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SWEET AND SOUR EXPERIENCE OF PLANT COMMISSIONING

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DGM (Production & process)

Abstract.
The paper describes a successful of plant start-up despite the pandemic difficulties and introduces a set of first considerations about the possible future application of available digital technologies for remote and distributed control system from central control room commissioning of complex Dangote Fertilizer Plants. The numbers of problem were faced during commissioning stage ultimately the 17th march 2021 was the historical date for achieved plant production of line-1 plant .The major problem was pandemic due to which scarcity of staff availability. However numbers of problems faced in Ammonia and urea plants. About 4 time's unsuccessful attempt were done and finally we got historical success. In this paper we described the failure attempt and types of problems faced in ammonia and urea plants and each time problems were differ from previous.

Keywords'-Commissioning, carryover, Granular, choking, strainers. Plant design.

Introduction

Dangote Fertilizer Project is the largest Granulated Urea Fertilizer complex coming up in the entire fertilizer industry history in the World, with an investment of 2.5 Billion USD capacity of 3 Mil TPA. Acquired 500 hectares of land for the Fertilizer Complex. Natural gas is the main raw material for the plant. SAIPEM, Italy, is the Engineering, Procurement and Construction (EPC) Contractor for the project. Tata Consulting Engineers, India, is the Project Management Consultants (PMC) for the project. The Dangote Fertilizer complex consists of Ammonia and Urea plants with associated facilities and infrastructure, to produce 3 MMTPA Urea.

The complex envisages :

- 2 x 2,200 MTPD Ammonia Plants based on Halder Topsoe technology
- 2 x 3850 MTPD Melt Urea Plants based on Saipem technology
- 2 x 3850 MTPD Urea Granulation Plants based on Uhde Technology
- A Captive Power plant comprising of 3 Steam Turbine Generators of 40 MW capacity each. Total 120 MW
- 3 Auxiliary Boilers for 40 ata steam generation of 200 te capacity each

Process Description

The Saipem ammonia stripping process is characterized by a urea synthesis loop operating at about 160 kg/cm^2 (g) with ammonia to carbon dioxide molar ratio at urea reactor inlet of 3.3 - 3.6.This allows a CO_2 conversion into urea of 60 - 63% in the reactor itself, also thanks to the perforated trays which prevent back-flow and favour gas absorption by the liquid.There are two kinds of chemical reactions at the same time in the urea reactor:

$2NH_3 + CO_2 = NH_2\text{-}COO\text{-}NH_4$ + 136230 kJ/kmol of carbamate (at 1.03 kg/cm^2; 25°C);

$NH_2\text{-}COO\text{-}NH_4 = NH_2\text{-}CO\text{-}NH_2 + H_2O$,- 17575 kJ/kmol of urea (at 1.03 kg/cm^2; 25°C)

The First reaction is strongly exothermic and the second one is weakly endothermic and occurs in the liquid phase at low speed. Downstream the urea synthesis the decomposition (and relevant recovery) of unconverted chemical reagents is carried out in three subsequent steps: High

Pressure Decomposition in H.P. stripper; Medium Pressure Decomposition in M.P. Decomposer and, finally, Low Pressure Decomposition in L.P. Decomposer. The decomposition reaction is the reverse reaction of the first one above showed, viz.:

