Rotating Cavitation

Inducers or impellers in pumps that do not show any sign of rotating stall while operating under noncavitating conditions may exhibit a superficially similar phenemenon known as "rotating cavitation" when they are required to operate at low cavitation numbers. However, it is important to emphasize the fundamental difference in the two phenomena. Rotating stall occurs at locations along the head-flow characteristic at which the blades may stall, usually at flow rates for which the slope of the head/flow characteristic is positive and therefore unstable in the sense discussed in the next section. On the other hand, rotating cavitation is observed to occur at locations where the slope is negative. These would normally be considered stable operating points in the absence of cavitation. Consequently, the dynamics of the cavitation are essential to rotating cavitation. Another difference between the phenomena is the difference in the propagating speeds.

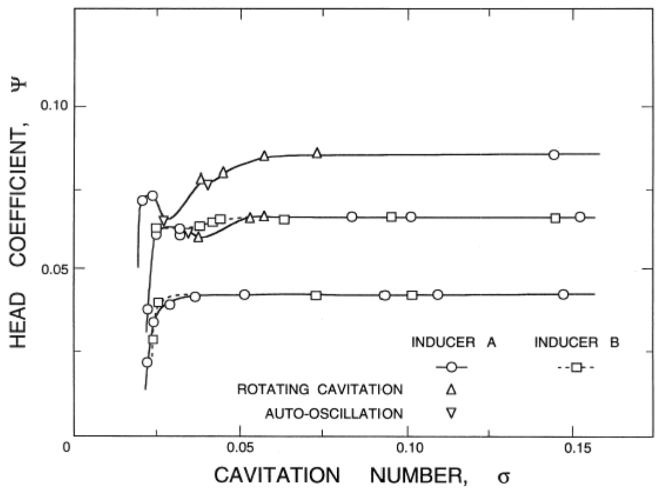

Figure 1: Occurrence of rotating cavitation and auto-oscillation in the performance of the cavitating inducer tested by Kamijo *et al.* (1977).

Rotating cavitation was first explicitly identified by Kamijo, Shimura and Watanabe (1977) (see also 1980), though some evidence of it can be seen in the shaft vibration measurements of Rosemann (1965). When it has been observed, rotating cavitation generally occurs when the cavitation number, σ, is reduced to a value at which the head is beginning to be affected by the cavitation as seen in figure 1 taken from Kamijo *et al.* (1977). Rosenmann (1965) reported that the vibrations (that we now recognize as rotating cavitation) occurred for cavitation numbers between 2 and 3 times the breakdown value and were particularly evident at the lower flow coefficients at which the inducer was more heavily loaded.

Usually, further reduction of σ below the value at which rotating cavitation occurs will lead to auto-oscillation or surge (see below and figure 1). It is not at all clear why some inducers and impellers do not exhibit rotating cavitation at all but proceed directly to auto-oscillation if that instability is going to occur.

Unlike rotating stall whose rotational velocities are less than that of the rotor, rotating cavitation is characterized by a propagating velocity that is slightly larger than the impeller speed. Kamijo *et al.* (1977) (see also Kamijo *et al.* 1992) observed propagating velocities $\Omega_{RC}/\Omega \approx 1.15$, and this is very similar to one of the somewhat ambigous propagating disturbance velocities of 1.1Ω reported by Rosemann (1965).

Recently, Tsujimoto *et al.* (1992) have utilized the methods of section (Gbc) to model the dynamics of rotating cavitation. They have shown that the cavitation compliance and mass flow gain factor (see section

(Gbcj)) play a crucial role in determining the instability of rotating cavitation in much the same way as these parameters influence the stability of an entire system which includes a cavitating pump (see section (Gbch)). Also note that the analysis of Tsujimoto *et al.* (1992) predicts supersynchronous propagating speeds in the range $\Omega_{RC}/\Omega = 1.1$ to 1.4, consistent with the experimental observations.