DOWNTIME ANALYSIS OF AMMONIA AND UREA PLANTS

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Abstract

Downtime data of ammonia and urea plants was collected and analysed for the 3-year period of 1999-2002. Downtime data with respect to plants related problem and external problem was segregated. A detailed analysis of equipment related problem was carried out to identify the areas and equipment in the plant which caused significant downtime. Analysis should help the plant management and equipment manufacturers to focus attention on design, material of construction, fabrication, maintenance and operation of the critical equipments. Energy consumption trends are also included to give an assessment of energy efficiency levels of the plants.

Factor determining the performance of fertiliser plant includes feedtstock, vintage, availability of the utilities, labour relations, market conditions. The most critical of these factors is the reliability of the plant and equipments. Maintenance and inspection functions play a vital role in improving the reliability and availability of the continuous process plant. Sustained and efficient performance with respect to production can only be achieved with systematic inspection and maintenance programme. This also helps in improving the safety of the plant and personnel.

Indian ammonia and urea industry has grown significantly over the last three decades. Installed capacity of ammonia and urea at present are 13.7 and 20.5 million metric tonnes respectively making it one of the most vibrant industries in India. During the first 20 years of operation, the focus of plant management had been on achieving reasonable operating levels by way of replacement/repair of unproven equipment and adoption of better maintenance and operation practices. The average capacity utilisation of ammonia plants have shown significant improvement from less than 70% in 1970s to almost 100% in the recent years. Similar trends have been observed in energy consumption which are now close to the design figures. This has been possible due to construction of palnts in the 1980's and 1990's using the latest technology with proven equipments and use of natural gas as feedstock. Natural gas emerged as the dominant feedstock for the production of nitrogenous fertilisers with a share of 50% in 2002-03 followed by naphtha at about 27%. (**Table 1)**

Capacity utilisation and energy efficiency of the plants are affected by unscheduled shoutdown frequency and downtime due to equipment problems. Keeping this in view, the Fertiliser Association of India has been monitoring the downtime of ammonia and urea plants in India for last several years. Present paper reports results of the analysis of data collected for downtime for the period April 1999 to March 2002. Energy consumption trends in ammonia and urea production in the country are also presented briefly.

Downtime Data

Downtime data pertains to a 3-year period of 1999-2002 (April-March) for 32 ammonia and 30 urea plants. These plants accounted for a total of 33.0 million tonnes of ammonia and 51.7 million tonnes of urea production during 3-year period, which represent 88.5 and 88.3 percent of the total production of ammonia and urea respectively. The survey includes a mix of plants with respect to vintage, size and feedstock. The vintage of the plants varied from 1960's to 1990's. Majority of the ammonia plants belong to 1970's and 1980's (9 and 11 respectively) while 10 plants are of 1990's. The 17 ammonia plants utilise natural gas as feedstock, 10 utilise naphtha and use fuel oil as feedstock. The size of the plants varied from less than 600 MTPD to more than 1350 MTPD for ammonia and less than 600 MTPD to more than 1800 MTPD for single stream urea plants.

Based on the detailed information obtained from these plants, the average downtime under various categories was calculated in terms of downtime in days per plant per year (DDPY).

DDPY = Number of days of downtime/Number of plants/Number of years

Result of present analysis have been compared with the results of previous survey periods**(1)**

Downtime in Ammonia Plants

Average duration of planned turnaround (maintenance shutdown) of 32 ammonia plants was 22.5 days per plant per year (DDPY) as against 18.4 DDPY for the previous survey period of 1996-99(1). The planned turnaround was about 25 percent higher for both reforming and gasification plants than last survey period. As expected, average duration for turnaround of 5 gasification plants was longer (34.2 DDPY) than 27 reforming plants (20.2 DDPY) (**Table 2**). There was a significant reduction in forced shutdown at 8.2 SPY from 12.3 SPY for the last survey period. Number of forced shutdowns was lower at 6.9 shutdown per plant per year (SPY) for reforming plants than 14.0 SPY for gasification plants. For the period 1999-2002, there was a loss of production of about 3.7 million tonnes of nitrogen due to forced shutdown of plants. Forced shutdown due to equipment failures accounted for about 22.6 percent of these losses in production (**Table 3**). Other reasons for forced shutdown include short supply of feedstock and utilities, power problem, labour problem and other business related factors.