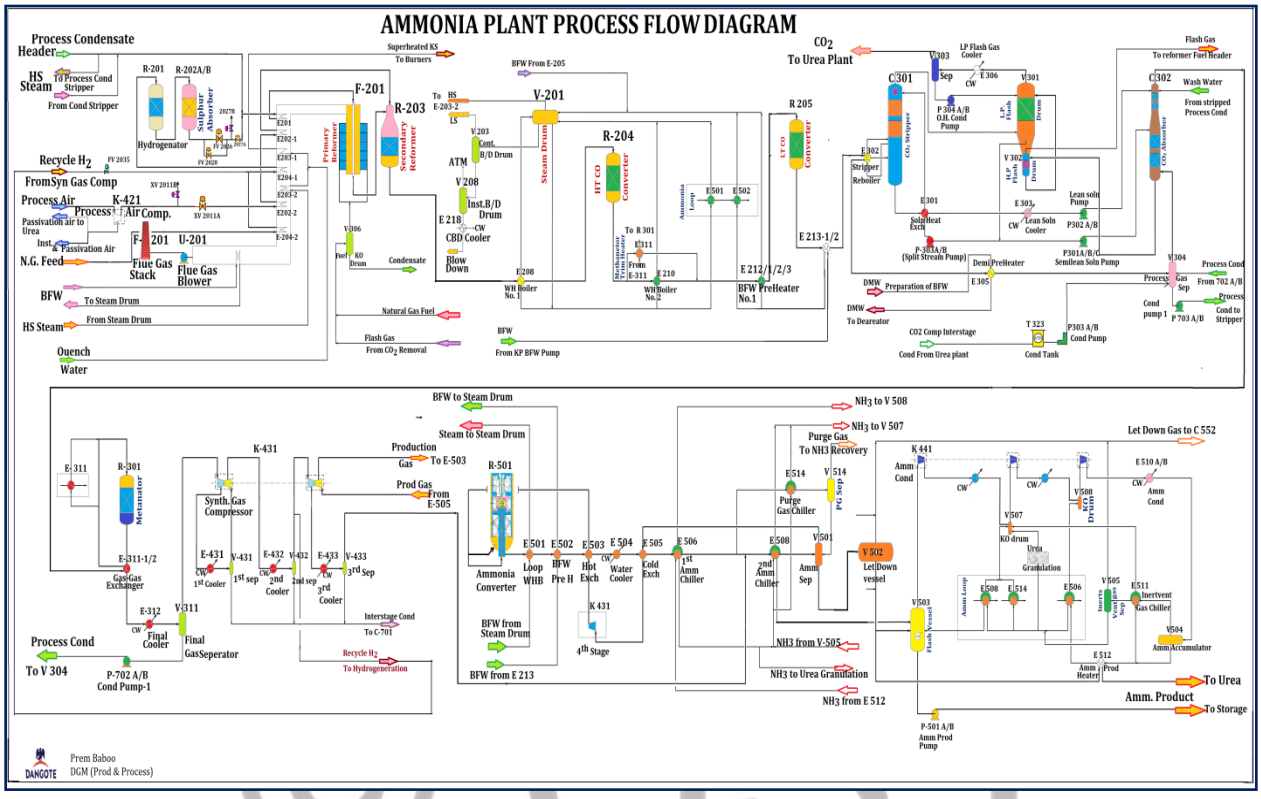

Fig-1(Ammonia Plant Flow diagram)

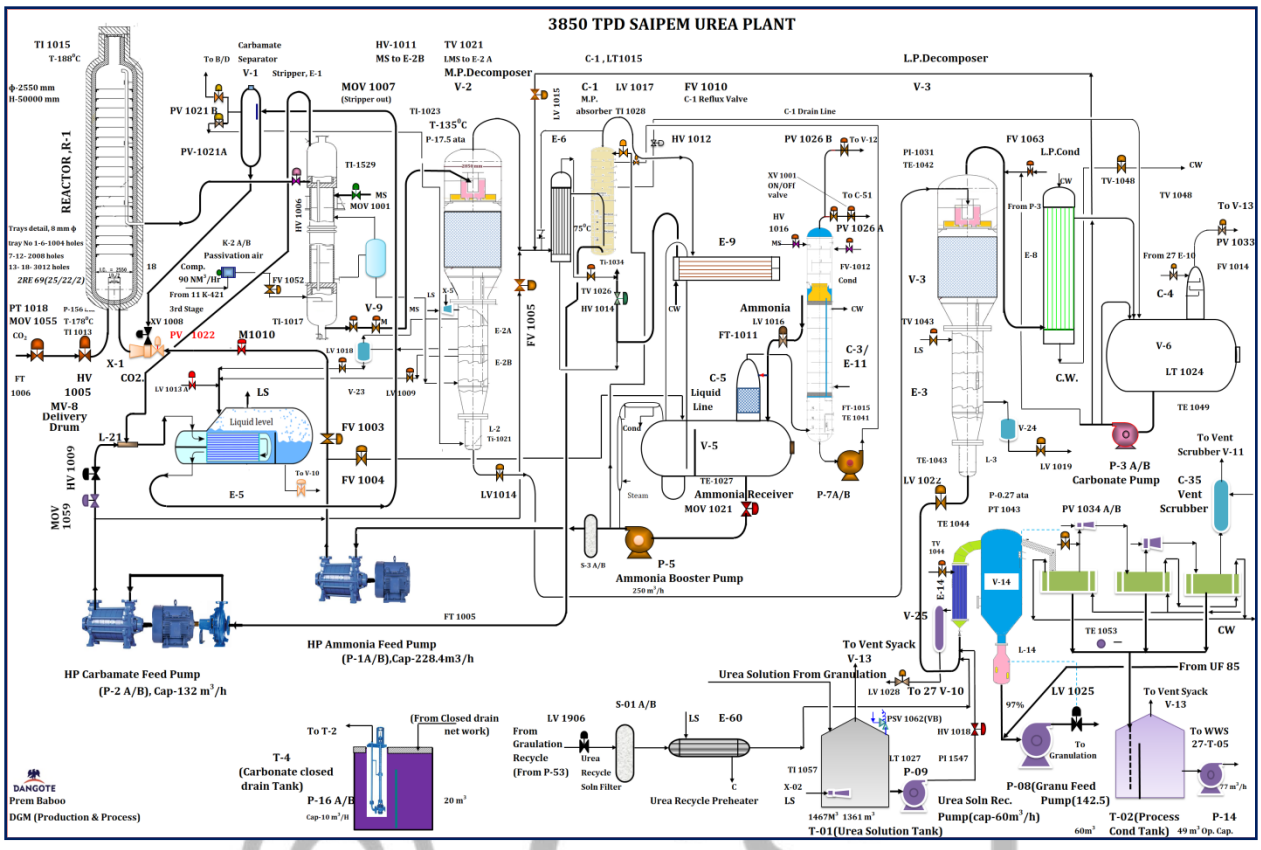

Fig-2(Urea Plant Flow diagram)

NH_2-COO-NH_4 = $2NH_3$ + CO_2 (- Heat) , and, as can be inferred from the equation, it is promoted by reducing pressure and adding heat.

Water treatment Plants

"The Dangote group" has acquired the requisite industrial land in the Lekki Free Trade Zone, for setting up the Fertilizer Complex. To meet the water requirement of Fertilizer plant, there is a Raw Water Treatment Plant. The Dangote Fertilizer Project Site is located in Nigeria, Lagos State, and Lekki Free Trade Zone. The Lekki Lagoon is a large expanse of shallow fresh water located in both Lagos and Ogun state of Nigeria. This lagoon is considered to be a reservoir of relatively fresh water but TDS varies from low values in wet season to high value in dry season. The DANGOTE GROUP has ventured into the business of manufacturing and marketing of fertilizers. The proposed Fertilizer complex consists of Ammonia and Urea plants with associated facilities and infrastructures.

