JUST THE RIGHT PRESSURE

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explain the development of a new safety valve for use in the synthesis sections of urea plants.

Full-lift safety valves are typically used in the synthesis sections of a urea plant due to the high discharge capacities. It is often the case that several safety valves are installed in parallel, each with a slightly different set pressure so as to prevent all valves from draining simultaneously. Between opening and closing, large quantities of carbamate gas (ammonia [NH_3] and carbon dioxide [CO_2]) are released into the atmosphere, depending on the plant design. This poses environmental issues.

Conventional safety relief valves also experience crevice and erosion/corrosion problems that can cause small leaks that often go undetected. These can in turn lead to an increased risk of carbamate solution crystallisation in the outlet line of the safety relief valve, even if heat tracing is used in the body of the safety valve. Furthermore, by increasing the effective seat area, due to the effects of corrosion the safety valve may open before the set pressure is reached.

Overpressure protection system development

The following requirements were specified for the development of an overpressure protection system:

- The safety valve should start to relieve as close as possible to, and not before, the set pressure in order to achieve maximum tightness up to the set pressure.

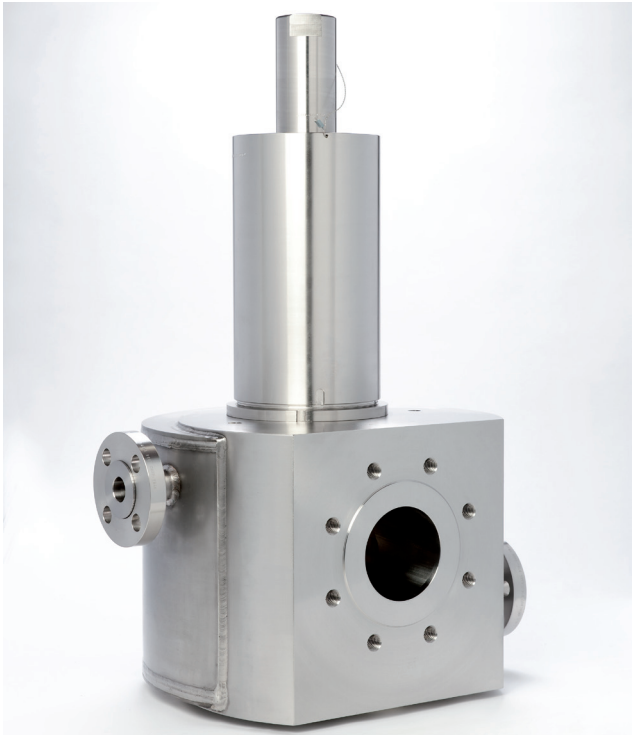

Figure 1. LESER block design for urea synthesis.

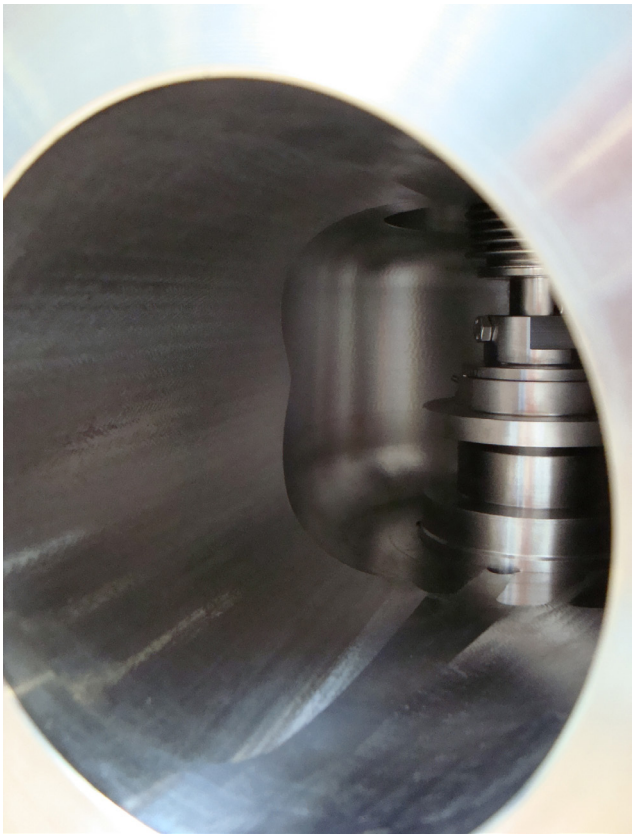

Figure 2. Close-up of the steam purge.

