EXECUTIVE SUMMARY

0.1 GENERAL

0.1.1 Nylon Tyre Cord:

Nylon tyre cord is made from high tenacity continuous filament yarn by twisting and plying. There are two major types of nylons used as tyre cord, i.e. nylon-6 and nylon-6,6. The properties of nylon-6 and nylon-6,6 vary marginally and are controlled by the manufacturing process, type of stabilisers and additives used.

In India only nylon-6 is produced commercially for tyre cord.

The types of nylon-6 tyre cord used in India are 840/2, 1260/2, 1260/3, 1680/2 and 1890/2 where number indicates denier of ply / no. of plies in the cord. The denier per filament is 6.

0.1.2 Tyre Cord:

The other materials used as tyre cord are cotton, rayon, polyester, fibre glass, steel, aromatic polyamides. Each of these materials has its own merits and demerits.

The major criteria for acceptance of any material in tyre are its tensile strength, dimensional stability, durability, thermal stability, hysteresis and adhesion.

Tests and actual application conditions have shown that although other cord materials meet one or more specific requirements, nylon by and large meets the desirable requirements for almost all the performance criteria.

0.1.3 Tyres:

The tyre cord fabric provides the tyre its fundamental properties such as shape, size, load carrying capacity, abrasion resistance, fatigue resistance, etc.

A tyre is a composite of cord and rubber. There are three varieties of tyres viz. bias-angle tyres, radial tyres and bias-belted tyres. They differ in the way the tyre fabric plies are laid inside the tyre.

0.1.4 Manufacturing Process:

The manufacturing process for nylon-6 tyre cord can be broadly divided into following production steps:

(a) Polymerisation of caprolactam to manufacture nylon chips.

(b) Extraction and drying of chips.

(c) Melt spinning of chips to manufacture nylon tyre yarn.

(d) Preparation of cord from tyre yarn by twisting and plying.

(e) Recycling of nylon-6 waste.

0.1.5 Polymerisation:

Nylon is made by polymerisation of caprolactam with certain additives like amino acids and dicarboxylic acid salts and certain heat stabiliser such as copper based organic compounds. The polymerisation process involves ring opening polycondensation and polyaddition reactions. All the three polymerisation reaction steps are equilibrium reactions.

A typical process of polymerisation of nylon can be either a batch or a continuous process. The continuous process, developed after the batch process was commercialised, offers simplicity of design, ease of operation and control and high capacity.

An optimal polymerisation process would involve two stages, wherein, the first stage involves pressure at high initial water concentration. In the second stage a rapid transition from high water content to a low water content is achieved by release of pressure and subsequent application of vacuum.

Industrial grade nylon-6 with relative viscosity 3.2 to 3.5 has higher degree of polymerisation compared to textile grade nylon-6 with relative viscosity 2.2 to 2.6.

0.1.6 Extrusion and Drying of Chips:

The nylon chips are washed to remove water soluble impurities and then dried. The process may be batch or continuous.

0.1.7 Melt Spinning:

The polymer chips are melt in extruder. The molten polymer is then spun through a spinnerette. The molten filaments are quenched or cooled by a laminar flow of air.

The spin finish is applied on filament and then wound on spin bobbins and drawn to make tyre yarns.

In the conventional process, the spinning and drawing was done in two steps. In the spin-draw process, a step is reduced compared to 2-step conventional process. As a consequence, some sources of process disturbances are eliminated which results in improved yarn uniformity.

0.1.8 Preparation of Cord:

Nylon tyre yarns are then twisted in S or Z direction and plied having 2 or 3 plies to form a tyre cord.

0.1.9 Recovery of Nylon-6 Waste:

Depending on the quality of waste, any of the following method may be used for recycling of nylon waste.

- Direct use of fibre waste
- Regrannulation- i) without melting
  ii) with melting.
- Polymer Powder- i) deploymerisation and filteration
  ii) precipitation from solutions
- Recovery of caprolactam by deploymerisation.
- Recovery of amino caproic acid.