Downtime data in ammonia plants are grouped under mechanical, electrical, instrumentation, process and miscellaneous failures. The total downtime in 32 ammonia plants has slightly increased from 28.3 DDPY in 1996-99 to 30.2 DDPY during 1996-99 (**Table 4**). The higher downtime was due to the factors external to the plant mainly shortage of raw materials and are classified under Miscellaneous reasons. Plant related downtime was almost unchanged from the previous survey period. However, mechanical failures are still the major cause of downtime in ammonia plants and accounted for 48.7 percent of downtime. Consequently, the downtime due to mechanical failures was analysed in detail.

Sectionwise downtime data due to mechanical failures for 27 reforming plants and 5 gasification plants are shown separately in **Table 5**. Reforming plants accumulated a total the downtime of 1149 days. Contribution of secondary reformer (SR) was the highest at 47.9 percent. FACT, Cochin ammonia plant was shutdown fro extended period due to failure of RG Boiler and accounted for more than 50% high downtime in SR section of ammonia plant. Other contributors to the downtime in SR include KRIBHCO-Hazira and IFFCO-Aonla and contributed almost 26 percent of the downtime. Downtime in primary reformer and syngas compressor were the other significant contributor to the downtime. All other sections like purification, synloop and refrigeration and other compressors and turbines were also responsible for forced downtime.

Downtime in Urea Plants

Downtime data from 30 urea plants for the period 1999-2002 was analysed in the present analysis of data. The trends in downtime for various causes are similar to those observed in ammonia plants. The downtime for planned turnaround at 25.2 DDPY in 1999-2002 was higher than 17.7 DDPY in 1996-99 and but lower than 32 DDPY in 1993-96. The average number of shutdowns in urea plants at 18.0 SPY during the analysis period (1999-2002) was lower than 23.6 SPY during 1996-99. GSFC-Baroda, IFFCO-Kalol, FACT-Cochin, MFL-Manali, NFL-Bhatinda and NFL-Nangal encountered high number of shutdowns.

Average downtime in urea plants was lower at 38.3 DDPY during the analysis period compared to 39.8 DDPY during 1993-96 and 46.4 DDPY during 1990-93 (**Table 8**). However, as in case of ammonia plants, the largest share in downtime of urea plants was accounted for by miscellaneous reasons which include cap on production of urea due to EC allocation, shortage of feedstock and utilities, labour problems, etc. There was a significant reduction in downtime caused by mechanical failures at 6.2 DDPY and is the lowest so far.

CO_2 Compressors contributed significant downtime in IFFCO, Phulpur II and NFCL-Kakinada II. NLC-Neyveli, IFFCO-Phulpur-I and CFCL-Gadepan-II reported significant downtime due to problems in urea reactor. RCF-Thal & RCF-Trombay, IFFCO-Phulpur-I and NFCL-Kakinada reported high downtime due to stripper problems. CO_2 compressor, rector, stripper, piping, valves and heat exchangers, etc. need attention for reducing the overall downtime in urea plants.

On Stream Efficiency

The onstream days of a plant can be calculated by subtracting the shutdown due to maintenance turnaround and equipment failures or forced shutdown for other reasons from the total number of 365 days in a year. For ammonia plant, average on stream days of 311 days the survey period (1999-02) was lower than pervious survey period of 318 days. The onstream efficiency of ammonia plant for this survey period was 94.2% based on 330 days and 85.2% on 365 days basis. The onstream days for urea plants were lower than ammonia plant at 301 days. Fertiliser units faced extreme shortage of natural gas during the period. In addition, there were several interruption in the supply. Cap on production due to EC allocation also contributed to longer planned shutdown and have lower on-stream days.

Summary of Downtime

It is observed that duration of turnaround has increased for both ammonia and urea plants. It is felt that many plant took extended shutdown due to cap on production of urea during the period. Downtime due to mechanical failures has remained almost same for ammonia plant and significantly reduced for urea plants compared to previous survey period of 1996-99. There are a number of areas which require attention of plant management. These include reformer tubes, RG boiler, heat exchangers and synthesis and other compressors in ammonia plant and reactor, stripper and CO_2 compressor in urea plants.

