GESTRA Steam Systems

GESTRA Information A 2.3

Energy Savings through Correct Selection of the Check Valve

When designing pump discharge lines, a correct match between pump and pipe system plays an important part with regard to the energy costs to be expected. In this connection, the design engineer has also to rely on the exact data and specifications supplied by the manufacturer of the check valves.

Starting from a comparative calculation which gives rise to errors but is often encountered in advertising publications, the following sections give a calculation of the energy costs on the basis of the pump and pipeline characteristics.

1. The System

Discharge of water from a tank below pump level into a tank situated at a higher level.

Static discharge head	H	=	16 m
Nominal size	DN	=	250 mm
Loss coefficient of pipeline*)	ζ	=	6
Volume flowrate	$\dot{V}_v$	=	670 m³/h
Pump efficiency	η_P	=	0.83 at nominal operating point
Motor efficiency	η_M	=	0.9 at nominal operating point
Price of electrical power	K_h	=	€ 0.10/kWh
Operating time	t_v	=	2000 h/year

*) ζ for pipelines corresponds to $f \dfrac{l}{d}$

The pipeline is equipped with a wafer-type non-return valve. Because of its short overall length, this valve has a relatively high loss coefficient $\zeta_v = 9$. The pressure drop across the valve is:

$$\Delta p_v = \zeta_v \cdot \frac{\rho}{2} \cdot V_v^2$$

$$\rho = 1000 \text{ kg/m}^3$$

$$V_V = 3.79 \text{ m/s}$$

(velocity in the line)

where

$$\Delta p_v = 64{,}600 \text{ Pa} \mathrel{\widehat{=}} 0.65 \text{ bar}$$

2. Calculation of the Electrical Power Costs caused by the Non-Return Valve

The power loss converted in the valve (subscript "V") into heat amounts to

$$N_V = \Delta p_v \cdot \dot{V}$$

$$\Delta p_v = 64{,}600 \text{ Pa}$$

$$\dot{V} = \frac{670}{3600} = 0.186 \text{ m}^3/\text{s}$$

$$\underline{N_V = 12{,}000 \text{ W}}$$

The overall efficiency of pump and motor amounts to

$$\eta_0 = \eta_P \cdot \eta_M$$

$$\eta_P = 0.83$$ (strictly speaking only valid for the nominal operating point)

$$\eta_M = 0.9$$

$$\eta_0 = 0.75$$

The electrical power costs per year amount to

$$E_V = t \cdot \frac{1}{\eta_0} \cdot K \cdot N_V$$

$$t_V = 2000 \text{ h}$$

$$\eta_0 = 0.75$$

$$K = 0.2 \cdot 5^{-3} \text{ €/Wh}$$

$$N_V = 12{,}000 \text{ W}$$

$$\underline{E_V = \text{€ } 3{,}200/\text{year}}$$

3. Substituting the Non-Return Valve for a Check Valve with a Reduced Loss Coefficient (subscript "S")

Valve manufacturers in their struggle with competitors often make the following comparative calculation of cost savings:

The calculation in accordance with section 2 results for the new check valve, e. g. a split-disc valve with $\zeta_S = 1.2$, in a pressure drop of

$$\Delta p_S = 8{,}600 \text{ Pa } (0.086 \text{ bar})$$

and thus in annual electrical power costs of

$$E_S = \text{€ } 443.2/\text{year}$$

so that the savings obtained with the new check valve amount to

$$\underline{\underline{\Delta E = \text{€ } 2828.98/\text{year}}}$$

This is based on the assumption that the pump efficiency remains virtually unchanged. The following section demonstrates that a serious error may creep into the calculation if it is done in this way.

4. Calculation on the Basis of the Pump Characteristic

A correct result can only be obtained taking into consideration the interaction of pump and pipe system on the basis of their characteristics. It should also be kept in mind that the annual pump operating period is reduced when the same water volume is to be discharged yearly. The chart shows the pipeline characteristic with non-return valve and split-disc check valve. With the volume flowrate $\dot{V} = 0$, the static discharge head is approx. 1.6 bar.

The points of intersection with the pump characteristic represent the operating points.

Furthermore the variations in the pump efficiency have to be considered as the nominal operating point is hardly ever obtained in practice.

