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Bi- Metallic Stripper Failure

Mr. Ali Al-Majed
Manager, Technical Support Dept.
Saudi Arabian Fertilizer Co. (SAFCO)
(SABIC Affiliate)

Saudi Arabia

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SAFCO:

Saudi Arabian Fertilizer Company (SAFCO), an affiliate of Saudi Arabian Basic Industries Corporation (SABIC), is having 4 fertilizer complexes located in Dammam (safco-1) and Jubail Industrial city (Safco 2, 3 & Ibn Albaytar).

Safco produces Ammonia (1900,000 MTPY), Prilled & granulated Urea (2,300,000 MTPY), Melamine (27,000 MTPY), Sulphuric acid (110,000 MTPY) and DAP & compound Fertilizer (310,000 MTPY).

Ibn Al Baytar (IBB) complex has its Ammonia plant commissioned in 1988 and Urea and Compound Fertilizer plants in 1991.

The urea plant is a single stream unit of plant capacity 1500 MTPD. Its Process Licenser is Snam Progetti, Italy and EPC contractor was TPL, Italy.

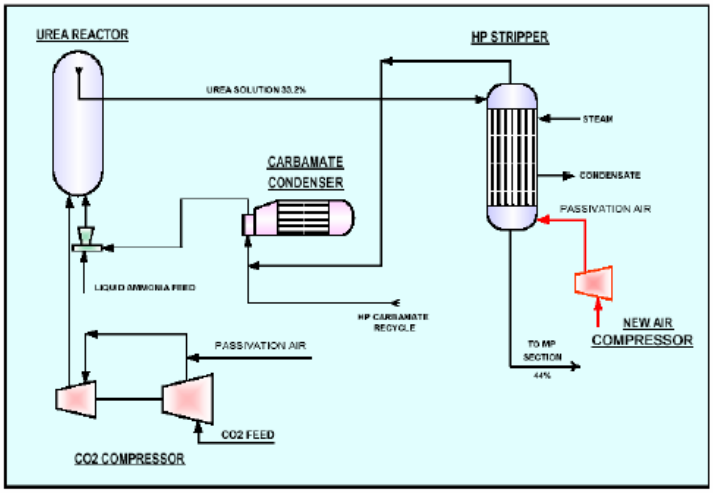
High Pressure Stripper:

The IBB urea plant has a very critical vertical exchanger called "High pressure urea stripper". The Outlet Solution (urea + carbamate) from HP Urea Reactor is heated in the "HP urea Stripper" using medium pressure steam. The function of the stripper is to strip off the unconverted CO2 and NH3 vapours from urea solution and the rich urea solution is sent to medium pressure section for further processing. Carbamate solution (33% urea) enters HP Stripper from the top, gets stripped off in the tube bundle and rich urea carbamate solution (44% Urea) leaves the stripper through the bottom nozzle. The stripper was designed by Process licenser Snamprogetti and fabricated by IMB-Italy.

Process Parameters:

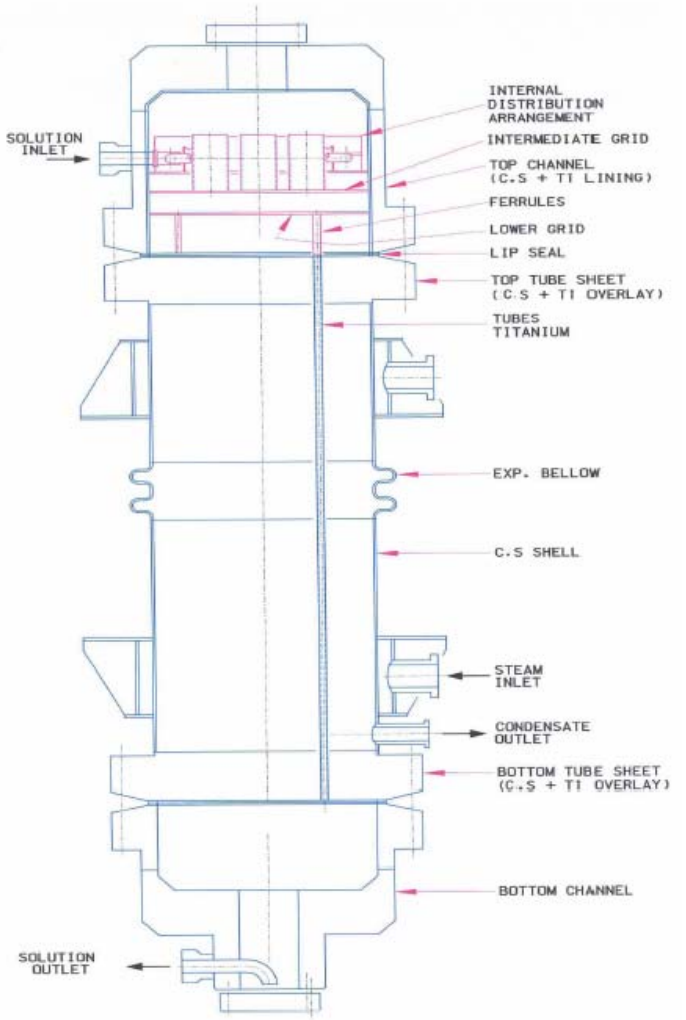
		Normal	Design
Shell Side	Fluid	Steam	
	Temperature °C	219	230
	Pressure Kg/cm2.G	22	28
Tube Side	Fluid	Urea + Ammonium Carbamate Solution	
	Temperature °C	205	230
	Pressure Kg/cm2.G	147	165