Energy Consumption

FAI has been monitoring the energy consumption of both ammonia and urea plants for several years. For computing energy consumption figures lower heating values of the fuels used as feedstock (feed+fuel for reformer or feed for gasifier) are used. Power and steam are converted using standard conversion factors as per accepted practices and included in the energy consumption figures.

Energy consumption in ammonia and urea plants showed significant reduction over the years (**Table 10**). The weighted average energy consumption for all India ammonia plants has reduced from 12.48 mKcal/MT of ammonia in 1987-88 to 9.30 mKcal/MT of ammonia during 2002-03. Similarly, for urea plants, the weighted average energy consumption has come down from 8.87 mKcal/MT of urea in 1987-88 to 6.59 mKcal/MT of urea in 2002-03.

Further, analysis of the data on feedstock basis for ammonia plants (**Table 11)**, it was observed that the energy consumption of gas-based plants was the lowest at 8.67 mKcal/MT of ammonia which is quite significant considering the vintage of the plants that varies from 4 to 34 years. The energy consumption for gas-based urea plants was 6.18 mKcal/MT of urea during 2002-03. These efficiency levels are comparable with similar plants elsewhere in the world. It has been possible due to adoption of modern management techniques in operation and maintenance of plants, modification/replacements of old equipment, better catalyst and use of better process technologies. There have been numerous systematic efforts, big and small, made by the fertiliser units during last 3 years which have contributed to higher energy efficiency of almost all the units. Better maintenance of various static and rotating equipments has also contributed in reduction in energy consumption. Energy conservation efforts have recently been documented by FAI (2).

Conclusion

A survey of downtime in ammonia and urea plants for three years period of 1999-2002 reveals large part of downtime is being contributed by factors external to the plant viz. disruption in supply of feedstock and utilities and business related factors. The sample or which data was available accounted for more than 85% of the ammonia and urea production in the country. Analysis of downtime shows that there was increase in turnaround period for both ammonia and urea plants. This could be due to cap on production of urea due to EC allocation. The downtime due to equipment failures was almost at the same level of 14.7 DDPY for ammonia plant but much lower for urea plant at 6.2 DDPY than previous survey periods. Major equipments like RG boiler, reformer tubes, gasifiers, syngas compressor contributed significant downtime in ammonia and stripper, reactor and CO_2 compressor in urea plants. These equipments need continued attention of plant management.

Energy consumption of ammonia and urea plants has been maintaining downward trend over the years. Average energy consumption figures of all the ammonia and urea plants in the country were 9.30 mKCal/MT and 6.59 mKCal/MT respectively.

References:

1. Nand, S. & Manish Goswami, "Causes of Downtime in Indian Ammonia and Urea Plants", Fertiliser News, Vol 45 (12), 2000.
2. Nand, S. & Sood, V. "Energy Conservation Efforts in Indian Ammonia and Urea Plants". Workshop on Energy Conservation and Management in Fertiliser Industry, 3-4 March 2003, New Delhi. .

Table 1: Installed Capacity of Nitrogen Feedstock Wise

Year	Natural /Associated Gas	Naphtha	Fuel oil	Coal	Others (COG/Coke/ ext.amm)
1960	-	-	-	-	100
1970	10.2	65.3	-	-	24.5
1980	13.0	51.7	19.6	9.9	5.8
1985	24.0	42.5	19.8	7.7	6.6
1990	41.9	29.5	14.5	5.6	8.5
1995	47.6	27.4	13.6	5.0	6.4
1996	50.7	26.0	13.0	3.3	7.0
1997	52.5	25.1	12.5	3.2	6.7
1998	49.4	29.8	11.2	2.9	6.7
1999	47.2	31.6	10.7	2.7	7.7
2000					
2001					
2002	47.4	29.0	10.4	-	13.2
2003	50.2	26.8	9.1	-	13.2

Table 2- No. of Shutdown and Duration of Turnaround in Ammonia plants

(1996-99)

PLANTS	**NO. OF SHUTDOWN PER PLANT PER YEAR (SPY)**	**DURATION OF TURNAROUND PER PLANT PER YEAR (DDPY)**
Reforming Plants	6.9	20.2
Gasification Plants	14.0	34.2
All Plants	**8.2**	**22.5**

