Energie saving of a centrifugal pump (or fan) by using frequency control

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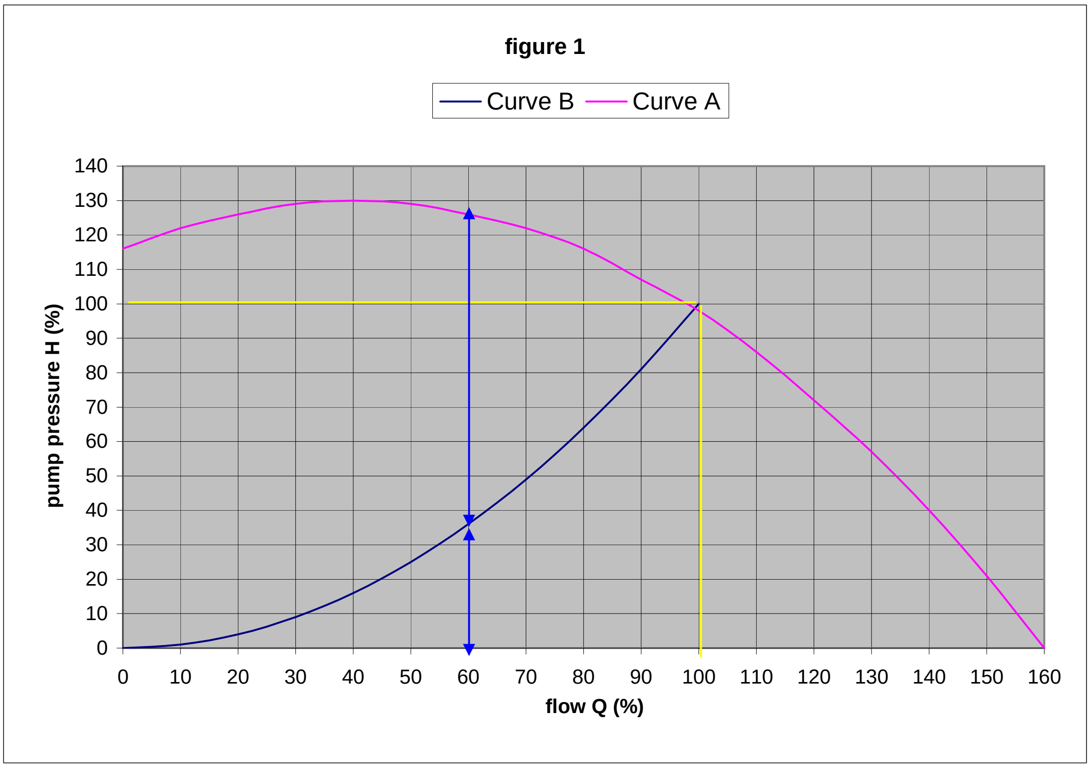
1. Introduction

Many pumps are powered by a three-phase induction motor, directly connected to the main power. When
the flow must be reduced, this is often obtained by throtteling valves.
The efficiency of the installation is disadvantuously influenced, as the system pressure (mostly unwanted) increases.
By using a drive with regulated speed, these negative effects can largely be compensated.
In that case we save energie.

