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D03664

Distribution
LIMITED

ID/WG.123/18
15 June 1972

United Nations Industrial Development Organization

Original: ENGLISH

Expert Group Meeting on Transfer of Know-how
in Production and Use of Catalysts

Bucharest, Romania, 26 - 30 June 1972

PRESENT STATUS AND FUTURE POSSIBILITY OF CATALYSTS PRODUCTION IN INDIA[1/]

by

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CONTENTS

TABLES

I. INTRODUCTION

1. Soon after independence in 1947 the Government of India decided to implement its plans for a chemical fertilizer factory based on coal gasification at Sindri. The plant was set up by a public sector company known as Sindri Chemicals & Fertilizers Limited. A small research and development cell was organised within the company to study the technologies involved in the manufacture of chemical fertilizers. During the commissioning stage of the Sindri plant, apparently due to an upset in the operations, the high temperature carbon monoxide conversion catalyst operating at near atmospheric pressures was observed to have lost some of its activity. This 270 tonnes charge of catalyst imported from U. K. was regenerated by the efforts of the research and development cell of the Sindri Fertilizers.

2. The success in the regeneration of a catalyst provided the necessary impetus and confidence to undertake further developments towards the production of the catalyst itself in India. These efforts resulted in producing, sometime before the mid-fifties, a small quantity of indigenous high temperature shift catalyst for operations at pressures close to atmospheric pressures only. Soon thereafter Sindri Fertilizers also produced some quantities of an iron oxide mass for desulphurisation of raw gas obtained from coal gasification. Both these catalysts found immediate application in the Sindri ammonia plant. However the success so achieved in the production of indigenous catalysts did not result in covering much of the demands of the developing fertilizer industry.

II. TOWARDS SELF SUFFICIENCY IN CATALYST PRODUCTION

3. A survey carried out as late as 1965 revealed that the

requirements of every type of catalyst for all the ammonia plants then under construction, without exception, were still to be met by imports usually through the procurement by the engineering contractors concerned. Even the Sindri Expansion carried out in the late fifties had its initial and spare charges of catalysts imported, and the first Sindri plant continued to import its requirements of ammonia synthesis catalysts. This will be clear from Table I which lists the various ammonia plants in 1965 which were either using or had ordered imported catalysts for the initial and spare charges.

4. The survey also considered the projected growth of the ammonia industry. Table II lists the various ammonia plants that had been projected more or less on a firm basis for startup before 1969. It also lists the various catalysts types to be used in these plants. It was clear that establishing an additional ammonia capacity of about 2.0 million tonnes per annum in terms of nitrogen by 1969 would necessitate large scale imports of catalysts.

Table I: Ammonia Plants in India using or ordered imported catalysts in 1965.

	Plant	Capacity Tons/year Nitrogen	Type of Catalysts	Feedstock
1.	Sindri I FCI	65,000	j	Coke Oven Gas
2.	Sindri II FCI	50,000	a,e,f,j	Coke Oven Gas
3.	Rourkela HSL	120,000	a,f,j	By product coke oven gas
4.	Nangal FCI	80,000	j,k	Electrolytic hydrogen
5.	Trombay FCI	90,000	f,j	Partial Oxidation Naphtha
6.	Gorakhpur FCI	80,000	a,f,j	- do -
7.	Namrup FCI	50,000	b,e,f,i,j	Natural Gas Reforming

8.	Alwaye II FACT	15,000	f, j	Partial Oxidation Naphtha
9.	Alwaye III FACT	20,000	f, j	- do -
10.	Neyveli NLC	70,000	a, f, j	Lignite gasification
11.	Varanasi NFC	10,000	a, f, j	Coke
12.	Ennore Parry	10,000	f, j	Partial Oxidation Naphtha
		660,000		

Table II: Ammonia Plants in India Projected in 1965 for startup before 1969.

