EXECUTIVE SUMMARY

0.1 POLYPROPYLENE FIBRE/FILAMENT YARN

Polypropylene fibre is a long chain of synthetic polymer composed of stereoregular isotactic polymer. Polypropylene fibre/filament possess all the outstanding properties associated with the Polypropylene Polymer. Being lightest amongst fibres, polypropylene yields higher length of fabric, than any other commercial fibre. It has high tensile strength, wrinkle resistance and abrasion resistance. This fibre is made to suit mostly all the segments of textile, industrial, upholstery and carpet requirements in a desired range of denier. Due to its unique feature of lowest moisture absorption amongst textile fibres it offers desired comfort for undergarment use and is widely used for hosiery and knitwears.

Polypropylene filament and fibre are manufactured from polypropylene chips by melt spinning process. In this process molten polymer from a manifold is metered through various spinnerettes, having number of holes to form fibre or filaments. These fibres are then solidified by air quenching and after application of spin finish are collected in cans or wound on take up winders. The fibre so manufactured is stretched, relaxed and crimped to be made suitable for various spinning systems. The filaments could be formed as stretched yarn, partially oriented yarn or fully drawn yarn.

Fibre grade polypropylene resin of particular melt flow index is used for its manufacture. Depending upon the end product and the process of manufacture of fibre and filaments, different melt flow index (MFI) is required. Polypropylene is manufactured by polymerisation of propylene in the presence of Ziegler Catalyst like Titanium Tetrachloride ($TiCl_4$) in the petrochemical industry. The melt flow index, molecular weight distribution and isotactic index of polypropylene resin suitable for fibre poductions are :

a) Melt flow index (gm/10 min):

10-12 for high tenacity yarn
18-20 for normal tenacity, flat yarn
35-40 for POY yarn

b) Polydispersity

$$\frac{M_w}{M_n} = 3 \text{ to } 4$$

Molecular weight range from 35,000 to 50,000

c) Density of 0.91

Nowadays polypropylene resins with very high melt flow indices, low molecular weight distribution and controlled melt rheology are available.

The spinning process used earlier was having a very simple set up for control of parameters. Even the quality of polypropylene used was of non-fibre grade and was resulting into production of non-uniform fibres. Due to hydrophobic nature and absence of dye receptor sites, polypropylene could not be dyed and grey fibre was being produced. However, with the development in mass-coloration techniques the fibre could be dyed, and today the fibres are manufactured in various colours, shades and hues. The spinning process has also undergone a change from two stage to one stage and from low speed spinning of few hundred mtrs/min to high speed spinning of more than 3500 mtr/min.

Alongwith the process developments, products developments have resulted into manufacture of partially oriented and fully drawn yarns which eliminate the need for some of the subsequent processes. New and better products such as fine denier per filament yarns, high tenacity yarns, the hosiery yarns are now produced having better product properties for different end uses.

0.2 INDIAN STATE OF ART

Total licensed and installed capacity as on September '89 was 6000 and 4300 M.T. per annum for staple fibre, and 8000 and 4580 M.T. per annum for filament yarn respectively. A growth in the capacity of filament yarn is expected. The additional licensed capacity for PPFY has been diverted by the manufacturers for producing other synthetic filament yarns like polyester and nylon under broad banding policy of the Government.

In India, there is only one manufacturer of staple fibre M/s Neomer Ltd., Baroda and two manufacturers of filament yarn namely Gujarat Filament Ltd., Baroda and Rajasthan Petro Synthetics Ltd., Udaipur beside a few units in medium and small scale sector which were set up in 1989, totalling to a capacity of about 2500 TPA. The filament production in the country was however pioneered by National Rayon Corp. Ltd., Bombay at their pilot plant.

Production of staple fibre started in the year 1977 and has slowly increased since then. The fibre production has increased from 191 M.T. in 1977 to 1300 M.T. in 1988 and 1760 M.T. in 1989. Demand projections show that demand of staple fibre will be 2300 M.T. by 1990 and 9200 M.T. by 1995. The imports are in small quantities and there is no export.

