Run Times
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The ideal centrifugal pump would operate reliably over its entire curve, be very efficient, be low cost and require little NPSH. These can sometimes be conflicting objectives that involve trade-offs between operating performance, cost and reliability.

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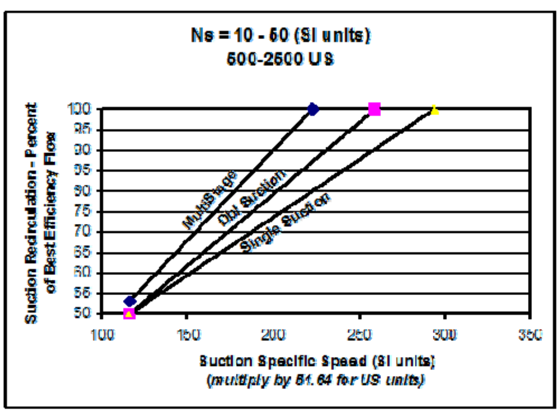
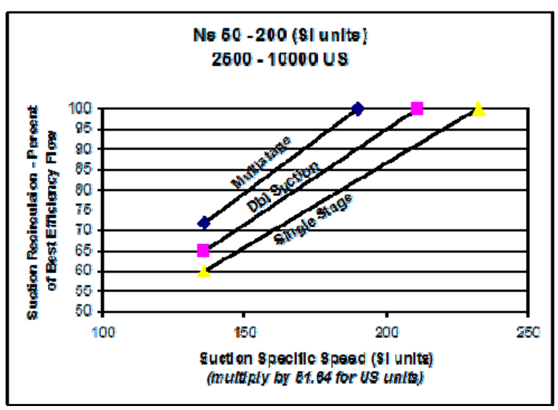
Operating Range

A centrifugal pump is designed to operate at a single operating point, the best efficiency point (BEP). At the best efficiency point the angle of the impeller blades in the impeller eye closely matches the angle of the approaching flow, and recirculation within the pump is at its minimum level. Operation at any point, other than best efficiency point flow, results in an increase in internal recirculation. Internal recirculation causes efficiency to diminish on either side of the best efficiency flow rate. The most common form of recirculation, often referred to as 'leakage' by designers, travels from the volute/diffuser along the casing walls, past the wear rings, back to the impeller eye. As pump operation moves further away from the BEP, the amount and severity of recirculation will increase and, at some point, the pump will also experience the onset of suction or discharge recirculation. Suction and discharge recirculation is recirculation between the inlet, or respectively the volute, and the confines of the impeller blades. Every pump has an operating point at which suction recirculation will occur, and a point where discharge recirculation will occur. The extent of damage that may occur from operating in these recirculation zones is dependent on the fluid pumped, the speed of the pump and the power density level present.

Damage to the impeller may result from cavitation that is independent of the net positive suction head available (NPSHA). A recirculation vortex will often have a significantly low, localized, pressure at its eye so as to enable the onset of cavitation, even at the impeller discharge.[1] If solids are present, off-BEP operation will decrease the wear life of both the impeller and wear rings due to increased recirculation velocities. The charts below are adaptations of charts developed by Fraser[2] for safe operating ranges established for pumps operated away from BEP.





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[1] Last months issue, April 2007, presents a more detailed discussion on the topic of discharge recirculation.

[2] Flow Recirculation in Centrifugal Pumps, Warren Fraser, Worthington Pump Company, ASME 2002

Efficiency and NPSHR

As mentioned at the beginning of this article, optimum flow through a centrifugal pump is determined by the design of the pump inlet. Every centrifugal pump has a best efficiency point. The level of efficiency attainable is partly determined by the impeller eye design. The impeller inlet design is also a major determining factor of NPSHR. However, the inlet design that yields the best NPSHR is not the inlet that yields the best efficiency. Pumps that are designed for lower NPSHR generally have a larger eye than an impeller designed for optimum efficiency.

Increasing the eye diameter of an impeller for lower NPSHR will result in a correspondingly larger suction specific speed. High suction specific speed pumps are prone to reliability problems. In recognition of the inherent problems associated with high suction specific speed pumps, many purchasers routinely specify that centrifugal pumps should not exceed a suction specific speed of 194 (10,000).

Low cost

Cost is among the decisions that a purchaser makes. For a specific set of hydraulic conditions and pump stages, the required impeller diameter will vary directly with the operating speed. A centrifugal pump operating at higher speeds will, in most cases, cost less than it's lower speed counterpart. The pump will be smaller in diameter, have thinner casing walls, smaller diameter mechanical seals, and take less time to manufacture. In an environment of "lowest cost that meets the specification" procurement, the higher speed, lower cost pump is often appealing. However, there is a trade-off in reliability that, in some circumstances, will have a dramatic negative impact on the reliability related ownership costs over the lifespan of the equipment.

Higher speed pumps are also higher wear pumps when solids are present. Wear will increase by a exponential factor of about 2.5 applied to the relative velocity difference between two pumps of similar materials in the same application. A pump with twice the relative velocity will have a wear rate of about $2^{2.5}$ or over 5x the wear rate of a lower velocity unit.

Higher speed pumps with identical NPSH requirements are also higher suction specific speed pumps. A significant portion of mechanical seal failures, bearing failures, and wear problems are related to cavitation and off-design operation. Taken as a group, high suction specific speed pumps will account for more pump problems than their lower suction specific speed counterparts.

In closing, every pump application should be evaluated; giving priority to the most critical desired attributes. Standard operating conditions and upset conditions should be clearly differentiated, identified as such, and communicated to the pump manufacturer. The pump should be a part of a new process design and not the result of one. Once a mistake is installed it is very difficult, if not impossible, to change, and is always more expensive.