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Understanding Water Horsepower

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A brief explanation of the origin of the horsepower unit and how it relates to the power ratings of modern irrigation pumps – along with information about water horsepower, pump horsepower and pump efficiency.

Origin of the Horsepower Unit

James Watt was an engineer, inventor and entrepreneur who lived during the late 1700s. His work on improving the efficiency of the steam engine was crucial to the industrial revolution.

During the time of Watt's life, horses were the main source of energy for applications like pulling carts, turning grinding mill wheels and providing movement to industrial machines. As the availability of steam engines increased, a means of providing understandable power ratings became important. Comparing the power output of a steam engine to a corresponding number of horses was an easy way for prospective engine owners to understand and compare power ratings.

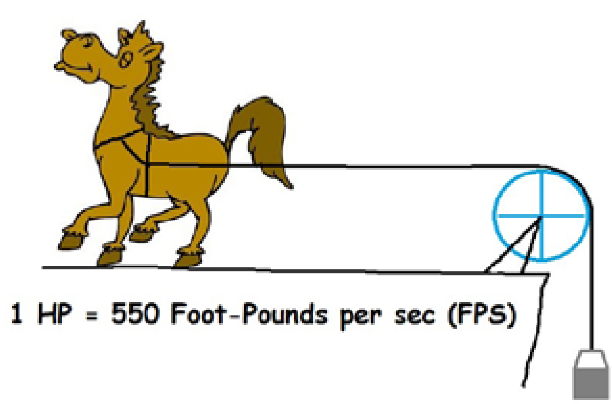


Diagram demonstrates the determination of horsepower.

Watt determined that by recording the distance a horse traveled in a specific time while pulling a known weight against gravitational force could measure the power the horse produced. After several observations, Watt concluded a strong horse could provide 550 foot-pounds per second of power.

Water and Pump Horsepower

To fully understand water horsepower, it is important to understand the terminology involved in deriving such a unit. The term energy is defined as the capacity to do work. Power is the rate at which energy flows or at which energy is used per unit of time. It also is the rate at which work is performed. In other words, power is the amount of energy used to do work or how quickly work can be done. Water horsepower is the minimum power required to move water. In other words, it is the power a pump would require if the pump was 100 percent efficient. The water horsepower can be determined if the flow rate of the water and the force (pressure) required to produce that flow is known.

To calculate water horsepower, the following formula can be used.

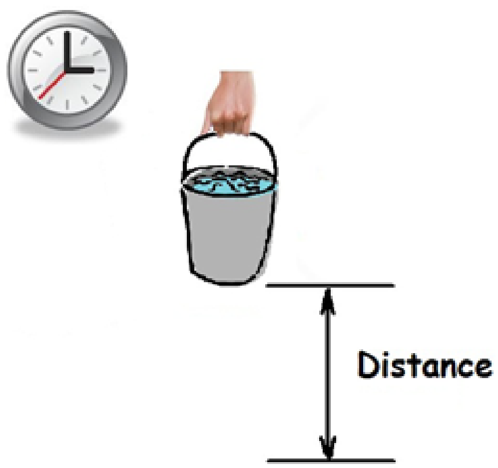
$$Water\ Horsepower = \frac{HQ}{3960}$$

In this formula, H is the change in pressure measured in height of water in feet and Q is the water flow rate in gallons per minute. This equation was derived knowing that one horsepower is equal to 550 foot-pounds per second.

For example, if an irrigation pump located at ground level is pumping 460 gallons of water per minute from a well where the water level is 112 feet below the ground level and is discharging that water at ground level, the water horsepower the pump is delivering is:

$$\textit{Water Horsepower} = \frac{112 \times 460}{3960} = 13$$

So the pump is providing 13 water horsepower when it lifts water 112 feet at a rate of 460 gallons per minute.



Water horsepower is illustrated as moving a volume of water a specified distance.

Pump Efficiency

No pump can convert all of its mechanical power into water power. Mechanical power is lost in the pumping process due to friction losses and other physical losses. It is because of these losses that the horsepower going into the pump has to be greater than the water horsepower leaving the pump. The efficiency of any given pump is defined as the ratio of the water horsepower out of the pump compared to the mechanical horsepower into the pump.

$$\eta = \frac{hp_{water}}{hp_{of\,pump}} \quad 0 < \eta < 1$$

If the pump in the last example required 17 horsepower to provide 13 water horsepower, the pump efficiency is:

$$\eta = \frac{13}{17} = 0.76 \textit{ or } 76 \textit{ percent}$$

The pump is 76 percent efficient, and 24 percent of the input energy is lost to friction and other losses.

Most modern pumps have an efficiency of 50 percent to 85 percent. When choosing a pump, it is important to remember that with increased efficiency comes increased fixed capital cost. It is also important to remember that fuel or energy cost is decreased with increased pump efficiency. Although more efficient pumps come with an increase in capital cost, the overall fuel consumption will be lower, resulting in lower annual fuel or electricity costs.

It also should be noted that the discussion in the previous paragraph was for a pump properly sized for the application. If the pump does not match the application, it may have to operate in an inefficient range, and fuel or electricity will be wasted. Consult a professional engineer or a pump supplier if there are questions about a specific pump or application.

References

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