropriate impeller style for a pump always involves trade-offs between desired features. For instance, in a low-head application a semi-open impeller may be a good choice due to its higher efficiency and solids handling capability. In a higher head application however, an enclosed impeller might be more reliable than a semi-open impeller from an axial thrust standpoint. Below is a comparison of impeller styles relative to axial thrust characteristics.

IMPELLERS – FROM LOWEST AXIAL THRUST CONFIGURATION TO HIGHEST

	Description/Advantages	Disadvantages
	**Double Suction impellers** are designed to be inherently hydraulically balanced. They are characterized by their symmetrical design such that all opposing surfaces are exposed to counterbalancing forces. Double suction pumps have excellent NPSHR characteristics due to the dual inlets and the resulting larger eye area.	The flow passages are smaller than other impellers of the same capacity, limiting solids passing capability. The casings are more complex and tend to be more expensive than a comparable end suction configuration.
	**Single suction enclosed impeller w/wear rings** use balance holes arranged in a circular pattern inboard of close running wear rings to balance the pressure between the front and back side of the impeller. In most designs this method is 90+ percent effective at balancing hydraulically generated thrust. Single suction is a simpler design than the double suction, and is reasonably efficient if there are no abrasive solids present.	Abrasive wear will rapidly increase the wear ring clearance and relief hole diameters with a corresponding head and efficiency loss. The pump will have to be removed from service because of worn rings long before the impeller vanes have worn out.
	**The single suction enclosed impeller with pump out (repelling) vanes** is designed specifically for handling abrasive slurries. The pump-out vanes act like impellers to impede recirculation and reduce pressure along the shrouds. In abrasive environments this impeller will typically outlast a wear ring impeller by a 3 to 5 factor, while maintaining nearly constant efficiency over the impeller's useful life.	The potential for axial thrust is somewhat higher and "out of the box" efficiency is lower than for an impeller with tight fitting wear rings and relief holes. The axial thrust levels are typically not unreasonable for a properly designed impeller.
	**Open Impellers** have a single back shroud that is removed to the extent possible to still sufficiently support the impeller blades. The shroud removal eliminates surface area on which thrust forces can act, and has the added benefit of removing weight from the impeller. Open impellers are commonly found in horizontal process pumps. Open impellers are efficient and handle solids reasonably well.	Open impellers are not considered the best choice for abrasive services because they rely on tight running vane clearances for efficiency. Suction lift is more limited on vertical pumps with open impellers than with other styles.

	**Semi-open impellers with pump out vanes** are often applied on vertical sump applications where an open impeller would be inappropriate, and solid passing capability would be problematic for an enclosed impeller. Semi-open impellers have higher efficiency than enclosed impellers.	Semi-open impellers are inherently thrust imbalanced. The back full shroud is exposed to impeller exit pressure and the front of the impeller has a pressure gradient extending from the eye to the impeller exit. Use of pump-out vanes can alleviate the thrust somewhat, but the effectiveness is limited. Relief holes may also be added. Semi open impellers that are smooth on the back shroud are the worst from the standpoint of axial thrust management.

Multistage Pumps

Enclosed impellers are most often used in multistage pumps because they are less susceptible to tolerance stack-up within the stages during assembly. Axial thrust in a multistage pump is additive in each stage. It is a common design practice to oppose half of the impellers or install some form of thrust balancing device on the rotor.

In addition to hydraulically generated axial thrust, vertical pumps have to contend with the rotor weight, which can be substantial on a large pump. While some vertical multistage pump designs attempt to hydraulically counter-balance the mechanical loads, many vertical multistage pumps are often designed without any counter- balancing provision.

In Closing

Impeller selection should be made to obtain the best performance and the lowest lifecycle cost. Any of the impellers discussed in this newsletter are available for most pump applications. The choice of an impeller design should not be an arbitrary one. The advantages and disadvantages should be weighed with a perspective of the application requirements to make the best selection.