The first three processes require relatively purer and undegraded form of waste. Amongst the last two, caprolactam recovery is mostly adopted by Indian industry due to ease of purification of recovered caprolactam.

0.1.10 Raw Materials, (Catalysts, Additives, Spin Finish Etc.):

For nylon-6, the only major raw material required is caprolactam. Water is required as an initiator for ring opening during polymerisation. Nitrogen gas is required for blanketing, drying and conveying of polymer.

0.1.11 Additives/Catalysts:

Aminoacids and diamine dicarboxylic acid salts which provide water on condensation have been found to be useful for enhancing the rate of polymerisation.

0.1.12 Stabilisers:

Nylon is susceptible to degradation by light, heat, oxygen etc. To make it suitable for the purpose of tyre cord, stabilisers are added. The light stabilisers used are manganous chloride + hypophosphorous acid and imidazoles. Diphenylamine and acetone condensates give excellent resistance to heat. Copper complexes as halides, acetate, phosphates, salts of higher fatty acids like stearates, palmitates, laurates, etc. are quite effective as heat and light stabilisers.

Spin Finish:

The functions of spin finishes are to reduce friction to get proper filament cohesion and to provide static protection. Lubricants used to reduce friction are usually mineral oils, fatty glycerides. The antistats used to provide static protection are surface active organic compounds.

In case of nylon tyre cord, where molten polymer is drawn in yarn stages and fabric is dipped at a very high temperatures (upto 210° C), preference has been towards the use of non-fuming type spin finishes.

0.1.14 Major Capital Equipments:

The major capital equipments for each section of the plant viz polymerisation, spinning, cord making and caprolactam recovery are listed in para 1.7.

0.1.15 Development of Technology:

The developments in technology can be grouped into the following:

- Product development.
- Development in the polymerisation process.
- Development in extraction and drying.
- Development in melt spinning process.

A. Product Development:

Till 1937, cotton used to be the only tyre cord material throughout the world. Thereafter rayon became popular. Subsequently with the advent of synthetic fibres, the use of nylon increased, which continues to be used in both the developed and developing countries, Other materials used are polyester introduced in 1962, fibre glass in 1967 and steel in 1970.

NTC was earlier spun as 210 d yarn and then plied to give 840 d tyre cord. With the development of technology, now, directly 840 d yarn can be spun and then plied to get denier ranges of 1260, 1680 and 1890 tyre cord. The denier per filament has however remained at 6 though some attempts have been made to use 8 deniers filaments also. It has been possible to increase tenacity from 8 gpd to 9.2 gpd.

B. Developments in Polymerisation Process:

In early process, a relatively crude batch autoclave reactor was used for polymerisation. The V K tube reactors for continuous polymerisation, were introduced during early 50s.

Initially, V K tube reactor had capacities of 1.5 TPD which has now been increased upto 40 TPD. Over a period of time, number of stages of polymerisation has also increased from one to seven.

Continuous developments have also taken place for modifying the design of reactors to achieve plug flow condition and uniform flow and temperature gradient, improve residence time, conversion rate and quality of products. The details of some such developments are discussed in para 1.8.

C. Developments in Extraction and Drying:

In this area also, batch type extraction and drying process have been replaced by continuous processes. Chips are now stored in S.S. tanks and conveyed pneumatically to spinning section.

D. Developments in Spinning Process

Melting of chips was done by oil heated grids in the pre-world war era, then by electrically heated grids. In the late fifties a short barrel screw extruder was introduced which is now replaced by long barrel extruder.

Another development is increase in the spinning capacity by increased number of spinning positions and also increased number of ends per spinning position.

Other improvements are in yarn solidification and quenching process, spin finish application methods etc.

During late seventies, the spin-drawn process was introduced to get higher productivity and better product. During the same period, high speed spinning with take up speed of 3,000 to 4,000 mtrs/min (as compared to upto 1500 mtrs/min in case of conventional process) was developed.

0.2 STRUCTURE OF INDUSTRY AND STATE OF THE ART:

0.2.1 Structure of Industry:

Licensed and Installed Capacity

The total licensed and installed capacity of NTC in India at present is around 29,500 TPA and 22,500 TPA respectively, as per the details given in para 2.1.10. LOI/IL have been issued which cover capacity of 54,200 TPA.