The results obtained under 2 and 3 can be recalculated with the data found in the chart using the equation for the overall electrical power costs of the pump:

$$E = \frac{1}{\eta_P \cdot \eta_M} \cdot K \cdot \Delta\rho \cdot \dot{V} \cdot t$$

Valve downstream of pump

For the non-return valve the operating costs mentioned below result from the following data:

$$\eta_M = 0.9$$

$$\eta_P = 0.78$$

$$\Delta p = 267{,}000 \text{ Pa } (2.67 \text{ bar})$$

$$\dot{V} = 0.186 \text{ m}^3/\text{s} \ (\mathrel{\widehat{=}} 670 \text{ m}^3/\text{h})$$

$$t_V = 2000 \text{ h/year}$$

$$K = 0.2 \cdot 5^{-3} \text{ €/Wh}$$

$$\underline{E_V = \text{€ } 14{,}469.56/\text{year}}$$

Only about 60 % of these costs are used to discharge the water to a level of 16 m; the remaining 40 % are converted into heat.

Substituting the Non-Return Valve for a Split-Disc Check-Valve

$\eta_M = 0.9$

$\eta_P = 0.7$

$$\left.\begin{aligned}\Delta p &= 220{,}000 \text{ Pa } (2.20 \text{ bar})\\ \dot{V} &= 0.202 \text{ m}^3/\text{s } (\triangleq 730 \text{ m}^3/\text{h})\end{aligned}\right\} \text{New operating point}$$

$t_S = 2000 \cdot \frac{670}{730} = 1835$ h/year

(Reduced discharge time for the same annual quantity)

$K_{(costs)} = 0.2 \cdot 5^{-3}$ €/Wh

$\underline{\underline{E = € \ 13{,}242.45/\text{year}}}$

The electrical power costs saved by substituting the split-disc check-valve for the non-return valve amount only to

$\underline{\underline{\Delta E = € \ 1{,}227.10/\text{year}}}$

instead of € 2,828.98/year as calculated in section 3.

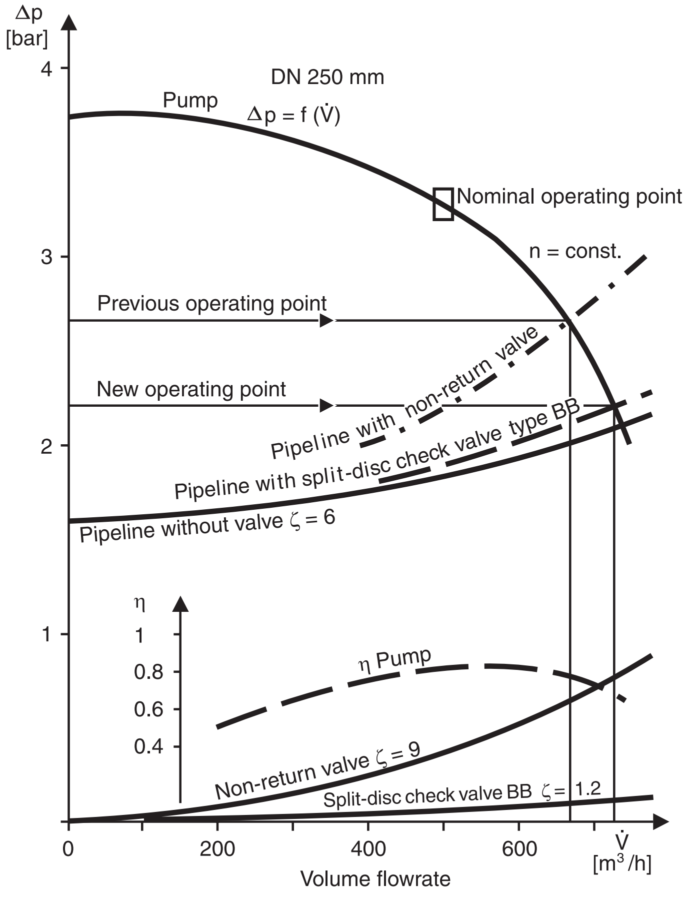
This great difference is explained by the fact that although by installing the split-disc check valve, the energy losses in the valve, as calculated in section 3, are reduced, however, the overall water discharge now takes place at a lower degree of efficiency, as the operating point has been displaced still farther from the nominal operating point of the pump ($\dot{V}_n$ = 500 m³/h) to higher capacities.

5. Summary

The example referred to demonstrates that comparative calculations that only take into consideration the pressure drop in the check valve cannot give a correct result. This can only be obtained if the interaction of pump and pipeline system is considered.

The reduction in savings is caused by the large increase in the volume flowrate and a decrease in the pump efficiency.

On the other hand, it is also possible that the installation of a check valve with a reduced loss coefficient produces an additional advantage by an increase in efficiency, i.e. if the operating point is situated on the left of the nominal operating point.



Relationship between check valve – pump – pipeline

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