40.17 Which of the following is not a reason for pumps to be placed in parallel?

A. To increase pressure

B. To increase volume flow rate

C. To improve efficiency

D. To add redundancy

Examine each choice:

A: When pumps are run in parallel, the differential pressure across the pump set is equal, not greater. Therefore pumps would not be placed in parallel to increase pressure. They would need to be placed in *series* to add pressure.

B: Parallel pumps provide additional volume at the same pressure.

C: Parallel pumps may improve efficiency if using variable speed drives and programmed with the appropriate intent.

D: Parallel pumps may provide redundancy if a sufficient quantity are used.

Answer A

40.18 Crude oil is pumped by a centrifugal pump with a performance curve given by the equation $H_p = 50 - Q - \frac{Q^2}{25}$, where head is in units of feet and flow rate is in units of cubic feet per second. The system curve is described by the equation $H_s = \frac{Q^2}{25} + \frac{Q}{10}$, with the same units. Neglecting efficiency and losses, what is the power required by the pump?

A. $16hp$

B. $30hp$

C. $35hp$

D. $53hp$

The intersection between the performance curve for a given pump and the system curve is the operating point. By setting the equations equal, the volume flow rate and head pressure at the operating point can be determined, and then used to determine the power.

$$H_p = H_s$$

$$50 - Q - \frac{Q^2}{25} = \frac{Q^2}{25} + \frac{Q}{10}$$

$$\frac{2Q^2}{25} + \frac{11Q}{10} - 50 = 0$$

Multiply by 50 to eliminate fractions, then solve the quadratic equation:

$$4Q^2 + 55Q - 2500 = 0$$

Recall there will be two possible roots taking the form: $Q = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$, where $a = 4$, $b = 55$, $c = -2500$

$$\sqrt{b^2 - 4ac} = \sqrt{(55)^2 - 4\,(4)\,(-2500)} = \sqrt{43,025} \approx 207.42$$

Note that one of the roots taking the form $Q = \frac{-b - \sqrt{b^2 - 4ac}}{2a}$ will have a negative value. This is mathematically valid but practically not reasonable, so that solution should be discarded. The root with a positive value is the volume flow rate for the operating point.

$$Q = \frac{-b + \sqrt{b^2 - 4ac}}{2a} = \frac{-55 + 207.42}{2\,(4)} = 19.05 \frac{ft^3}{s}$$

Alternatively, quadratic equations may be readily solved using the calculator, and instructions for doing so using each of the approved calculators are easy to find online. The reasoning above still holds for discarding the negative root and keeping only the positive root.

Convert to gpm:

$$Q = 19.05 \frac{ft^3}{s} \left(\frac{7.48gal}{1ft^3}\right) \left(\frac{60s}{1min}\right) = 8550gpm$$

Substitute back into either of the equations to find the corresponding head pressure at the operating point:

$$H_s = \frac{Q^2}{25} + \frac{Q}{10} = \frac{(19.05)^2}{25} + \frac{(19.05)}{10} = 16.43ft$$

Note the head pressure is given in units of feet; however, it is feet of crude oil—not water. Therefore the specific gravity, sg, must be accounted for when the power is determined. Also note the efficiency is to be neglected, thus $bhp \sim whp$.

$$bhp = whp = \frac{Q_{[gpm]} \Delta h_{[ft]} \cdot SG}{3960} = \frac{(8550)\,(16.43)\,(.86)}{3960} = 30.5hp$$

Answer B