Revamp of the Medium Pressure Decomposer at

Fauji Fertilizer Company Ltd Mirpur Mathelo (former Pak Saudi Fertilizer)

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Summary

The operational functioning of the Medium Pressure Decomposer (MPD) at Pak Saudi Fertilizer was not good already along its complete history. Several modifications in the vessel were implemented, however high biuret, tube leakage, capacity limitation and solution carry over problems were still persisting. After acquisition of plant by Fauji Fertilizer Corporation a detail study on the MPD was carried out and the problem area was identified. On the basis this study short and long term solutions were proposed. Vessel was replaced in 2008 after operation of 5 years even at 125% plant load.

Content

1. Introduction

Fauji Fertilizer Company Ltd [FFC] was incorporated in May 1978 as a joint venture between Fauji Foundation and Haldor Topsoe, Denmark. FFC is the largest urea manufacturer in Pakistan, operating three ammonia-urea plants; two at Goth Machhi in Punjab and one at Mirpur Mathelo in Sindh. All ammonia plants employ Haldor Topsoe design, while urea plants are based on Snamprogetti technology. The first ammonia-urea plant [Plant-I] was commissioned at Goth Machhi in 1982 with design capacities of 1000 metric tons ammonia and 1725 metric tons urea per day. The plant was successfully revamped to 122 % of design capacity in 1992. The second ammoniaurea plant [Plant-II] was commissioned at Goth Machhi in March 1993 with design capacities of 1100 MeT ammonia and 1925 metric tons urea per day. The third ammonia-urea plant [Plant-III] at Mirpur Mathelo was acquired in 2002 through privatization of the PakSaudi Fertilizers Limited. This plant has design capacities are 1000 metric tons ammonia and 1740 metric tons urea per day. The plant was successfully revamped to 125 % of design capacity in 2008.
FFC also has a majority shareholding in a subsidiary company called Fauji Fertilizer Bin Qasim Limited [FFBL], producing granular urea and di-ammonium phosphate, and 12.5% share-holding in Pakistan Maroc Phosphore, Morocco [a joint venture between FFC, FFBL, Fauji Foundation, Pakistan and Office Cherifien des Phosphates, Morocco].

This paper discusses the troubleshooting of the Medium Pressure Decomposer are Fauji Fertilizer Company Urea Plant- III . Please find in Figure 1 a typical flow scheme of the Saipem urea process.

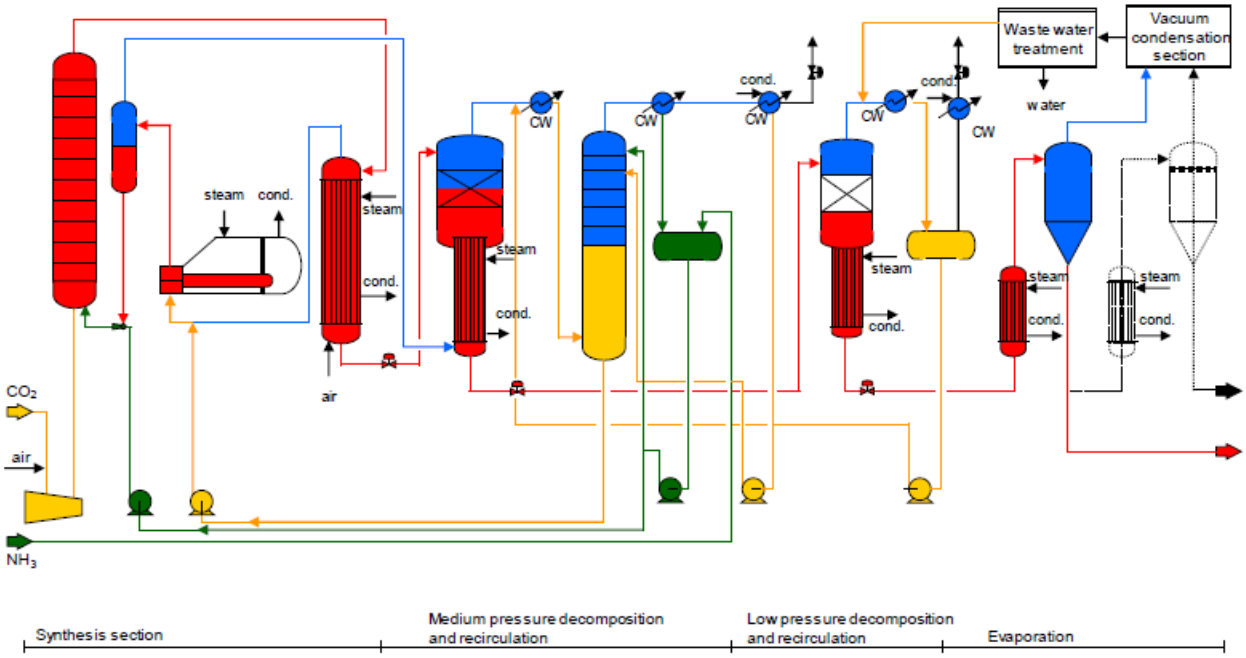


Figure 1: Typical flow scheme of the Saipem urea process.

