GESTRA Steam Systems

GESTRA Information A 4.1

Cutting the Cooling-Water Consumption

A vital interest for every plant

A perfect operation of cooling systems is only possible, if a uniform distribution of the cooling water to all consumers mounted in parallel is ensured.

Only a well-balanced system where short-circuiting – i.e. excessive cooling of the units nearest the pump and insufficient cooling of the units at the end of the system – is avoided can operate efficiently. For balancing a cooling system the pressure drop across individual units has to be considered. Any change of the pressure drops across the various units, be it as a result of accumulated deposits, an extension to the existing system or shut-down of some parts, requires rebalancing of the system.

Manual balancing with the aid of orifice plates involves an enormous amount of work. For reasons of safety, the cooling-water flowrate is thereby established to match the maximum demand. This implies that the pump is constantly operating at its maximum speed and that enormous water quantities are being used. However, water is increasingly scarce, and water-treatment costs are growing continually. The costs for water treatment may even exceed those for its procurement. There are cases where legislation requires the discharge of the cooling water into special clarification systems. In addition, scarcity results in water of inferior quality being used for cooling, and this requires a considerable amount of costly treatment.

The cooling water consumption should therefore be reduced to a minimum without endangering correct cooling of all units.

We have frequently observed the cooling-water outlet temperature to be only a few degrees higher than the inlet temperature, i.e. since the system is not well balanced the valves are completely open to be on the safe side.

The higher the cooling-water return temperature, the lower the cooling-water consumption. The cooling-water return temperature should therefore be increased to the maximum permissible for the cooling process. The following should, however, be considered: For reasons of environmental protection, cooling water must not be discharged at too high a temperature. From a temperature of approximately 50 °C the rate of calcium precipitation in the water increases considerably, and with rising temperatures the growth of algae is accelerated.

The exact distribution of the cooling water throughout the system requires the installation of appropriate controllers. Within a certain range, these controllers will also maintain constant cooling-water outlet temperatures, including any periods of partial cooling. Even if the outlet temperatures must not be increased or can only be increased slightly, in systems equipped with controllers, water is saved al least during periods of partial cooling. And what plant is always operating under full load?

In most cooling systems cooling-water control valves are perfectly suited as controllers (see **Fig. 1**). These valves are proportional controllers installed in the cooling-water return line as close as possible to the cooler. They control the water flowrate as a direct function of the cooling-water outlet temperature.

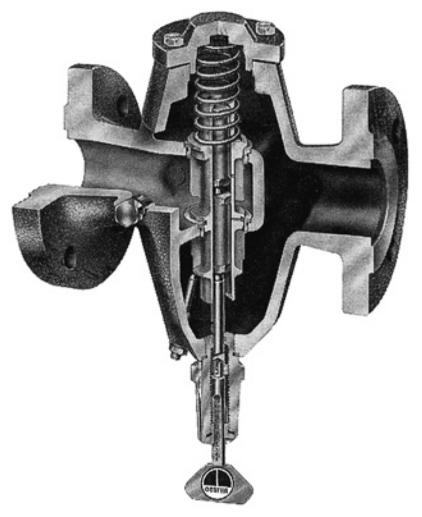


Fig. 1
GESTRA cooling-water control valve type CW 41

In the cooling water at the outlet is cold, the cooling-water flowrate is cut with the exception of a slight bleed flow. As soon as the cooling-water temperature rises, the valve will open to a corresponding degree, i.e. the cooling-water flowrate is regulated in accordance with the adjusted temperature. Steady cooling-water discharge temperatures are maintained.

Cooling-water control valves ensure automatic balancing of the cooling system, so that short-circuiting is prevented. A sufficient cooling-water supply throughout the system is ensured, even for coolers fitted at the end of the plant or at the highest point.

Cooling-water control valves cannot be applied if a product temperature has to be maintained at a precise value. In such a case control has to be effected as a function of the product temperature. Depending on the degree of accuracy required, controllers with auxiliary power or self-acting controllers **(Fig. 2)** with temperature feelers and capillary tubes should be used. In most cases the latter type will suffice. Controllers with auxiliary power ensure a more precise control, but are also far more expensive.

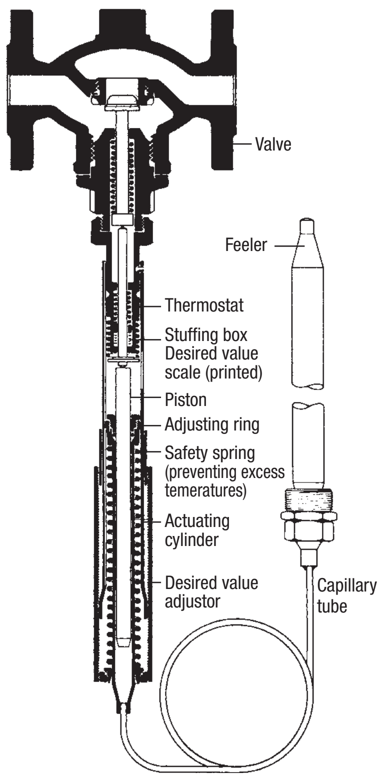


Fig. 2
GESTRA typical self-acting temperature controller

In cooling systems operating at atmospheric pressure, cooling-water control valves cannot be used either. In these cases self-acting temperature controllers with the feeler installed directly into the product line or cooling-water discharge line can be used.

Below an example of the water savings obtained with a GESTRA cooling-water control valve CW 41:

Heat capacity of cooler
$Q = 2 \cdot 10^5$ W [J/s]

Cooling-water inlet temperature $t_i = 10$ °C,
Cooling-water outlet temperature $t_{01} = 15$ °C.

