

screen in the well with a suitable filter pack between the old screen and the new one, although the latter procedure may reduce the well yield somewhat.

Another cause of pump failure is cavitation. Cavitation usually results from not maintaining enough net positive suction head (NPSH) over that head specifically required by the manufacturer for proper operation of the pump. When negative pressure occurs, bubbles of vapor form near the impeller surfaces. Subsequent collapse of the vapor bubbles against the metal surfaces creates extremely high localized stresses that produce pitting of the impeller. Pumps must be run at flow rates close to their maximum efficiency, because flow paths taken by the water in the bowls at other rates lead to destruction of the impeller vanes.

To reduce cavitation effects, centrifugal pumps should be started under reduced or no flow conditions (Walker, 1980). If the pump continues to run under shut-off head conditions, however, the heat build-up may become excessive within a short time and cause the water in the bowls to boil. Any water in the column would be immediately displaced by steam; with no water lubrication, the shaft bearings and any sealing device would be severely damaged. Also, heat expansion of the pump shaft in a deep-well vertical turbine pump may reduce the impeller clearance in the bowls.

Corrosion of pump surfaces by chemically aggressive groundwater accounts for many pump maintenance problems. For example, galvanic cells can be set up between steel shafts and bronze impellers, producing nonuniform corrosion (Figure 19.13). A zinc-free bronze alloy is more resistant to waters with high carbon dioxide concentrations and low pH; use of this alloy will lengthen the serviceable life of the impellers (Clark, 1980).

Changes in flow direction and the compression of gas bubbles in the pump bowls leads to extensive corrosive effects and cavitation. Carbon dioxide contained in the

gas bubbles often produces local concentrations of carbonic acid ( $H_2CO_3$ ) around bubbles. This corrosion effect adds to the metal loss caused by the low pH and differential velocity (erosive) effects when the water changes directions in the pump bowl. Graphitization occurs frequently in cast-iron bowls when iron particles become the anodes in the galvanic process and graphite particles become the cathodes. Under low-pH conditions the iron goes into solution, leading eventually to a greatly weakened structure consisting mostly of graphite and the corrosion products of iron (Figure 19.14). Cast-iron bowls may be destroyed in as little as four years (Clark, 1980). Table 19.11, compiled from the records of many Australian wells, indicates the longevity of pump bowls and impellers, made from similar and mixed metals, in waters with varying pH.



Figure 19.13. Destruction of this pump shaft has been caused by the creation of galvanic cells between the steel shaft and the bronze impeller. (Bergerson-Caswell Inc.)