Development of New Products in Indorama Haldia Plant

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Abstract

The flagship product at Indorama, Haldia, Di ammonium phosphate (DAP), was facing margin pressures. Also, the farmers demanded a fertilizer with significant sulphur content considering the soil. After scanning potential products, team Indorama, Haldia narrowed down on two products viz. NP 16:20:00:13 and NP 14:28. NP 16:20:00:13 could meet farmer's requirement for higher sulphur. Also, help in optimizing the Haldia site's captive resource sulphuric acid plants and thus help in generating higher contribution. The innovation becomes special as it was done without engaging any outside agencies or professional consultants.

Successful innovative solutions were developed through brainstorming and Benchmarking. New product variants of NP 16:20:00:13 and NP 14:28 were successfully developed after lab and plant trials. The plant was originally designed in 1985 with pressure reactor system for the product DAP. Process safety, risk assessment and HAZOP study and FMEA have been carried out before taking the plant trial run. Standard operating procedure (SOP) was developed during lab trial. After lab trial, commercial production was started in August 2021, initially with an average plant throughput of 550 MTPD. The throughput was gradually stabilized to 700 MTPD for NP 16:20:0:13 and 850 TPD NP 14:28 by the end of 2021. This paper highlights the innovative actions implemented in pressure reactor, granulator, drier and in the scrubbing system.

Key words : Di-ammonium phosphate, NPS 16:20:0:13, NP 14:28, pressure neutralizer reactor, specific consumption, (design of experiment, regression

Introduction

Indorama India serves a diverse set of customers focussing on essential materials and creating better living conditions. The company's growth strategy is developed and communicated across the Enterprise through "Indorama Compass" that navigates the organisation in the right direction to keep moving forward through the 4 key elements of Purpose, Vision, Capabilities and Values.

Keeping in view the core values, the required skills and performance levels are achieved to address the major customer segment aligned to Indorama mission and purpose. Indorama Haldia has embarked on a journey of growth - a journey that will build on what has been already achieved over last few years through Team work and collaboration.

At Indorama Haldia, we are having two trains for manufacturing Sulphuric acid, two trains for manufacturing DAP & NPKs and one SSP plant. Haldia 1st DAP plant was originally designed in 1985 for DAP production with unique pressure reactor system instead of an atmospheric reactor. Pressure reactor is having a competitive advantage over atmospheric reactor in terms of superior product quality and lower energy consumption. The process diagramme is shown in **Figure 1.**

Need for New Product

Most phosphatic fertilizers (like DAP, NPK 10, NPK 12), contain very low sulphur. NP 16:20:0:13 has 13% sulphur and while its demand was on the increase in other regions with certain soil conditions. Therefore, a project was initiated to identify future product opportunities for the phosphatic business, considering farmer's requirements, likely contribution margin, production feasibility, etc. The following methodology was used:

- Initial desk research shortlisted products, based on
  - NP/NPKS products that are sold in Eastern India which Indorama-Haldia does not make.
  - NP/NPKS products that are sold in rest of India which are not sold in the East.
  - NP/NPKS products that are approved under FCO, but not sold anywhere in India.
- Prepare product-wise profit and loss for each of the shortlisted products.
- Undertake laboratory & production trials to explore production feasibility, risks, constraints, etc.
- Discuss with sales team to arrive at the final choice of products

Based on the above criteria developed in HIT (Haldia Innovate to Transform) project, following products were shortlisted.