The water requirement at normal capacity for the fertilizer project for various purposes is as follows:

► DM water (Flow rate: 120 m3/Hr. max.).
► CT make-up (Flow rate: 2140 m3/Hr. max.)
► Service water, Fire water & Potable water (Non-drinking) (100 m3/Hr.).
► Firefighting water.

The design total treated water flow requirement for fertilizer plant is minimum 2500 m3/hr.

The unit includes the following functional sections:

1. Demineralized Water Production and Storage;
2. Condensate Polishing System.
3. The plant, located in Lekki free trade zone, Okunraye, Ibeju at Lagos state. State will be an excellent example of

how to utilize a substantial amount of the country's significant gas resources, as a raw material in the Ammonia-Urea fertilizer process. Ultimately, the project, when completed will make the country self-sufficient in fertilizer production, thereby saving it the huge foreign reserves presently spent on importation of fertilizer. Dangote Group is one of the most diversified business conglomerates in Africa with a hard - earned reputation for excellent business practices and products' quality.

- Dangote Fertiliser Project is the largest *Granulated* Urea Fertiliser complex coming up in the entire fertiliser industry history in the World, with an investment of 2.5 Billion USD capacity of 3 Mil TPA.
- Acquired 500 hectares of land for the Fertiliser Complex.
- Natural gas is the main raw material for the plant.
- Saipem, Italy is the Engineering, Procurement and Construction (EPC) Contractor for the project.
- Tata Consulting Engineers, India, is the Project Management Consultants (PMC) for the project.
- Current consumption of Urea is 700,000 tonnes. Very Poor per hectare usage of fertiliser leading to very poor crop yield.
- By 2020, Nigerian Population - around 207 Million which would lead to increased food consumption.
- Estimates point out that around 5 million tonnes of Fertilisers are required per year in Nigeria in next 5-7 years bifurcated into 3.5 Mil tonnes of Urea and 1.5 Mil tonnes of NPK
- Current production levels are at 1.6 Mil tonnes

Process Design

The Raw Water Treatment Plant will comprise of the following:

1. Intake System from Lekki Lagoon
2. Biological Treatment System (SBR)
3. Dual Media Filters
4. Ultra filtration (UF) System
5. Reverse Osmosis system
6. Outfall piping & sub-sea diffuser piping for Reject disposal.

