Minimum Flow-Through Pump

The difference between the power put into a centrifugal pump and the useful power performed by the pump, or the difference between the brake and water horsepowers, is converted into heat, most of which appears as increased temperature of the water. The brake-horsepower curve of a pump rated at 500 gal/min against a 2600-ft head and the corresponding water-horsepower curve are shown in Fig. 8-18. If we neglect bearing losses, which are minor, the difference between these curves at any capacity represents the horsepower absorbed by the water in the form of heat. Multiplying these differences by 42.4 gives the Btu generated in the pump per minute. Dividing these values by the flow in pounds per minute gives the temperature rise at each capacity. This curve is plotted in Fig. 8-18.

This temperature rise is generally not important in single-stage pumps, particularly if they are handling cold water, but for pumps handling hot liquids, such as boiler-feed pumps, it may become a serious matter. Then the resulting rapid temperature rise may cause the internal rotating parts to expand more rapidly than the heavier encircling parts so that severe rubbing may occur, or the impeller may even become loose on the shaft. Also the temperature of the water may rise to a point at which the water flashes into steam, causing the pump to become vapor-bound.

The temperature rise in a pump may be calculated from the formula

$$\Delta t = \frac{(1 - \eta)H}{778c\eta}$$

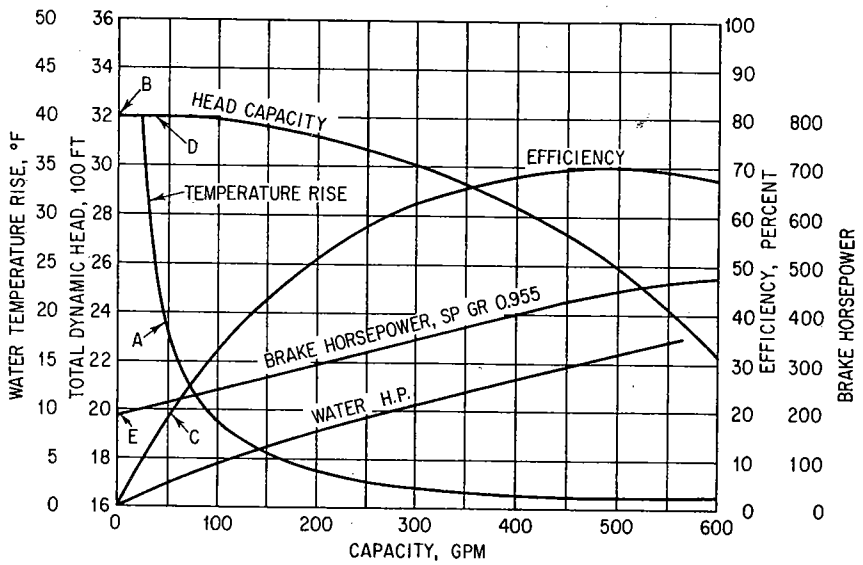


FIG. 8-18

where Δt = temperature rise, °F
η = overall pump efficiency, expressed as a decimal
c = specific heat of fluid being pumped (equals 1.0 for water)
H = total head of pump, ft

The allowable temperature rise of the water before it flashes into steam depends upon the suction conditions, or NPSH, of the pump. NPSH is the net head above the vapor pressure corresponding to the temperature of the liquid handled. As outlined in the subsection "Net Positive Suction Head, or NPSH," every installation has two types of NPSH: that available in the installation and that required by the pump. The maximum allowable vapor pressure at the pump inlet is found by converting the available NPSH into pounds per square inch and adding this to the vapor pressure corresponding to the temperature of the liquid being handled. This pressure is the vapor pressure corresponding to the temperature to which the liquid may be raised before it will flash into vapor.

After the allowable temperature rise has been established, an approximate minimum safe continuous-flow efficiency can be obtained by rewriting the previous equation in the form

$$\eta = \frac{H_{so}}{778(\Delta t)c + H_{so}}$$

where H_{so} = heat at no flow, or shutoff head
c = specific heat of liquid

The flow corresponding to this efficiency is found on the pump-performance curves.

In boiler-feed pumps having single-suction impellers, all facing in the same direction, a leak-off balancing arrangement is used to compensate hydraulic

thrust. If the balancing leak-off flow is returned to the suction of the pump, flashing can occur at extremely low rates of delivery. Therefore, the balancing flow is frequently piped to an open heater in the feed system of the pump, where, by flashing, the temperature of the water will be reduced to that corresponding to the pressure and there should be no valve of any kind between the junction of the balancing connection and the heater. Many installations do pipe the balance flow to the pump suction line.

With the advent of the larger, higher-energy boiler-feed pumps of the 1960s and 1970s, it became apparent that the higher vibration and pressure pulsations occurring at partial capacities would affect the minimum-flow setting. Consequently, minimum-flow values of 25 percent of the flow at best efficiency became commonplace, with higher levels in special cases.