BADOTHERM Pressure Measurement Solutions improve safety and reliability, improve performance figures, avoid unnoted ammonia losses and reduce environmental impact of your urea plant.

Summary

Like many chemical processes, also in urea plants pressure safety valves safeguard against too high pressures. Urea plants are however unique because the very corrosive and easy crystallizing ammonium-carbamate poses challenges to assure a safe and reliable operation of these safety valves. Passing safety valves can cause clogging of the outlet line and is a serious threat for safeguarding your equipment against too high pressures. Also loosing valuable ammonia and risking a negative environmental impact are related consequences.
The synthesis section of a urea plant is safeguarded against too high pressures by synthesis safety valves. Operators prefer to operate the synthesis at a maximum operating pressure to realize a maximum conversion of ammonium carbamate into urea. But at the same time they need to be careful not to pop up the safety valves causing a major environmental impact and an unplanned expensive shut-down.
This technical paper addresses abovementioned issues and presents the innovative BADOTHERM solution, which realizes a reliable and accurate measurement of the synthesis pressure and a detection method for passing safety valves. This solution can also be applied in other sections of a urea plant such as the recirculation section and hydrolyzer/desorber section.

Introduction

Today typically one measures the synthesis pressure at a location in the synthesis, where the circumstances are relatively corrosion friendly and the risk of crystallization is less: For example in the ammonia feed line. However there is a difference between the pressure in the ammonia feed line and the pressure at the synthesis safety valve of typically some 2-3 bars. Because of this, the operator needs to take into account an extra margin when choosing the maximum synthesis operating pressure, which is determined by the risk of popping up of the synthesis safety valve.

In case one would be able to measure the synthesis pressure directly at the synthesis safety valves, so in the high pressure ammonium carbamate gas line, one will be able to avoid this extra margin and operate the synthesis at some 2-3 bar higher pressure. This will increase the conversion of ammonium carbamate into urea in the reactor and will lead to a higher (some 5%) urea production and/or lower (some 5%) energy consumption figures.

And in case one likes to implement a HIPPS system, as recommended by Stamicarbon, measuring the synthesis pressure directly at the synthesis safety valves is even more important to realize the significant benefits when one can operate the synthesis at a higher operating pressure.

BADOTHERM in the Netherlands has successfully developed a reliable pressure measurement for specific service, specific for high pressures and ammonium carbamate ammonium-carbamate gas phase applications. This innovative solution can be applied in the synthesis section but also in the recirculation section and hydrolyzer / desorber section.
Further it can be applied in the blow off line of a safety valve to detect passing of the safety valve reducing significantly ammonia losses and reducing the negative environmental impact.

The CFCL project to reduce ammonia emissions from safety valves

More and more environmental protection is on the agenda all around the world. In several instances, plants have been forced to stop because of uncontrolled high emissions, including ammonia and urea plants. There is growing emphasis on safety of environment. There is a risk of release of ammonia through the safety valves vent stack. However, typically very few safeguards are available to prevent environmental pollution in urea plants. Sometimes flare stacks are offered in urea plants but the cost is prohibitive and the environmental effectiveness is questionable. Chambal Fertilisers and Chemicals Limited (CFCL), Gadepan, District Kota, Rajasthan in India has devised an innovative solution to address this potential environment hazard in urea plants (ref. 1).

CFCL concluded that since the flow through vent stacks always remained within a certain range under normal circumstances, so would be the pressure in the vent stack. This was verified by installing a pressure transmitter in the vent stack. It was also seen that there was measurable variation in the value of the pressure with change in flow. As a consequence, concept of providing pressure-based automatic detection and control of emission from safety valves discharge through PLC trip logic was conceived.
Installation of pressure transmitters downstream of all safety valves of the urea plant and concept of defining trip logic for urea plant was proposed:

(i) To prevent blowing of safety valves and their discharge to atmosphere, pressure transmitters are provided to indicate system pressure and plant trip logics are defined with set value below the safety valve set points. Following this, plant will get shut-off before reaching to set point of safety valve. This is to avoid blowing of safety valve even in case of process upsets.