Production:

The production of NTC in India started in 1971 with 595 tonnes and increased to around 23,600 tonnes in 1985. NTC has replaced rayon tyre yarn as tyre cord

yarn and market share of NTC at present is 75%.

Capacity Utilisation:

The licensed and installed capacity is based on certain denier while production is of different deniers and the product-mix of all manufacturers varies depending on market requirements. However, the overall average capacity utilisation of NTC in India has been aorund 105% during the last five years.

Distribution of Units:

Active NTC manufacturers are public limited companies spread almost all over India with average capacity of 4000 TPA.

Performance of Industry:

The production, sales, net fixed assets, net worth of all the NTC manufacturers show an upward trend. There is a general growth rate of 20% per annum on sales turnover during last five years.

Import/Export:

Import of NTC increased from 1677 tonnes in 1980-81 to 5295 tonnes in 1983-84

The price of NTC at international level is just half of the price in India. This is mainly due to high cost of raw materials, higher conversion costs due to old technologies and small size of Indian plants as compared to the plants in developed countries. Due to this, export of tyre yarn from India is negligible.

Sources of Technology and their Broad Performance:

Unitika, Japan has supplied technology and plant to three out of five Indian manufacturers of NTC. The other two manufacturers started with imported plants. The details of these collaborations are given in para 2.15.2. Performance of all the collaborations is satisfactory.

Though, indigenous technology comprising of batch polymerisation and conventional spinning process have been developed, none of the NTC plants in India has yet started with such indigenous technology. The latest technologies comprising of multi-stage continuous polymerisation, continuous extraction and drying of chips, spin draw technology or high speed spinning process are not yet available indigenously.

The recent trend in India to look to the 'east' for technology may be due to the availability of technology comparable to those available from the west at a lower know how fees and lower plant costs.

2.2 Technological Status of Indian Industry (Unit wise):

The comparison of installed capacities, actual production and capacity utilisation and financial analysis in terms of net sales, net fixed assets, net profit and net worth over the period of last five years and present specific raw materials and utilities consumptions, wastage generation and recovery etc. for the following selected units is given in para 2.8.

- J.K. Synthetics Ltd.
- National Rayon Corpn. Ltd.
- Shri Ram Fibres Ltd.
- Nirlon Synthetics Fibres & Chemicals Ltd.
- Baroda Rayon Corporation Ltd.

Details of the historical background, sources of technology, research and development efforts, results achieved, etc. for each of the above units are summarised hereunder.

a) J.K. Synthetics Ltd:

J.K. Synthetics Limited, pioneer in the manufacture of NTC, have absorbed to a great extent the conventional technology over the last 2 decades. The company has its own research insitute—The Sir Padampat Research Centre (SPRC) and has recently floated a company—Jaykay Tech. which can supply the conventional technology. As far as horizontal transfer is concerned, conventional technology developed and absorbed by J.K. has little commercial relevance.

J.K.'s licenced and installed capacities are 6000 to 5000 TPA respectively. The company has recently entered into technical collaboration with M/s Tong Yang of south Korea for their latest Spin-Draw technology. The new unit with a capacity of 12.5 TPD is coming up.

b) The National Rayon Corporation Ltd. (National Rayon):

National Rayon commenced production of rayon tyre cord in 1961 and nylon tyre cord in 1976. The company has a technical collaboration for the latter with Unitika, who have supplied the technology and plant.

The company had installed indigenously developed equipment for conversion of polymer waste to granules of spinnable grade.

They have successfully indigenised manufacturing of all additives through in-house research as well as developing other suppliers.

National Rayon's licensed and installed capacities are 5,000 and 5,250 TPA respectively. The company's performance during 1983 and 1984 had been adverse due to closure of plant because of labour problems. The production during 1985 to 1988 is more than the licensed capacity.

As a part of modernisation and expansion programme they have installed spin-draw machines. The spin-draw yarn produced and made into fabric has already been approved by the customers.