- The safety valve should close as soon as possible after relief to minimise media loss.
- The safety valve should close without the need for overhaul to minimise plant downtime.
- Availability and reliability should be sufficient to achieve maximum uptime.

From development to solution: steam injection of the valve

First, it was investigated whether a full-lift safety valve could be modified by introducing a steam injection system that heats and rinses the seat. This steam injection achieves an indirect heating of the seat on the process side and a direct heating/purging of the safety valve body and pressure line in one step. In addition, steam injection flushes the seat in the closed position, which reduces the risk of seat erosion/corrosion. Even in the event of a small leakage, such a flushing system could prevent carbamate crystallisation in the seat area and also in the outlet of the safety valve. LESER installed these safety valves in three urea process lines in 2008 and 2009. During a shutdown in 2011, the valves showed no corrosion or contamination on the upstream or downstream side. However, the technology did not achieve all of the objectives set.

Supplementary loading system: control unit and actuator

A safety valve was designed to include an additional supplementary loading system (SLS) that improves the valve's opening and closing characteristics. In the case of the supplementary loaded safety valve, the spring-loaded closing force is subjected to an additional force from a pneumatic actuator. A control system ensures that the pneumatic pressure is supplied to the actuator through control lines. Impulses are transmitted to the actual control unit by way of redundantly arranged, medium-carrying pressure tapping lines.

The individual control unit automatically discharges the pneumatic loading pressure, via relief valves in the control unit, when the specified set pressure is reached in the plant section to be protected. The safety valve can then open as intended. The opening action is supported, if the plant operator requirements demand, and the opening tolerance is reduced when the controlled but oppositely acting pneumatic lifting pressure is applied in the actuator. If the pneumatic lifting pressure is active, the valve opens independently of the back pressure. The pneumatic loading pressure is reapplied when the pressure of the main valve falls below the specified value. If the external control energy fails, the control unit does not change the loading or unloading of the main valve. The safety valve still operates like a spring-loaded safety valve. Other safety valve models can also be equipped with the supplementary loading unit, provided they are suitable for the control force.

With an additional loading system or pilot-operated safety valves, it is possible to operate the synthesis pressure much closer to the set pressure than with the direct acting safety valves. The SLS is more suitable for the protection of the urea synthesis area, since a pilot-operated safety valve can have problems with the crystallisation of the process medium carbamate during the corresponding pilot functions.

Development of a special pressure transmitter system

Due to the corrosion and crystallisation risks associated with carbamate, the pressure cannot be measured directly. The company therefore decided to develop a pressure transmitter for measuring pressure.

In order to use an SLS safety valve, it must be ensured that the pressure transmitter system transmits the same pressure that is applied to the safety valve. The permissible length of the capillaries is restricted and it is essential that the distance between the control unit and the actuator on the safety valve is limited to ensure that the safety valve responds sufficiently quickly.

This means that it is also important to measure the pressure in the high-pressure carbamate gas line where the safety valves are installed. A special pressure transmitter system with a tantalum diaphragm suitable for the high-pressure carbamate gas has been developed, which enables accurate and reliable monitoring of the synthesis pressure. Crystallisation and corrosion risks on the diaphragm are avoided by special (no dead zones) design details.

Results

The three developments discussed have been combined to form a complete SLS safety valve system that uses pressure transmitters located on the protected system, instead of a process fluid transmitting system located directly in the control unit, as used in steam boilers for example. This pressure transmitting system is approved by TÜV Nord in Germany according to the European Pressure Equipment Directive and ISO 4126-5.

