Evaluation of variable speed pumps in pressurized water distribution systems

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Abstract

In pressurized water distribution systems, a constant speed pump is often used because of its simplicity. However, constant speed pipes are not easily able to deal with changing demands in water flows. When the demand for the discharge differs from the design discharge, the required demand (discharge and head) could be met by changing the pump speed without making any special changes in the system. Using an electronic drive circuit, the electrical frequency can be changed and the rotation speed of the pump motor can thus be modified. In this study, the application of variable speed pumps in pressurized irrigation systems is investigated. Two pumping station scenarios including a fixed speed pump and a variable speed pump are considered. The results show that using a variable speed pump increases the average pump efficiency by 18.7%. In addition, the variable speed pump system reduces the electrical consumption 57.6 % compared to a fixed speed pump. Therefore, the use of variable speed pumps in pressurized systems is recommended.

Keywords: Pumping station; variable speed pump; pressurized pipe; efficiency; pump power

1. Introduction

In recent years, the cost of energy has increased faster than other agricultural costs. While agricultural pumping stations, their energy consumption, and efficiencies have been improved (Abadia et al., 2008), there are still opportunities for further improvements. Water pumping stations usually use fixed speed pumps that have a good efficiency over a small range of pressure and flows. If different flows and pressures are required, unsuitable pump speeds will yield excessive energy losses. This imposes additional costs, especially on pressurized irrigation systems, which are constantly changing their irrigation needs, sometimes monthly. Today, more than 60% of electricity consumption in the industry is from electric motors. Therefore, increasing their efficiency leads to significant savings in energy consumption (Li, 2019) and a reduction in pollution. Constant speed pumps have a fixed rotational speed of the impellers which limit the ability to modify the flow. Consequently use of a constant speed of impeller reduces the flexibility of the pumping system. In contrast, there are variable speed pumps (VSP) that have the ability to adjust the impeller rotation and can be used to make desired changes in the pumping system.

2. Material and methods

The agricultural study is located in Tazeh Kand village, 30 km southwest of Tabriz. The water pumping station includes a fixed-speed centrifugal electric motor pump for use in a sprinkler irrigation system. The selection of this pump is based on the maximum consumption of the sprinkler irrigation network in July. As shown in Fig. (1), in the sprinkler irrigation system, three lateral pipes are connected to the main pipe. The required discharge for these three lateral pipes are 20 l/s. The required head at the inlet of each lateral pipe is 35.14 m. The pipes are made of

Polyvinyl Chloride (PVC) and the system capacity is 60 l/s. The suction head is 2.5 m and the friction loss due to the joints, bends and filter in the suction pipe is equal to 1.0 m.

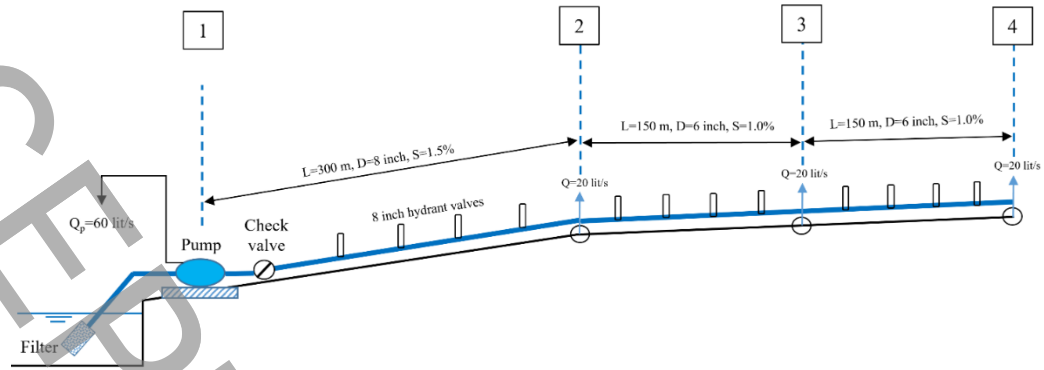

Fig. 1 Sprinkler irrigation system consists of three lateral pipes branching from the main pipe

The maximum network consumption in July is 60 l/s and the total dynamic head is 58.11 m. To determine the system curve for the variable discharge, the total dynamic head value must be calculated according to the above method for a number of discharge flows. Based on these calculations, a suitable centrifugal pump type EA-125-50/2 has been selected. At a 50 Hz frequency, the engine speed is 1450 rpm. The diameter of the pump impeller is 319 mm. In Fig. (2), the characteristic curves of the pump and the characteristic curve of the pipe system are plotted together and their intersection defines the operating point. Based on Fig. (2), the operating point of the pump is found to correspond to Q=0.052 m^3/s and H=55.60 m.