	Ammonia Plant Owner/location	Capacity Tons/year Nitrogen	Type of Catalysts	Feedstock	Startup Before
1.	Visakhapatnam Coromandel	84,000	c, d, e, f, g, h, i, j	Naphtha Reforming	1968
2.	Baroda GSFC	96,000	- do -	Naphtha/Gas Reforming	1968
3.	Durgapur FCI	150,000	- do -	Naphtha Reforming	1969
4.	Cochin FACT	140,000	- do -	- do -	1969
5.	Trombay II FCI	240,000	- do -	- do -	1969
6.	Alwaye IV FACT	30,000	- do -	- do -	1969
7.	Baroda II GSFC	110,000	- do -	- do -	1969
8.	Kanpur IEL	240,000	- do -	- do -	1969
9.	Goa Zuari	150,000	- do -	- do -	1969
10.	Madras MFL	190,000	- do -	- do -	1969
11.	Kota Sriram	120,000	- do -	- do -	1969
12.	Mangalore Mangalore Govt.	150,000	- do -	- do -	1969
13.	Kothagudem Allied	60,000	a, f, j	Coal gasification	1968
14.	Sindri Reformer FCI		c, d, f	Naphtha Reforming	1969
15.	Rourkela Reformer HSL		c, d	- do -	1969
		1,770,000			

Key to Tables I & II

a	denotes	desulphurisation catalysts iron oxide
b	"	desulphurisation catalysts treated carbon
c	"	desulphurisation catalysts zinc oxide type
d	"	hydrotreating
e	"	cracking/reforming
f	"	high temperature CO conversion
g	"	low temperature CO conversion
h	"	chloride/sulfur guard
i	"	methanation
j	"	synthesis
k	"	de oxo
FCI	"	Fertilizer Corporation of India Limited
HSL	"	Hindustan Steel Limited
FACT	"	Fertilizers & Chemicals Travancore Limited
NLC	"	Neyveli Lignite Corporation Limited
Parry	"	E. I. D. Parry Limited
Coromandel	"	Coromandel Fertilisers Limited
GSFC	"	Gujarat State Fertilizers Company Limited
IEL	"	Indian Explosives Limited
Zuari	"	Zuari Agro Chemicals Limited
MFL	"	Madras Fertilizers Limited
Sriram	"	Sriram Fertilisers and Chemicals
Allied	"	Allied Chemicals of U.S.A.

5. In consultation with the welknown Catalysts & Chemicals Inc. of Louisville, Ky., U.S.A. a further study was carried out. The conclusions of this study were broadly that:

i. a minimum economic capacity for a catalyst manufacturing unit in India, such as would enable the consumer to buy indigenous catalysts at a price not exceeding the price he would pay for imported catalysts, required a market potential equivalent to the catalysts requirements of:

a) operating ammonia plants of atleast 1,000,000 tonnes per year of nitrogen capacity and
b) new ammonia constructions of atleast 500,000 tonnes per year of nitrogen capacity,

ii. a catalyst manufacturing unit should preferably be in a position to supply the complete range of catalysts required for large ammonia plants based on modern technology,

iii. a catalyst manufacturing unit located in India would be advantageously placed to serve the catalyst requirements of the petroleum refineries, hydrogen and ammonia plants in the West Asian region,

iv. a catalyst manufacturing unit in India could also cater to the catalyst requirements of the Indian refineries and petrochemical industry,

v. the successful marketing of catalysts was possible only if the catalysts being offered had proven excellence in commercial operations and the performance could be guaranteed to meet the parameters of the plant design.

6. On the basis of this study, collaboration was sought from Catalysts and Chemicals Inc., and an application for a licence to manufacture catalysts in India was made to the Government of India in September 1965. In June 1967, the project received preliminary approval. The collaboration agreement received preliminary approval in February 1969 and final approval in November 1970. Catalysts and Chemicals India West Asia (CCIWA)'s catalyst factory commenced commercial production by April 1971. The licensed installed capacity of CCIWA's factory in Kerala is given in Table III.