Water consumption so far

$$m_1 = \frac{Q}{c \cdot (t_{01} - t_i)}$$

$$= \frac{2 \cdot 10^5 \cdot 3600}{4187 \cdot (15 - 10)}$$

$$= 34392 \text{ kg/h} \mathrel{\hat{=}} 34.4 \text{ m}^3\text{/h}$$

(where c = specific heat of water = 4187 J/kgK)

After fitting a CW valve set to discharge at a temperature of

t_{02} = 28 °C

the flowrate is reduced to

$$m_2 = \frac{2 \cdot 10^5 \cdot 3600}{4187 \cdot (28 - 10)}$$

$$= 9553 \text{ kg/h} \mathrel{\hat{=}} 9{,}5 \text{ m}^3\text{/h}$$

The savings are 72.4 %.

In addition to the water savings less pump energy is required. In the charts **(Fig. 3)** the discharge head, the efficiency and the power consumption of a standard centrifugal pump are plotted as a function of the displaced volume.

The power consumption calculated in accordance with the equation

$$P_e = \frac{V\,[\text{m}^3/\text{h}] \cdot p\,[\text{bar}]}{\eta \cdot 36} \quad [\text{kw}]$$

was 6.5 kW before installation of the CW valve and only 3.5 kW after installation of the valve.

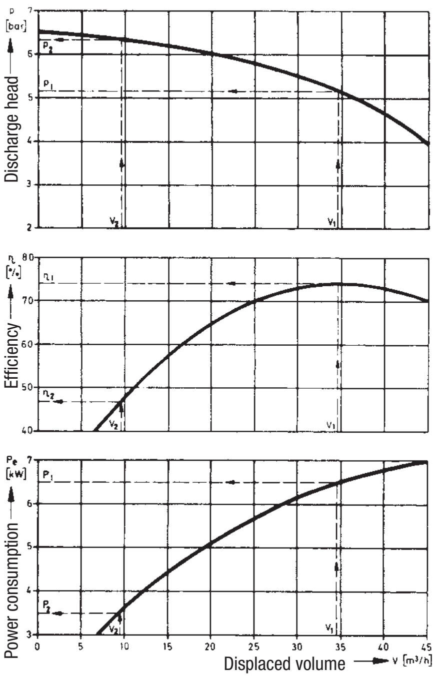


Fig. 3
Savings in pump energy by decreasing the displaced volume

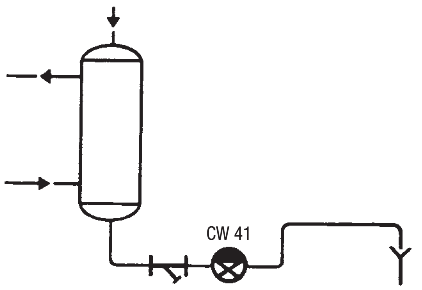
Despite the reduced pump efficiency (see second chart, **Fig. 2**), 46.2 % of pump energy are saved.

To complete the analysis, we must also consider that there are obvious savings in water-treatment costs. Water treatment is required to protect the plant from corrosion, to reduce scale formation on the cooling surfaces, and to remove organic matter from the cooling water.

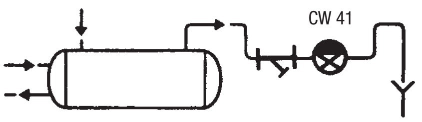
The cooling-water control valves pay for themselves in a very short period. If the installation of cooling-water control valves in a new plant is planned right from the beginning, capital costs can be considerably reduced, as smaller pumps, pipework and filtering equipment can be used.

As cooling water might be more or less polluted, the question arises whether the performance of the control valve and of the cooler will be affected when the valve is in a throttled position because of the reduced flow velocity across the cooler and the prolonged period that the water is in the cooler.

We know from experience that even with heavily polluted cooling water, neigther failure of cooling-water control valves nor breakdown of coolers was caused provided correct measures were taken, such as the installation of a strainer upstream of the CW valves or the arragement of a loop seal downstream of the valves with free discharge to prevent the valve from drying out **(Fig. 4)**.



Application of CW downstream of a counter-flow cooler



Application of CW downstream of an oil cooler

Fig. 4
Appropriate installation of cooling-water control valve

Water pollution by bacteria, algae and suspended matter is not only a problem encountered in systems using river water but also in open systems with a cooling tower. It is a well known fact that complete pipe systems can be clogged within a few hours due to the rapid growth of certain strains of bacteria.

For control of bacteria in closed systems chlorine is, for example, added to the circulated cooling water. Chlorination is, however, in most cases not sufficient to control soil-borne bacteria. For this purpose stronger biocides are required. There are biocides which are decomposed within a period of 12 hours. These are specially suited for the control of mucilaginous bacteria. To an increasing extent ozone is being used for water treatment. The advantages in comparison with biocides are ovious.

As the throttling of the cooling-water flowrate by the CW valves leads to a reduction in the flow velocity there remains the question whether mucilage formation depends on the flow velocity across the cooler. We know from experience that such formation is not restricted to low flow velocities, but has been observed in condensate lines at a velocity of 2.5 m/s which is quite high.

In practice this means that a reduced flow velocity across coolers does not per se involve a higher risk of deposits on the pipe walls.

If possible, coolers should be used where the cooling water is flowing through the pipes and not on the shell side. In the latter case the risk of deposition on the walls is rather high due to the very low flow velocities, and this is independent of whether a cooling-water control valve is fitted downstream of the cooler or not; mechanical and chemical water treatment must meet a particularly high standard.

For further information on GESTRA cooling-water control valves please ask for detailed literature.

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