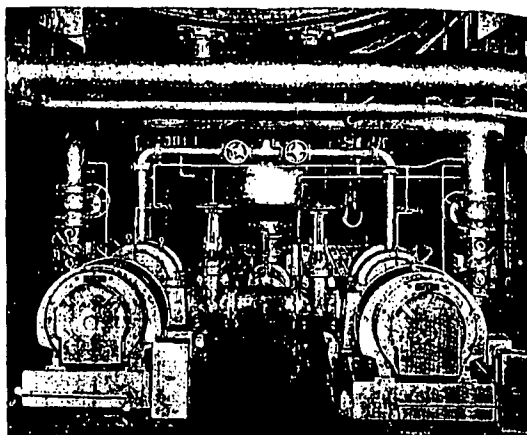


Here are the requirements for successful condensate-pump control by hotwell water level. Also given are the way pumps perform when their discharge is regulated by this means, as well as the advantages and disadvantages of control by submergence

By PIO NARDONE
Mechanical Engineer
Foster Wheeler Corp.



CONDENSATE-PUMP INSTALLATION. Two 2-stage centrifugal motor-driven condensate pumps are connected to the hotwell below the surface condenser serving a large steam turbine in a modern public-utility central-power generating plant

Suction Submergence Controls

► **CONDENSATE PUMPS** remove liquid from vessels under vacuum, such as steam-turbine condenser hotwells. Centrifugal pumps are generally used on these applications. Because of large load changes on the turbine, discharge rate of these pumps must be adjusted to maintain hotwell liquid level within safe operating limits. This can be done automatically by float or submergence control. The latter method is discussed in this article.

What is Submergence? Submergence is generally considered as being the difference in elevation between the hotwell level and the pump's center line (horizontal unit). This head, however, represents only approximately the energy available to deliver liquid to the impeller eye, when the pump is near the hotwell and connected directly by overize suction pipe. The true net positive suction head (npsH) at the pump's suction flange is the total available head (static plus velocity head) corrected to the impeller's center line above the vapor pressure at this point. Even though the term submergence, because of its popularity, is used hereafter, it should be borne in mind that npsH is the

criterion for successful pump operation.

Centrifugal pumps, as generally built, have a rising head-capacity characteristic like Fig. 1. At constant speed, as the discharge decreases the total dynamic head developed by the pump increases. For example, in Fig. 1 at 375 gpm the pump develops 275-ft head, point B, where at zero discharge the head is 350 ft, point A.

On the other hand, the total head required to cause the liquid to flow through the system decreases as the volume decreases. Again, in Fig. 1 at point C, the system head at 400 gpm equals 258 ft. At 300 gpm, system head drops to 163 ft, point D.

If flow from a centrifugal pump is not regulated there is only one condition where it will operate. This is the point where the system-head curve intersects the pump's head-capacity curve, point C, Fig. 1. At this point, head developed by the pump just overcomes the system resistance to the liquid delivered. At all lower capacities, head developed is greater than the system requires.

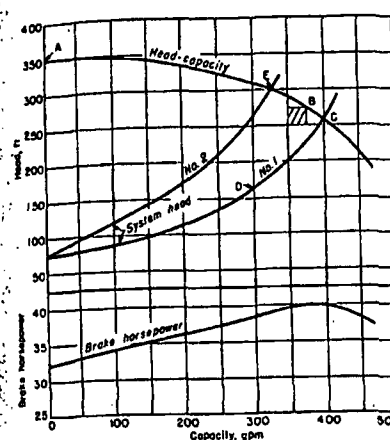
With many installations, it is neces-

sary at times to change the rate at which liquid flows through the system, which can be done by throttling the pump's discharge. This artificially increases the system head so that it crosses the pump's head-capacity curve at a lower capacity, as is done with system-head curve 2, which crosses the head-capacity curve at E.

