Dutch thermal power station reduces cavitation damage via the utilisation of Schubert & Salzer sliding gate valves

An application report by Theo de Bruijne, Benny Cap and Tristan Lejeune

ELSTA "Electricity and Steam Association" is a thermal power station located close to the city of Terneuzen in the south of the Netherlands.

ELSTA, a joint venture between Delta, Essent and the American company, AES, is one of the most environmentally-friendly thermal power stations on Earth. Compared to older power stations of the same design, ELSTA has a very impressive 75 % efficiency and consequently, makes a significant contribution to reducing CO_2.

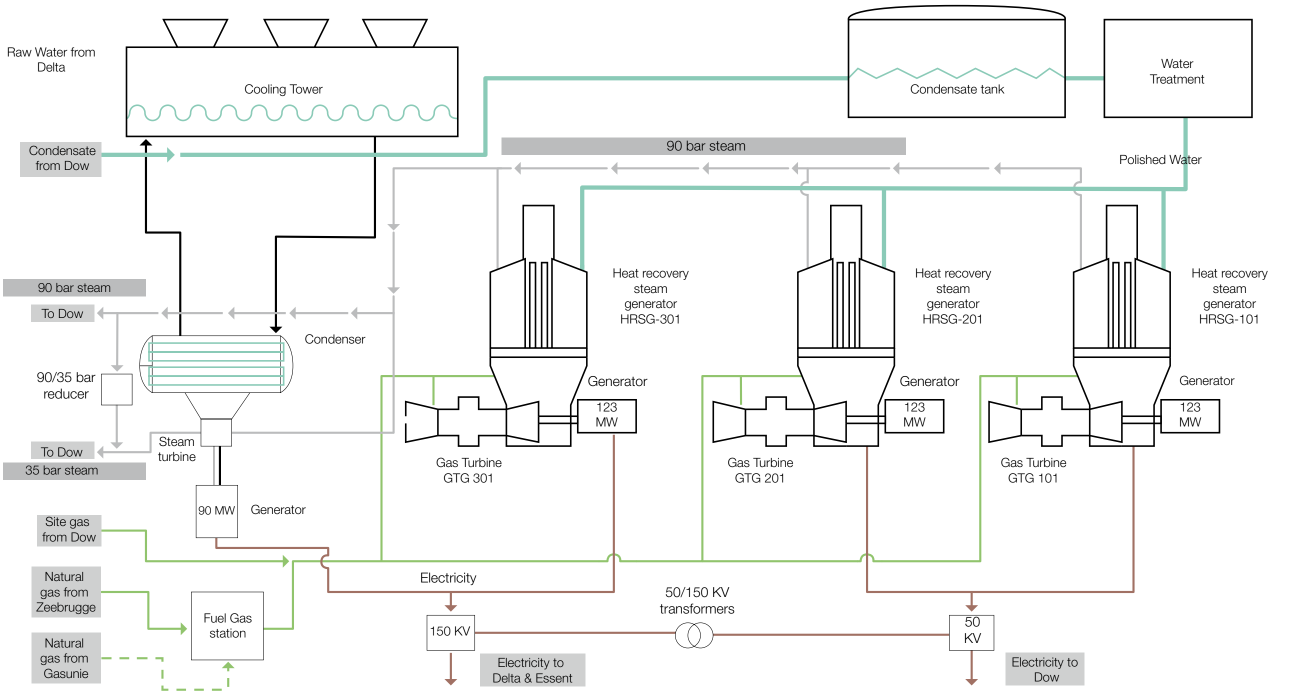
In addition to generating electricity for the Dutch power supply network and the neighbouring chemical complex operated by Dow Chemicals, the Terneuzen-based power station also generates heat in the form of steam for 17 neighbouring industrial companies with a total of 1,700 employees.

Equipped with the LEC (Low Emission Combustion) system, the power station operates with significant reductions of pollutant emissions: NO_x is reduced by 65 % and CO_2 is reduced by 90 %.

