Run Times
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For any given set of application requirements a pump buyer usually has a choice of more than one operating speed. In this month's issue we will present some of the factors that should be considered when choosing between a faster or slower direct drive pump.

Dale B. Andrews
Dale B. Andrews – Editor

For the purpose of this article we arbitrarily chose a duty point of 500 GPM at 250 ft of Total Dynamic Head (TDH).[1] We used one of many pump selection softwares available on the internet to choose two pumps manufactured by the same manufacturer; one pump curve was based on 3480 rpm operation, the other based on 1740 rpm. Both pumps were at approximately 85% of their best efficiency point. Table 1 provides relevant information on the selections.

TABLE 1

	Pump 1	Pump 2
Flow (USGPM)	500	500
TDH (Ft.)	250	250
Speed	1740	3480
Imp. Dia. (in.)	15.75	8
Efficiency (%)	67	78
Power (1.0 sp.gr)	47	41
NPSHR (Ft)	10.8	12.2
Casing	Volute	Volute
viscosity - N/A	-	-
No. of Vanes	7	6
Vane width (in.)	0.43	1.22
Eye Diameter (mm)	128	124
NS	619	1238
Nss	6531	11920

The first thing to note is the impeller diameter. Faster pumps require smaller impeller diameters to achieve the same TDH. It's not the diameter that determines the centrifugal action of the impeller but the peripheral speed of the impeller. In this instance both pumps have a tip speed of about 120 ft/sec.[2] Consequently, the same TDH is achieved with about half the diameter and, coincidently, half the casing size. This makes for a much less expensive pump.

Another bonus is the efficiency. The higher speed pump bests the slower unit by 11 points, or six hp. Using an electric rate of $0.05/kWh yields a $1,500 annual power savings at 85% utilization. The higher efficiency is primarily due to the lower disc friction losses from the smaller diameter impeller. Note the higher specific speed of the higher speed pump.[3] The disc friction penalty is substantial on low specific speed impellers that are characterized by low flows and large diameters.

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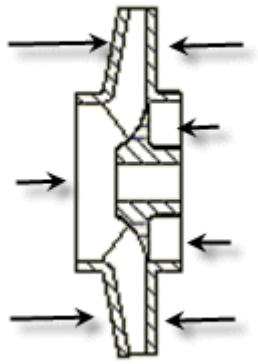
[1] For an explanation of TDH please see our July 2006 Newsletter.
[2] Tip: To calculate tip speed (π*D*n/720) where D is in inches and n equals rpm.
[3] Our September 2004 newsletter covers efficiency losses relative to specific speed.



An added concern is thrust forces. Axial thrust is a force caused mainly by the differences in pressure that exist between the suction side and discharge side of an impeller**.** Whether axial force is a concern is largely dependent on impeller design.[4] In the present example, the impellers are enclosed with front and back seal rings. If well designed, axial thrust, in the absence of a high suction pressure or abrasive solids, is probably not a great concern. However, if this were a semi-open style impeller with a full back shroud and no front shroud, a design common on many vertical pumps, axial thrust would be about four times higher on the slower speed larger diameter impeller.

So far, it looks pretty good for that high speed pump. It has a lower cost, it's more efficient, and in a horizontal configuration, has no major problem with axial thrust. NPSHR doesn't look too bad either, being slightly higher at 12.2 feet with the higher speed pump and 10.8 feet in the lower speed pump. But now look at the suction specific speed. It's almost 12,000 for the higher speed unit versus 6500 for the slower unit. Suction specific speed is a first order consideration when selecting a centrifugal pump. It is an indicator of the sensitivity of the pump to cavitation problems during off design operation. Pumps with suction specific speeds greater than 10,000 tend to have more maintenance and operational problems than those that have lower suction specific speeds. High suction specific speed pumps are especially sensitive to off–design operation. This pump would likely be a problematic choice for any application where flow is likely to be variable.

Radial thrust is also an area for concern. Radial thrust results from a pressure gradient that exists at along the circumference of an impeller as fluid exits into the casing section. This pressure gradient acts on the exposed width of the impeller creating a force that deflects the shaft away from its static position. Radial thrust is a function of impeller diameter, width, and the net pressure distribution. The net pressure distribution varies with casing style, but in general tends to increase with Ns.[5] In this case the higher speed pump would have a higher side thrust that would be a multiple of the radial thrust exerted on the lower speed pump. If bearings are the same size, bearing life of high speed will be closer to 1/3 that of the low speed. However, in many cases higher speed pumps have smaller bearings, which will further decrease bearing life.

A final consideration worth mentioning is solids. If the pump is going to be exposed to abrasive solids, the higher speed pump will wear at a higher rate than its lower speed counterpart. A rule of thumb[6] is that as speed changes in a pump wear will increase exponentially as a function of the speed ratio [(speed ratio)$^{2.5\text{-}3.0}$]. Although the impellers have the same peripheral speed, the higher speed impeller and casing surfaces are more

[4] Our April 2008 newsletter provides a comparison of axial thrust capabilities for various impeller styles.
[5] For more information on the subject see ANSI/HI 1.3 Rotodynamic (Centrifugal) Pumps for Design and Application.
[6] ANSI/HI standard 12.1-12.6 (2005)

heavily loaded. Just like applying increased force against a grinding wheel will increase the rate of material removal, so does increasing the force against an impeller vane or casing surface. Furthermore, a pump equipped with wear rings will rapidly lose both its efficiency and possibly its thrust balance as a result of abrasive wear.

Higher speed pumps are a viable and cost effective option for many pump applications. A word of caution though; not unlike race cars, high speed and high performance demand smooth roads and experienced handling, else frequent and costly crashes are likely to occur.