National Rayon have a fullfledged R&D centre approved by the Government of India and is engaged in import substitution, technology absorption, machinery development and trouble shooting. National Rayon have developed process technology for polypropylene industrial yarn of high tenacity and has been regularly supplying polypropylene yarn for market development. It has also developed rayon industrial yarn, an industrial fabric for non tyre applications.

National Rayon have recently installed, for the first time in India, air jet looms for making tyre fabrics of high quality.

c) **Shri Ram Fibres Limited (SRF):**

SRF's plant for manufacture of nylon tyre cord and yarn was commissioned in 1974 in technical collaboration with Unitika. Company's present capacity is 6,335 TPA. SRF has a full-fledged Research and Development Laboratory and is constantly updating process methods and technology for product development.

SRF have an independent research institute too. A very recent process developed and patented is that for polymerisation of nylon-6,6.

d) **Nirlon Synthetic Fibres & Chemicals Ltd. (Nirlon)**

Nirlon commenced production of nylon filament yarn and tyre cord in 1962. The company had recently gone into technical collaboration with Zimmer for an expansion of their nylon tyre cord plant. Their present capacity is 5,000 TPA. Zimmer's design is based on multi polycondensation process and single stage spin draw process.

Nirlon has a well established research and development base. The company had absorbed the conventional technology for manufacture of nylon tyre cord and is concentrating in developing and acquiring more modern manufacturing process.

e) **The Baroda Rayon Corporation Ltd. (Baroda Rayon)**

Baroda Rayon commenced production of rayon in 1962. Subsequently, the company commenced production of nylon tyre cord in 1981 in technical

collaboration with Unitika. Their present installed capacity is 2,000 TPA. Expansion of their plant to 4,000 TPA is under implementation and is expected to be commissioned by end 1987.

f) The following new units likely to come up in the near future. The present status / each of these projects is given in detail in para 2.1.

Garware Nylons Limited:

Presently the company manufactures nylon and polyester filament yarn and is expanding its activities to manufacture nylon tyre cord, nylon tyre and industrial fabric in collaboration with Allied Corporation, U.S.A., the largest producer of tyre cord in the world.

Century Enka Limited:

The company's major activity is manufacture of nylon and other man made fibres and plastics. Century Enka has a collaboration with their principals Enka International of Holland for the technology for manufacture of nylon 6 tyre cord. The production has commenced recently.

Ballarpur Industries Ltd. and E.I.Du Pont Nemours & Co. of U.S.A.:

They have jointly proposed to promote a Rs.130 crores joint venture company to produce nylon-6,6 tyre cord for the first time in the country in collaboration with economic development corporation of Goa. An annual production of 16,700 tonnes of nylon-6,6 tyre yarn is envisaged.

Kanoria Alkalies & Plastics Ltd:

They have entered into collaboration for technical know-how, plant and machinery for manufacture of nylon tyre cord with Unitika which has been approved by Government of India.

0.2.3 Status of Raw Material Industry:

At present only Gujarat State Fertiliser Corpn. Ltd., Baroda manufacture caprolactam with the capacity of 20,000 TPA in India. Three LOI have been issued by the government with a total capacity of 2,20,000 TPA.

The demand projections for caprolactam made by the Committee for Perspective Planning of Petrochemical Industry by 2000 AD are 1,16,000, 1,96,000 and 3,02,000 TPA for year 1989-90, 1994-95 and 1999-2000 respectively.

Hence, till the units who have LOI go into production, imports of caprolactam is unavoidable.

The quality of indigenous caprolactam in terms of its permanganate no. and also in terms of consistancy between various batches of manufacture is not comparable to that of imported caprolactam.

0.2.4 Status of Tyre Industry International:

There are three types of tyre construction viz., bias, bias-belted and radial. Radial and bias belted construction are more efficient than simple bias construction. In the world tyre market, radial tyres dominate. They were first inroduced in passenger cars then in commercial vehicles, buses and truck respectively. In U.S.A. market, no rapid change over from bias to radial tyres took place because of the tremendous capital investment required. Instead, belted bias tyres which could be manufactured on existing equipments were developed.