This makes ELSTA one of the cleanest gas-fired power stations in the world

The heart of the thermal power station consists of three gas turbines, one exhaust gas boiler and one steam turbine (**Fig. 1**). The gas turbines are able to supply a total of 123 MW of electricity and 450 tonnes of 90-bar-steam per hour. The steam turbine produces an additional 90 MW of electricity and releases 35-bar-steam for the chemical complex in the form of process steam.

The entire thermal power station is flexible enough to operate with a widely variable process demand. This applies to both steam



(350 – 850 tonnes per hour) as well as for the generated electrical energy.

A particular challenge within the ELSTA complex in terms of control application is the so-called 'flash steam control' at the outlet of the economiser, (a component located at the end of the steam boiler medium pressure system). For process-related reasons the flash steam controller (which was a poppet-conical-control valve when the power station was originally equipped), was subject to enormous wear by means of cavitation.

Fig. 2 Existing valve

The economiser itself preheats the boiler feed water using hot smoke gases and is fundamental to the increase of efficiency for the entire installation.

The primary task of the flash steam controller in this process is to prevent the generation of steam in the economiser in the event of a low boiler load. If the boiler load is low, the boiler feed water heats up relatively quickly and evaporates before reaching the actual steam vessel. As this is not desired, the flash steam control valve opens so that part of the overheated feed water is guided back into the feed water vessel. A large amount of feed water at an optimised low temperature is now available at the economiser outlet.

The flash steam control valve is temperature-controlled and the target value of the temperature depends upon the steam pressure on the valve inlet side. In this application, the task of the control valve is therefore to keep the feed water temperature beneath the saturation temperature of the steam at the relevant pressure level.

In normal operating conditions, the control valve works with a linear characteristic curve for 12 hours per day with a valve opening of between 0 % and 30 %, a valve primary pressure of between 3.5 bar and 8 bar and a valve outlet pressure of between 0.7 bar and 2 bar. As the valve controls mainly in the lower part of its operational range, a significant load is placed on the throttling element. The original control valve selected by the plant manufacturer (poppet-conical design) in (**Fig. 2**), had been equipped with an anti-cavitation poppet-conical set. The seat and the connection were both produced using an extremely expensive stainless martensitic steel alloy. Despite these design measures, this component had to be laboriously repaired by completely replacing the valve bottom section after 2 years of operation due to severe damage to the valve housing and seat area.

For a long time, Theo de Bruijne, Maintenance Manager at ELSTA and Benny Cap, Maintenance Technician searched for a valve solution for this problematic application. In doing so, special focus was given to achieving a longer service life and reducing the maintenance costs. Their objective was achieved in this challenging application, by using the 8021 Sliding Gate Control Valve from Schubert & Salzer Control Systems.

The cause of the problem is the generated cavitation which occurs due to the pressure drop in the valve (**Fig. 3**). As the water at the valve outlet is already close to its boiling point, a further drop in pressure causes the water to evaporate. The generated steam bubbles then implode further downstream when the pressure increases once again. Related to this are high local pressure peaks that lead to material erosion and even failure, if they occur in close proximity to adjacent walls (e.g. valve housing).

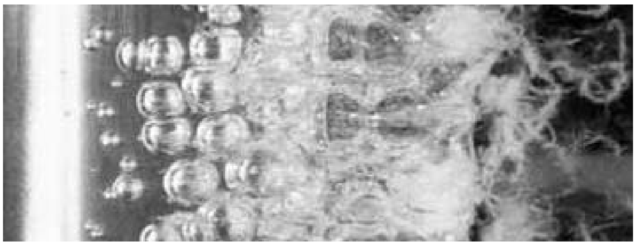


Fig. 3 Cavitation implosions

Tackling cavitation

The principle of the sliding gate valve makes it easier to tackle cavitation in the flow. The 8021 range with its stainless steel design in conjunction with stellite sealing discs were utilised for this purpose at ELSTA.