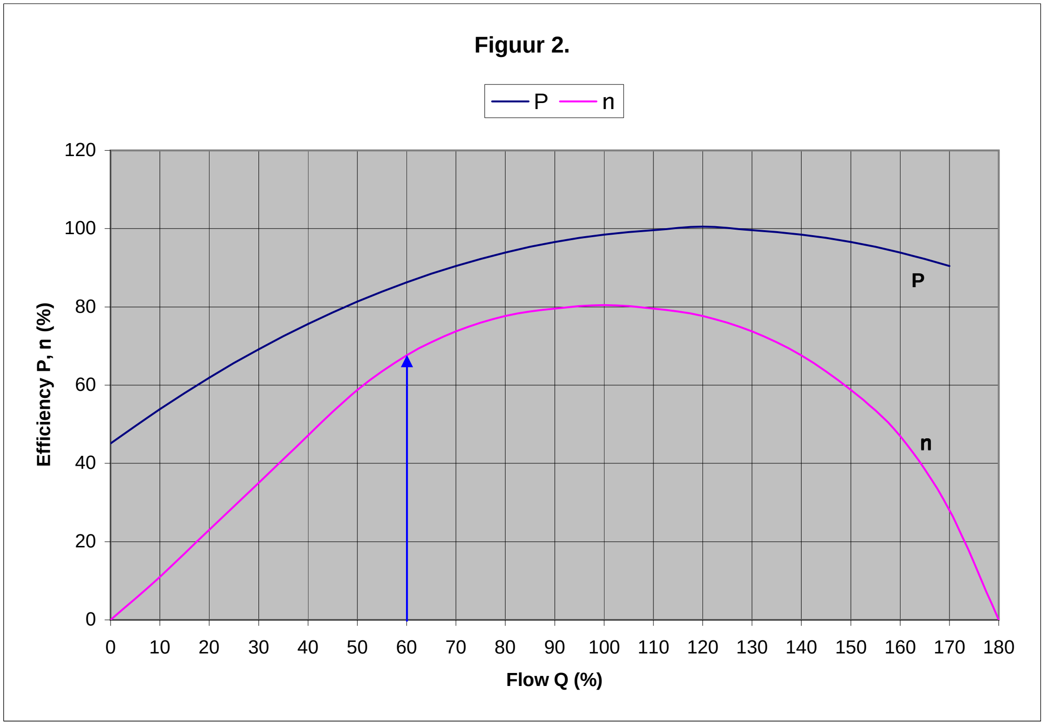
2. pump characteristics



Curve B depends on and is given by the pump design.
The pump operates at its optimum when the product of the pressure H, the flow Q and the efficiency is optimal.
At this optimal working point, the associated pressure and flow are the indicated 100% values.
Notice that both pressure and flow can reach more than 100%.

Curve A indicates the pressure loss of the installation, piping, etc. in relation to the flow.
Notice that the pressure loss increases quadratically.

The pump needs to be selected in such way, or the installation needs to be designed in such way, that curve A crosses curve B in the optimum point.
The optimal working point of the pump is strongly dependent on the design. The efficiëncy will normally vary between 40 and 80%.
In this example, 80% is used. Other efficiency points in the pump curve can be read from the curve in figure 2



3. Calculating the power needed in a throttled system

To calculate the needed power we use the formula

P=Q . H / n (**P**=power,**Q**=flow, **H**=pump presssure, n=pump efficiency)

Normally, P represents the power of the installed pump.
When no throtteling for flow regulation, is active, the power is:

P=1 (100%) **. 1** (100%) **/ 0.8** (80%) **= 1.25** (calculation value). (1.25 is equal to the installed power.)

If the sytem is throttled to the point where a flow of 60% is reached, the pump pressure becomes 126%. (figure 1) and the efficiency becomes 0.7 (figure 2).

The consumed power is now:

P = 0.6 . 1.26 / 0.7 = 1.08 (calculation value).

That means the supplied power has decreased with only 14,4% due to the reduction of flow to 60%.

4. Calculating the power needed in a system with frequency control

The basis is an equal flow reduction to 60% as in the previous calculation.
Globally, the flow of a pump is increased/decreased proportional to the increas/decrease of the pump's revolutions
At a flow of 60%, as we can see in figure 3, the needed pump pressure is reached at 60% of the speed of the pump.
The efficiency curve shifts by the reduction of the speed.
The uptake of power is now calculated as:

P = 0,6 . 0,38 / 0,8 = 0,285 (calculation value).