- NPS 16:20:0:13
- NP 14:28

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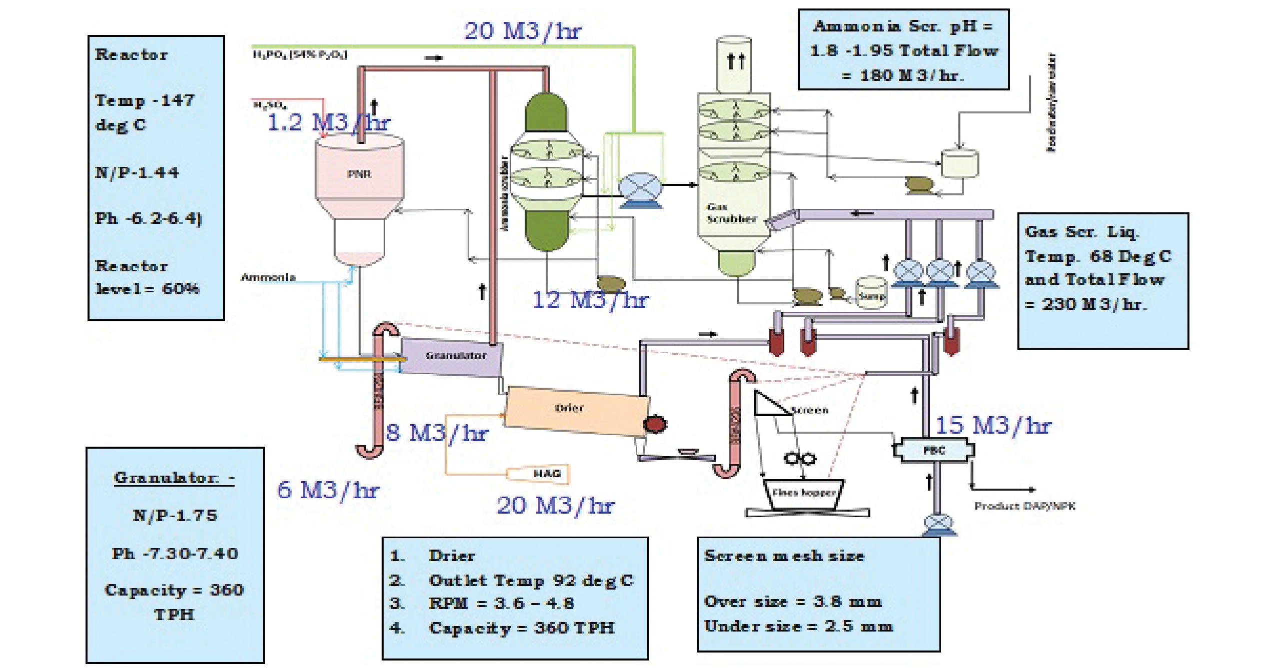

Figure 1. Process flow diagramme of DAP production

Why NP 16:20:0:13

i. Customers (soil & the farmers) seem to demand a fertilizer like NP 16:20:0:13.

ii. NPS 16:20:0:13 production can utilize the captive assets of Haldia (sulphuric acid plants and power generation by using byproduct steam). Haldia Plant's profitability depends on the ability to utilize the captive assets.

Laboratory and Plant Trials

Lab trial revealed that can be produced NP 16:20:0:13 and NP 14:28 but was not sure whether it will be feasible in plant scale with existing pressure reactor and reactor slurry gravity flow of the reactor slurry to the granulator **Figure 2**.

After successful lab trial, New SOPs (standard operating procedures) were developed for plant trial **(Table 1)**. New material balances were developed for both NP 16:20:0:13 and NP 14:28 with internal team and then validated by the actual plant trial run.

The Challenges

- DAP 1 & 2 plants were designed originally for manufacturing DAP. There were several limitation in equipments & set-up for existing plant designed for DAP production to manufacture NP 16:20:0:13.
- Technical hurdles were faced in adapting the plant operation for NPs 16:20:0:13
- Consultants such as JACOBS & PDIL quoted significantly high costs towards advice and equipment modifications

Challenge for Haldia to compete with plants designed specifically for NP 16:20:0:13 in terms of quality, technical efficiency & throughput.

i. *Pressure Reactor:* Presence of a pressure reactor instead of atmospheric reactor with pumping arrangements. There was narrow band operating in the pressure reactor.

ii. *Drier Limitations:* Being designed for DAP, the drier was not suited to remove moisture levels of over 2MT per hour.

iii. Unable to increase the throughput beyond 25 TPH.

