EXECUTIVE SUMMARY

1. Introduction :

The report is aimed at bringing out the present status of the technology in the field of Caprolactam in India. The study covers the review of operating units in India, comparison of manufacturing processes followed and the problems faced by the manufacturers regarding technology. The study was conducted by contacting the existing and potential manufacturers, the technology suppliers and the users of Caprolactam and compiling the information received.

Caprolactam is the basic raw material of Nylon-6 and almost all the Caprolactam produced in India is used for manufacture of Nylon-6. However, with the advent of other synthetic fibres such as polyester, the use of Nylon in the form of filament yarn for dress material has declined. There has been a marginal increase in the use of Nylon for non-fibre applications but the main use of Nylon today in India is for preparation of Nylon tyre cords.

Caprolactam can be manufactured starting from a number of raw-materials depending on the process route followed. The major raw-materials for manufacture of Caprolactam in India are phenol, benzene, toluene, ammonia, sulphuric acid, hydrogen and others. As India is one of the largest producers of ammonia in the world, the existing Caprolactam projects use ammonia.

2. Structure & Status of Indian Industry :

The production of Caprolactam started in India in 1974 when GSFC commissioned their 20,000 TPA plant at Vadodara. This capacity was stagnant till FACT commissioned their 50,000 TPA plant at Cochin in 1990 and GSFC commissioned their second plant of 50,000 TPA at Vadodara in 1993.

The production of Caprolactam in 1995-96 was about 103,000 MT in India. The demand for Caprolactam has been higher than the production level in the last few years and there had been import of Caprolactam to the tune of 10,000 to 30,000 MT per year in the last five years. Although there has been some export to countries like Sri Lanka, Taiwan and Korea, the quantity has been small.

Since the textile industry is one of the major users of Caprolactam, the future of Caprolactam industry is closely linked with the usage of Nylon for garments. In this sector, Nylon faces a stiff competition from polyester and the market for Caprolactam is limited.

Indian started for Caprolactam is available and the manufacturers of Caprolactam are able to produce the material as per the desired specification.

A few prospective manufacturers of Caprolactam were planning to put up plants and had obtained letters of intent in 80's. However, there has been no serious progress made in the last few years.

The present estimated annual demand for Caprolactam is about 120,000 to 130,000 MT which is expected to rise to a level of 150,000 to 160,000 MT by the end of this century.

After globalisation, Indian industry now faces competition from all parts of the world. Till recently, Caprolactam was a protected item and there were severe constraints on import of Caprolactam. With the relaxation of imports, it is unlikely that new Caprolactam plants would be coming up in the near future. The prices paid for the raw-material by the existing Caprolactam manufacturers are higher as compared to the rest of the world. The manufacturers of Caprolactam abroad are favourably placed with respect to the size of the plant and the prices of raw-materials and electricity.

The technology to manufacture Caprolactam is not easy to obtain since the process licensers are themselves the manufacturers of Caprolactam.

3. International Scenario :

One of the raw-materials for the manufacture of Caprolactam, Ammonia, is readily available in large fertilizers complexes. Hydrogen and Oleum/ Sulphuric Acid are available, while the major by-product, Ammonium Sulphate, is used as fertilizer. It is not surprising, therefore, that Caprolactam plants are put up as an integral part of fertilizer complexes in India, as well as in the rest of the world.

The major process licensers for Caprolactam are DSM/Stamicarbon, BASF, Ube, IFP & CIECH. The present world production of Caprolactam

is 3.5 million MT per year. About 80% of this goes for the manufacture of Polyamide fibres and 20% for the production of Polyamide resins.

It is interesting to note that no new plants have been put up either in USA or in Western Europe since 1991. The new plants are coming in Eastern Europe and South East Asia, especially in Taiwan, Korea, China and Thailand. Since Ammonium Sulphate, a by-product of Caprolactam, is not a proper fertilizer in the rest of the world, efforts are being made to reduce the production of this by-product. However, Ammonium Sulphate has a good demand as Fertilizer in India.

4. R&D Efforts, Technology Absorption :

The two manufacturers of Caprolactam in India, GSFC & FACT, have engaged in serious R&D activities in the field related to Caprolactam and Nylon manufacturing. GSFC have developed processes for the recovery of by-products/sideproducts and have carried out work for in-situ polymerization of Caprolactam using casting and injection moulding techniques. FACT have developed three catalyst for use in the various manufacturing steps of Caprolactam out of the six. After successful plant trials, these catalyst are in regular use and foreign exchange outgo has thus been reduced on this account.