Table III: Capacity of Catalysts & Chemicals India (West Asia)

	Catalyst	Tonnes/year
1.	Desulphurisation catalysts	40

2.	Petrochemical catalysts	50
3.	Hydrot eating catalysts	200
4.	Naphtha & Hydrocarbon Cracking & Reforming catalysts	80
5.	High Temperature CO Conversion catalysts	450
6.	Low Temperature CO Conversion catalysts	450
7.	Methanation catalysts	60
8.	Ammonia Synthesis catalysts	300
9.	Zinc oxide type Desulphurisation catalysts	300
10.	Petrochemicals Hydrogenation catalysts	15
11.	Catalytic Reforming catalysts	20
		1975

7. Meanwhile the Fertilizer Corporation of India has also established production of a large range of catalysts (manufactured entirely on the knowhow developed themselves). It is understood that at present, Fertilizer Corporation of India offers to ammonia industry the following catalysts:

i. Naphtha and gas cracking and reforming catalysts,
ii. Desulphurisation catalysts of iron oxide type,
iii. Desulphurisation catalysts of zinc oxide type,
iv. High temperature CO conversion catalysts,
v. Low temperature CO conversion catalysts,
vi. Zinc oxide desulphurisation catalysts, and
vii. Methanation catalysts.

III. CATALYST REQUIREMENTS IN INDIA

8. The requirements of catalysts in India at present and projected upto 1974/75 are given in Table IV. The requirements have been estimated for only those catalysts that are presently approved for manufacture by CCIWA and excludes the requirements of catalysts for the plants operated or under construction by the Fertiliser Corporation of India.

Table IV: Catalyst Requirements in the Fertiliser & Petroleum Industry in India excluding the requirements of FCI plants. (Figures in Metric Tonnes).

	Catalyst	Average life years	1972-73	1973-74	1974-75	Total
1.	Desulphurisation (treated carbons)	2	30	30	60	120
2.	Desulphurisation (zinc oxide type)	1½	130	130	200	460
3.	Hydrotreating catalysts	5	250	250	350	850
4.	Cracking/Reforming catalysts	4	45	50	80	175
5.	High Temperature CO Conversion	3	125	125	250	500
6.	Low Temperature CO Conversion	1½	100	100	200	400
7.	Methanation	4	20	40	80	140
8.	Ammonia Synthesis	7 plus	nil	100	200	300
9.	Petrochemicals catalysts	various	50	50	50	150
10.	Petrochemicals Hydrogenation	various	15	15	15	45
11.	Catalytic Reforming catalysts Pt. type		10	10	10	30

9. The requirements have been estimated after taking into consideration, among other factors, the following:

i. the total installed design volumes of operating ammonia plants as given in Table V,

ii. the total design catalyst volumes of ammonia plants scheduled for startup before 1973/74 as given in Table VI,

iii. average operating life of the catalysts as indicated in Table IV which itself is based on the technologies involved and operating experience in the several plants

as known to CCIWA's technical service division. Incidentally, Tables V & VI also give the totals of the design volumes of plants in operation and those under construction which are scheduled for startup before 1973/74 for both FCI and non-FCI ammonia plants in India.

iv. the requirements of the petroleum refineries and petrochemical plants as guess-estimates by CCIWA's sales division.

Table V: Total installed/design volumes in operating ammonia plants in India.

	Catalysts	FCI plants Cu.M.	Non-FCI plants Cu.M.	Total Cu.M.	Total Tonnes (estimated)
1.	Desulphurisation (iron oxide type)	1300	670	1970	1600
2.	Desulphurisation (treated carbons)	10	50	60	35
3.	Desulphurisation (zinc oxide type)	3.3	212.2	215.5	225
4.	Hydrotreating	3.5	151.2	154.7	125
5.	Cracking/Reforming	48.5	226.6	275.1	275
6.	High Temperature CO Conversion	371.8	351.0	722.8	800
7.	Low Temperature CO Conversion	Nil	224.2	224.2	250
8.	Methanation	7.7	91.4	99.1	80
9.	Ammonia Synthesis	29.1	129.2	158.3	455

Table VI: Total design catalyst volumes of ammonia plants starting up during 1972/73 and 1973/74 in India.