Table 1. New SOP for plant trial

Parameter	Operating range	Frequency
Reactor pressure	1 kg Cm^{-2}	Online
Reactor temperture	138-140 °C	Online
N/P	1.0-1.1	Once a shift
PH	4.4 to 5.3	Hourly
Ammonia to reactor	6 $m^3 hr^{-1}$	Online
Ammonia to granulator	3.2 $m^3 hr^{-1}$	Online
Phos acid flow	4 $m^3 hr^{-1}$	Online
Weak acid	4.45 $m^3 hr^{-1}$ (30%)	
Sulphuric acid flow	5.9 $m^3 hr^{-1}$	Online
Water flow	11.5 $m^3 hr^{-1}$	Online

AMMONIUM PHOSPHATE SULPHATE (16:20:0:13) - Lab scale Trial

PARAMETERS	SPECIFICATION	Batch -1	Batch3(1)	Batch3(1I)	Batch3 (III)
Moisture per cent by weight, Maximum	1.00	0.40	1.15	1.10	1.15
otal Ammoniacal Nitrogen per ent by weight, Minimum	16.00	18.74	16.11	16.55	16.82
vailable Phosphorus (as 2O5) per cent by weight, Ainimum	20.00	20.28	20.50	20.69	20.74
Vater Soluble phosphorus (as 2O5) per cent by weight, Ainimum	17.00	18.74	19.45	19.75	19.80
ulphate Sulphur (as S) per ent by weight, Minimum	13.00	15.63	13.11	13.45	13.35
artical Size, Minimum	90% of the material shall be retained between 1 mm and 4 mm IS sieve	91.00	88.00	93.00	94.00

** NOTE : Tolerance : Moisture - (+)0.3, Nutrient - (-)0.5, Size -(-) 3.0

Sulphur Analysis started by Nephelometer and Skalar Auto Analyzer

Figure 2. Lab trial for feasibility study: New product NPS 16:20:0:13 in laboratory

Resolution of challenges: The challenges were resolved through multiple step-by-step interventions.

- Increase reactor pressure & reduce temperature and put steam injection into reactor bottom to improve reactor slurry homogenous mixing improve slurry flowability.
- Utilize full capacity of hot air generation (HAG) ID fan by increasing the motor rating.
- Reduce speed of the driver using VVF drive
- Addition of sulphuric acid into granulator bed and overcome the moisture issues.

The Phases of Innovation Journey

Initially, plant operators were facing challenges in high moisture in product and high nutrient give away (%P_2O_5 and %N). High Moisture issues were due to limitation in drier and were overcome by using Lean Six Sigma Tools (MSA, Regression analysis and Why analysis). **Figure 3** shows regression analysis carried out to find critical factors affecting production through-put.

Regression Analysis: production versus Ammonia Tec, P2O5 Tech e, ...

The regression equation is
production = 162 - 2278 Ammonia Tech Effi - 815 P2O5 Tech effi
+ 87.2 Running hours + 56.1 %N in Nutrient - 19.0 %P2O5 in Nutrient
- 5.14 Amm Scr pH + 6.8 FNR pH - 9.1 Granulator pH
+ 4.70 Product Size (+2mm) + 0.198 Stack SPM - 0.020 Stack NH3

Predictor	Coef	SE Coef	T	P
Constant	162	1844	0.12	0.904
Ammonia Tech Effi	-2277.6	416.4	-5.47	0.000
P2O5 Tech effi	-814.7	606.7	-0.52	0.605
Running hours	87.2428	0.6198	60.08	0.000
%N in Nutrient	56.10	54.12	1.04	0.302
%P2O5 in Nutrient	-19.00	38.10	-0.50	0.619
Amm Scr pH	-5.141	8.864	-0.58	0.568
FNR pH	6.77	40.65	0.17	0.868
Granulator pH	-9.08	34.25	-0.27	0.791
Product Size (+2mm)	4.702	1.729	2.72	0.008
Stack SPM	0.1988	0.6082	0.88	0.748
Stack NH3	-0.0196	0.1092	-0.18	0.858

Factors with p-value of >.05 are insignificant and will be eliminated in the next cut

S = 25.2082 R-Sq = 97.5% R-Sq(adj) = 97.3%

Figure 3. Regression to find out critical factors affecting production throughput (first cut)

Overcoming Hurdles

Various hurdles were faced during commercial production of NPS 16:20:0:13. There were issues with the quality of phos acid with high R_2O_3 and solid content. High R_2O_3 content detrimentally affected nitrogen fixation in ammonium phosphate and retain high moisture in product. High solid content created the reactor liquor thick. To maintain the liquor flowability, more water is required which led to high moisture content in the product. To maintain the granulation properly sulphuric acid input reduced which lowered the %S in the product.