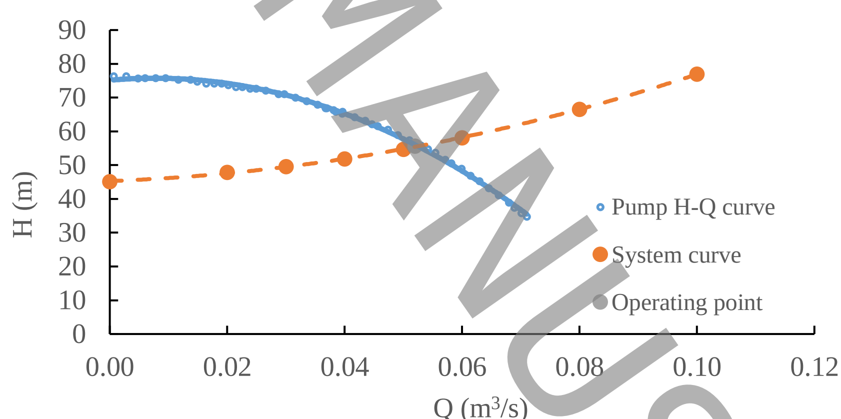

Fig. 2 The intersection of the pump characteristic curve and the system curve determine the operating point

Variable frequency drive (VFD) refers to a type of motor controller that can rotate the electric motor by changing the frequency and voltage in the electric motor. As the required motor speed in the intended application changes, the electric drive can easily meet modified requirements by raising and lowering the motor speed. A VFD circuit consists of three parts: (i) the rectifier section, (ii) the filter section and (iii) the switching or inverter section.

3. Results and discussion

Calculations of pump speed change with required discharge changes in different months, as listed Figure (3) shows the changes in the power consumption of the pump in different months for the two pump modes. Power consumption in different months for the constant speed pump mode varies between 440.2 to 801.96 kWh. On the other hand, for the variable speed pump mode varies between 294.65 to 558.19 kWh. The results show that the variable speed pump system reduces energy consumption about 57.6% compared to the fixed speed pump. Therefore, using a variable speed pump saves electricity consumption.

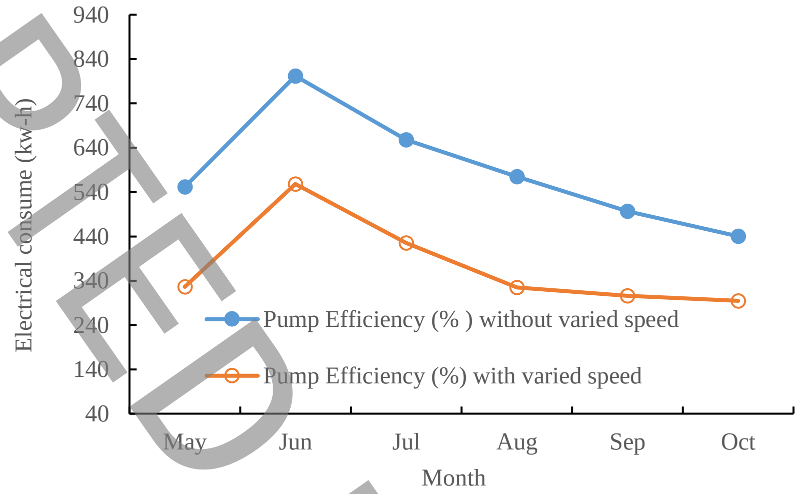

Fig. 3 Pump power consumption in different months for two modes of pump operation

4. Conclusions

In this study, the efficiency of stations equipped with variable speed pumps under all operating conditions exceeds that of stations equipped with fixed speed pumps. The results showed that the use of variable speed pumps not only increase efficiency but also aid in meeting water needs. The results showed that using a variable speed pump increases the average pump efficiency by 18.7%. The power consumption for a variable speed pumping station during irrigation seasons is much less than that for constant speed pump (ΔP=1288.6 kWh). This is 57.65% less than with a constant speed pump. As a result, the use of variable speed pumps in pressurized systems is recommended.

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