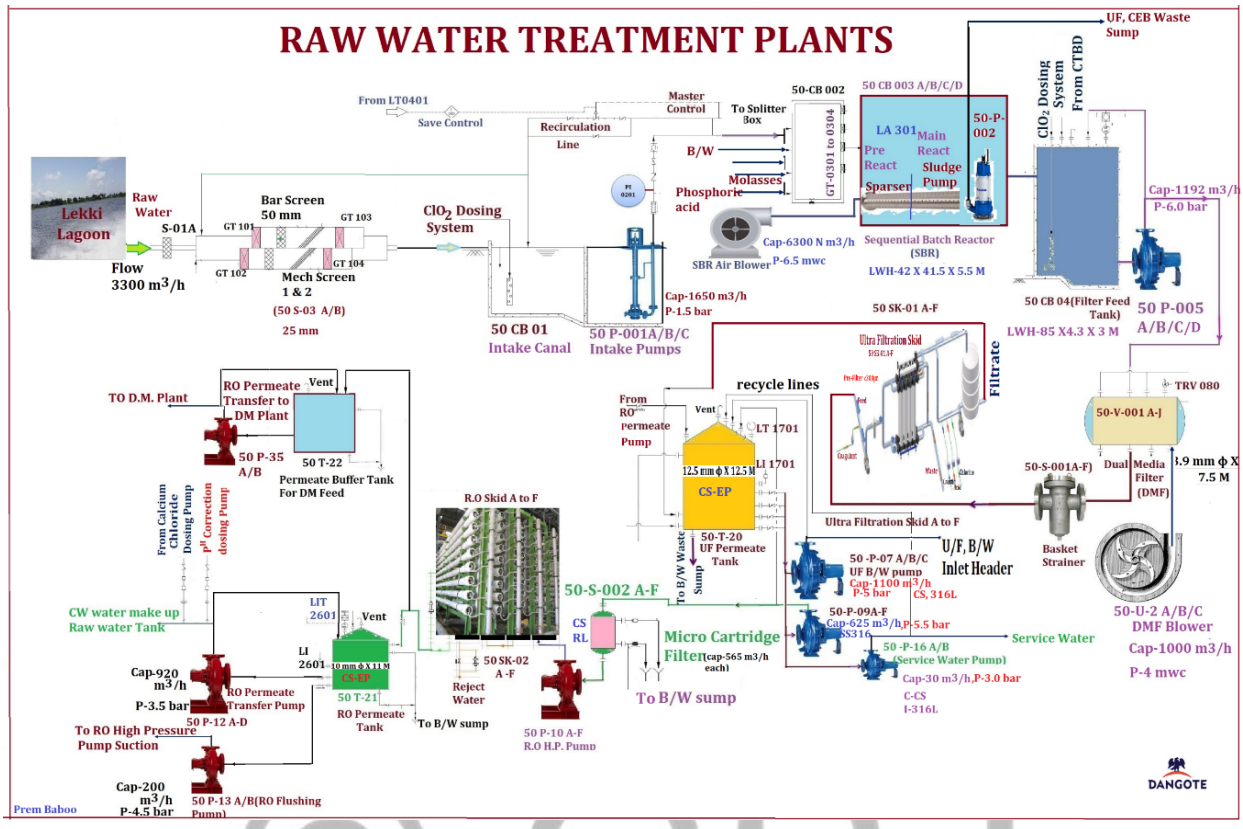

Fig-3

Pre-Commissioning Activities

The system was checked for conformance with the P&ID diagrams and necessary was tested. The purpose of this steam blowing to ensure the associated system is clean for unit start up. HS header and associated lines steam blowing were carried out with HS steam supplied from Utilities HS header. The HS lines above 6" was provided with a blow stack to minimize the noise pollution during steam blowing, in addition Turbine inlets with target plates as per Turbine vendor guidelines. Before starting steam blowing, clearance was taken from Utilities and their coordination. All catch pot drains in the HS header was kept opened to avoid hammering in the HS header. Before blowing started, protection of equipment/piping nearby the circuit outlets was carefully arranged, in order avoid any damage (equipment inlet flanges was disconnected or properly blinded). Kept close all the instrument impulse tapping root valves. Except the blowing loop related isolation valves, remaining all isolation valves in the system were closed. Steam Blowing was carried out with Utilities/Ammonia B/L 14"-11-HS2500-15A-I HS header 6" bypass valve. Before Steam blowing start, all steam lines was warmed up with the help of available drains and vents to avoid hammering of lines. After isolation of steam blowing loop, Vents and the drain valves was kept open during cooling down of the header.

Plant Start up.

For the Pre commissioning activities was done successfully and meaningfully carried out, it is necessary to have an overlap with the construction phase as many checks was performed during final phases of erection of the equipment. Such check was helping in taking rectification/modification actions, necessary within the least possible time as the job is still in progress with the construction program.

Conformity checks and documents that support requirements for Pre-commissioning and Mechanical Completion Partial or System. These procedures were provided guidelines and directions for the implementation of commissioning activities were carried out post equipment installation and prior to achievement of Mechanical Completion.

After number of problems faced ultimately a milestone achievement in the history of Nigeria birthed on the 17th of March 2021 by young talented and hardworking set of Engineers and experts of the Dangote Fertilizer Limited, Lagos Nigeria. A great feat that will indeed boost the agricultural sector of the country, Africa and the world at large has come. This moment was so delighted and greatly honored to be among the team of engineers who realized this milestone of the largest single train fertilizer plant in Africa of 2200MT of ammonia and 3850MT of urea granules production. we celebrate the dutiful commitments of our colleagues and superiors(Expats). We indeed put in so much from the piping to mechanical hand over, pre-commissioning & commissioning phase through to the production of our first urea granules.

The Commissioning activities were started for each Unit after Mechanically completion is certified. The main activities were following:

1. Hot alignment checked
2. Remove temporary strainers
3. Verified the proper operability of equipment
4. Run-in of pumps with water
5. Run-in of air coolers
6. Dry run operation of the granulator was done boiling out and chemical cleaning according to manufactures and contractors procedure.
7. Commissioning of lube oil and seal oil system circulate oil .
8. Run-in of centrifugal compressors
9. Dry out of furnace.
10. Functional check of control system.
11. Functional check of ESD system.

Project Outline

PROCESS PLANTS & UTILITIES

Sr. No.	Unit Number	Unit name
1	10,20	Urea Train -1 & 2
2	11,21	Ammonia Train -1 & 2
3	19,29	Urea Granulation Train -1 & 2
4	30	Ammonia Storage System
5	31	UFC Storage System
6	32	Urea Bulk Storage
7	33	Urea Handling System
8	34	Urea Bagging Unit
9	12	Water Treatment System
10	13	Steam & Power Generation System
11	14	Cooling Water System
12	15	Natural Gas System
13	16	Nitrogen Production & Storage
14	17	Instrument & Plant Air System
15	18	Potable Water System
16	22	Emergency & Power Diesel System
17	23	Effluent Treatment Plant
18	24	Fire Fighting System

19	25	Ammonia Plant Flaring System

Table-1

Natural Gas Consumption				
Sr. No	**Natural Gas**	**Nm^3/h**	**Number of Train/Equipments**	**Total for DFL Complex, Nm^3/h**
1	**Fuel Gas for Reformer**	**31845**	**2**	**63690**
2	**feed Gas**	**58799**	**2**	**117598**
3	**Start up Heater**	**1192**	**2**	**2384**
4	**Each Auxiliary Boiler**	**7419**	**3**	**22257**
			Total	**205929**
	At start up		**Per Day**	**4942296**
				4.942296×10^6
	Forty Nine Lacs Forty Two Thousand Two Hundred Ninety Six			
	4.9 Millians Forty Two Thousand Two Hundred Ninety Six			

Table-2

PRODUCTION & CONSUMPTION					
DANGOTE FERTILIZER LTD,.LAGOS,NIGERIA					
Sr. No.	Production/Consumption	Value for one unit	Number of Train/equipments	Value	Unit
1	Ammonia Per Day Production	2200	2	4400	MT/Day
2	Urea Per Day Production	3850	2	7700	MT/Day
3	Total Natural gas received for Complex			4942296	Nm^3/Day
4	Power Production(3 Power Generator)	41	2	82	MWH
5	Raw water Received from Lekki Lgon	3300		3300	M^3/hr
6	Cooling water Circulation	91083		91083	T/H
7	Boilers Steam Generation, P-46 kg/cm^2	200	3	600	T/H
8	Waste Heat Boilers Steam Generation(in Ammonia Plants) 3 Numbers	461.4	2	922.8	T/H
9	C.W. make up	2140		2140	M^3/hr
10	Treated water Flow	2500		2500	M^3/hr
11	Service water/Drinking /Fire water	100		100	M^3/hr
12	Urea Formaldehyde Consumption	1.203	2	2.406	T/Hr