The current trends in tyre design and manufacturing include:

- Use of fewer fabric plies in tyres by utilising larger and stronger cords.
- Use of special treatments in yarn manufacturing of the cord processing to reduce the creep of cords in tyre.
- Use of newer fibres such as polyester and modified nylons etc.

0.2.5 Status of Tyre Industry - Indian:

The installed capacity of Indian tyre industry is 12 million nos. per annum. the estimated demands of tyres by 1989-90 and 1994-95 are around 21 and 31 million nos. respectively, as per estimates of Automobile Tyre Manufacturers' Assocation (ATMA). Preference so far has been towards bias angle, because of the practice of overloading; practically no care of tyres by owners / drivers and poor road conditions. However, some radial passenger car tyres have also been introduced in the market.

Due to the higher melting point of nylon-6,6 and polyester as compared to that of nylon-6, the tyre curing temperature can be increased to 250° C from 210° C (for nylon-6). This would make curing of tyres faster and hence reduce curing cycle. This would result in higher output and also higher productivity. In practice, howevr, fast curing is not realisable in case of heavy duty tyres as the thick layer of tread rubber will get distorted by fast curing.

To take advantage of this higher productivity, the tyre manufacturers will have to install higher capacity curing furnaces, which will require substantial investment.

Hence, before tyre manufacturers decide to install such furnaces, they would like to confirm regular availability of nylon-6,6 tyre cords at reasonable prices preferably from more than one supplier.

The switch over from nylon-6 to nylon-6,6 would also result in more down time in tyre manufacturing. Similarly switch over from nylon to polyester requires change in dip condition, double dip processing and more downtime. Hence, whatever nylon they use, they will use it for 100% of their requirements.

0.2.6 Tyre Cord and its Suitability for Various Types of Tyres:

Different types of tyres require tyre cords with different properties, indicated in para 2.12.

Radial tyre or belted tyre designs take adavantage of these different requirements by placing different types of cords in the belt and in the carcass. As per the test carried out by one of the Indian radial tyre manufacturers, nylon-rayon was found to be the best combination for Indian conditions.

0.2.7 Status of Tyre Cord Industry - International:

Major varieties of cords suitable for tyres are cotton, rayon, nylon, polyester, steel, glass fibres and aromatic polyamides. Although flat spotting shown by nylon was originally objected to strongly, nylon has continued to be the preferred tyre cord material because of its price and its superior thermal and fatigue resistance. Nylon-6 is used in Europe and other developing countries while nylon-6,6 is more prominent in U.S.A. mainly due to the manufacturing facilities established and availability of basic raw material.

During the last ten to twelve years development have been largely of evolutionary nature aiming to overcome limitations of existing tyre fibres and to make them acceptable for wider use.

0.2.8 Status of Tyre Cord Industry in India:

Tenacity of NTC available to Indian tyre manufacturers locally varies from 8.4 to 9.4 with average value of 9.2 gpd.

The present demand of NTC in India is around 25,000 TPA which is likely to grow to 40,000, 50,000 and 61,000 TPA by 1990, 1995 and 2000 AD respectively. At least for next 10-15 years, even in case of radial tyres, nylon would continue to remain as one of the components either in carcass or as belt material. With the existing manufacturing facilities, the type of vehicles in use and existing road conditions, nylon-6 will remain the material of choice except for a small quantity of radial tyres for passenger vehicles where polyester may prove to be superior.

At present very little nylon-6,6 is used in India, both for textiles and industrial applications. Besides nylon-6,6 is not produced indigenously. Nylon-6,6 is costlier than nylon-6 worldwide and is likely to be more so in India.

Nylon-6,6 is unlikely to be used by tyre companies for their bus and truck tyres

(weightage 80%) in near future, mainly due to generation of high shoulder temperature.

In view of the above, establishment of fresh production capacities for nylon-6,6 industrial yarn in India may not have much scope considring interest of industry as well as the end-users.

0.2.9 State of the Art Scene (International)

Twenty five leading manufacturers of NTC in the world are listed in para 2.15.1.