	Catalysts	FCI plants Cu.M.	Non-FCI plants Cu.M.	Total Cu.M.	Total Tonnes (estimated)
1.	Desulphurisation (iron oxide type)	Nil	Nil	Nil	Nil

2.	Desulphurisation (treated carbon)	30	56.6	86.6	50
3.	Desulphurisation (zinc oxide type)	43.5	79.5	118.0	120
4.	Hydrotreating	46.6	117.1	163.7	130
5.	Cracking/Reforming	110.7	230.9	341.6	340
6.	High Temperature CO Conversion	163.0	507.0	670.0	750
7.	Low Temperature CO Conversion	156.5	268.0	424.5	475
8.	Methanation	50.0	91.7	146.7	115
9.	Ammonia Synthesis	67.4	215.9	283.3	815

IV. EXPORT POTENTIAL IN WEST ASIAN COUNTRIES

10. The principal potential for exports of catalysts manufactured by CCIWA is in countries of West Asia including Afghanistan, Iran, Iraq, Saudi Arabia, Kuwait, Jordan and the other Gulf States of Bahrein, Abu Dhabi, Dubai, Muskat, Oman etc. India's immediate neighbours, Pakistan, Bangla Desh and Ceylon are also potential markets, however their requirements have not been considered.

11. The total presently installed capacity of operating ammonia plants in this region is about 5000 tonnes per day or about 1.38 million tonnes per year in terms of nitrogen, including the ammonia plants at Shahpur and Shiraz in Iran, at Dammam in Saudi Arabia, three plants in Kuwait, at Doha in Qatar, at Basrah in Iraq and one plant in Afghanistan. Further, within the next three or four years additional ammonia capacity of 800 t/d in Iraq and 1000 t/d in Iran may be expected to materialize. In addition to these ammonia plants, there are three large oil refinery hydrogen plants in this area including those at Teheran in Iran, and two in Kuwait having a total capacity of about 140 MMSCF/day of hydrogen. Additionally, three more hydrogen plants in Iran, Saudi Arabia and Jordan may be expected to commence production within the next three or four years.

Based on the operational experience in these plants related to catalyst life, the catalyst demand in these countries has been broadly estimated by CCIWA's technical service division as given in Table VII.

Table VII: Estimated Catalyst Requirements in West Asian Countries - Figures in Metric Tonnes.

	Catalyst	1972-73	1973-74	1974-75
1.	Desulphurisation (treated carbons)	30	30	60
2.	Desulphurisation (zinc oxide type)	125	150	200
3.	Hydrotreating	250	250	350
4.	Reforming	40	50	80
5.	High Temperature CO Conversion	125	125	250
6.	Low Temperature CO Conversion	100	125	250
7.	Methanation	20	40	80
8.	Ammonia Synthesis	-	100	200
9.	Petrochemicals Hydrogen	-	-	5
10.	Petrochemicals catalysts various	-	5	10
11.	Catalytic Reforming Pt. type	-	10	10

V. SURPLUS CATALYST PRODUCTION IN INDIA

12. Considering the present installed capacity at CCIWA's factory in India and Fertilizer Corporation of India's production capacity, it is estimated that about 50% of CCIWA's capacity will remain surplus and available for exports after the total Indian requirements have been met for atleast the next three years.

VI. INDIA AS A CATALYST SUPPLIER TO WEST ASIA

13. India as a supplier of proven catalysts offers many advantages to the catalyst consumers in the West Asian countries. These advantages arise primarily because of its nearness to the region and since age old trade routes between India and these countries are well established. The consumer in West Asia can now depend on quick availability of his catalyst requirements and need not tie up his money unnecessarily in holding large inventories of catalyst spares. From India it is now possible for the catalysts to reach any of the consumers in this region within ten or fifteen days, whereas previously it required six to eight weeks or more. Further, it is now possible for them to obtain the services of a technical service engineer for any emergency situations within a few hours. Experience has shown that the importance of this prompt availability of technical service cannot be over-emphasized. The scope of technical services has been elaborated elsewhere in this paper.