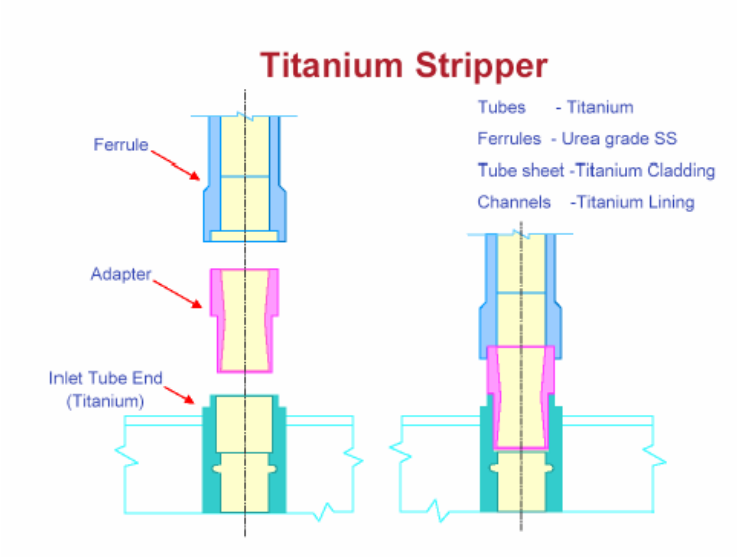
Process flow diagram:



Titanium Stripper Construction:

The Tube sheet of stripper is made of carbon steel (CS) with titanium cladded on carbamate wetted side. The top and bottom channel barrels are made of CS and lined inside with Titanium plates. There are 2281 tubes, made of Titanium material. Ferrules are fixed on the top end of the tubes and an adapter is introduced in between tube end and ferrule in the later stage.





Problems faced in Titanium stripper:

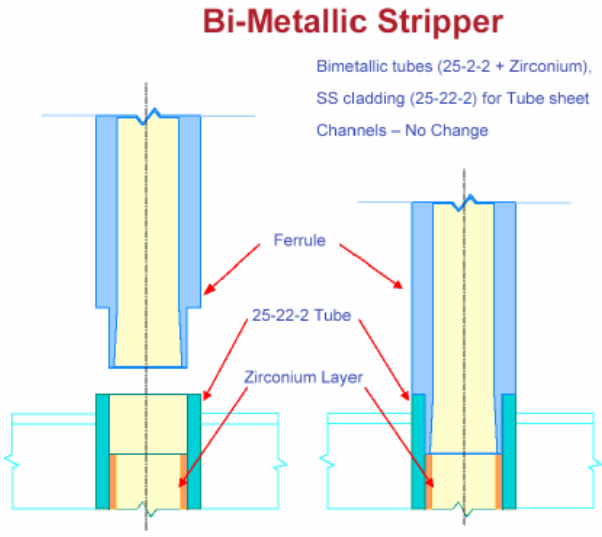
The Stripper was inspected periodically at every turn around. Initially, there was a problem of liquid bypass experienced in between tube end and ferrules. Hence, an adapter (with closer dimensional tolerance) was introduced in between tube end and ferrules and liquid bypassing was eliminated effectively. Subsequently, there was grooving effect found just below the adapter end, on the ID of Titanium tube. Thirdly, there was a uniform reduction in tube thickness observed in the tube portion within the top tube sheet.

In 1996, the titanium tubes reached the minimum thickness inside the top tube sheet area and the stripper tube bundle was reversed. In this revered condition, the stripper was in operation effectively for another 6 years. Since it was projected that the stripper would reach its retiring tube thickness in 2002, actions were taken to replace this titanium stripper.

