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PUMP CLINIC 3

What is Recirculation and Separation?

There is a small flow from impeller discharge to suction through the wearing rings and any hydraulic balance device present. This takes place at all capacities but does not usually contribute to raising the liquid temperature very much unless operation is near shut-off.

When the capacity has been reduced by throttling (or as a result of an increase in system head), a secondary flow called recirculation begins. Recirculation is a flow reversal at the suction and/or at the discharge tips of the impeller vanes. All impellers have a critical capacity at which recirculation occurs. The capacities at which suction and discharge recirculation begin can be controlled to some extent by design, but recirculation cannot be eliminated.

Suction recirculation is the reversal of flow at the impeller eye. A portion of the flow is directed out of the eye at the eye diameter, as shown in *Figure 1 Page 1* and travels upstream with a rotational velocity approaching the peripheral velocity of the diameter. A rotating annulus of liquid is produced upstream from the impeller inlet and through the core of this annulus passes an axial flow corresponding to the output capacity of the pump. The high shear rate between the rotating annulus and the axial flow through the core produces vortices that form and collapse, producing noise and cavitation in the suction of the pump.

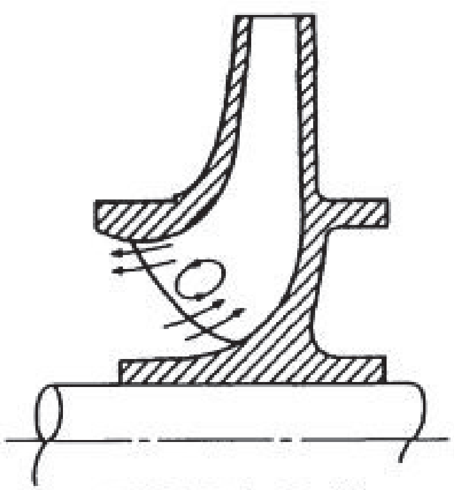
FIGURE 1 - Suction Recirculation

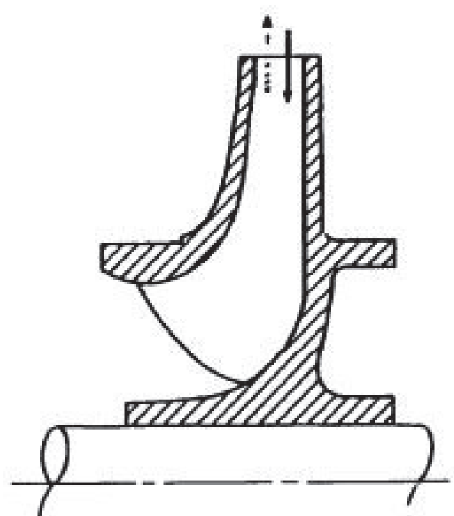
FIGURE 2 - Discharge Recirculation

Discharge recirculation is the reversal of flow at the discharge tips of the impeller vanes, as shown in *Figure 2 Page 1.* The shear rate between the inward and outward relative velocities produces vortices that cavitate and usually attack the pressure side of the vanes.

The capacity at which suction recirculation occurs is directly related to the design suction-specific speed ***S*** of the pump. The higher the suction-specific speed, the closer will be the beginning of recirculation to the capacity at best efficiency. *Figure 3 Page 2* shows the relation between the suction-specific speed and suction recirculation for pumps up to 2500 (1530) specific speed and *Figure 4 Page 2* shows the same relation for pumps up to 10,000 (6123) specific speed.

For water pumps, the minimum operating flows can be as low as 50% of the suction recirculation values shown for continuous operation and as low as 25% for intermittent operation. For hydrocarbons, the minimum operating flows can be as low as 60% of the suction recirculation values shown for continuous operation and as low as 25% for intermittent operation.

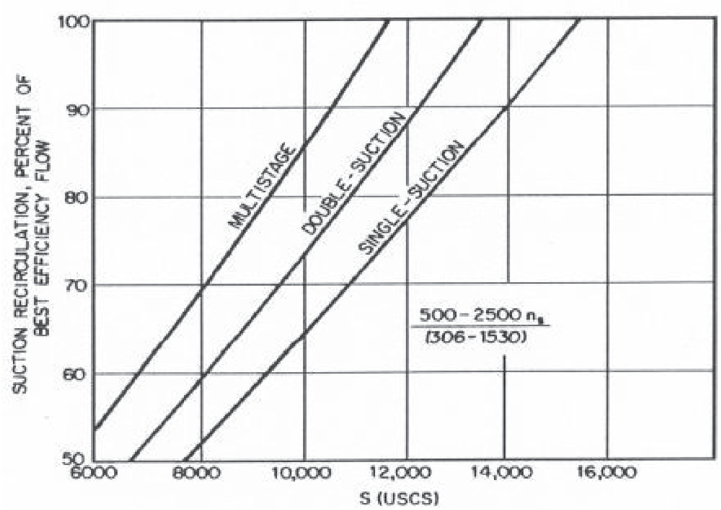

Figure 3: Suction-specific speed ***S*** at best efficiency flow, single suction or one side of double suction (to obtain ***S*** in ***SI*** units, multiply by 0.6123)