14. India, as a major fertilizer importing country, offers an outlet for the surplus fertilizer production in West Asia and their purchase of the catalysts produced in India would assist, though in a small measure, towards balancing of trade between the West Asian countries and India.

VII. CATALYST PRODUCTION AS AN INDEPENDENT INDUSTRY

15. The function of a good catalyst is to increase the rates of chemical reaction such as to make possible the production of products under much more favourable conditions of temperature and pressure than if no catalyst or an inferior one were present. Hence, the right catalyst is often the secret to successful manufacture of a particular chemical product.

16. Until 1950, catalysts were developed and produced only by very large chemical companies usually for use in their own chemical plants. These chemical companies jealously guarded the knowhow on catalysts both with regard to their production and use. Only when the chemical companies chose to do so, would they agree to sell the process together with the catalysts to another party on payment of huge license fees in addition to exhorbitant prices for the catalysts, the exact formulations of which were seldom or never disclosed.

17. Since that time, however, a few companies have been organised specifically to manufacture and market catalysts no longer just as adjuncts to another main chemical product. These companies began manufacturing catalysts that were either developed by others or by themselves. As such catalysts for specific applications then became available outside the group of the then existing large monopolistic chemical companies. Engineering contractors were now enabled to offer to build for new entrepreneurs economic chemical plants without having to pay large license fees and catalyst prices. To be sure, this also contributed, in no small measure, towards a wider ownership of larger chemical plants, particularly in the ammonia fertilizer industry, all over the world.

VIII. SUCCESSFUL MANUFACTURE OF CATALYSTS

18. The successful manufacture of catalysts requires, amongst other things, a clear appreciation of the fact that catalysts are not simple chemical compounds or mixtures of chemical compounds having a set or predetermined analysis. It must also be understood that the manufacture of catalysts can only be carried out batchwise or at best on a semi-continuous basis, since it is not the mere compounding of

materials to get properties that yields a good catalyst but the exact techniques of controlled precipitation, thermal treatment, activation, that results in high activity catalysts. The proper selection of raw materials and the avoidance of any poisonous contaminants even in the least concentrations is not less important in the manufacture of a good catalyst. The mastery of these techniques, which is almost an art for producing catalysts, requires years of experience, and the strictest quality control checks at various stages of manufacture. Having recognized the specialized and sensitive nature of catalyst manufacture, CCIMA opted to get this knowhow by collaborating with Catalysts and Chemicals Inc. whose skills in production had been clearly proven.

IX. TECHNICAL SERVICE

19. The marketing of catalysts also requires special technical assistance which is not generally available. This is so because the successful performance of a catalyst in operation requires substantially on knowhow regarding its use, process design and operating recommendations provided by the catalyst supplier based on his review of related commercial experience. Often more than one catalyst is suitable for a particular chemical reaction and usually several that will give the same results if the operating conditions are made to fit the catalyst for the service required of it. Thus a chemical design can be fitted to an available catalyst or alternatively a different catalyst may be employed to suit a more acceptable process design. Hence the selection of the operating conditions are just as important as the selection of the catalyst itself. A less active catalyst can also be made to perform but in doing so the user would have to probably adopt a less economic design involving higher capital outlays and at the same

time greater quantities of utilities such as steam and electric power would be consumed making his operations difficult and more expensive.

20. The catalyst supplier therefore has to have facilities and technical competence to provide:

i. process information to the engineering contractor or the customer during the initial stages of design and construction of the plant. Reliable information obviously can be provided only if the catalyst offered has been fully proven in commercial operation under several varying conditions of operations. Bench scale or even pilot plant data alone cannot possibly form the basis for providing such information.

ii. Startup services of competent experienced engineers when the catalyst is first being placed on stream. This assistance can only be provided properly if the service engineer has participated in a large number of such startups and has thereby gained the experience necessary to provide against avoidable fouling or overheating which could sometimes totally spoil the entire charge of costly catalyst.

iii. Subsequent follow-up service to assist the customer in maintaining optimum operating performance of the catalysts and to assist in the solution of any problems which relate to the use of the catalysts. This service has often assisted an operating company in keeping its throughput at the maximum while maintaining the desired quality of the product by recommendations of changes in operating conditions to compensate for any damage to the catalyst resulting from upsets in operation or unexpected contamination of the feed material.