Table-3

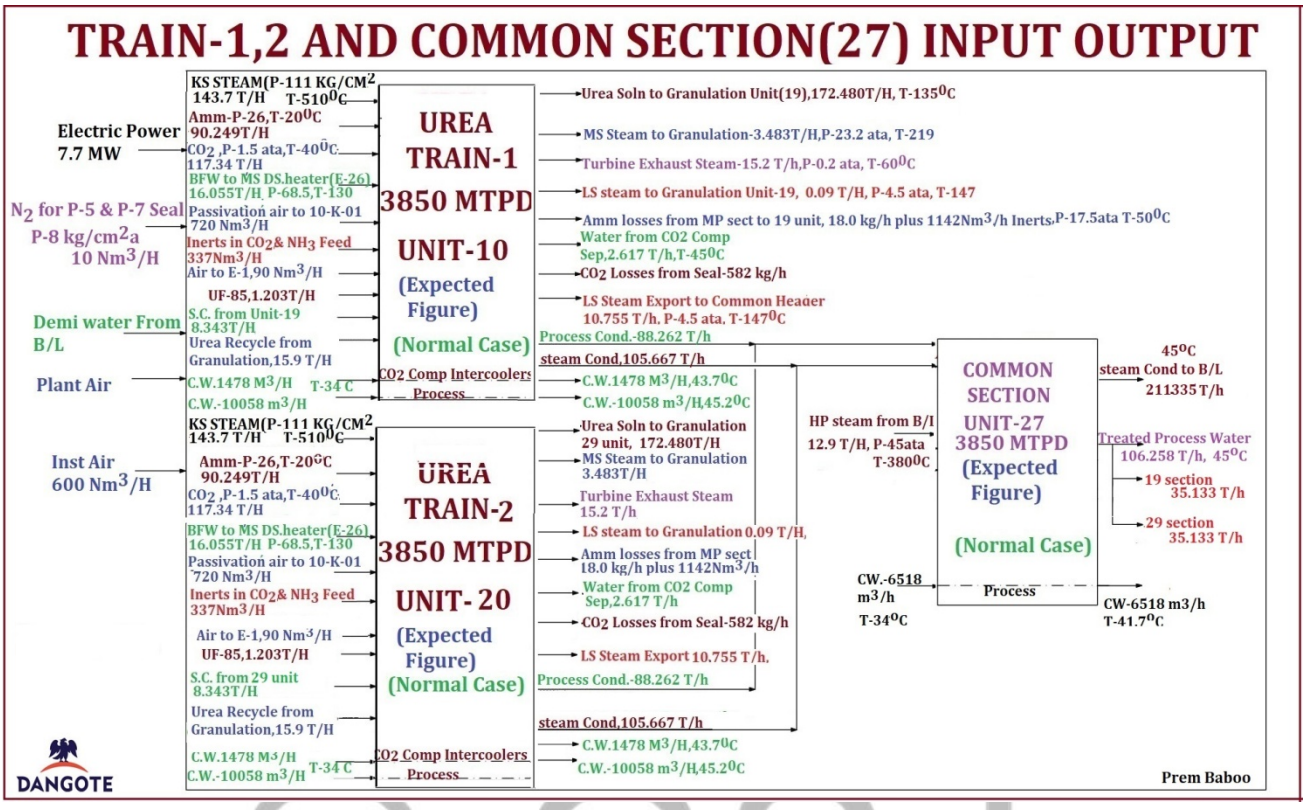

Fig-4(Complex input/output)

