6 Control of Centrifugal Pumps

General

In many pump plants due to various reasons the transmission flow is subject to more or less significant fluctuations. Fig. 10 illustrates a plant that, in order to maintain simplicity, consists of two equally sized customers in parallel order. If both of them have to be supplied with water, then the plant adjusts itself to operational point B_1 and the pump head pressure H_1 of the pump is equal to the plant pump head pressure H_{A1}. If, however, only

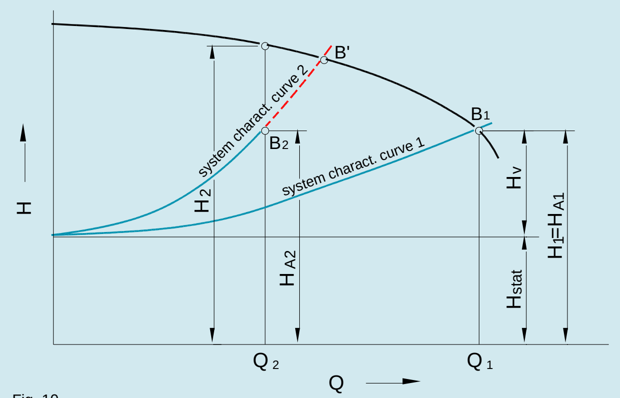

Fig. 10

one of the two customers is in use than the operational point of the pump characteristic curve moves to B', the point of intersection of the system characteristic curve 2 with the QH curve. This customer receives a transmission flow that is too large due to the increased pump head pressure. The control must reduce the pump head pressure H_2 of the pump to the plant pump head pressure H_{A2} . This will result in the desired operation point B_2, which when neglecting the changed pipe friction losses H_V in the common supply line assures for the customer a flow rate equal to that previously in point B_1.

1. The Throttling Control

The excessive pump head pressure at Q_2 is reduced by partially closing the sliding valve in the pressure line. The throttling control is a simple but uneconomic way of control. Its inefficiency increases with the increase in loss of pump head pressure due to adjustment. A pump with a flat QH characteristic curve should be preferred. The throttling control is not suitable for side channel pumps and axial rotary pumps whose power consumption increases with a decreasing transmission flow.

The throttling control is the most frequently used way of control despite the cited disadvantages.

2. The Rotational Speed Control

As already discussed in work sheet 2 "The characteristic curves", each rotational speed relates to a different Q-characteristic. All QH characteristic curves of a rotary pump are equal within the validity range of Affinity Laws. Related points of the various Q-characteristics are located on parabolas, i.e. the parabola $P_1 0$ in Fig. 11. All intersection points of this parabola with the Q-characteristics for the various rotational speeds are characterised by geodesically similar speed relations. The parabolas are designated as parabolas of equal impact condition depending on approach onto the impeller and inlet vanes.