The Medium Pressure Decomposer separates unconverted carbamate from the urea / water mixture coming from the High Pressure stripper. The picture below shows the medium pressure recirculation pressure of a typical Snamprogetti urea plant.

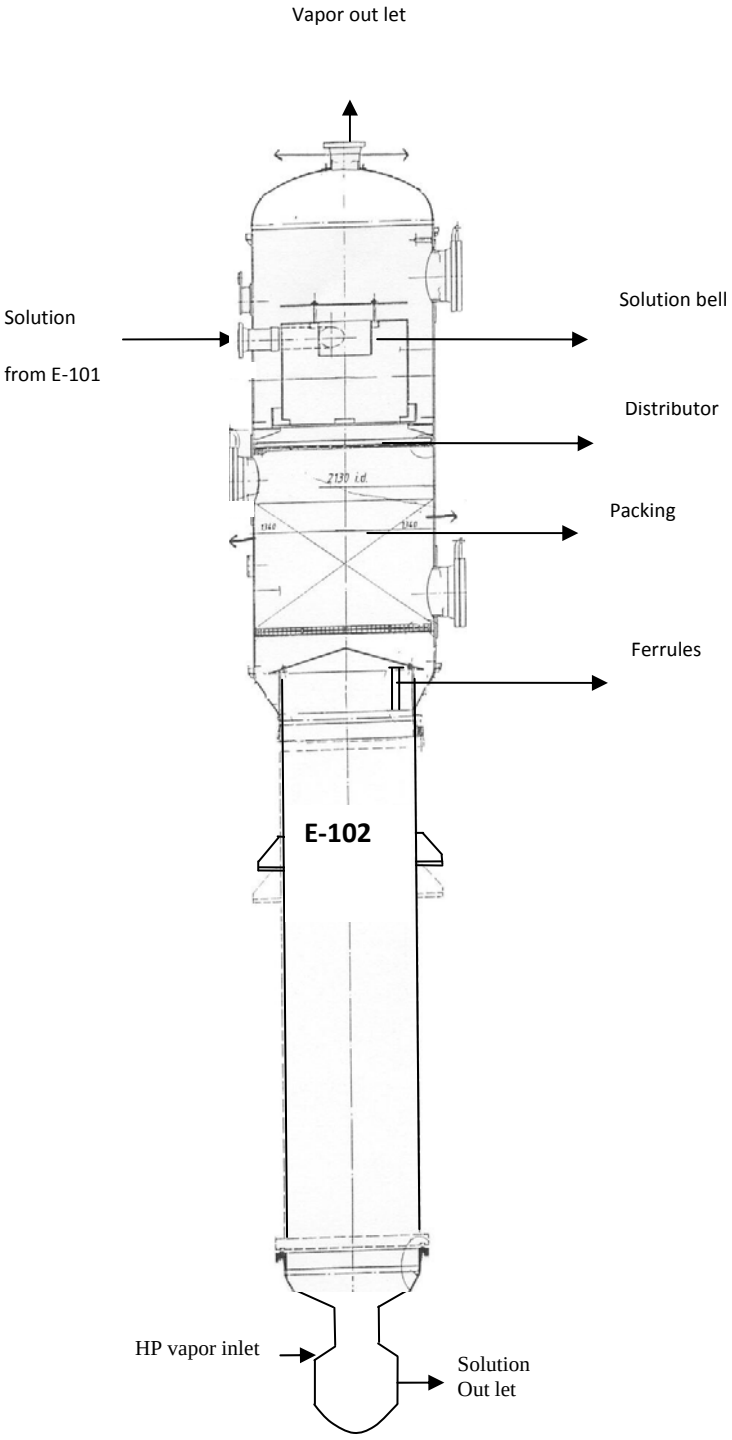
The operational functionality of the Medium Pressure Decomposer (MPD) at Pak Saudi Fertilizer was not good already along its complete history. Several modifications in the vessel were implemented, however high biuret, tube leakage, capacity limitation and solution carry over problems were still persisting. After acquisition of plant by Fauji Fertilizer Corporation a detail study on the MPD was carried out and the problem area was identified. On the basis this study short and long term solutions were proposed and ultimately the vessel was modified in 2008 after operation of 5 years even at 125% plant load.

