3 Parallel Operation of Centrifugal Pumps and the Specific Speed of Rotation

1. The Parallel Operation of Centrifugal Pumps

During the parallel operation two or more pumps deliver into a common pressure line. If for instance two **identical** pumps are supplying a common network and if initially only pump 1 is in operation, a characteristic plant curve R and an operation point B_1, which is equal to transmission flow Q_1 (Fig. 4), shall result. When pump 2 is switched on a common Q-characteristic is obtained by doubling the transmission flow of each pump for the respective pump head pressure. The characteristic curve R of the plant remains unchanged. The operation point now is B_2 with the transmission flow Q_2, whereby Q_2 is obviously substantially smaller than $2 \cdot Q_1$. The larger the head losses are in the plant, the steeper the plant characteristic curve rises. The increase in transmission flow will accordingly be less.

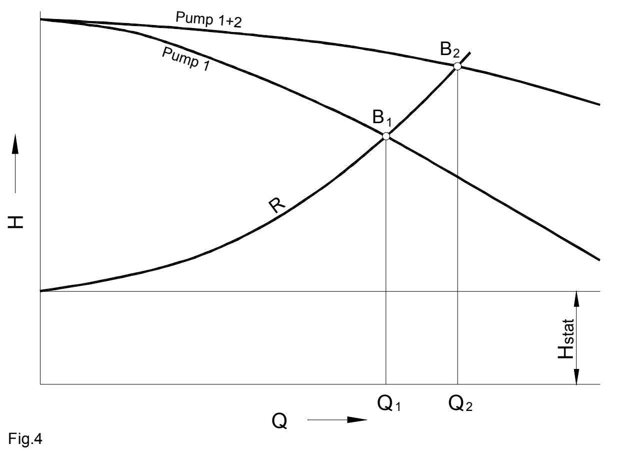

Fig.4

The relations are similar when two pumps with unequal Q-characteristics are switched parallel (picture 5). Curves 1 and 2 being the pump head pressure characteristic curves of pumps 1 and 2. The common Q-characteristic 3 is obtained by addition of the transmission flows of the respective pump head pressures. The resulting Q-characteristic from A to C coincides with the Q-characteristic of pump 2 because pump 1 with characteristic curve 1 in this section does not reach the pump head pressure of pump 2.

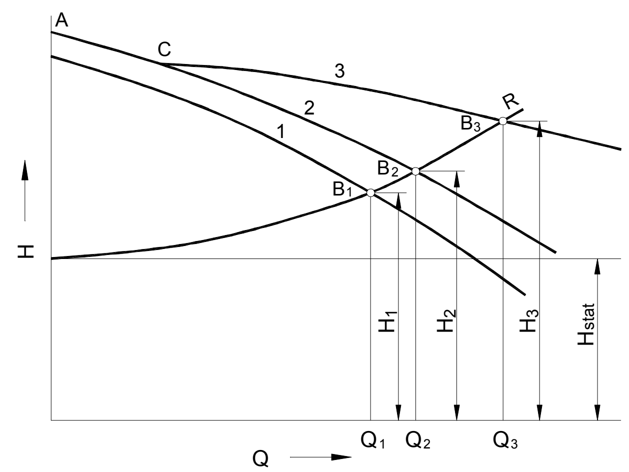

Fig.5

The larger pump head pressure of pump 2 closes the check valve of pump 1 and thus blocks pump 1 from the net. It can only start transmission when the pump head pressure of pump 2 has been reduced to the deadhead pressure of pump 1 (point C). When pump head pressure further reduces the transmission flows of both pumps add. If R is the characteristic curve of the system, then the common transmission flow Q_3 and the pump head pressure H_3 can be read off in the operation point for B_3 both pumps. If each pump would work by itself then pump 1 in operation point B_1 would have the transmission flow Q_1 and the pump head pressure H_1, and pump 2 in operation point B_2 the transmission flow Q_2 with the pump head pressure H_2. This also shows that the common transmission flow Q_3 is smaller than the sum of the transmission flows Q_1 and Q_2, which would result from the individual operation of both pumps. This is caused by the increase of the head losses due to friction of the liquids at common transmission.

2. The Specific Speed of Rotation

The specific rotational speed is a characteristic of the centrifugal pump. Pumps with a high specific rotational speed are designated as high-speed, and those with a low specific rotational speed as low-speed. Specific rotational speed and high speed should not be mistaken with the operational speed. A pump with a high operational speed can be slow speed, while others with slow operational speeds can be high speed. The specific rotational speed is independent of the real pump speed. This is the rotational speed of a pump with similar geometrical design, which has been altered in its dimension in such a way, that at a pump head pressure per step of 1 m there is a transmission flow of 1 m³/s. The specific rotational speed is therefore, in other words, the rotational speed of the “standard” rotor of the pump in question.

It is calculated according to the formula:

$$n_q = 333 \cdot n \cdot \frac{\sqrt{Q_{opt}}}{\sqrt[4]{(g \cdot H_{opt})^3}} \qquad (11)$$

With n in 1/s

Q_{opt}, the transmission flow in point of best efficiency in m³/s,

H_{opt}, head pressure in point of best efficiency in m, becomes n_q non-dimensional. (In multi-step rotary pumps the pump head pressure of **one** step and in dual-flow pumps the transmission flow of **one** side of the pump is to be inserted).

The specific rotational speed has a significant effect on the efficiency of the pump. When disregarding the less significant mechanical losses due to bearing and shaft seal friction, then the pump efficiency is determined by the hydraulic losses in drive and lead rotor and the rotor friction loss.

In case of an extended radial extension of the rotor, the signature of the slow speed machines, these losses are especially noticeable. Therefore the slow speed machine can only be expected to deliver a median efficiency. To improve the efficiency the highest possible rotational speed should be applied. As long as the transmission conditions allow this to be achieved, by **increasing the operating speed** and reducing the pump head pressure per step, means an **increase in the number of steps**.

Aside from the high speed, the absolute efficiency is determined by the hydraulically efficient design of the pump.

The increased pump efficiency due to increase of the specific rotational speed is opposed by a decrease of the pump's suction efficiency, thus in some cases precluding an increase of high speed.