Single solution to the formation of polymers in top of the Vacuum Separator of a Urea Plant

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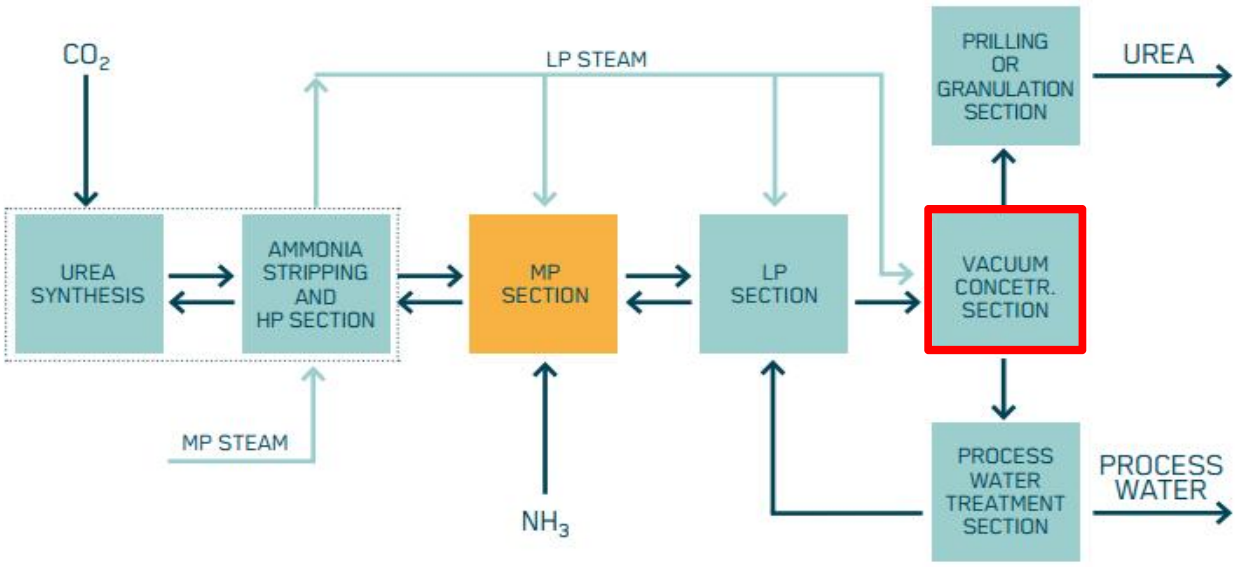
Introduction

Two major urea melt technologies are the Saipem NH_3 stripping technology, which has been introduced since 1971 [1]. The medium pressure section is one of the main differences with the Stamicarbon CO_2 stripping technology. Refer to Fig.1 [2]. In this paper, we discuss our experience with and propose an innovate solution for the vacuum concentrator, the most unstable part in the our Saipem NH_3 stripping plant.



Problem description

The vacuum concentration in Saipem technology includes three units: pre-concentrator, the first concentrator and the second concentrator. The pre-concentrator is applied to minimize the temperature and residence time in order to reduce the biuret formation. For the prilled product, the requirement for concentration of molten Urea is minimum 99.6wt%., preferably 99.8wt% [3].

At that condition, high concentrated Urea solution is entrained by the water vapour to the top of second vacuum concentrator causing urea polymer lump formation on the separator's wall and outlet nozzle. Another proposed mechanism for the urea polymer lump formation is the dissociation of Urea into gases ammonia and isocyanic acid (HNCO) which then reacts to form solid Urea at cold spots. Further reaction with Urea will create higher polymers like biuret, triuret etc. These lumps affect seriously the operation of the Urea unit and quality of the product even leading to a necessary shut down of the plant.
To avoid lump formation, Saipem designed a Urea melt spraying system in the top of the second vacuum separator to wet the internal wall [3]. According to our experience, this washing step needs to be take place once per two weeks in which the Urea melt is diverted to a specific tank. Water and a small recycle of Urea melt are utilized to wash the polymer from top respectively. Based on a visual check, when there are no traces of polymers in the bottom of the holder, a stop signal for washing process will be issued.

