Leveraging the power of parallel pumping

Best efficiency staging achieved with technologically advanced controllers and variable speed drives

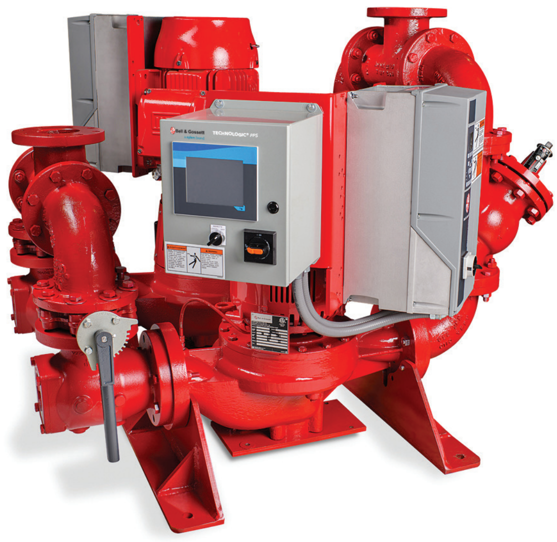
Vince Lombardi's Green Bay Packers were famous for their power sweep, and ran the play over and over again with great success. When opposing teams began making adjustments to stop the sweep, Packers quarterback Bart Starr read the defense at the line of scrimmage and could alter the play to ensure the best outcome.

In a parallel pumping system, the controller is the quarterback that dynamically makes decisions based on what the defense – or current flow and head requirements – shows. Variable speed control in a parallel pumping system is a proven method of increasing efficiency and reducing costs, but even greater efficiencies and savings are attainable when designers combine advanced logic controllers and today's more economical variable speed drives.

Think of it as employing a bit of West Coast Offense to the pump staging process to create a powerful solution that comes with high efficiency, backup capacity and potential savings on space and initial investment.

In an environment where partial loading is the norm, optimizing system performance isn't as simple as optimizing pump performance at a single duty point. The entire profile of the pump's efficiency at varying flows and speeds must be considered. In a parallel pumping environment, this makes both selection and staging strategies that much more complex. That's where technology comes into play to help get to these solutions more easily, and parallel pump controllers with best efficiency staging capability pay dividends.

Selecting a pump for parallel operation using the same methods as choosing a single pump involves simply cutting the flow in half or a third and picking the most efficient option. When flow gets past 120 percent of Best Efficiency Point (BEP), it's time to stage the next pump. However, that process doesn't leverage technology, and though the system will provide required head and flow, it likely won't be at optimal efficiency.



To meet the demand for energy-efficient pumping systems in today's commercial buildings, the Bell & Gossett PPS Parallel Pump System offers advanced features that provide users the ability to better control pump operation and provide critical information on pump efficiency and pump performance.

How can one be sure that pump staging is really optimized for efficiency? By examining different staging scenarios and comparing and contrasting the weighted part load efficiency values (PLEV), the challenges and solutions of designing parallel pumping systems become clear.

In the first scenario, the full load requirement is 4000 GPM at 65 feet of head with a control head requirement of 19.5 feet. These design parameters should be carefully considered, as they dictate the system curve that will be driving the selection decisions – grossly overestimating head values will lead to challenges in commissioning.

With that large of a pump, the selection would likely be a double suction pump. In **Figure 1**, the curve depicts an efficient solution, especially at full load. There is some tapering at 50 percent and 25 percent of load, yielding a weighted part load efficiency value (PLEV) of 81.6 percent. This is a 10x12x15.5 pump with a 100 hp 6-pole motor, a large investment and footprint, but one that provides zero backup capacity.

Now let's examine an option for parallel pumping that provides backup capacity and even greater PLEV. **Figure 2** shows two end suction pumps in parallel – 8x10x13.5-inch pumps with 50 hp motors. This constant speed graph demonstrates efficiencies over 86 percent for portions of this curve, which means that there will only be improvements over the curves when variable speed is introduced into the equation. In general, the system curve crosses all of the test speed curves and demonstrates acceptable efficiencies.

Figure 3 reflects individual pump efficiency improvements created by variable speed. Dividing the flow between both pumps at full load, efficiency is 86.3 percent – even higher than the double suction pump in **Figure 1**. If both pumps continue to run at partial loads, the weighted efficiency comes in at 77 percent, below the double suction performance. As demand decreases, the second pump must be destaged. As system requirements drop below 2400 GPM, the two-pump efficiency is actually dropping below 80 percent, while the single-pump efficiency is increasing from 80 percent and climbs to 88 percent as demand drops to 1400 GPM. In the case of this particular pump based on this system curve, it appears that the best staging/destaging occurs around 10 percent past BEP. With two parallel pumps one pump can drop off and the system will still operate at 75 percent capacity.