21. These technical services to be provided by the catalyst producer are of the utmost importance for successfully marketing a catalyst.

22. The engineering contractors and the customers, particularly the ammonia manufacturers are becoming increasingly conscious of the importance of these services and often insist that a clause providing for these expert services is written into the contract while purchasing the catalyst. Of course at the same time, they demand suitable performance and life guarantees on the catalyst. There is no doubt that the catalyst vendor recognizes the right of the purchaser to demand these services and welcomes it, particularly if the purchaser demanding these services is the chemical manufacturer. This is so because such close co-operation results not only in the engineering contractor providing an optimum design rather than a minimum design but also the customer getting best performance and life out of the catalyst with minimum down time and maximum throughputs.

23. Among other services that a catalyst vendor provides is operator training which includes a discussion of theoretical aspects relating to the catalysts with special emphasis on the practical application of the catalysts in the customer's plant. It also includes a discussion to evaluate the various factors that influence the performance of the catalysts, the physical properties of the catalysts, various precautions necessary in using the catalysts, loading and unloading procedures, startup and shutdown procedures and methods of evaluating the performance of the catalysts.

X. CONSIDERATIONS FOR SETTING UP NEW MANUFACTURING UNITS

24. It will be clear from the foregoing that a good catalyst per se does not ensure success in its marketing. Price also therefore, is not a consideration when an unproven catalyst is being marketed against a proven catalyst. A prerequisite for setting up a catalyst producing unit, in

a developing or any country is firstly availability of acceptable knowhow, either developed from commercial experience over several years or obtained by a transfer through licensing or outright purchase.

25. While price may not be a consideration when comparing an unproven catalyst to a proven catalyst, it assumes considerable significance when selection is to be made between two proven catalysts for the same service. Already there are atleast three or four renowned catalyst suppliers competing severely for the limited markets presently available.

26. The mushrooming of the ammonia industry all over the world during the early and mid sixties resulted in large catalyst manufacturing facilities being established not only in U.S.A. but also elsewhere in the world. For instance, Catalysts and Chemicals Inc., in collaboration with Mechim (Societe Generale) and Mitsui Toatsu, established catalyst manufacturing plants in Belgium and Japan respectively, in addition to the CCIWA plant in India. At the same time catalysts are produced by other companies in U.S.A., in U.K. and Europe. With the subsequent slackening of growth in the fertilizer industry, there now exists a large surplus catalyst production capacity with resultant severe competition and very low sale prices.

27. Raw material availability at competitive prices therefore has assumed greater importance. Not every country developed or developing is assured of low priced raw materials.

28. Similarly, of great importance is the cost of technical expertise. India is particularly well placed in this respect because of the high order of technical competance available in the country at rates perhaps one-third or less than those in the developed countries.

XI. CONCLUSION

29. Successful manufacture of highly sophisticated and sensitive catalysts requires a mastery over the production techniques, which is almost an art in itself. The manufacturing knowhow must be available, either developed independently after many years of experience or obtained by transfer through licensing or outright purchase. Only a very few companies in the world possess this knowhow.

30. A necessary factor in the successful marketing of catalysts, apart from price and product acceptability, is the capability of the catalyst vendor to provide competent technical service assistance during the design stages of a chemical plant, at the time of catalyst loading, during initial plant startup and thereafter throughout the lifetime of the catalyst. The catalyst vendor must also provide acceptable performance and life guarantees on his catalysts. Yet another very important factor in this regard is that the catalyst vendor must be in a position to meet the emergency requirements of catalysts and technical service promptly at, sometimes, very short notice.

31. There is surplus capacity for ammonia catalysts on a worldwide basis resulting in severe competition between the manufacturing companies for the limited markets presently available. Longterm growth of demand, however, may be expected on the premise that ammonia production must be stepped up considerably to meet the desired levels of fertilizer use particularly in the developing countries.

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