Picture 1: Snamprogetti Medium Pressure Recirculation section

2. Description Medium Pressure Decomposer

The function of the Medium Pressure Decomposer is to treat the liquid coming from the High Pressure Stripper, more precisely the unconverted carbamate is separated from the urea/water mixture.
Figure 2 shows the lay out of the Medium Pressure Decomposer.

Figure 2: Lay out of the Medium Pressure Decomposer



Distributor with base

Paul ring Packing

Ferrules top showing

Ferrules

The Medium Pressure Decomposer consists of three main parts:

2.1 Separator

This is the top portion of MPD and used for vapor liquid separation.
It consists of:

- **Solution bell**
  It provides tangential path to the inlet solution.

- **Distributor**
  The solution distributor is meant to realize an equal distribution of solution on the packing. This distributor is a perforated plate having 764 holes of 8mmΦ.

- **Packing**
  Packed bed is used for providing maximum contact between vapor and liquid. Pall rings are used in this bed.

- **Umbrella**
  Umbrella is used to avoid direct pouring of solution into the ferrules.

- **Ferrule**
  Ferrule is used for making falling film in the tubes; it has four tangential holes at its lower end.

2.2 Heat Exchanger

It is falling film (fixed tube) sheet exchanger. Solution travels downward inside the tubes and the steam condensate has counter flow arrangement in the shell.

2.3 Holder

It maintains liquid seal to avoid MP section vapors bypassing to LP section.

3. Operation of the Medium Pressure Decomposer

The Medium Pressure Decomposer is used to increase urea concentration from 48.32 wt% to 64.39 wt% and heat for decomposition of the carbamate is supplied by the MC condensate coming from the High Pressure stripper. MS steam transferred its latent heat in stripper and condensate is fed to the shell side of MPD for heating purposes.

A direct MS steam injection option is also provided along with condensate to fulfill heat requirement at higher operating load.

Further High Pressure Vapor from the synthesis section is injected at the bottom of the MPD to facilitate the decomposition of carbamate.

The normal operating temperature of MPD bottom / top is 166 °C / 139.5 °C. Operating pressure is 15 Kg/cm^2.

4. History

The Medium Pressure Decomposer remained problematic since commissioning. The equipment was internally inspected a number of times but no abnormalities were found. Packing type was changed from Raschig rings to Pall rings to reduce pressure drop & flooding tendency. The occasional overflow problem frequency was reduced but not completely rectified. After about 17 years of service, tube leakage problem also appeared for the first time in 1997. Plant load was increased after FFC acquisition gradually up to 120% and a capacity limitation was experienced. In turnaround-2003 ferrules hole size was increased from 4.0mm to 4.5mm.

5. Problem analysis

The following four problems were faced after FFC acquisition.

- Tube Leakage
- Capacity Limitation
- High Biuret Formation
- Solution Carry Over

5.1 Tube leakage

Four tube leakage incidents occurred in the MPD till 2002 and 19 tubes have been plugged out of 621. The leaking tubes are on the shell side condensate inlet of the heat exchanger.

The susceptible cause of the MPD tube leakage is indentation due to striking against the baffles (also called baffle hammering), mainly because of

- Higher tube length without any intermediate baffle.
- A mix phase of steam & condensate flow in shell side due to poor operational parameters (uncontrolled NH_3/CO_2 ratio in HP loop).
- Inadequate design of impingement plate in condensate inlet.
- Higher clearance between baffle and tubes OD due to corrosion as a result of High Pressure stripper leakages in past.

5.2 Capacity limitation

The second problem in MPD is capacity limitation this problem is due to:

- Less heat transfer area available.
- Low heat available for decomposition due to single shell arrangements. As modern MPDs are consist of two shells

5.3 High biuret formation

Biuret is a urea bi-mer. Its high concentration in the urea product can decrease the fertility of soil. Favorable conditions for biuret formation are higher residence time and high temperature.
Following are the reasons for high biuret formation in the MPD:

5.3.1 Film Disturbance

The solution film in the MPD tubes can be disturbed due to higher velocities of rising gas or mal-distribution of solution in tubes. If the film thickness inside the tubes reduces solution overheating problem in some tubes starts which causes high biuret formation.
The causes of film disturbance inside the tubes are:

- Higher opening of HP section pressure control valve (01-PRC-1) results in high vapor velocities inside the tubes and ultimately disturb the solution film.
- The MPD holder is a converging type (as shown in Annex-I) that increases the velocities of the vapor in the central portion of the tube sheet. So the solution in central tubes over heats and results in high biuret formation.

