Attached or Sheet Cavitation

Another class of large-scale cavitation structures is that which occurs when a wake or region of separated flow fills with vapor. Referring back to the figure in section (Nte), we note that Kermeen (1956) only observed dense traveling bubbles when the angle of attack was small. At angles of attack greater than about 10° (or less than about -2°) cavitation occurred as a single vapor-filled separation zone as illustrated in Figure 1. This form of cavitation on a hydrofoil or propeller blade is usually termed "sheet" cavitation; in the context of pumps it is known as "blade" cavitation.

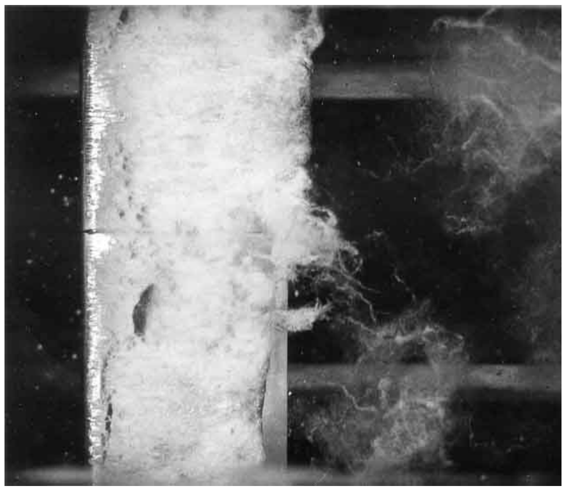

Figure 1: Sheet cavitation on the suction surface of a NACA 4412 hydrofoil at an angle of attack of 12°, a speed of 10.7 m/s and a cavitation number of 1.05 (Kermeen 1956). The flow is from left to right.

Bluff bodies often exhibit a sudden transition from traveling bubble cavitation to a single vapor-filled wake as the cavitation number is decreased. An example is shown in Figure 2 which includes two photographs of a cavitating sphere; the transition occurs when the bubbly wake in the picture on the left suddenly becomes a single vapor-filled void as seen in the picture on the right. In the context of bluff bodies, a vapor-filled wake is often called a "fully developed" or "attached" cavity. Clearly sheet, blade, fully developed, and attached cavities are terms for the same large-scale cavitation structure.

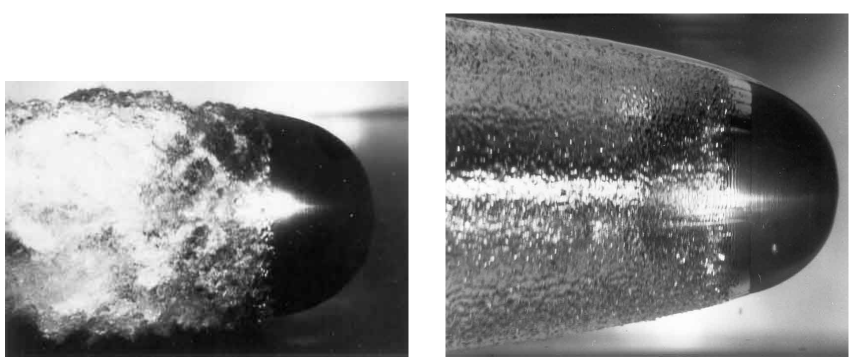

Figure 2: Two photographs of a cavitating, 7.62 cm diameter sphere. The left photographs shows bubble cavitation and bubbly wake prior to the transition to the fully developed cavity shown on the right (Brennen 1970). The flow is from right to left, the velocities being 5.6 m/s and 10.7 m/s, respectively.

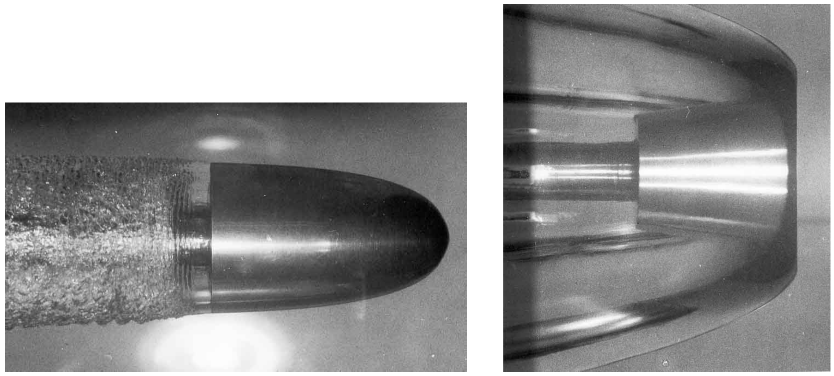

Figure 3: Two fully developed cavities on a 5.95 cm diameter ogive (left) and a 7.62 cm diameter disc (right) set normal to the oncoming stream (Brennen 1970). The flow is from right to left and the velocities are 7.62 m/s and 10.7 m/s, respectively.