(ii) To automate detection and control of release from process safety valves, due to spurious reasons of safety valve's malfunctioning, etc., pressure transmitters are installed in the discharge pipelines of the safety valves to sense any pressure change in blow-down header caused by sudden passing of or else popping of any safety valve. Following this, indication and alarm shall be available to pin-point a stray safety valve and its location for timely action. However, plant will get shut-off at pre-set value of trip logic to prevent excessive release to atmosphere.

With implementation of above concept of providing pressure sensing linked automatic detection and control of emissions from safety valves discharge of urea plant, risk of any potential environmental hazard from urea plant is eliminated.
Figure 1 on the right side shows the pressure in the discharge line before passing and during mild passing of the safety valve.

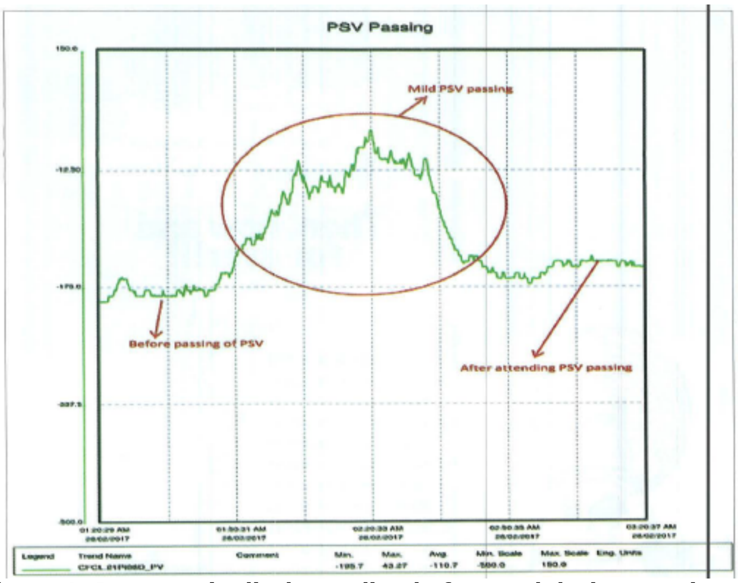

Figure 1: Pressure in discharge line before and during passing

Safety valve and HIPPS

There are two ways of protecting the system from overpressure. One, by using mechanical devices such as a safety valve. Other, by using a safety instrumented system such as high integrity pressure protection system (HIPPS). An HIPPS protects the pressure vessel and piping systems by removing the source of overpressure when pressure in the system reaches a pre-set value. This value must be less than or equal to the design pressure of the system.

An HIPPS is designed and built according to the International Electrotechnical Commission (IEC) standard 61511 (Functional Safety — Safety Instrumented Systems for the Process Industry Sector), part 1, part 2 and part 3. It consists of pressure sensors, logic solver(s) and shut-down valves as main components. The shut-down valves remain open as long as pressure sensors sense a value less than the predetermined value (that corresponds to less than or equal to design pressure of the system). As soon as pressure sensors sense a value equaling the predetermined value, the logic solver based on the signal from the pressure sensors gets activated and closes the shutdown valves. Pressure sensors and shut-down valves are generally provided with redundancy to meet the required level of performance of the HIPPS. Level of performance of a HIPPS is expressed in terms of Safety Integrity Level (SIL): Higher SIL means higher level of performance.
Whereas a safety valve protects against over-pressurization by releasing the excess fluid from the system, an HIPPS protects the system by cutting-off the supply of fluid to the system. Thus, a safety valve may necessitate installation of facilities for disposal of the fluid contained in the system e.g. a flare system, whereas no such facility is required in case of an HIPPS. Thus, the use of HIPPS can reduce the cost of a flare system substantially.
While safety valve’s operation may cause harmful impact on environment and people, HIPPS protects environment by not releasing any emission in the atmosphere. Thus, application of HIPPS may get preference over safety valve where stricter environmental laws are in force or where one wants to reduce consumption figures. Nowadays Stamicarbon recommends a HIPPS in the synthesis and recirculation section in their plants (ref. 2).