5.3.2 Solution Hold-up

The solution hold-up at any point in MPD increases residence time that cause high biuret formation.
In the MPD the solution can hold at the following locations despite normal level in the holder:

- Distributor
- Packing
- Top tube sheet of heat exchanger

To reduce the solution hold up at top tube sheet, we have already increased the ferrule tangential hole size. While the chances of solution hold-up on packing and top distributor are still high due to less flow area available on top distributor for solution flow, high packing volume and higher velocities of rising vapors.

5.3.3 High Operating Temperature

As the plant is being operated at higher load, to meet the design boil-off ratio of NH_3, the bottom operating temperature of MPD is kept at 165°C as compared to the design value 156°C which also favors high biuret formation.

5.3.4 Ferrules Dislodging

Ferrule dislodging results in solution film disturbance inside the tubes due to uneven solution distribution. Higher flow in some tubes cause their overloading while flow in the rest of the tubes decreases which causes overheating of solution and ultimately results in high biuret formation.
Ferrule dislodging occurs due to following reasons:

- Higher vapor velocities in the central portion of heat exchanger due to converging type of holder
- Mechanical looseness
- Pressure surges in start-up due to variation of HP section pressure control valve opening.

5.4 Solution carry over

Solution carry over is the phenomenon that solution goes along with MPD overhead vapor towards condenser E-107 due to any hold-up. Our plant is facing this problem in MPD since plant commissioning. But this problem minimized to some extent by changing the type of packing,

installation of segregated Medium Pressure Decomposer ferrules from Low Pressure Decomposer and partial routing of vapors to the LP section by keeping MPD level control valve opening on higher side.

Chances of solution hold-up on top distributor are still high due to less flow area available.

6. Solutions

Originally supplied packing type raschig rings were replaced with pall rings in early nineteen eighties to reduce pressure drop and solution carry over problem.

Top Distributor base plate hole size increased from 8 Φ mm to 10 Φ mm to reduce hold-up on top distributor.

Partial re-routing of High Pressure loop gases from MPD bottom to top for reduction of vapor load and improve film inside the tubes. This reduced biuret formation and steam consumption in MPD.

Packing height decreased to reduce pressure drop across the packing to reduce carry over problem. Volume lowered from 15 to 5.0 m^3.

Ferrules replaced with larger diameter tangential holes and tight fitting for proper film formation inside the tubes.

Grid was installed on the top of ferrules to avoid dislodging in the new MPD.

The MPD holder design changed from converging to diverging type for decreasing the vapor velocity in exchanger central tubes (refer to Annex 1). This will help in reduction of biuret formation and over all decomposition efficiency will improve. The holder design was changed to diverging type when installing a new vessel in 2008.

Annex 1: Revamp of MPD holder

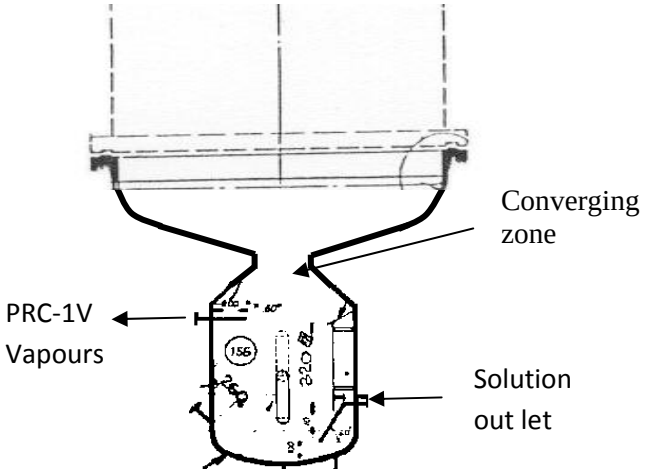


Figure 3a. Old design MPD holder

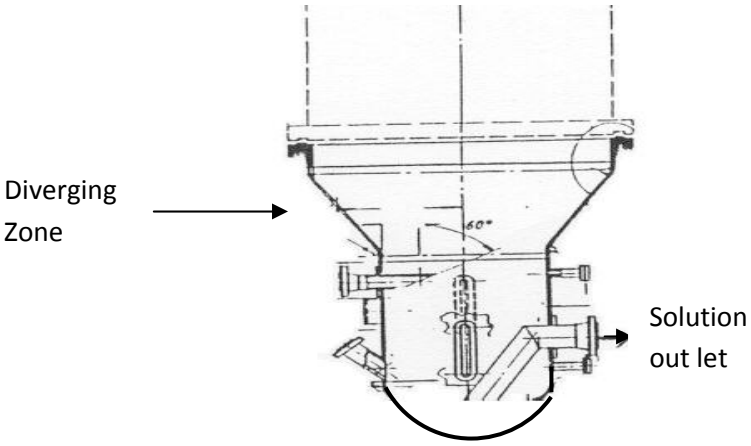


Figure 3b. New design MPD holder