Production of filament yarn, on a commercial basis has started only in 1985 by M/s Gujarat Filaments Limited. The production was enhanced by M/s Rajasthan Petro Synthetics Ltd. which commenced production in 1986. The production has increased substantially from 131 M.T. in 1985 to 1870 MT in 1988 and 2950 MT in 1989. Demand projections for PPFY show its demand to be about 9100 M.T. by 1990 and 18200 M.T. by 1995. Filament import too is very small and there is no export.

Source of technology with M/s Neomer Ltd., the sole manufacturer of staple fibre in the country, is from M/s James Mackie & Sons of UK, who are the manufacturer of staple fibre and equipment for melt spinning since early sixtees. The technology is for a one step short gap slow speed spinning with speed ranging from 40 to 130 m/min and on line stretching process. The technology provides for negative extrusion line.

For filament yarn, M/s Gujarat Filaments Ltd., Baroda have acquired the technology from M/s Fare of Italy and M/s Rajasthan Petro Synthetic Ltd. have acquired Cora Technology of Switzerland. The technology from M/s Fare employs a slow speed spinning of 350 mtr/min and on line warp stretching process while that from Cora Engg is based on high speed spinning at more than 2500 m/min. for POY and on line stretching for making fully drawn yarn.

Plant sizes in India are comparable with average plant size in the world. The flexibility of producing different lots is more important in polypropylene fibre Industry than mass production.

The ancillary industries are existing in this sector to perform post spinning operations like twisting and texturising on job work basis.

0.3 INTERNATIONAL STATE OF ART

World production of staple fibre has increased from 181,000 M.T. in 1975 to 6,89,000 M.T. in the year 1988. The largest producer for staple fibre in the world is USA followed by Belgium. Similarly the filament yarn production in the world has increased from 65,500 M.T. in 1975 to 2,38,823 M.T. in 1986. The biggest producer for filament yarn is also USA followed by Belgium.

Production of PPSF shows a shifting trend from Italy to Belgium in Western Europe. Western Europe, USA and Japan have respective percentage share of 45%, 32.4% and 8% in the total world production. Similarly production of filament yarn is also showing a shifting trend from Italy to Belgium in Western Europe. Western Europe, USA and Japan have respective percentage share of 36%, 42% and 7% in the total world production of PPFY.

Polypropylene share in the total synthetic fibre is increasing at a rapid pace. It has increased from 3% in 1976 to 12% in 1986.

0.4 CONTEMPORARY TECHNOLOGIES AND THEIR EVALUATION

Manufacturing process, employed by various contemporary technology suppliers is the same and the difference in the technology of these suppliers is in design of plant and equipment, which ultimately results into versatility in product range, product quality and higher productivity. Suppliers of fibre technology equipment world wide are Neumag, Germany, Meccaniche Moderne, Italy, Filteco, Italy, Scam Engineering, Lurgi, Cora Engg, James Mackie & Sons, etc. They offer the technology of high speed spinning, one step and two step process for producing staple fibre, POY, FDY and BCF filament yarn.

0.5. LATEST DEVELOPMENTS AT INTERNATIONAL LEVEL

Major change in technology at international level is in the polypropylene resin manufacturing technology. The resin being produced has the characteristics of various ranges of melt flow Index (MFI), better homogeneity and lesser variation in melt behaviour suited for various spinning processes.

High speed and compact machine for spin draw process to produce FDY have adopted for textile denier and industrial yarns respectively.

In the product development, shrinkable type staple fibre and more suitable structure of bulk continuous filament (BCF) have been developed.

0.6. STATUS OF INDIAN INDUSTRY

M/s Neomer, a division of Alembic Chemical Works & Co., Baroda started manufacturing polypropylene staple fibre in 1977 in technical collaboration with M/s James Mackie & Sons. It had a licensed capacity of 6000 MT and installed capacity of 4300 MT. The capacity has remained same since then. It is operating on conventional short gap slow speed process. The performance of M/s Neomer had been tardy in the beginning as the product was produced for the first time in the country and it had slow acceptability. The production has gradually increased and at present it is performing well.To date M/s Neomer are the only manufacturer of polypropylene staple fibre and they have recently installed a filament yarn manufacturing plant of 1000 Ton/annum capacity.