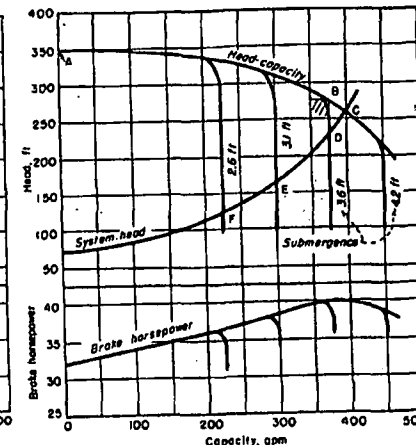
Capacity of the pump can also be reduced by bypassing some of the liquid discharged by it back to the suction. For condensate service we may use another method, known as submergence control—that is, control by the liquid level in the hotwell.

Submergence Control Operation. For successful operation of this control with a centrifugal pump a given submergence is required to cause a given quantity of liquid to enter the impeller. At this submergence the pump can deliver no more than this quantity.

At a given submergence and capacity the head developed by the pump decreases sharply because of partial evaporation of the liquid at the impeller eye. Point at which this drop in head occurs is known as the break. The head developed by the pump decreases



1 CHARACTERISTIC CURVES. Head-capacity, system-head and brake-horsepower curves for a centrifugal condensate pump. When pump discharge is decreased, its head increases



2 EFFECTS OF SUBMERGENCE. Head-capacity, system-head and brake-horsepower curves for a condensate pump which show how suction submergence determines discharge rate

Condensate-Pump Discharge

until it equals the system head at this capacity. Fig. 2 shows the characteristic curves for a pump with only a few break points indicated. There are, however, an infinite number of these points at which the pump can operate.

For a pump to operate properly with submergence control, it must be selected so the base head-capacity curve intersects the system-head curve at some capacity, point C, beyond the maximum flow desired, point B. If submergence at a desired maximum flow were sufficient, total head developed by the pump would be greater than the system head. The unit must be selected so maximum submergence available is greater than the submergence for operation at required capacity. Operation will be as follows:

Pump Operation. If a maximum flow of 375 gpm, point B, comes into the hotwell from the condenser and the submergence is 4.2 ft, the pump will operate at about 400 gpm, point C. Thus, the pump removes more water from the hotwell than the condenser adds to it. Hotwell level is lowered until the submergence is equal to 3.6 ft. At this submergence the pump becomes stabil-

ized and operates at point D. This is the point where the head-capacity curve (in the break region) crosses the system-head curve.

The pump then delivers just as much water as is added to the hotwell and the level remains constant. If the steam condensed decreases to where 300 gpm flows into the hotwell the pump temporarily continues to remove from it more water than is added until submergence decreases to 3.1 ft, when the two curves cross at E. The pump then becomes stabilized once more and the hotwell level remains constant at 3.1-ft submergence.

The reverse applies if the steam flow increases. Thus, stabilization takes place rapidly and for any steam flow to the condenser up to point C. At all times, therefore, the total head developed by the pump is equal to the system head and the pump delivers as much water as is added to the hotwell.

Note that a pump operating with submergence control always operates in the break regions or off the head-capacity curve. This is evidently so because the pump operates on the base

curve only at point C, which is greater than the maximum flow, or if the submergence were artificially maintained, greater than the amount required for any particular flow. For the latter, some type of float control would be required and throttle or bypass control would be necessary.

Main disadvantage of submergence control is that some vaporization of the liquid always accompanies operation in the break regions. Because of the rise in pressure these vapor pockets or bubbles collapse as they flow through the impeller. This action is accompanied by noise and in time by pitting and corrosion of the impeller passages. Undue bearing wear may also result from varying shock loads imposed when cavitation occurs (pump operating in the break region).

But power for operating in the break regions will always be less than that required along the base head-capacity curve ABC since the total dynamic head that the pump develops is less than indicated on this curve. This decrease in power and the elimination of external controls are the chief merits of submergence control.