Salient Features of Contemporary Technologies:

The technology for manufacture of NTC is standardised as far as polymerisation process is concerned. Product characteristics of different technologies may vary marginally depending upon the type of additives and stabilisers used, design of equipment and control method of production parameters. However, design of spinning plants differs from supplier to supplier.

Salient features of contemporary technologies of the following technology suppliers who have supplied/offered technologies to India are discussed in detail in para 2.15.2.

- Zimmer A.G., West Germany.
- Lurgi GMBH, West Germany.
- Unitika Ltd., Japan.
- E.I. Du Pont De Nemours & Co., U.S.A.
- Snia BPD, Italy.

Some important features of these technology suppliers are described in subsequent paragraphs:

Zimmer A.G.:

- Zimmer offers production of nylon-6 in continuous polymerisation operation. The specific Zimmer design allows lower water/chip ratio resulting in a high extract content in washing water, thus saving energy to caprolactam recovery plant. The company offers economic standard design for production capacities of 10 to 50 TPD for high viscosity polymer (tyre cord grade).
- For caprolactam recovery, Zimmer prefers batch operation for higher flexibility regarding quality and capacity. The plant is specifically designed for low caprolactam concentration in waste water, so that it can be either reused in polymerisation plant, or discharged as innocuous waste.

- For spinning and drawing, Zimmer offers both, the two step separate process and the one step spin draw process. The former process favours production of:

  i) lower deniers economically

  ii) low shrinkage yarns

  iii) large variety of yarn types.

- The one step spin draw process favours continuous production of heavier denier yarns in large capacities. It results in improved yarn uniformity.

Lurgi GmbH:

- Lurgi offers both continuous polycondensation and batch polycondensation route for nylon-6 for use in tyre cord and other technical/ industrial yarn. Lurgi also offers caprolactam recovery unit deploymerisation and condensation plant and equipment for evaporation of the extracted water, treatment of concentrated caprolactam water and distillation.

- The company offers technology for conventional speed spinning as well as high speed spin draw process.

Untika Ltd., Japan:

- Unitika offers continuous polymerisation process having a pre-polymeriser coupled with continuous extraction, washing and drying of chips. It also offers caprolactam recovery process. In its polymerisation process, Unitika claims 50% saving in polymerisation time. Viscosity of melt can be adjusted as per requirement during pre-polymerisation.

- The spinning process offered is both conventional spinning and drawing as well as spin draw process.

E.I. Du Pont de Nemours & Co., U.S.A.:

- Du Pont's industrial yarn process is based on nylon-6,6 salt i.e. hexamethylene diammonium adipate.

- The company has practised the continuous polymerisation technology and has developed conditions which maximise conversion, maintain precise viscosity control and ensure extended service life. Nylon-6,6 is produced continuously in a series of five vessels - evaporator, reactor, flasher, separator and finisher. Streamlined design of polymer vessels and distribution system minimises gel formation, recapture of heat and diamine and hence reduces cost of operating system.

- Preferred Du Pont technology is based on coupling the spinning machine directly to the continuous polymeriser. It also utilises coupled spindraw. The advantages are elimination of chip making, handling, drying and re-melting as also provision of maximum polymer uniformity.
- Du Pont offers extensively developd quality control and laboratory testing procedures and a single, specially formulated fibre finish for all products.

SNIA BPD:

- SNIA is an Italian company giving process knowhow, plants and equipments for manufacture of nylon filament yarn and tyre cord. The company has the spin draw technology.

0.2.10 Latest Developments in Manufacturig Process/Design of Equipment:

Product Development:

Recent developments have been in the areas of improved dimensional stability of the cord, higher tenacity of tyre cords and improved heat stabiliser formulations to reduce the mechanical loss due to heat generation in tyres.

Improvements in Polymerisation Process:

Recent developments in this area include attainment of higher molecular weight by vacuum finishing, solid phase poymerisation to get final polymer free of extractables etc., addition of chain - coupling agents.