Troubles experienced
Though wetting system can temporarily remove the lumps on the wall in the top of the second vacuum separator and the washing time every two weeks normally is 2 hours, our factory still faces some obstacles:

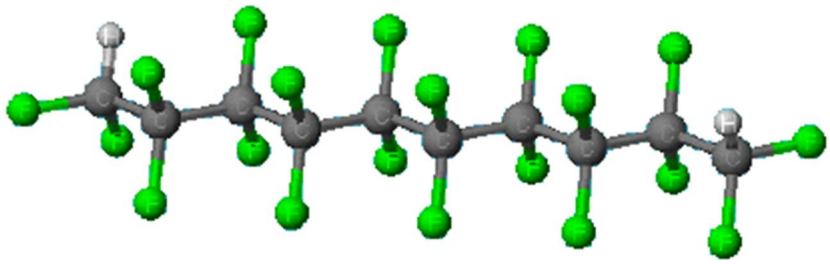
- During the plant operation, our DCS staff has to solve the vacuum pressure issue whenever the vacuum is low. Flushing with water and steam in the nozzle and the top of the seperator could save the vacuum which proves that washing with Urea melt and hot water every two weeks doesn't remove the lumps completely.
- Moreover, washing in two hours means increasing the residence time of the Urea melt, which facilitates the reaction of biuret, triuret and others side products. This contributes for the low quality of product.
- The prilling process is inactive for 2 hours due to washing which decreases considerable our productivity. Also, an amount of energy has to be spent for the flushing process.

The main reason for the lump formation is the low temperature of the wall. Based on that concept, many plants installed a tracing system which guarantees that the wall temperature higher than 132.7 degC (the melt point of Urea) and there are no cold spots present. This additional design however is not always applicable for every plant when considering the energy and the capacity.

Proposed Innovative solution

Make the surface non-sticky is an affordable solution for this problem. The most common non-stick materials using in day-life also in industry are PTFE and Ceramic.

- PTFE (Teflon)



Teflon, $-(CF_2CF_2)-$

PTFE prevents the problem of attachment due to the high bonding energy in the C-F bond resulting in an inert surface chemistry [4].

- Ceramic

Ceramic comprises of metal, non-metal or metalloid atoms linked by ionic and covalent bonds. The compositions of ceramic are various depending on the application. Until now, the mechanism of how ceramic behaves like a non-sticking layer is still on debate. It could be the surface layer glaze that fills and smooths the micropores in the base layer metal or ceramic or it relates to the crystal and amorphous structure.

We prefer PTFE above ceramic due to some technical issues:

- Expansion coefficient

The target materials for coating are the metal and alloys which are highly thermal expansion. Thus the coating material has to adapt that condition. PTFE is the better candidate due to its high thermal expansion ($218*10^{-6}$/degC in range of 25 to 300 degC) [5] is close to metal and alloys while ceramic thermal expansion coefficient remains ten times lower ($0\text{-}22.3*10^{-6}$/degC in range of 25 to 300 degC) [6].

- Durability

In general, all kind of PTFE are stable below 200 degC. However, ceramic can lose their non-stick property after a period of using due to their messing components.

- Cost

To meet the requirement of this application, PTFE stands out to be reasonable price while ceramic must be complimented at very high cost.
The only risk is that the peeling off of the non-sticking layer could contaminate the process stream. The thickness of this layer is in range of micrometers so the problem above could be ignored.
The most relevant patent is about the mixing device for mixing Urea and air [7]. This device utilizes PTFE to avoid the clogging effect when mixing Urea with air and water at temperature above 132^{o}C.

Conclusions

Although we have to consider about the durable and risk assessment when coating with PTFE, the achieved benefits would be positive. At least, less time will be spent for vacuum separator washing or even no washing may be necessary anymore. The accumulation of Urea will reduce significantly resulting in smooth operation.

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