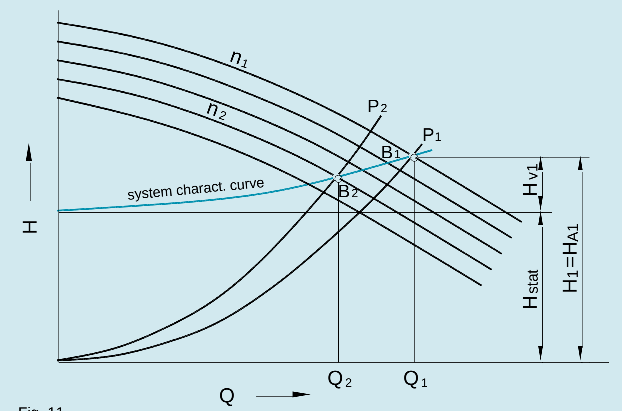

Fig. 11

Within a limited rotational speed range the pump efficiency along such a parabola remains nearly constant. Fluctuations arise because the power consumption of the rotary pump includes factors that will change according to other laws. In a speed regulated pump plant the efficiency will only then remain constant when the plant pump head pressure is exclusively of a dynamic type. Only then the plant characteristic curve equals the parabola $P_1 0$. The pump initially operates in point B_1, the point of intersection of the system characteristic curve with the QH curve for the rotational speed n_1. It has a transmission flow Q_1 and a pump head pressure H_1. If the rotational speed is lowered from n_1 to n_2 then the operation point on the plant characteristic curve changes from B_1 to B_2 with the transmission flow Q_2 and the pump head pressure H_2. Since B_2 is the point of intersection of the system characteristic curve with the Q-characteristic for n_2, pump and plant pump head pressure H_{A2} are equal. The decrease of the transmission flow from Q_1 to Q_2 has been accomplished without a pump head pressure loss.

The transition from the parabola $P_1 0$ to $P_2 0$, however, represents a change in efficiency. If the operation point B_1 is located at the optimal transmission flow or to the left, then the process results in a loss in efficiency, which is even more significant the greater the degree of static pump head pressure and the flatter the dynamic characteristic curve is.

This type of pump control requires a variable speed drive. The machines used in the past, such as direct current motors, asynchronous motors with slip ring rotors, motor-generator combinations or geared motors have significantly lost their importance, and frequency inverters have become more popular. This also applies to pole switchable three-phase motors, which are, however, only suitable in extreme situations due to their great steps in rotational speed. Less affected from this development are voltage regulated small type motors that still allow an economical solution of control problems.

Variable speed drives combustion in combination with combustion engines or steam turbines will naturally retain their purpose in special areas.

The frequency inverter without doubt offers the ideal solution to rotational speed adjustment since it operates almost without any loss and virtually maintenance free. Its greatest advantage, however, is the possibility of being able to use a standard three-phase motor. Also of advantage is the high performance factor, which, depending on manufacturer, can reach values of up to $\cos \varphi = 0.95$ and remains practically constant throughout its entire control range. In practical operation this motor has a surprisingly low power consumption.

However, it must be noted that the motor will become warmer than if it is fed by a sinus shaped current. The resulting power reduction amounts, depending on the manufacturer of inverter and motor, to up to 15%. An also available increase in rotational speed in excess of the characteristic rotational speed of the motor should be limited to 20% in serial type motors.

The high purchasing costs suggest that a test in economy is performed versus other control types.

This is essential for pump systems with low power performances, at small consumption fluctuation, or when the control range is limited to tight tolerances due to large geodesic values. A typical example is the pressure increase system in a high-rise building. Here, the pressure must be maintained even at the highest drain point, for the slightest water use. The possible decrease in rotational speed resulting thereof is only minimal and the rotational speed regulation would only be justifiable if greater pressure fluctuations were occurring within the supply system.

3. The Pump Sequence Circuit

Although it is not a pump control in the original sense, the demand-controlled sequence circuit of one or more smaller capacity pumps operating in parallel offers a quite economical alternative. The application of rotary pumps with a flat characteristic curve and the appropriate distribution of the water supply not only guarantees a very economical system but also a practically constant supply pressure.

4. Other Control Types

A solution predominantly found in side channel pumps is the bypass control. In this case a partial stream is redirected to the suction side by means of a secondary line and slide valve fitted after the pressure fitting. The operating point moves to the end of the characteristic curve, which can easily cause motor overload in radial pumps. Independent of the pump type the moving of the operating point to greater transmission capacities leads to a more unfavourable NPSH. If critical suction conditions exist then cavitation must be expected.

Additional control types, although only applicable for specific design types, are the impeller vane adjustment and pre- spin control. The former is being used in axial pumps. It is equally advantageous as a rotational speed adjustment and allows the maintenance of a positive efficiency over a wide transmission range. The pre-spin control is also limited to pumps with a high specific rotational speed, preferably half-axial pumps. It depends on the use of adjustable inlet vanes that are positioned before the entrance to the impeller vane. An equalized or opposite spin is generated by adjusting these vanes, which decreases and/or increases the transmission flow and pump head pressure