Other significant advances includes:

For removal of unconverted monomer	Falling film / spray reactors, reactors working under vacuum.
For lower level of water extractables in nylon polymer	Organic polymer coating, internally, of V K tube reactors.
For improved flow and temperature distribution	Incorporation of a tubular heat exchanger in the reactor.
For transferring heat to the centre of the reactor and also to equalise flow rates	Provision of perforated plates and vertical aluminium partitions.

Improvements in Spinning Process:

The developments are directed to achieve higher spinning output upto 97% and to spin NTC of high molecular weight and melt viscosity to have high tenacity tyre cord upto 10 gpd.

0.2.11 Critical Evaluation of Contemporary Technology:

During initial stage the technology of the synthetic fibre remained with only a

few giants in the category of front line producers. Because of their conservative attitudes, no rapid technology changes were forth coming. However, the role played by the independent engineering companies which took the risks has been a great boon in the development of technology.

Technology suppliers can be broadly classified as front line suppliers having production back up like Unitika, Du Pont etc. and engineering companies like Zimmer, Lurgi, etc.

Technology from front line producers is superior technology, requiring less time and wastage generation during production stabilisation at plant commissioning stage. However, know-how fees of these suppliers is higher compared to that of engineering companies.

Engineering companies have vast experience in plant erection, basic and detailed engineering. Know-how fees of these companies are comparatively lower.

The present trend is to look to the East for technology compatible with that of western countries as it is more economical, although of late, they too are becoming expensive.

A project profile based on the typical offer of contemporary technology for a 6,000 TPA NTC project is placed at Annexure I. Instead of putting up many small size plants, it would be advisable to put up a few large size plants for economy of scale.

The improvement in quality of polymer is a developmental activity which is continuous at international level. Indian companies should also endeavour to improve quality by adopting new engineering and equipment development either through their own R&D department or through their technical collaborations. New and better type of additives and catalysts development at international level should be incorporated by the Indian companies.

Spinning plants having higher spinning efficiency and compactness, are always advisable for a country like India,to reduce the cost of production. One step process of very high spinning speed to make full drawn yarn may not be relevant in India, as at present most of the weaving and cord preparatory processes are of conventional type. So the ideal thing would be to change over to readily available higher throughput equipment.

0.3 TECHNOLOGY ABSORPTION AND GAPS:

0.3.1. R&D Efforts in National Laboratories/Institutions and Their Tie Up With Industry:

Institutions like IIT, SASMIRA, MANTRA etc., private research institutions like

Sir Padampat research Centre, Shri Ram Institute of Industrial Reserach etc. and in-house R&D centres of manufacturing industry are engaged in minor research projects for optimisation of production parameters or improvement of product characteristics.

Developing countries like India although gradually laying more emphasis on its research and development, have not been able to catch up with their developed or advanced counterparts i.e. there is a considerable time lag between adoption of any particular process in some advanced part of the world and its commissioning in India. The efforts made to bridge this gap in the following areas are as follows:

- Indigensation of capital equipments, spares etc.
- Indigenisation of raw materials.
- Modifications and improvements in process, plant and equipments.

The major constraint faced by manufacturers of indigenous equipments and spares are:

- non-availability of design and detailed engineering drawings.
- patented designs of proprietory equipments by technology suppliers.
- sources of capital equipments recommended by technology suppliers.
- limited indigenous demand of such equipments.

0.3.2 Indian Standards Specification:

As a part of standardisation, the Bureau of Indian Standards has developed IS Specifications for methods of tests for tyre yarns as per the following details.

IS:4910	Tyre yarns, cords and tyre cord fabrics made from man made fibres, methods of tests for.
Part I	Linear density.
Part II	Breaking load, elongation at break and tenacity.
Part III	Dip pick up
Part IV	Heat shrinkage and heat shrinkage force.
Part V	Wet contraction and wet contractive force.
Part VI	Definition of terms.

Part VII Heat degradation.

Part VIII Thickness (gauge)

Part IX Sampling

Part X Growth

Part XI Commercial weight.

The specifications of polyamide tyre cord warp sheet for automotive tyres published by the bureau is, IS 11926:1987. The specifications are given in Table 4.