GSFC have been working in close association with National Research Laboratories in respect of R&D related work. In collaboration with IICT, they have developed a catalyst for Beneze Hydrogenation reaction as a substitute for imported catalyst. In collaboration with IICT, they are working on the development of a catalyst for dehydrogenation of Cyclohexanol to Cyclohexanone and are developing an alternate route for Oximation.

All Indian manufacturers of Caprolactam have well equipped testing laboratories with sophisticated instruments for analysis of their product.

The safety of the Caprolactam plant is of paramount importance and some reported cases of accidents which occurred abroad are discussed. Both FACT and GSFC have undertaken to reduce the risk of accidents. Both GSFC & FACT had been continuously upgrading the technology. Most of the items of equipment have been indigenised.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The production of Caprolactam, the raw material of Nylon-6, has witnessed a significant growth in India during the last two decades. With a modest beginning of a 20,000 TPA plant of GSFC in 1974 the capacity increased six fold upto early 90's. Thereafter the capacity has been stagnant at 120,000 TPA over the last three years. There are only two manufacturers of Caprolactam in India namely Gujarat State Fertilizers and Chemicals Ltd. (GSFC) and The Fertilizers and Chemicals Travancore Ltd. (FACT). Both these manufacturers have based their plants on modern technology and are running to almost design capacity.

Both the manufacturers have absorbed the technology successfully and have made significant progress towards indigenisation of equipments, spare parts etc. They are able to operate their plants at the consumption norms for raw materials and utilities guaranteed by their process licensors. They are also engaged in the Research & Development activities of new catalysts, recovery of by-products/sideproducts and development of Nylon applications such as Engineering Plastic.

No serious technology related problems surfaced during the discussion with the manufacturers of Caprolactam in India. Both the manufacturers are able to produce Caprolactam to the specifications acceptable worldwide. However, the poor quality of Benzene available and control of iron content in the product are some of the difficulty faced by them.

Indian Caprolactam manufacturers are facing a stiff competition from the imported product during last few years. After liberalization, Caprolactam was put under OGL and the import duty was reduced. However, both the Indian manufacturers have responded well to this changed scenario and have succeeded in maintaining their production levels and market share. GSFC have carried out several modifications of their old plant (Caprolactam - I) such as installation of Cx recovery unit, low boiling anone recovery unit, modification of flow scheme by addition of certain pieces of equipment and replacement with more efficient equipment.

Both the Indian manufacturers have been operating their Caprolactam plants in a safe manner. Mock drills are regularly conducted as a part of the safety programme so that the plant personnel

are fully aware regarding the course of action to be taken under the situation of emergency. The liquid effluents coming out from the plant are treated in the effluent treatment plants so that the discharge with respect to BOD, COD etc. is within the norms specified by the local authorities or are incinerated. The unsafe gaseous effluents are either scrubbed to make the discharge nontoxic or burnt off.

Most of the equipment required for a plant manufacturing Caprolactam can be fabricated in India. Various energy saving schemes were undertaken by the Indian manufacturers to reduce the cost of production of Caprolactam.

The demand for Caprolactam by the end of this century, estimated by various committees, exceeds the present production by a substantial margin. However, a new grassroot plant of the size of GSFC/FACT would require an investment of approximately Rs. 1200 crores. The cost of production of Caprolactam from such a plant would be burdened with heavy depreciation and such plants would not be viable unless there is a change in the duty structure. The gap between the demand and supply would be filled by imports and/or expansion/debottlenecking of the existing plants.

Some of the areas where R&D work may be concentrated are:

1. Development of indigenous catalysts
2. Indigenisation of certain equipment
3. Indigenisation of spare parts
4. Energy conservation schemes
5. Recovery of valuable products from waste such as Dicarboxylic Acid, BVA Acid, Formic Acid etc.
6. Development of more energy efficient process steps
7. Process change to result in reduced ammonium sulphate by-product solution

It is reported that both FACT & GSFC are working in this direction. Some of the equipment in the Caprolactam plant are of proprietary nature. However, they can be fabricated in India if the drawings are made available. While considering a new plant the possibility of importing only the Fabrication Drawings instead of importing the complete equipment may be looked into while negotiating the price of Technology with the prospective Know-how Supplier.

Recommendations

Based on the above findings. the following recommendations are made :

- A new plant for the manufacture of Caprolactam may not be viable under the existing circumstance

- The existing manufacturers should step up their R&D work in the areas identified in association with national laboratories and academic institutes

- Work related to fabrication of equipment may be taken up by the industry if the requirements are large and/or repetitive in nature in future

- Safety being paramount in this industry, considering the nature of material being handled, continuous efforts to implement ongoing safety measures should be implemented by industry.