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PUMP CLINIC 18

PUMP AFFINITY LAWS

There are occasions when you might want to permanently change the amount of liquid you are pumping, or change the discharge head of a centrifugal pump. There are four ways you could do this:

- Regulate the discharge of the pump by using a valve or orifice.
- Change the speed of the pump by changing the motor or using a variable speed drive
- Change the diameter of the impeller.
- Purchase a new pump

Of the four methods the middle two are generally the most sensible ones. In the following paragraphs we'll learn what happens when we change either the pump speed or impeller diameter, and as you would guess, we will see what other characteristics of the pump are going to change along with these values.

To determine what is going to happen we begin by taking the new speed or impeller diameter and divide it by the old speed or impeller diameter. Since changing either one will have approximately the same affect we will refer to only the speed in this part of the discussion.

As an example:

$$\frac{\text{NEW SPEED}}{\text{OLD SPEED}} = \text{A VALUE}, \quad \text{or} \quad \frac{1500\text{ RPM}}{3000\text{ RPM}} = 0.5$$

The capacity, or amount of fluid you're pumping, varies directly with this number.

- Example: 50 metres^3 per hour x 0.5 = 25 Cubic metres per hour

The head varies by the square of the number.

- Example : 20 metre head x 0.25 (0.5^{2}) = 5 metre head

The Power required changes by the cube of the number.

- Example: A 9 kW motor was required to drive the pump at 1500 rpm. How much is required if you go to 3000 rpm?
- We would get: 9 x 8 (2^3) = 72 kW is now required.
- Likewise if a 12 kW motor was required at 3000 rpm and you decreased the speed to 1500 the new kilowatts required would be: 12 x 0.125 (0.5^3) = 1.5 kW required for the lower rpm.

The following relationships are not exact, but they give you an idea of how speed and impeller diameter affects other pump functions.

The net positive suction head required by the pump (NPSHR) varies by the square of the number.

- Example: If the NPSHR at 1450rpm is 3m, what would be the NPSHR for the given pump if its speed was increased to 2900rpm
- A 3 metre NPSHR x 4 (2^2) = 12 metre NPSHR at 2900rpm

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The amount of shaft run out (deflection) varies by the square of the number

- As an example you had 0.07 mm run out at 2900 rpm and you slowed that shaft down to 1450 rpm the run out would decrease to 0.07 mm x 0.25 (0.5^2) or 0.018 mm.

The amount of friction loss in the piping varies by approximately 90% of the square of the number. Friction loss through fittings and accessories varies by almost the square of the number.

- As an example: If the system head loss was calculated or measured at 65 metres at 1450 rpm, the loss at 2900 rpm would be: 65 metres x 4 (2^2) = 260 x 0.9 = 234 metres

The wear rate of the components varies by the cube also

- Example: At 1450 rpm the impeller material is wearing at the rate of 0.5 mm per month. At 2900 rpm the rate would increase to: 0.5 x 8 (2^3) or 4.0 mm per month. Likewise a decrease in speed would decrease the wear rate eight times as much.

We started this discussion by stating that a change in impeller speed or a change in impeller diameter has approximately the same effect. This is true only if you decrease the impeller diameter to a maximum of 10% This is true because as you cut down the impeller diameter, the housing is not coming down in size correspondingly so the affinity laws do not remain accurate below this 10% maximum number.

The affinity laws do however remain accurate for speed changes and this is important to remember when we convert from gland packing to a balanced mechanical seal. We sometimes experience an increase in motor speed rather than a drop in amperage during these conversions and the affinity laws will help you to predict the final outcome of the change.