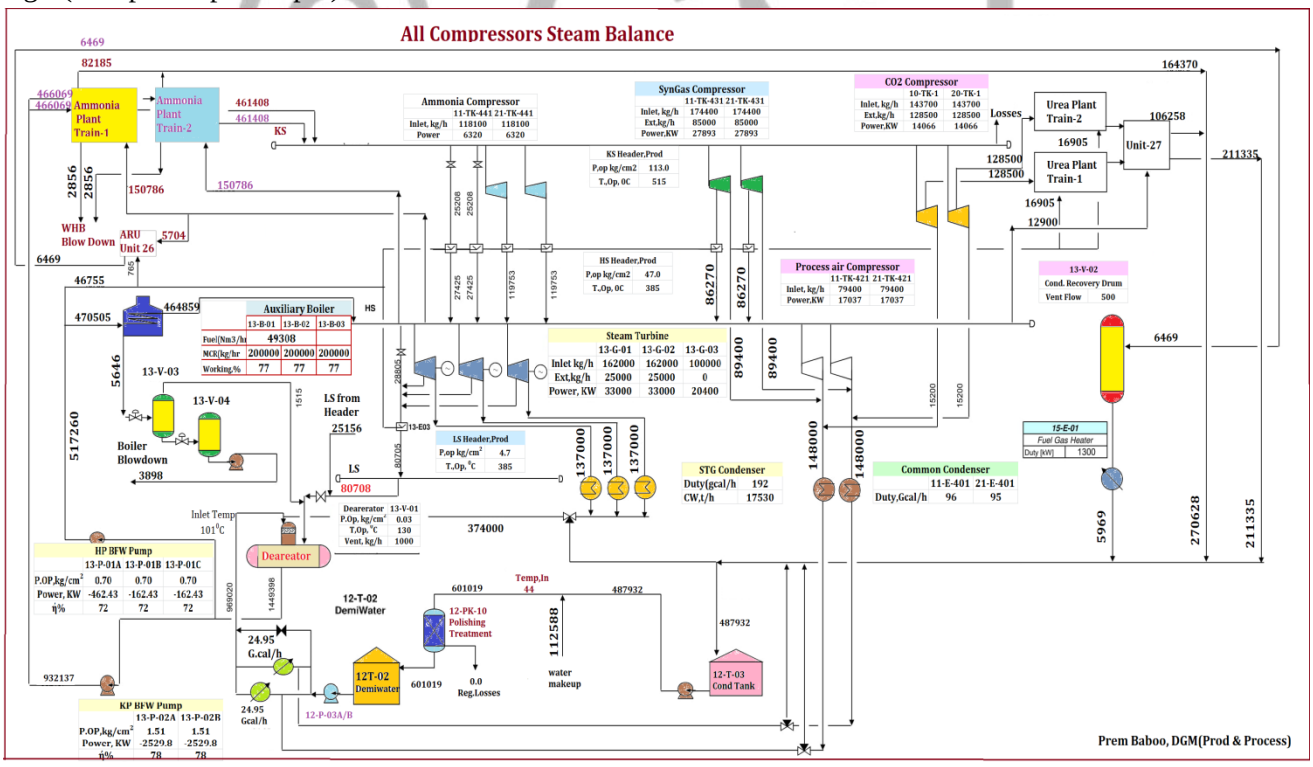

Fig-5(All Compressor Steam balance)

Problem faced in first start up

The CO_2 carryover from MP absorber to ammonia receiver was took placed in first feed in resulting the ammonia booster pump was cavitated and left load the reflux to M.P absorber valve was not operated at the time resulting the temperature reached more than 80^0C.The first feed in done on dated 12/04/2021,the fed in rate kept low because the temperature control in urea reactor. The activities as following

Sr. No.	Time	activities
1	07.00 hrs	Plant check up for control valves and stock checking
2	11.00 hrs	The H.P. loop heating started through L.S.
3	14.00 hrs	The H.P loop K.W. heating started at the rate of 50^0/hr
4	16.00 hrs	Ammoniation started at the rate of 30kg/cm2/hr
5	19.00 hrs	Feed in done
6	21.00 hrs	Overflow observed
7	22.00 Hrs	CO_2 Carryover to ammonia receiver. And feed cut

Table-4

3 unsuccessful attempts also done but each time feed was cut due to numbers of problem some of the PSV of MP loop passing observed. Finally on 17th April success achieved and urea granules sent to silo but after 14 hrs operations feed was cut due to MP loop PSV popped.

Following problem were faced in plant start up

1. Reformer burner choking frequently
2. Trim heater problem faced in startup
3. Synthesis reaction rate very slow in start up
4. Many time disturbed CO_2 absorption section.
5. Power failure in many times
6. Flare was extinguished many times
7. In urea plant CO2 carryover from MP absorber to ammonia receiver.
8. Frequently choking of pumps suction strainers
9. Waste water section was overloaded
10. Waste water section disturbed many times
11. Choking of granulators inlet nozzles.
12. PSV of MP loop passing observed resulting ammonia in environment and disturbed of waste water section.
13. Choking of 2nd bed cooler.
14. Choking of vibrating screens
15. Steam lines PSV popped.
16. Shortage of NG.

Overall view of the Plant

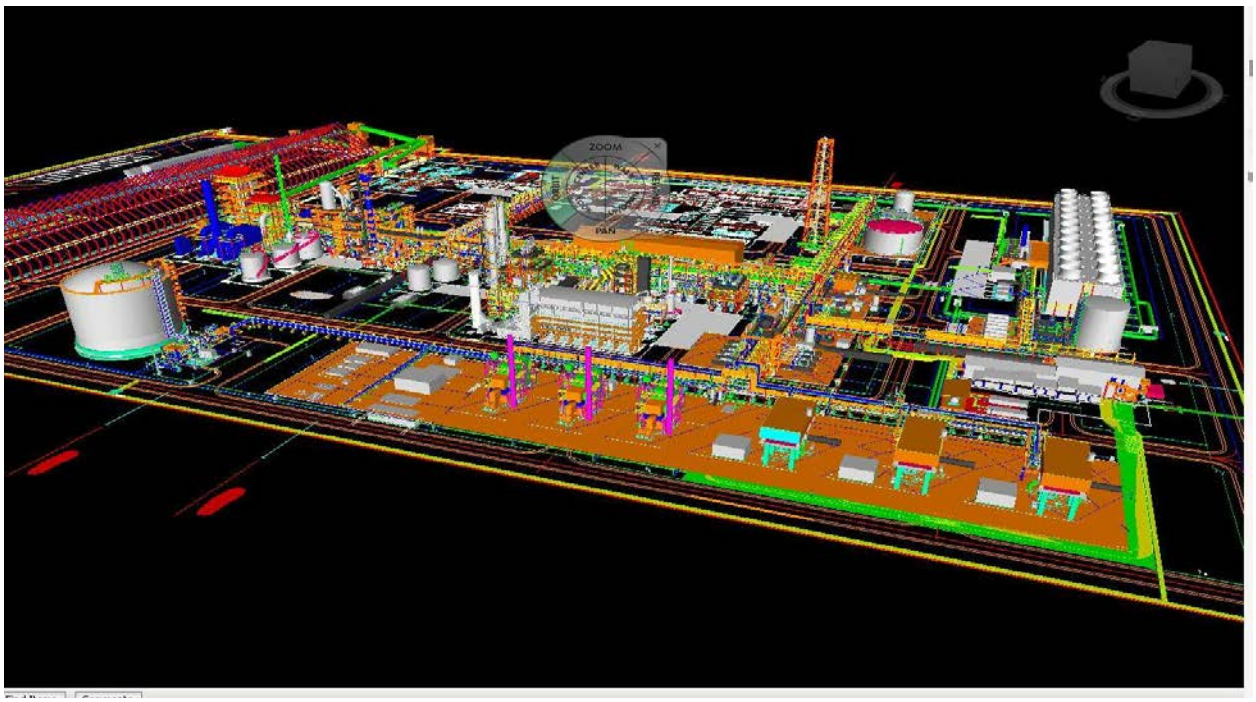

Fig-6(Plant Overview)