0.3.3 Profitability of Indian Industry and its Relationships with Technology:

At present the profit margins of NTC manufacturers are fairly satisfactory, even with the present conventional technologies and small capacity plants.

Interaction with user industry by NTC manufacturers is also quite good. However, the constraints in respect of technology absorption faced by Indian NTC industry are:

- low capacities of plant.
- imported capital equipments, parts and spares.
- non-availability of trained technological manpower.
- poor labour-management relations.

0.3.4 Export Performance

Due to high cost of raw materials and also higher conversion costs due to small capacity plants based on older technologies, the Indian NTC industry has not been able to contribute in the export market.

0.3.5 Comparison of Product Specification Between Units:

In India, the product range and specifications of all the manuacturing units is almost identical.

0.3.6 Modernisation Need:

As mentioned earlier, cost of production of Indian NTC industry is higher due to small capacity plants based on older technologies. There is an urgent need to modernise these plants to adopt most advanced technologies and a much higher level of operations.

However, for such modernisation substantial funds willl be required. Financial Institutions are giving soft loans under technology development funds and industries have started taking advantage of this scheme.

0.3.7 Technology Gap:

Technology gaps in following areas have been identified and discussed in para 3.9

- Product developments
- Plant capacity
- Polymerisation process
- Melt spining process
- Indigenous manufacture of plant and equipments
- Indigenous availability of raw materials, additives and spin finishes etc.

Internationally, cords with yarns having 8 deniers per filament and upto 3,000 deniers of cords and 11 gpd tenacity are available, while in India cords with yarns having only 6 deniers per filament and 9.2 gpd tenacity are manufactured.

The average plant capacity of NTC in India, till 1983, was 2,000 TPA against the defined economic size of plant of 6,000 TPA.

Polymerisation:

Since the modern continuous polymerisation, extraction, washing and drying systems are suited to large capacity, till recently only conventional batch processes were used. Further, continuous polymerisation lines eliminating chip formation (especially in nylon-6,6) and remelting are not in use at preesent, in India.

Melt spinning:

More efficient large capacity spinning equipments are being used in the world. These have sophisticated yarn sensing and monitoring systems and hence the quality of yarn is much better with higher throughput. Such latest spinning processes are not available in the country and such technology is now being imported.

Reasons for technological gaps are:

- seller's market situation
- large number of small capacity plants.
- total absence of export market.
- good financial performance of Indian Industry even with the available technologies.
- general / absence of R&D efforts and know-why exercises.
- limited developments in the Indian automobile industry.
- lack of product upgradation at tyre manufacturer's end.

To bridge the technological gaps, import of latest spinning equipments and process know-how for spin draw and high speed spinning process, designs and drawings for modernisation of existing polymerisation processes are required.

0.4.0 SUGGESTED: STEPS TO BRIDGE TECHNOGICAL GAP

The following suggestions are made to bridge the technological gap:

a) Latest technology comprising of continuous polymerisation in two stage V K Tube reactors, continuous extraction and drying of chips, spin draw technology or high speed spinning processes for fully oriented yarn may be imported and horizontally transferred in India. Although some pilot units have been installed by spinners, the industry seems to be waiting for customers' acceptance.

b) Develop indigenous manufacture of selected equipments, wherever it is economically viable and import only latest plant and equipments on selective basis.

c) Develop basic and detailed engineering expertise in Indian engineering companies to necessitate import of only design and drawings for new plants rather than package import. An engineering organisation having expertise in basic and detailed engineering should be encouraged for development and transfer of technology for NTC and related products.

d) Widen R&D efforts both at industry and research institutions level with active association and close cooperation between them.

e) Provide necessary incentives to indigenous development of manufacture of plant and equipment.

f) Permit only large sized plants.

g) Provide incentives for intensified research activities at industry level with close monitoring of such incentives.

- Establish a central tyre research institute with facilities to test developments in new designs of tyres, new tyre cord materials and modifications in tyre cord materials.

- Develop skills in technical personal, by arranging training abroad or by arranging training programmes by institutions like IIT, SASMIRA, etc. and constant interaction with foreign experts.