The Innovative Way out

Lowering the N/P ratio of reactor slurry pre-MAP range from 1-1.10 range to 0.7-0.75 range highly impacted on sustainability of the product NP16-20. Reactor slurry flowability found good that gives the opportunity to optimize water addition and hence maintaining moisture content of the product. This also provides the opportunity to balance ammonia addition in granulator that helped improving product granulometry and reducing moisture content of product. The good slurry flowability and good granulation provides the opportunity to increase sulphuric acid addition in reactor and thereby helps increasing %S content in product. Due to improved balance of nutrients in products, filler addition increased causing significant reduction of nutrient give away.

Concerns and Mitigation Actions during Commercial Production of NP 14:28

Manufacturing concerns for NP 14:28 related to filler supply and filler quality

- Plant outage due to unavailability of filler due to very high consumption rate for NP 14:28
- Ingression of foreign materials with filler
- Issues for colour homogeneity in product due to filler colour variation
- High filler (wet filler) flow causes scaling in all material transfer chutes, buckets and casing area – frequent chockage causes plant downtime for cleaning.
- More dust generation in system due to high filler intake – causes more spillages.

Mitigation Actions

- Regularize filler supply during this high demand situation with continuous discussion and negation with filler suppliers
- Visit to filler mines and discussion with supplier for resolving quality issues of filler
- Utilization of existing QC hopper as additional intake medium for filler due to higher consumption rate
- Regular inspection and sampling of filler shed material by Quality control team

