

Optimize Parallel Pumping Systems

When multiple pumps operate continuously as part of a parallel pumping system, there can be opportunities for significant energy savings. For example, lead and spare (or lag) pumps are frequently operated together when a single pump could meet process flow rate requirements. This can result from a common misperception—that operating two identical pumps in parallel doubles the flow rate. Although parallel operation does increase the flow rate, it also causes greater fluid friction losses, results in a higher discharge pressure, reduces the flow rate provided by each pump, and alters the efficiency of each pump. In addition, more energy is required to transfer a given fluid volume.

Parallel Pumping Basics

Designers can expand the operating range of a pumping system by specifying parallel pumping configuration (see Figure 1). A greater increase in flow rate will be seen when adding parallel pump to a static head-dominated system. Parallel pumps can be staged and controlled to operate the number of pumps needed to meet variable flow rate requirements efficiently.

The total system flow rate is equal to the sum of the flow rates or contributions from each pump at the system head or discharge pressure. Parallel pumps provide balanced or equal flow rates when the same models are used and their impeller diameters and rotational speeds are identical. When possible, recommended design practice is to have parallel pumps moved from beyond Best Efficiency Point (BEP) at low system flow rates (fewer pumps operating) to the left of BEP at the highest flow rate. An ideal scenario will allow the pumps to have the highest possible average operating efficiency for the overall flow rate vs. time profile.

Dissimilar pumps may be installed in parallel, as well, as long as the pumps have similar shutoff head characteristics and/or are not operated together

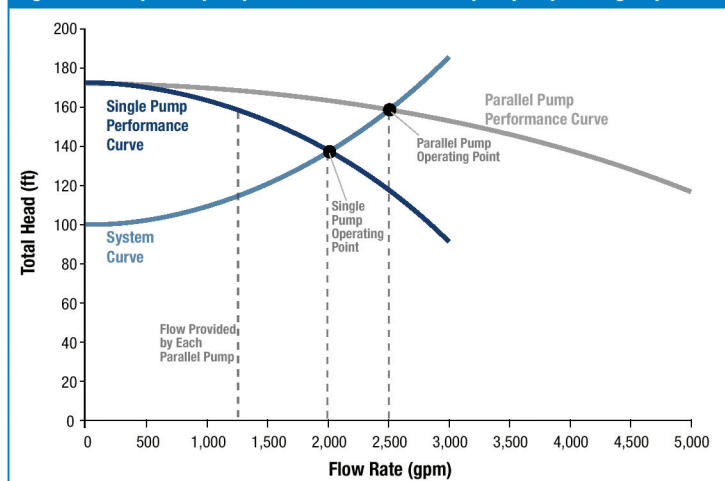
continuously unless provisions are made to prevent dead-heading.

Applications

In general, parallel pumps provide good operating flexibility in static head-dominated systems, but are not nearly as effective in friction-dominated systems. It is advisable to avoid operating two pumps in parallel whenever a single pump can meet system requirements. One exception is certain storage applications with time-of-day energy rates or high “peak period” demand charges. Also, be sure to take into consideration the amount of energy consumed by multiple pumps in contrast to the amount consumed by a single pump with adjustable speed drive control. Multiple pumps should be selected with head-versus-capacity performance curves that rise at a constant rate when these pumps approach no-flow or shutoff head.

Some efficient, high-head/low-capacity, centrifugal pumps used in process industries have “drooping” pump performance curves. These pumps supply peak pressure at a certain flow rate, and the pumping head decreases in approaching no-flow conditions. Identical pumps with drooping head-versus-capacity curves should not operate in parallel at variable flow rates under conditions in which capacity requirements can approach zero.

Figure 1. Composite pump curve for two identical pumps operating in parallel



Example

A split-case centrifugal pump operates close to its best efficiency point while providing a flow rate of 2,000 gallons per minute (gpm) at a total head of 138 feet (ft). The static head is 100 ft. The pump operates at an efficiency of 90% while pumping fluid with a specific gravity of 1. With a drive motor efficiency of 94%, the pumping plant requires 61.4 kW of input power.

When an identical parallel pump is switched on, the operating point of the composite system shifts to 2,500 gpm at 159 ft of head (see Figure 1). Each pump now operates at 80% efficiency while providing a capacity of 1,250 gpm. Although the fluid flow rate increases by only 25%, the electric power required by the pumping system increases by 62.2%:

$$P_{2\text{ pumps}} = \frac{0.746 \text{ kW/hp} \times (2,500 \text{ gpm} \times 159 \text{ ft})}{3,960 \times 0.8 \times 0.94} = 99.6 \text{ kW}$$

Suggested Actions

- Consider operating the minimum number of pumps that the system requires at any given time; one exception might involve off-peak pumping to storage tanks.
- Evaluate and compare multiple-pump scenarios to single-pump systems with adjustable speed controls.

For fluid transfer applications, it is helpful to examine the energy required per million gallons of fluid pumped. When a single pump is operating, the energy intensity (EI) is as follows:

$$EI_1 = \frac{61.4 \text{ kW}}{2,000 \text{ gpm} \times 60 \text{ minutes/hour} \times \text{million gal}/10^6 \text{ gal}} = 512 \text{ kWh/million gallons}$$

When both pumps are operating, the EI increases as follows:

$$EI_2 = \frac{99.6 \text{ kW}}{2,500 \text{ gpm} \times 60 \text{ min/h} \times \text{million gal}/10^6 \text{ gal}} = 664 \text{ kWh/million gallons}$$

When both pumps are operating in parallel, approximately 30% more energy is required to pump the same volume of fluid. The electrical demand charge (kW draw) increases by more than 62%. If the current practice or baseline energy consumption is the result of operating both pumps in parallel, pumping energy use will decrease by 23% if process requirements allow the plant to use a single pump.

References

Control Strategies for Centrifugal Pumps with Variable Flow Rate Requirements, U.S. Department of Energy Pumping Systems Tip Sheet #12, 2006.
Pump System Matter, www.PumpSystemMatter.com

Hydraulic Institute (HI).

Hydraulic Institute, the largest association of pump producers in North America, serves member companies and pump users worldwide by developing comprehensive industry standards, expanding knowledge by providing education and training, and serving as a forum for the exchange of industry information. In addition to the ANSI/HI pump standards, HI has a variety of resources for pump users and specifiers, including Pump LCC and VSP guidebooks, "7 Ways To Save Energy" training program and more. To download FREE executive summaries of HI's "Pump Life Cycle Costs", "Variable Speed Pumping", and an index to ANSI/HI Standards, visit www.Pumps.org and www.PumpLearning.org.

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