PLANT LAYOUT

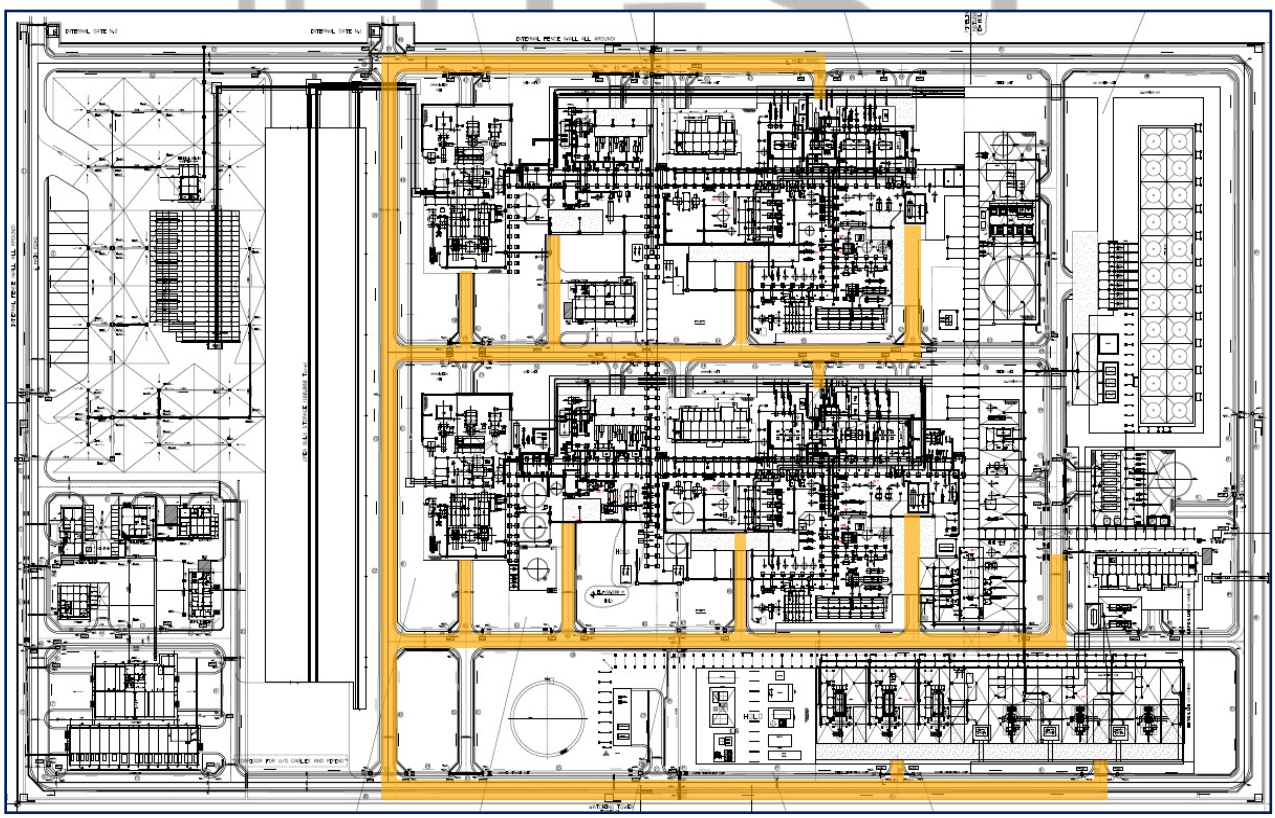

Fig-7(Overview of the Project)

Fig-8(Urea granular)

Fig-9(Happiness when production achieved)