Table 3: Major reasons for Loss of Production of Nitrogen for the period (1996-99)

Reasons	Quantity ('000 MT)	As % of the total loss
1. Equipment Breakdown	845.2	22.6
2. Power problems	64.9	1.7
3. Shortage of raw materials	1829.8	48.9
4. Labour problems	24.0	0.6
5. Others	981.6	26.2
Total	**3745.5**	**100.0**

Table 4- Downtime in Ammonia Plants for Various Survey Period (all the plants)

(DDPY = Downtime in Days/Plant/Year)

Reasons	**1993-96 (DDPY)**	**1996-99 (DDPY)**	**1999-2002 (DDPY)**
1. Mechanical	24.1	14.7	14.7
2. Electrical	1.9	0.6	0.7
3. Instrumentation	1.8	1.1	1.0
4. Process	1.3	1.6	1.9
5. Miscellaneous	7.2	10.3	11.9
Total	**36.3**	**28.3**	**30.2**

Table 5 - Mechanical Failure Downtime in Ammonia Plants for 1999-2002 (Based on reforming process)

Major Sections (27 plants)	Downtime days	%
1.Pretreatment section	0.4	-
2. Primary reformer	151	13.1
3. Secondary reformer	550	47.9
4. Purification	43	3.7
5. Synloop & Refrigeration	87	7.6
6. Syngas Compressor	110	9.6
7.Other Compressors & Turbines	99	8.6
8.Miscellaneous Major Equipments	109	9.5
Total	**1149**	**100.0**

Table 6 - Mechanical Failure Downtime in Ammonia Plants for 1999-2002 (Based on gasification process)

Major Sections (5 Plants)	Downtime days	%
1.Gasifier	31	16.5
2. Air Seperation Unit	41	21.8
3. Purification	6	3.2
4.Synloop & Refrigeration	11	5.9
5.Syngas Compressor	50	26.6
6.Other Compressors & Turbines	15	8.0
7.Miscellaneous Major Equipments	34	18.0
Total	**188**	**100.0**

Table 7- Details of Downtime due to Mechanical Failure in Ammonia Plants

	Sections	1993-96	1996-99	1999-2002
A	**Steam Reforming process (plants)**	**(28)**	**(28)**	**(27)**
	1.1 Pretreatment section	0.12	0.05	0.44
	ii) Primary reforming			
	Tubes	1.58	0.88	0.86
	Riser	0.00	0.00	0.06
	Manifolds/Pigtails	0.21	0.00	0.13
	Transfer header	0.80	0.01	0.00
	Convection section	1.60	0.18	0.13
	ID/FD Fans	0.43	0.22	0.11
	Miscellaneous	0.65	0.65	0.62
	Total	**5.27**	**1.93**	**1.91**
	iii) Secondary reforming			
	WHB	1.39	1.40	5.22
	Secondary reformer	1.18	0.10	1.63
	Miscellaneous	0.57	0.00	0.12
	Total	**3.14**	**1.50**	**6.97**
B.	**Gasification process (plants)**	(6)	(6)	(5)
	i) Pretreatment section	0.00	0.00	0.00
	ii) Gasification			
	WHB	0.00	0.02	0.97
	Refractory	0.49	0.20	1.45
	Gasifier	8.52	0.30	2.03
	Fuel oil guns/burner nozzle	0.24	0.04	0.00
	Valves/tubes/piping	0.28	0.20	0.39
	Others	0.04	0.30	0.24
	Total	**9.57**	**1.06**	**4.73**
	iii) Air separation unit			
	Air compressor	3.73	2.44	0.22
	Oxygen compressor	0.46	3.56	0.09
	Nitrogen compressor	1.49	0.28	0.00
	Exchangers	0	0.72	1.33
	Valves/piping	2.42	0.38	1.05
	Total	**8.10**	**7.39**	**2.70**
C.	**Purification (plants)**	(34)	(34)	(32)
	Exchangers	1.12	0.90	0.16
	Vessels/Scrubber	0.47	0.85	0.19
	Pumps & motors	0.31	0.17	0.09
	Piping/Valves/Flanges	0.70	0.61	0.05
	Miscellaneous	0.12	0.03	0.02
	Total	**2.72**	**2.57**	**0.51**
D.	**Synloop & Refrigeration (plants)**	(34)	(34)	(32)
	Exchangers	1.69	0.64	0.45
	Vessels	1.29	1.29	0.27
	Pipes/Valves/Flanges	0.31	0.13	0.30
	Others	0	0.05	0.01