Bi-metallic stripper:

During that time, the process licenser developed and patented a new stripper. The tubes of the new stripper are bimetallic with outer tube made of 25-22-2 and the inner tube made of zirconium. As per Process licenser, the inner Zirconium layer has high corrosion/erosion resistance properties and thus the erosion problem of titanium would be eliminated in the bimetallic tubes. The wetted portion of tube sheet is overlayed with 25-22-2 material to enable the TTS welding of the outer tube layer.

In April 2002, Titanium stripper (after 11 yrs in service) was replaced by the Bi-metallic stripper, as per the recommendation and specification of Process Licensor. Existing Channel heads were reused without any changes. Expected life of the new bi-metallic stripper was 25 years.



Problems faced in Bi-metallic stripper:

New Stripper started leaking within 11 months of operation. On internal inspection, following are observed:

- Heavy corrosion at bottom TTS (tube to tube sheet) weld joints.
- Heavy corrosion at bottom tube sheet SS overlay.
- Heavy corrosion at tube end (25-22-2 portion).
- Zirconium portion was found intact.
- The top tube sheet and TTS welds were found intact.

In 2003, extra Passivation air (30 m3/hr) was introduced in the outlet channel, using a separate air compressor. Subsequently corrosion rate was noticed considerably less and however, the plant was operating at a lesser load. Urgent action was taken to replace the bi-metallic stripper at the earliest, by re-tubing the old Titanium Stripper.

The overall production loss due to the sick bi-metallic stripper was more than 100,000 MT of product Urea, in addition to the expenses incurred due to the equipment replacement.

Failure Analysis:

An external inspection agent was appointed for investigating the root cause of the failure. During investigation, manufacturing defect was ruled out after checking all QC documents and manufacturing procedure. Sample analysis of material from the corroded part indicated starvation of oxygen in the corroded part.

Operating conditions of bottom channel is more severe in terms of temperature, carbamate concentration and lack of Oxygen content due to stripping action. However, titanium part did not show any deterioration in the top or bottom channels. The 25-22-2 materials in the top channel were found intact. Hence, it was concluded that 25-22-2 material cannot resist corrosion for the severe condition prevailed in the bottom channel without additional supply of Oxygen.

From the 4th Licensers symposium held in Oct 2004, it was reported that bimetallic stripper without additional passivation air has failed during first year of operation in 3 other plants in Argentina, India and Pakistan.

Direct cause of failure:

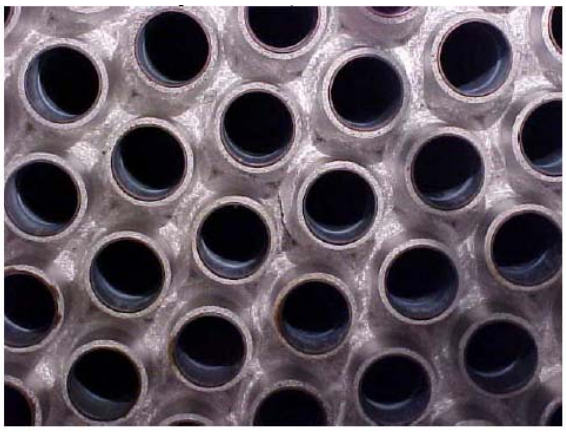
The direct cause of the bimetallic stripper failure is “Inadequate Air Passivation” at the bottom channel, where 25-22-2 could not resist the severe corrosion due to non-conducive operating condition.

Root cause of failure:

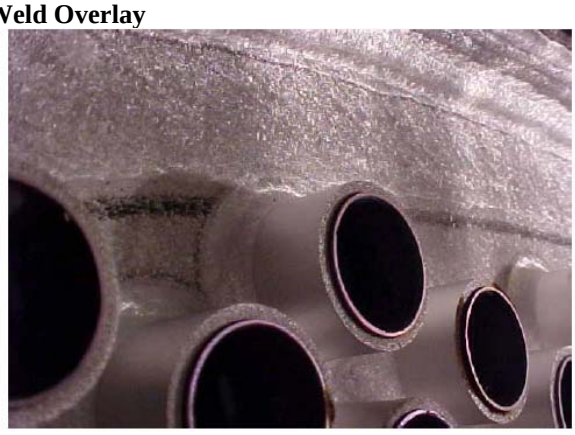
The root cause of the failure is **“improper design“** of the bimetallic stripper which failed to recognize that 25-22-2 couldn’t withstand the severe operating conditions prevailing in the bottom channel of the stripper.
The material 25-22-2 material requires more air passivation comparing Titanium.

Photos:

Corrosion at TTS welding and at tube tips



Corrosion at Tube sheet – Weld Overlay



Plugged Tubes