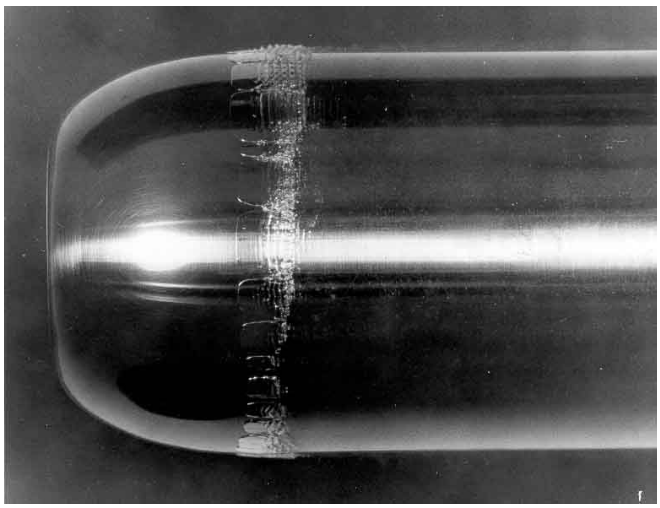

Figure 4: Sheet cavitation on the ITTC headform. The flow is from left to right with a speed of 12.2 m/s and a cavitation number of 0.424. Reproduced with the permission of A.J. Acosta.

When a sharp edge provides a clean definition for the leading edge of a fully developed cavity, the surface of that cavity is often glassy smooth since the separating boundary layer is usually laminar. This initially smooth surface can be seen in the right-hand photograph of Figure 2 and in the photographs of Figure 3. Depending on the shape of the forebody the interfacial boundary layer may rapidly undergo transition to a turbulent interfacial layer, as is the case in the photograph of the cavitating ogive in Figure 3 and the cavitating sphere in the photograph on the right of Figure 2. For other headforms transition may be delayed almost indefinitely, as in the case of the cavitating disc of Figure 3 (see Brennen 1970).

When there is no sharp edge to initiate a fully developed cavity, several different phenomena may occur. Cavitation separation may still occur along a well-defined and stable line on the body surface, as exemplified by the photograph on the right in Figure 2. Or the separation line may be interrupted, as in the photograph of Figure 4. For example, such a scalloped leading edge is typical of cavitation in bearings (Dowson and Taylor 1979).

Other forms of developed cavitation can be strikingly different from that of Figures 3 or 4. Sometimes the cavities occur as streaks, as exemplified by the photograph in Figure 5 of cavitation on the surface of a biconvex hydrofoil (Arakeri 1975). Again a tranverse periodicity appears to occur in which one can envisage that the expansion of the flow in the streamtubes containing cavities results in an increase in the pressure in the fluid in between these cavitating streamtubes and therefore inhibits further lateral

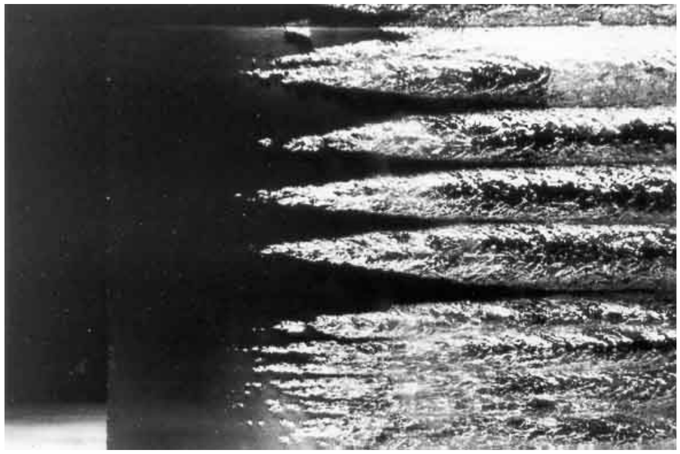

Figure 5: Streak cavitation on a biconvex hydrofoil at a speed of 15.5 m/s and a cavitation number of 0.11 (Arakeri 1975). The flow is from left to right and the leading edge of the foil is about 1 cm from the left-hand edge. Reproduced with the permission of V.H. Arakeri.

spreading of the cavitation. Currently there does not appear to be any clear understanding of the reason for the transverse periodicity of Figures 4 and 5.