	Total	**3.29**	**2.11**	**1.04**
E.	**Syn gas compressor (plants)**	(34)	(34)	(32)
	Compressor	2.05	2.18	1.20
	Drives (turbine/motor)	0.84	0.36	0.39
	Miscellaneous	0.23	0.26	0.11
	Total	**3.12**	**2.80**	**1.71**
F.	**Other Compressors**			
	Process Air Compressor	0.01	0.88	0.41
	Recycle compressor	0.23	0.07	0.13
	Refrigeration compressor	0.42	0.66	0.67
	Total	**1.66**	**1.60**	**1.21**
G.	**Miscellaneous equipment**	**3.19**	**0.84**	**1.52**

Table 8 - Downtime in Urea Plants for Various Survey Periods
(all the plants)
(DDPY = Downtime in Days/Plant/Year)

Reasons	**1993-96 (DDPY)**	**1996-99 (DDPY)**	**1999-2002 (DDPY)**
1. Mechanical	11.2	10.5	6.3
2. Electrical	1.1	0.5	1.0
3. Instrumentation	0.8	0.6	0.5
4. Process	0.4	0.4	0.5
5. Miscellaneous	32.9	27.8	30.2
Total	**46.4**	**39.8**	**38.2**

Table 9- Details of Downtime due to Mechanical Failure in Urea Plants
(DDPY = Downtime days/plant/year)

EQUIPMENT ITEMS	1993-96	1996-99	1999-2002
1. Ammonia preheater	0.09	0.34	0.08
2. Ammonia pump	0.40	0.77	0.12
3. Carbamate pump	0.55	1.82	0.06
4. Slurry & other pumps	0.02	0.41	0.01
5. CO_2 compressor	2.80	1.73	1.10
6. Autoclave/reactor	1.15	1.08	1.64
7. Let down valve	0.01	0.07	0.03
8. Heat exchangers	0.78	0.45	0.50
9. Decomposer/stripper	2.10	0.83	1.31
10. NH_3/CO_2 recovery column	0.09	0.03	0.02
11. Absorber/recovery vessels	0.20	0.56	0.07
12. Evaporator/crystalliser	0.00	0.13	0.02
13. Centrifuge	0.07	0.05	0.03
14. Steam ejector/vacuum generator	0.02	0.00	0.03
15. Dryer/cooler	0.02	0.10	0.02
16. Blower/fan	0.09	0.17	0.02
17. Conveyer/elevator	0.34	0.60	0.06
18. Prill tower	0.10	0.25	0.13
19. Piping/valves	0.42	0.50	0.39
20. Miscellaneous	1.90	0.62	0.55
Total	**11.15**	**10.50**	**6.17**

Table 10: Average Energy Consumption for Ammonia and Urea Production in India

Year	Ammonia Plants (mKCal/MT ammonia)	Urea Plants (mKCal/MT urea)
1987-88	12.48	8.87
1990-91	11.62	8.42
1992-93	11.38	8.29
1994-95	10.99	7.90
1995-96	10.97	7.84
1996-97	10.88	7.78
1997-98	10.28	7.36
1998-99	10.18	7.22
1999-00	9.80	6.96
2000-01	9.59	6.89
2001-02	9.36	6.88
2002-03	9.30	6.59

Table 11: Feedstock wise energy consumption of Ammonia and Urea Plants (2002-03)

Feedstock	Ammonia plant		Urea Plant	
	Capacity Utilisation (%)	Energy (mKcal/MT of ammonia)	Capacity Utilisation (%)	Energy (mKcal/MT of urea)
1. GAS	93.9	8.67	94.1	6.18
2. Naphtha	77.6	9.27	82.1	6.64
3. Fuel Oil	98.3	12.78	99.1	8.75
Total	**89.3**	**9.30**	**91.0**	**6.59**