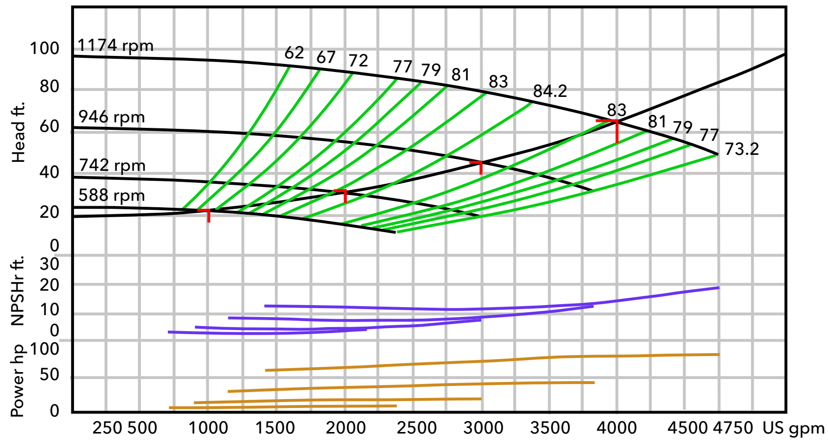


Figure 1.10x12x15.5 double suction pump with 100 hp 6-pole motor

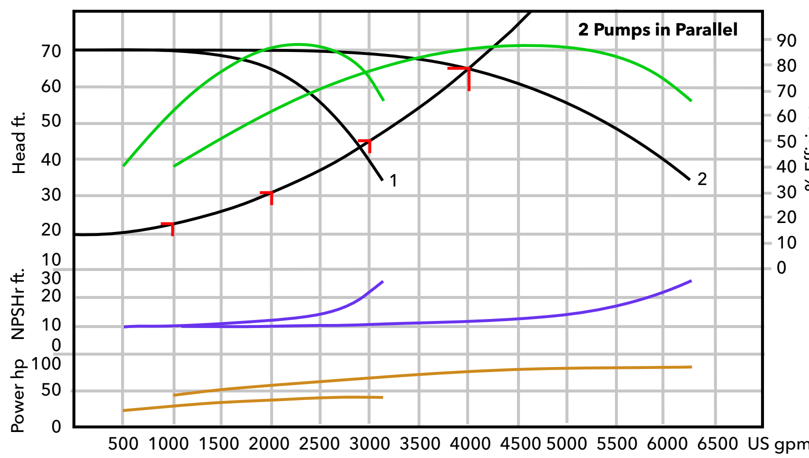


Figure 2. 2 parallel 8x10x13.5 end suction pumps with 50 hp 6 pole motor

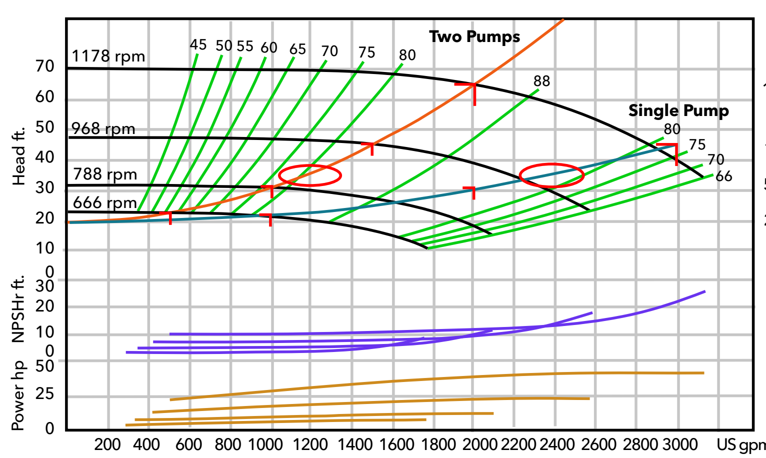


Figure 3. Single 8x10x13.5 end suction pump variable speed curve running as one of two pumps and solo at 100%, 75%, 50% and 25% of load

Figure 4 outlines a three-pump option with a 6x8x9.5 end suction pump. With this combination similar efficiency is achieved with 4 pole motors. Note that versus the total 100 hp in the previous examples, it's now at 90 total hp (three, 30 hp motors).

Figure 5 demonstrates coverage up to 50 percent of load with one pump – if system losses have not been underestimated. (This would need to be tested in use and the system throttled if necessary). With two pumps, nearly 90 percent of load is covered. In fact, if the requirement was to meet full duty with two pumps, motors and drives could be upsized to 40 hp and the pumps over-sped to almost the same efficiency as the pumps in **Figure 5** that is just short of 60 feet at 2000 GPM per pump. Based on the efficiency profile of this pump, optimal system efficiency will be achieved by running two pumps from 3600 GPM all the way down to just over 100 GPM or the 25 percent partial load point.

The initial investment savings on three 30 hp 4-pole motors versus a 100 hp 6-pole motor is 40 percent. The initial investment savings on a three 6-inch pumps versus the single 10-inch pump is roughly 25 percent. (There will be some offset to the savings for the additional parallel piping.)

