Cavitation Surge in Pumps

In many installations involving a pump that cavitates, violent oscillations in the pressure and flow rate in the entire system can occur when the cavitation number is decreased to a value at which the volume of vapor bubbles within the pump becomes sufficient to cause major disruption of the flow and therefore a decrease in the total pressure rise across the pump (see section (Nkh)). While most of the detailed investigations have focused on axial pumps and inducers (Sack and Nottage 1965, Miller and Gross 1967, Kamijo *et al.* 1977, Braisted and Brennen 1980) the phenomenon has also been observed in centrifugal pumps (Yamamoto 1991). In the past this surge phenomenon was called *auto-oscillation* though the modern term *cavitation surge* is more appropriate. The phenomenon is described in detail in Brennen (1994). It can lead to very large flow rate and pressure fluctuations. For example in boiler feed systems, discharge pressure oscillations with amplitudes as high as 14 *bar* have been reported informally. It is a genuinely dynamic instability in the sense described in section (Nrh), for it occurs when the slope of the pump total pressure rise/flow rate characteristic is still strongly negative and the system is therefore quasistatically stable.

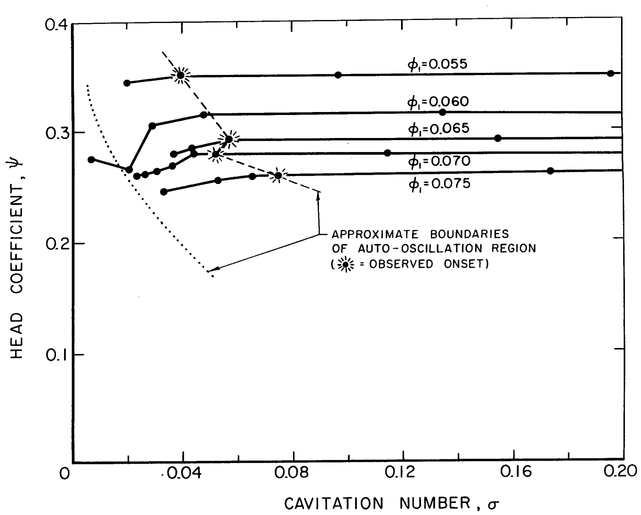

Figure 1: Cavitation performance of a SSME low pressure LOX pump model showing the approximate boundaries of the cavitation surge region for a pump speed of 6000 *rpm* (from Braisted and Brennen 1980). The flow coefficient, ϕ_1, is based on the impeller inlet area.

As previously stated, cavitation surge occurs when the region of head loss is approached as the cavitation number is decreased. However, since the onset is sensitive to the detailed dynamic characteristics of the system, it is not possible to quote any approximate guideline for onset. Current understanding is that the methodologies of Sections (Nrk) to (Nrm) are essential for any prediction of cavitation surge. Unlike compressor surge, the frequency of cavitation surge, Ω_A, scales with the shaft speed of the pump, Ω (Braisted and Brennen 1980). The ratio, Ω_A/Ω, varies with the cavitation number, σ (see equation (Nkh2)), the flow coefficient, ϕ (see equation (Nkh1)), and the type of pump. See Section (Mbfg) for further details.