LESER Flush Safety Valves

For ammonium-carbamate service, the German company LESER has developed state of the art safety valves with a special LESER Flush system, which leads to a higher safety and reliability standard. These safety valves are available in 316L Urea Grade, 25-22-2, duplex and Safurex® material (Ref. 3) and avoid that one needs to shut down the plant to service the safety valve after a pop-up / blow-off situation.
Further with the LESER Support Loaded System (SLS) one is able to operate close to the set pressure of the safety valves and reduce the environmental impact to a minimum extend (Ref. 4). A pre-condition for such a SLS system is that one needs to measure the pressure close to the safety valve. BADOTHERM has a proven and innovative solution available for this service.

The BADOTHERM Pressure Measurement Solutions

Ammonium carbamate and urea easily crystallize when temperatures become too low. In the early days, flushes were installed at the transmitter legs of pressure measurements to avoid crystallization, however its reliability was very limited and considerable attention and maintenance was required. Moreover, these measures introduced certain safety risks.
Nowadays extended diaphragm seals are applied, which do not require any flushes anymore, as the diaphragm is installed flush mounted with the process. However, in case of any damage of the diaphragm, the plant needs to shut down and this happens typically unexpected. This leads to production loss and related significant costs. One day unplanned shut down costs easily half a million US$ in a world scale urea plant.

The thin diaphragm of these pressures (and also level and delta-P transmitters) are sensitive for erosion, corrosion and mechanical stresses. For ammonium carbamate and urea applications, several materials have been considered to meet these challenges, however many materials only offer a limited lifetime. Especially in the ammonium carbamate gas phase the conditions are extremely tough as unwanted condensation leads to very corrosive liquid ammonium carbamate and erosion issues (droplets, solids from passive corrosion products) influence the reliability.

BADOTHERM has successfully overcome the extremely tough challenges of measuring pressure in an ammonium carbamate high-pressure gas phase. A BADOTHERM pressure measurement has been installed in the high-pressure ammonium carbamate gas line in a urea plant. The process conditions are very severe in this ammonium carbamate line as pressure are 140-150 bars and temperatures are 180-190 ºC. The BADOTHERM Transmitter has proven to be able to withstand these very harsh conditions already more than 4 years already without any issues (status as per January 2019).

Now BADOTHERM Pressure Measurement Solutions
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More information?

In case you are interested to receive more information about our this or other solutions, please contact:

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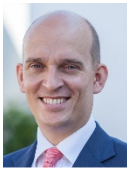

About Badotherm

Galileo Galilei once said 'measure what is measurable and make measurable what is not so.' Four hundred years later, this is exactly what we do. We are a family-owned company specialized in high quality mechanical process instrumentation. Founded back in 1957 as a production- and repair shop for thermometers, today we are a leading manufacturer of Diaphragm Seals, pressure gauges, temperature gauges, thermowells, valves and manifolds. Badotherm is headquartered in the Netherlands, and employs over 225 people in seven different countries and serve the most reputed end users on a global basis. We have offices and facilities in Europe, the Middle East, India, the Far East and Americas.

Badotherm has a strong focus on Diaphragm Seal Solutions. Diaphragm Seals, also known as remote seals, are used to separate the pressure instrument from the hash process conditions, to protect the vulnerable measuring element. We develop, engineer and manufacture tailor-made solutions for the most challenging conditions in the field of Diaphragm Seal measurements. The patented HTDS solution for pressure measurement up to 600°C by means of Diaphragm Seals is a great example of this, just as the low gauge pressure (LGP) measurement of just 5 mbar-g. In addition, we also developed a web-based performance calculation tool 'BaseCal' for Diaphragm Seal applications, to help engineers understand the impact of Diaphragm Seals, calculated under actual process conditions. And for UREA applications, there is the full zirconium extended type of diaphragm seal that has been developed.

References

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