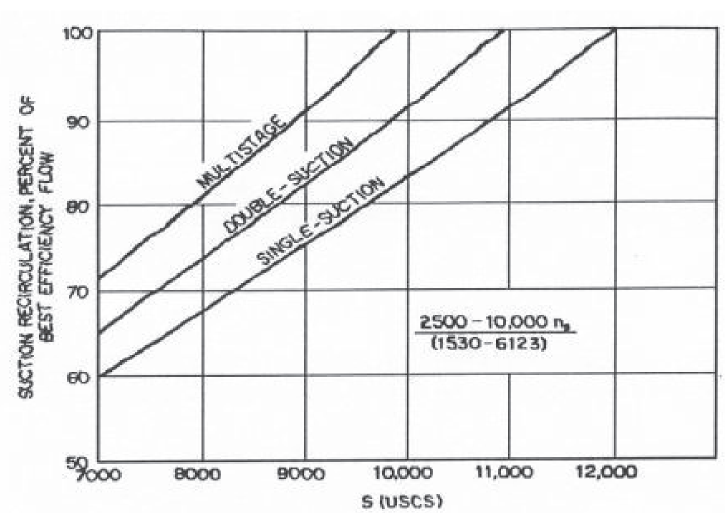

Figure 4: Suction-specific speed ***S*** at best efficiency flow, single suction or one side of double suction (to obtain ***S*** in ***SI*** units, multiply by 0.6123)

The high turbulence produced by recirculation and separation accounts for most of the high power consumed at shut-off. This may vary from about 30% of the normal power for pumps of very low-specific speed to nearly three times the normal power for propeller pumps. Separation and, possibly, cavitation may take place on the casing tongue or diffusion vanes at very low capacities. Operation near shut-off causes not only excessive heating, but also vibration and cavitation, which may cause serious mechanical damage.

Diagnosis of Suction and Discharge Recirculation

Cause and Effect: Recirculation occurs at reduced flows and is the reversal of a portion of the flow-back through the impeller. Recirculation at the inlet of the impeller is known as suction recirculation. Recirculation at the outlet of the impeller is discharge recirculation. Suction and discharge recirculation can be very damaging to pump operation and should be avoided for continuous operation.

Diagnosis From Pump Operation: Suction recirculation will produce a loud crackling noise in and around the suction of the pump. Recirculation noise is of greater intensity than the noise from low NPSH cavitation and is a random knocking sound. Discharge recirculation will produce the same characteristic sound as suction recirculation except that the highest intensity is in the discharge volute or diffuser.

Diagnosis From Visual Examination: Suction and discharge recirculation produce cavitation damage to the pressure side of the impeller vanes. Viewed from the suction of the impeller, the pressure side would be the invisible, or underside, of the vane. *Figure 5 Page 3* shows how a mirror can be used to examine the pressure side of the inlet vane for cavitation damage from suction recirculation. Damage to the pressure side of the vane from discharge recirculation is shown in *Figure 6 Page 3.* Guide vanes in the suction may show cavitation damage from impingement of the back-flow from the impeller eye during suction recirculation. Similarly, the tongue or diffuser vanes may show cavitation damage on the impeller side from operation in discharge recirculation.

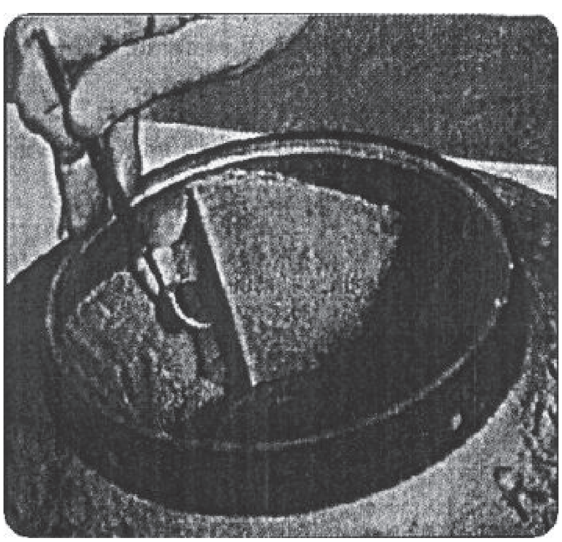

Figure 5: Examining the pressure side of the inlet vanes for suction recirculation.

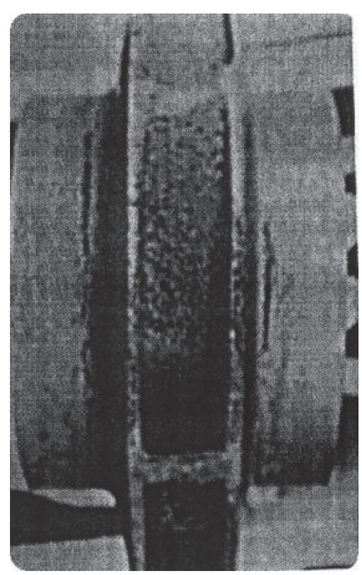

Figure 6: Damage to the pressure side of the vane from discharge recirculation.

Corrective Procedures: Every impeller design has specific recirculation characteristics. These characteristics are inherent in the design and cannot be changed without modifying the design. An analysis of the symptoms associated with recirculation should consider the following as possible corrective procedures.

1. Increase the output capacity of the pump.
2. Install a bypass between the discharge and the suction of the pump.
3. Bleed air into the suction of the pump to reduce the intensity of the noise, vibration and cavitation damage.
4. Substitute a harder material for the impeller to reduce the rate of cavitation damage.