Some of the other operational problmes which were

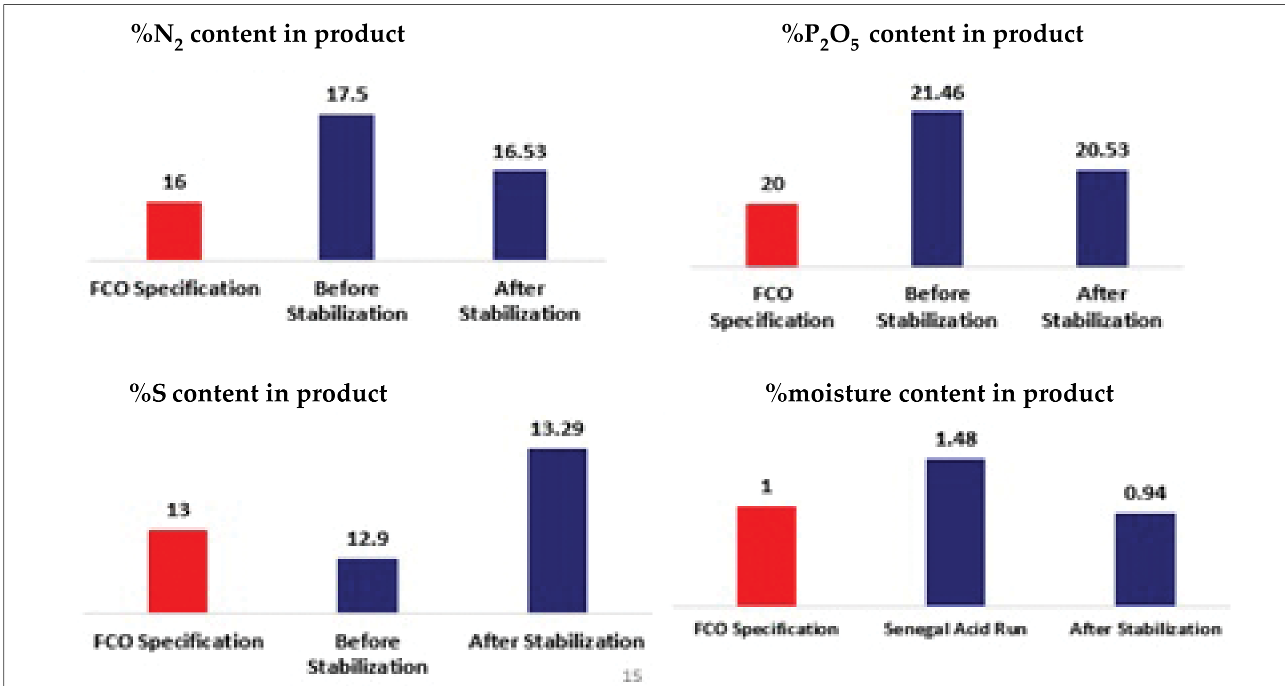

Figure 4. Benefit achieved after stabilization of products

Table 2. Root cuase and solution to some operational problmes

Root Cause	Solution
Granulator N/P	PNR slurry spray nozzles angle adjustment for better quality granules sizes
Nutrient give away	Installation of weigh belt feeder and daily calibration for accuaray
Reactor slurry is not homogenous and causing nutirent variation	Provision steam at the bottom of the reactor to make the reactor slurry propostion homongenous
Temperature of ammonia scrubber	Increase in air volume and draft by increase in granulator exhaust duct size
Product size % (2 to 4 mm)	SOP revised

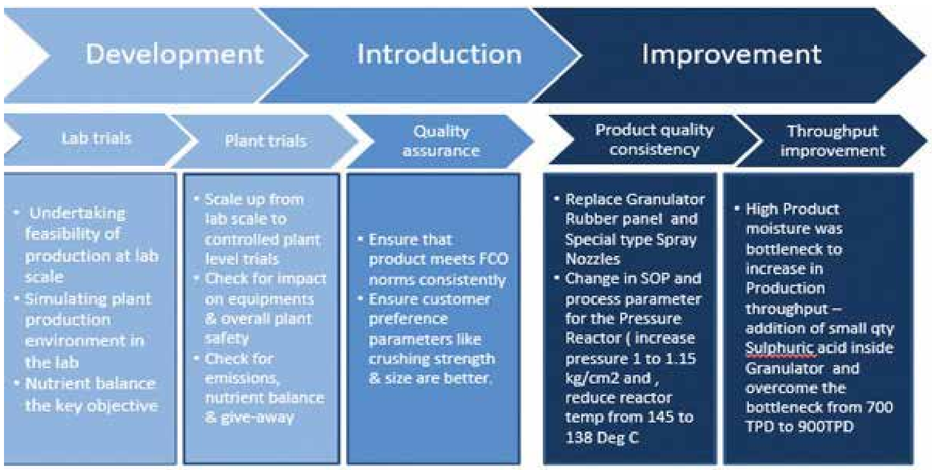

Figure 5. Phases of the innovation journey of NP 16:20:0:13 and NP 14:28

faced are given in **Table 2.**

Benefits achieved after process stabilization of new product NPS 16:20:0:13 are shown in **Figure 4**.

Project Summary

The project summery of various phases is given in **Figure 5**.

Challenges: Throughput, nutrient variation in product and optimum specific consumption of inputs raw material.

Results: NP 16:20:0:13 and NP 14:28 are successfully produced by maintaining the product quality consistence and meet the farmer demand of fertilizer with high sulphur content.

Conclusion

Indorama India is committed to deliver the promise of providing products and services of outstanding quality at competitive cost and be the company of choice for the customer. The transformation journey and the amalgamation of knowledge, experience coupled with intuition made the mission success. The large part of benefit gained by the team is the competence developed for other new variants in near future (NPK 15:15:15, NP20:20:13, etc). Successful development, introduction in the market and establishment of new product variants NP 16:20:0:13 and NP 14:28 ensured rated capacity utilization of sulphuric acid and power plants.

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