Figure 3

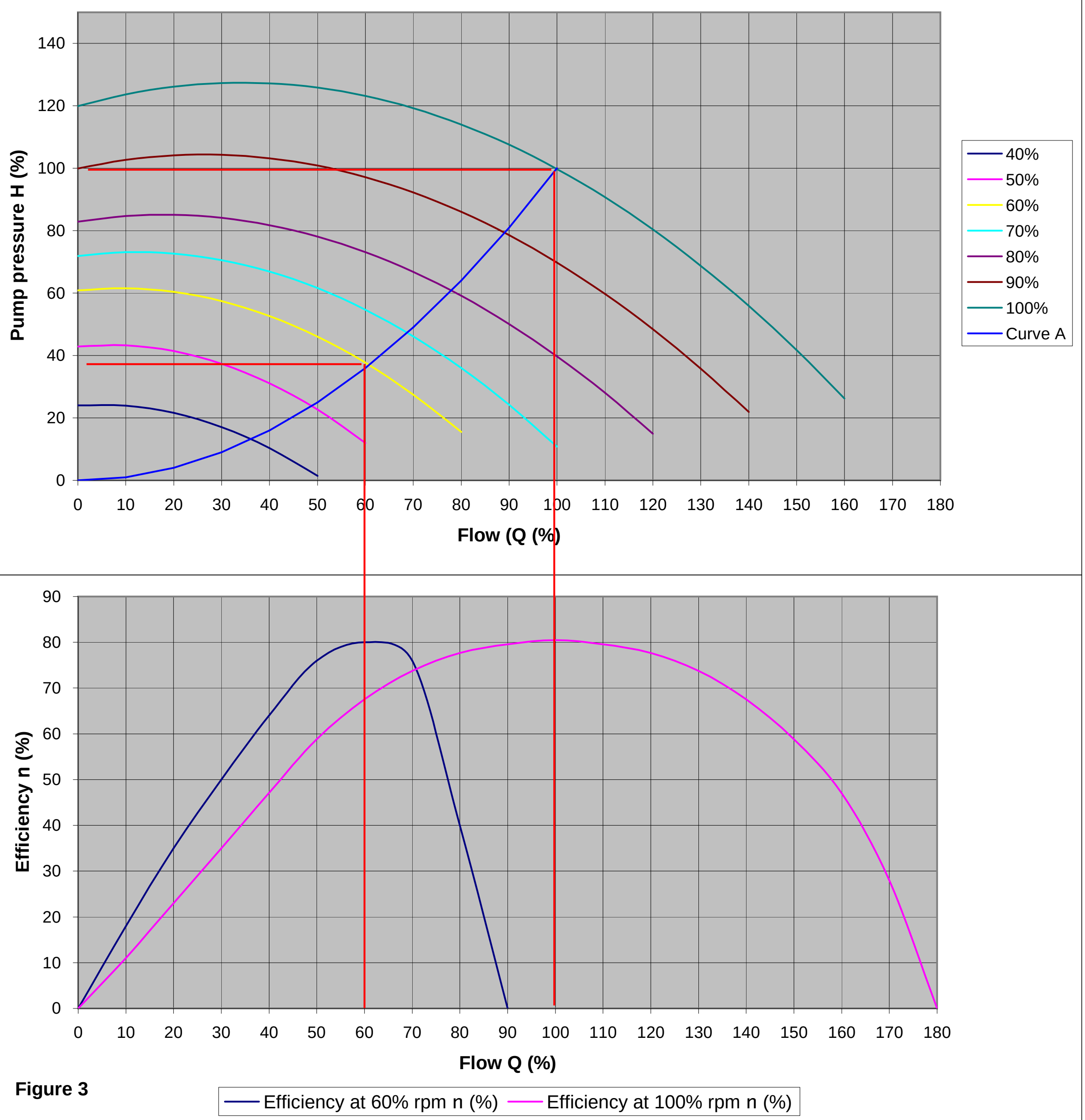


Figure 3

5. Calculation of possible expences cut down

Suppose that the pump takes 100kW of power at 100% Flow and 100% pressure.
Tha absorbed power from the mains supply is now 100 kW / efficiency motor = 100 / 0.93 = **107.53 kW (A)**.

At a flow of 60%, achieved by **throtteling**, 1.08 / 1.25 . 107.5 kW has to be supplied.
(1.08 and 1.25 are the previous calculation values) The delivered power is then **92.88 kW (B)**.

When using **frequency control**, the total efficiency of the drive decreases at the optimum working point (100%, 100%), as the frequency controller will consume energy too.
Suppose that the efficiency of the motor plus frequency controller decreases to 0.91 (motor only 0.93).
The absorbed power in this case is 100 kW / 0.91 = **109.9 kW (C)**.
At a flow of 60%, due to decreasing the pump revolutions, the asked power is:
0.285 / 1.25 . 109.9 kW = **25.06 kW (D)**.

Assume the pump operation period is as follows:
8 hours at 100% flow, 8 hours at 60% flow and 8 hours no operation per 24 hours, for 250 days a year.

The consumed quantity of energy per year when throtteling is:
(8 . 107.53(A) + 8 . 92.88(B) + 0) . 250 = 400820 kWh

The consumed quantity of energy per year with frequency control is:
(8 . 109.9(C) + 8 . 25.06(D) + 0) . 250 = 269920 kWh

That means an energie saving of: 130900 kWh per year.
At an electricity charge of € 0,07 per kWh, one saves here € 9.163,00 a year.