At the heart of this design are two slotted discs that slide against each other and form a seal. The sealing disc which is secured in the housing perpendicular to the direction of flow is equipped with a carefully calculated number transverse slots at the same height. A further sealing disc with the same slotted arrangement is moved vertically against the first disc, thus changing the flow. The differential pressure across the valve pushes both sealing discs against each other and ensures the sealing effect.

Fig. 4 A sliding gate valve in nominal size 80 weighs 13.4 kg.

This principle only requires approximately 10 % of the actuating power that is required to drive a seat / ball valve of a similar bore. Together with the relatively low strokes (6 – 9 mm), this results in a highly advantageous and extremely dynamic response behaviour in terms of the valve control technology. The compact nature of this valve design means that it is significantly lighter and has considerably lower power consumption than other, more traditional valve designs (**Fig. 4**).

In many processes it is impossible to avoid operation conditions that provoke cavitation

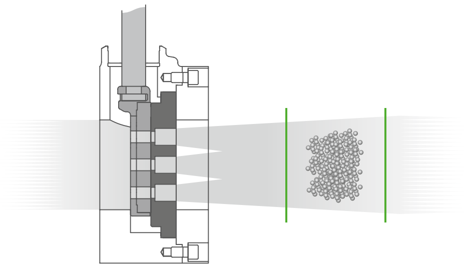


Fig. 5 The implosion of the cavitation bubbles takes place when the sliding gate valve is downstream of the valve and not within the valve housing.

The geometry of the sliding gate valve with its straight flow guidance and the short installation length, neutralises this problem as the implosion of the steam bubbles will only occur in the pipe downstream of the valve (typically approximately between 1 and 2 metres) (**Fig. 5**). If there are no adjacent pipe walls in this area (e.g. pipe bends), the cavitation will have no damaging effect. Therefore, it is usually sufficient to have only a small number of diameters of straight lengths of pipe down-stream of the valve. An expansion of the pipeline behind the valve reduces the speed and the length.

In order to demonstrate the cavitation resistance with the aid of a practical test, the existing conical seat valve from ELSTA and is replaced by a sliding gate valve from Schubert & Salzer (**Fig. 6**).

Following a year of operation, it was then disassembled during a planned Shut-down in order to be examined (**Fig. 7**). Except for the normal signs of usage, it was not possible to determine any wear on the sealing discs.

The special design of the throttling component means that cavitation is no longer an issue within the sliding gate valve. Traditional valve designs often exhibit cavitation, but sliding gate valves in similar applications are virtually unaffected by cavitation and demonstrate significantly extended service life. Short strokes and the low mass of moving parts mean the drive and the spindle seal are not subject to high stress and have a much longer service life. Due to the superior design, the maintenance of a sliding gate valve can be carried out quickly and easily by a single person and even directly on site. Consequently, the overall efficiency of a plant can be optimised by the utilisation of Schubert & Salzer sliding gate valves.

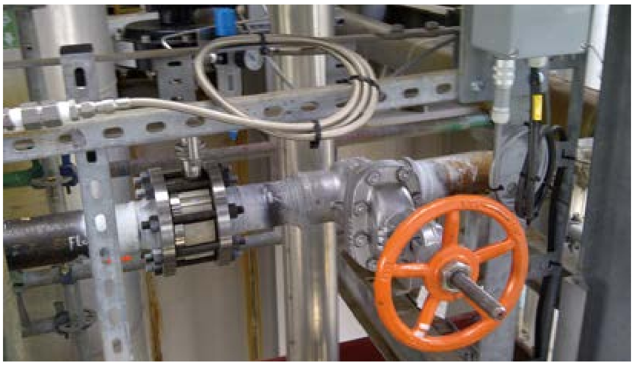


Fig. 6 The new sliding gate valve with 8049 positioner.

Fig. 7 The valve was dismantled after 1 year and no damage whatsoever and examined.

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