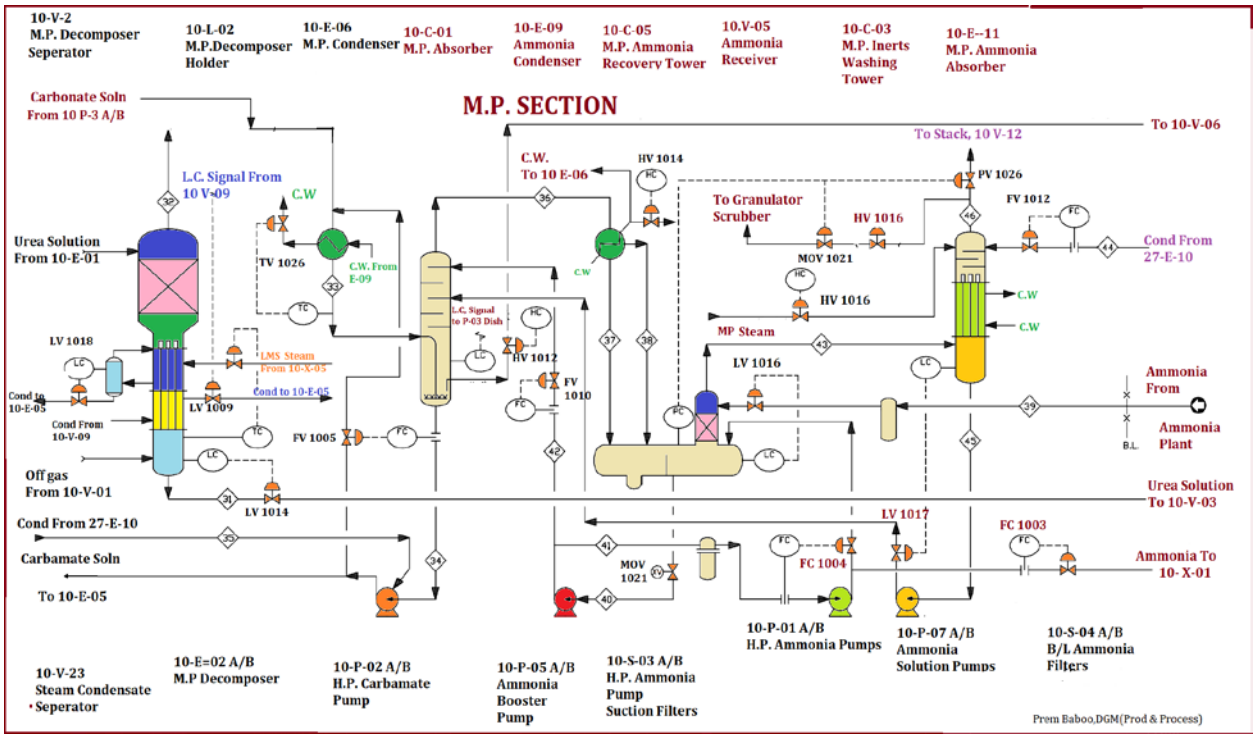

Fig-10(MP section)

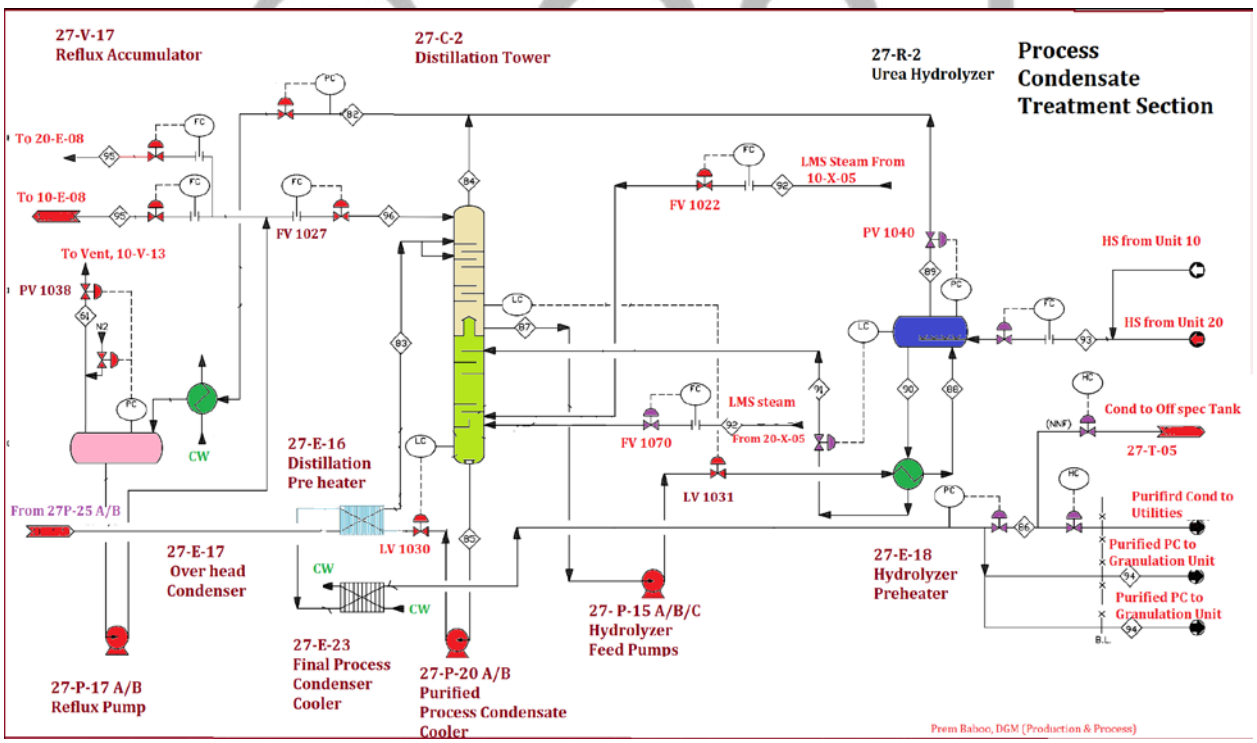

Fig-11(waste water section)

Fig-12(ammonia booster pump strainer damaged)

Conclusion

After a lot of trouble, pandemic, staff etc finally the plant got in operational. It was a huge challenge, in the end the plant got in production due to the efforts of M/S. Saipem and all the dignity of all the people brought in production of urea. It is beyond any doubt that Dangote Fertilizer Project has been a successful project and the key to the success is M/S. Saipem has made available to M/S. Halder Topsoe an innovative combination of know-how and technological solutions and an effective strategy of project execution, providing an efficient and reliable plant. With its extended portfolio of proprietary technologies and worldwide experience in executing projects at all levels of responsibility, Saipem has managed and executed the DFL project providing a single and complete point of competence from license through to Start-Up condition of the Plant. The synergic combination of Saipem know-how and process leadership in Ammonia & Urea technology and Dangote projects experience as global contractor, has brought unparalleled advantages to the project and finally to the end user. A successful commissioning effort generates site-specific knowledge that we used by the commissioning team to assist in the startup. Some common support functions include operator systems training, process systems troubleshooting, lockout-tag out practices and other safe work procedures, and pre-startup safety review participation.

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