Figure 6 shows the efficiency benefits that can be achieved by determining the optimal staging

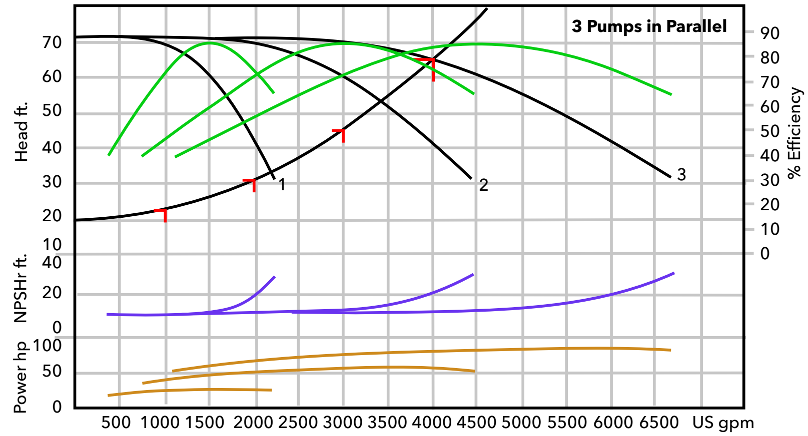


Figure 4. 3 parallel 6x8x9.5 end suction pumps with 30 hp 4 pole motors

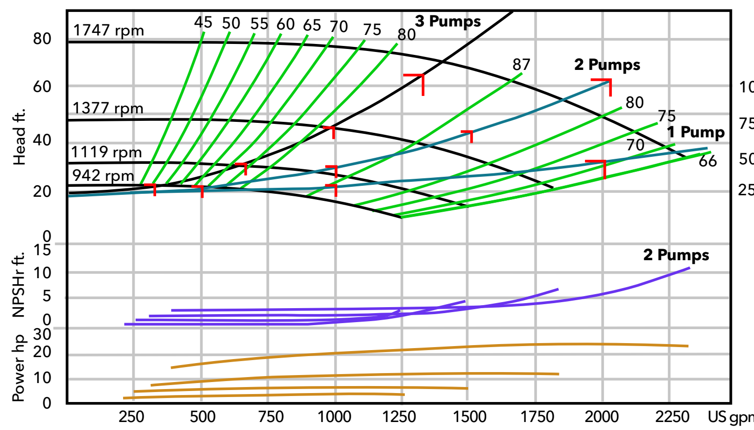


Figure 5. 6x8x9.5 end suction pump variable speed curve running in parallel as one of three pumps, one of two pumps, and solo at 100%, 75%, 50% and 25% load

	10x12x15.5 Double Suction	8x10x13.5 End Suction All Pumps Running	8x10x13.5 End Suction Optimal Staging	6x8x9.5 End Suction All Pumps Running	6x8x9.5 End Suction Optimal Staging
Speed in rpm	1180	1180	1180	1780	1780
hp	100	50	50	30	30
Trim diameter in inches	14.25	13.25	13.25	9	9
# Pumps	1	2	2	3	3
100% Flow (4000 gpm 65 ft) efficiency	82.5	86.3	86.3	84.6	84.6
75% Flow (3000 gpm 48 ft) efficiency	83.5	84.2	84.2	82.1	85
50% Flow (2000 gpm 36 ft) efficiency	83.5	76.9	88	73.3	85
25% Flow (1000 gpm 28 ft) efficiency	70.7	57.1	82	51.9	87
Average Part Load Efficiency (PLEV)	81.9	77.7	85.7	74.5	85.2

Figure 6. Table of part loads considering 100% flow at 1%, 75% flow at 42%; 50% flow at 45%; and 25% flow at 12%, considering no staging and optimal staging

point for each parallel pumping solution. It is important to evaluate the system curve and pump efficiency curves to optimize staging. In these scenarios, optimal staging in a parallel pumping solution can save 3 percent on energy costs versus the double suction solution while increasing backup capacity and potentially eliminating system downtime required for maintenance. However, if staging is not done properly, the system might actually operate 3 percent less efficiently than the single-pump solution, which could mean over $1,000 in increased energy costs per year depending on operating conditions and utility rates.

The staging points are based on the system design and anticipated system losses. In these examples, we are modeling the system utilizing a system curve, but we know the system will operate in this area. In actual application, this will need to be reviewed following commission. It should also be understood that in a diverse system, there is a control area rather than a simple control curve. The more diversity in the system, the larger this area and the greater the benefit from dynamic, real-time staging performed by a capable pump controller versus a fixed staging strategy based on predetermined staging points.

According to the 2016 ASHRAE Handbook for HVAC Systems and Equipment, Section 44.3.5: "The area in which the system operates depends on the diverse loading or unloading imposed by the terminal units. This area represents the pumping energy that can be conserved with one-speed, two-speed or variable-speed pumps after a review of the pump power, efficiency and affinity relationships."

Staging solutions for best efficiency can be complex, but with the aid of a capable quarterback — a parallel pump controller equipped with built-in best efficiency staging — all of these calculations happen dynamically, ensuring that the system can actually deliver these theoretical efficiencies.

Alan Jones is the global product manager for Bell & Gossett centrifugal pumps. He holds a bachelor of science degree in systems engineering from the United States Military Academy at West Point, and a master's in business administration from Syracuse University. He is an ASHRAE chapter member focused on customer experience, energy efficiency, system integration and value generation.