In August 2011, the SLS was retrofitted to the safety valves at the first process lines. During commissioning of the plant, the system was tested by injecting CO_2 into the synthesis in the presence of TÜV. During the tests it was demonstrated that the safety valves remained tight up to the set pressure, as no temperature drop could be measured.

The operators immediately noticed that they could operate the synthesis pressure at a higher value, i.e. closer to the set pressure. From an average synthesis pressure of 142 barg, they could now operate at 152 barg. Due to the higher pressure, the reactor turnover rate could be increased by approximately 2%, which led to significantly higher plant utilisation and/or lower steam consumption at the high-pressure stripper.

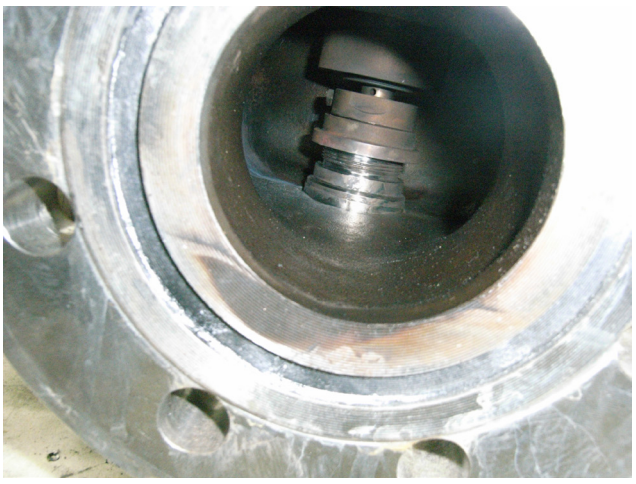

Figure 3. Inner body of LESER safety valve after two years of usage – no signs of crystallisation or corrosion.

Since the SLS safety valves close much earlier than the conventional safety valves, the blow-off quantity and thus the emission quantity was reduced by approximately 75% when using the former in urea synthesis.

In addition, the technology enabled a higher operating pressure to be achieved without the risk of leakage, due to the additional closing forces of the spindle on the seat caused by the additional load system.

Other advantages include:

- A shorter blow-off time between the set pressure and closing pressure.
- Less sensitivity to pressure pulsations and pipeline vibrations.
- No requirement to shut down the plant for maintenance work after blow-off.
- Reliable pressure measurement in carbamate gas, significantly higher plant capacities and lower energy consumption values.
- The material of all wetted parts can be corrosion-resistant.
- A constant nozzle temperature, which is higher than the condensation temperature of the carbamate solution, can be achieved in order to avoid negative corrosion effects and material structure effects of the sealing surface.
- Metal-to-metal sealing is possible with LESER's nanotightness process, designed for sealing surfaces, with roughness and flatness in the measuring range of 100 nm.
- 360° purging of the main valve body to prevent crystallisation in case of a blow-off situation.
- Systems in common use need up to five steam injection points to heat the nozzle. LESER's flushing system only requires one steam injection point to heat the nozzle and flush the outlet. It can be combined with a heating jacket to heat the outer area of the block body. This leads to reduced steam consumption (a third of common designs).

The system was implemented during a turnaround in the summer of 2012 in the other two urea process lines, and extended its inspection intervals from one to two years.

Conclusion

Since the development of this technology, the company has installed a number of such safety valves in urea plants in other countries. Over 320 are equipped with the steam purge system, which ensures that there is no clogging of the outlet line and no condensation and erosion corrosion in the seat area. In addition, more than 70 safety valves are designed with a standardised 3J4 block body design.

The synthesis sections of four lines in urea plants are equipped with the company's add-on loading system, allowing these plants to operate the synthesis pressure very close to the set pressure, resulting in higher conversion rates and 75% lower emissions in case of a blow-off situation. The results of this solution have been tested and approved by TÜV. WF