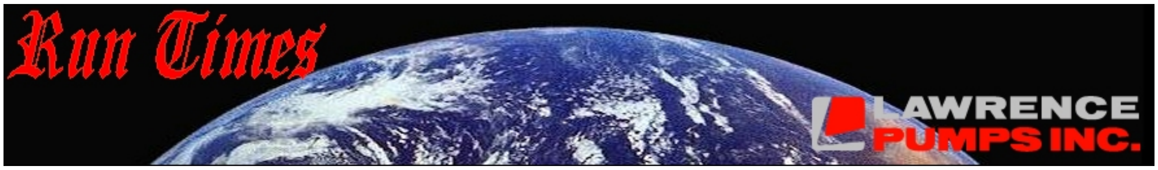


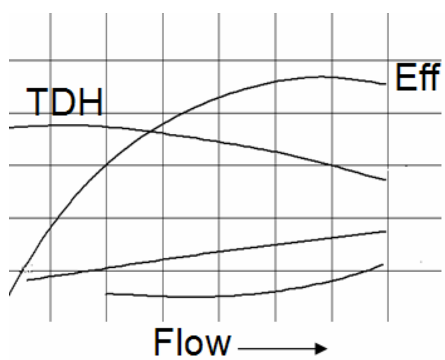
April 2007 vol.4_iss 4

The Suction side of a pump is not the only part of a pump that can be damaged by cavitation and recirculation. Discharge cavitation damage is less prevalent, but its effects can be equally damaging.

When most pump users talk about cavitation, they are referring to the classic condition where the total available suction head (NPSHA) falls below the vapor pressure of the pumped fluid. The rapid collapse of the resultant vapor pocket causes noise, vibration and results in damage to the adjacent impeller blade.

While it's true that cavitation is the result of local pressure that falls below the vapor pressure of the pumped fluid, the cause of the localized low pressure may be independent of the suction head available at the inlet of the pump. Cavitation may also occur as a result of low pressures in regions of turbulent flow.

The image at the left shows turbulence that occurs around a wing in an airstream. Turbulence is a complex subject, the mechanics of which are still not fully understood. Turbulence is characterized by chaotic changes in fluid flow that occur as a result of shearing forces between adjacent streamlines or boundary layers. Whenever fluid streams of different velocities merge, shear occurs due to friction between the fluid streamlines. At the risk of over-simplification, think of a grocery cart as a fluid streamline, and a broken wheel as drag on one side of that streamline. The combination of the cart's momentum and the uneven drag causes the cart to turn. A fluid stream reacts in similar fashion, turning inward on itself, forming a vortex. Pressures at the center of fluid vortices can be low enough for pump cavitation even in regions of relatively high pressure, such as in the volute or at the impeller outlet.



At right is a typical pump curve showing efficiency rising from zero to the best efficiency point and falling away again. If drawn to the maximum run-out flowrate, the efficiency curve would intersect the baseline at zero TDH and efficiency. The lower efficiency at off BEP conditions reflects energy consumed by recirculation and its consequential heat, vibration, and noise. This recirculation can create zones of high fluid shear, with resultant vortices and cavitation. The amount of recirculation is related to the distance the pump is operating from BEP and the energy available for damage is related to the kinetic energy within the pump. High energy pumps have more energy available to do damage off design than low energy pumps.

Discharge recirculation occurs when high pressure flow streams re-enter the impeller on the low pressure side of the impeller vane. This is caused by the pump operating back on its curve or with an inlet restriction. The reverse flow within the impeller passage shears across the outgoing flow, sets up vortices along the pressure wall of the impeller, and causes cavitation along the pressure wall and shrouds adjacent to the impeller outlet.

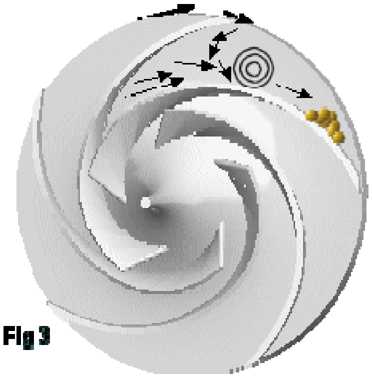
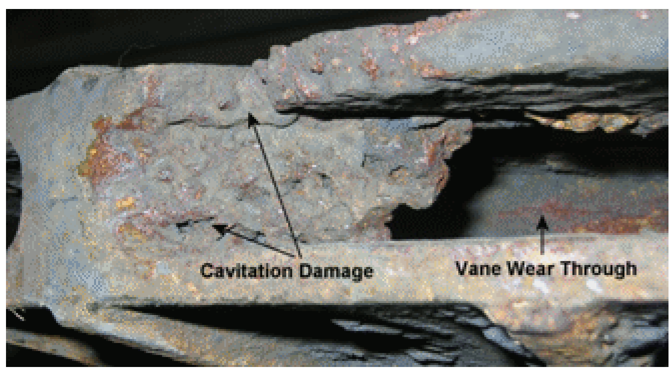


Fig 3

The photograph below is of an impeller from a pump recently returned for repair. The cavitation craters are evident at the pressure side blade tips and the adjacent shroud. Each vane has worn through on the pressure side along a section extending between 70% and 85% of the impeller diameter. The impeller was in a slurry service and the large holes in the vanes are most likely accelerated wear due to the internal turbulence. Note the almost pristine condition of the vane trailing edge at the far left of the photograph. Normal wear for a slurry pump impeller would be the evolution of knife-edge shrouds and blade tips, with the blades eroding back from the blade tips back toward the impeller eye.



This phenomenon can also manifest itself at the volute cutwater and can occur at both high and low flow conditions. Off design operation causes a high velocity wake to pass in the gap between the impeller and the cutwater. Cavitation occurs in the turbulent zone around the cutwater and is distinguishable by visible craters at the cutwater. Pumps designed with the maximum impeller diameter too close to the cutwater often experience noticeable noise and vibration at blade passing frequency related to the shock wave generated by the impeller blade impacting the high velocity wake zone.

Pumps operating off-design for extended periods are subject to increased operating costs and mechanical failure. The conditions that a pump is designed for are not necessarily the same operating conditions it will be exposed to 10-15 years later. A re-rate of an impeller can be worthwhile on large equipment and should be considered as a part of equipment life cycle cost management.

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