Affinity Laws

Pump affinity laws, are a set of equations that describe how changes in the operating conditions of a centrifugal pump affect its performance. These laws are used to predict the effects of changes in flow rate, head (pressure), or speed on a pump's performance without the need for extensive testing. The affinity laws are particularly useful in engineering and fluid mechanics to understand how pumps behave under different conditions.

There are three primary affinity laws:

1. Affinity Law for Flow (Q):

$$\frac{Q1}{Q2} = \frac{N1}{N2}$$

Where:

Q1 is the initial flow rate

Q2 is the new flow rate

N1 is the initial speed (RPM)

N2 is the new speed (RPM)

This law states that the ratio of flow rates is directly proportional to the ratio of the pump's speeds. For example, if you double the pump speed, the flow rate will also double if all other factors remain constant.

Affinity Laws

2. Affinity Law for Head (H):

$$\frac{\boldsymbol{H1}}{\boldsymbol{H2}} = \frac{\boldsymbol{N1}^2}{\boldsymbol{N2}^2}$$

Where:

H1 is the initial head (pressure)

H2 is the new head (pressure)

N1 is the initial speed (RPM)

N2 is the new speed (RPM)

This law shows that the ratio of head (pressure) is directly proportional to the square of the ratio of the pump's speeds. If you double the pump speed, the head (pressure) will increase by a factor of four if all other factors remain constant.

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3. Affinity Law for Power (P):

$$\frac{P1}{P2} = \frac{N1^3}{N2^3}$$

Where:

P1 is the initial power consumption

P2 is the new power consumption

N1 is the initial speed (RPM)

N2 is the new speed (RPM)

This law indicates that the ratio of power consumption is directly proportional to the cube of the ratio of the pump's speeds. If you double the pump speed, the power consumption will increase by a factor of eight if all other factors remain constant.

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Affinity Laws

It's important to note that these affinity laws assume that the pump's performance curve remains consistent with changes in speed, which may not always be the case for all pumps. Also, these laws don't account for other factors like efficiency changes and may not be accurate for large variations in operating conditions. Nonetheless, they provide a useful estimation of how a centrifugal pump will behave under different speed and flow rate conditions.