Gujarat Filaments started manufacturing Polypropylene filament yarn in 1985 with technical assistance from M/s Fare of Italy. It has a licensed and installed capacity of 1,000 Tons/annum. It has been able to realise 70% of its installed capacity. It had recorded a fast growth in attaining 70% capacity utilisation. It is operating on slow speed spinning one step process for producing heavy denier filament yarn. The financial performance of the company is impressive

Rajasthan Petrosynthetics Ltd started manufacturing filament yarn in 1986 by entering in technical collaboration with Cora Engineering of Switzerland. The plant has a licensed and installed capacity of

1,000 M.T. per annum for polypropylene filament yarn. The plant is equipped with modern equipment of high speed spinning for POY and with one step process for FDY. The products cater to wide range of applications. The company has realised over 100% capacity utilisation due to a good demand scenario in the market. The financial performance of the company is quite impressive.

M/s RPS Ltd. is going in for expansion of its production capacity from present 1000 M.T. per annum to 3200 M.T. per annum under the letter of intent held by the company for 15,000 M.T. per annum polyester filament yarn capacity. M/s GFL is also going for expansion of its production capacity from present 1,000 M.T. per annum to 4,000 M.T. per annum.

The manufacture of polypropylene filament yarn in the country was however, pioneered by National Rayon Corporation who started the filament yarn production on a pilot plant of 200 M.T. per annum capacity. The plant consisted of Windsor extruder and stretching line and the knowhow for the production was in house derived from the experience and expertise of working on other synthetic Fibre/Filament. Progressing from experimentation, it was able to produce filament, the fabric of which was successfully tried in Geo-textile and liner fabric applications. The company however discontinued the filament production after workers strike and instead switched over to nylon production. The company has however acquired a licensed capacity of 1,000 M.T. per annum for producing Polypropylene filament yarn. In the year 1988, company had acquired spin-draw barmag winder and the company had successfully developed and commercialised this on Nylon-6 and Polypropylene filaments.

In addition to above there are four small capacity manufacturers of filament yarn namely M/s Jwaharlal Phoolchand & Co., M/s Sanghi Synthetics Garware wall ropes, and Two Brothers. These plants are based on slow speed spinning and stretching in 2nd step process and are suitable for production of coarse denier filament yarn.

0.7. TECHNOLOGY ABSORPTION AND GAPS

The process and technology adopted in the country by various production units have been further developed to produce outstanding quality of PP fibre and filament yarns. M/s Neomar have been able to produce fibre denier and cross section earlier considered difficult with

short gap slow speed process. Similarly M/s Rajasthan Petro Synthetics Ltd are currently manufacturing textured yarn in denier range of 65/24 to 90/24 having quality equal to the best yarn available on international market. There have been good progress in filament/ fibre processing and product application area. PPSF & PPFY find application in all known areas and rather have been attempted in some new segments.

IIT has undertaken specific development projects for industries on improvements of texturisability of polypropylene filament. The research has also been done on the development of easy dyeable polypropylene fibres by regulating the structure through product including the polypropylene blending with other amorphous and semicrystalline polymers. Attempts are being made on the development of flame retardant polypropylene, high shrinkage PP fibres and solvent assisted dyeing of PP fibres.

The activities for in house research and development within the industry has been on low profile due to the nascent upcoming of the industries. The industries have undertaken know why exercises after opting for package import of available technology and produce locally acceptable fibre/filament and achieved success in commercialising the same.

For polypropylene staple fibre Neomer is the only manufacturer in the country producing staple fibre with denier from 3 to 60. Each spinning line can produce about 500 tons per annum and the company has 5 lines. The company is also equipped with 5 compounding lines for mass dyeing of polymer by the addition of master batch to produce coloured chips as feed stock for fibre spinning lines.

In the filament yarn production two major units viz. Gujarat Filament and Rajasthan Petrosynthetics have equal production capacities. Gujarat filament produces filaments of denier 840/120, 1260/ 240 & textured yarn of 1800 and 2600 denier and Rajasthan Petro Synthetic produces 65D and 90D single/double crimped yarn and 150, 300 and 840D twisted/flat yarn and 400, 900, 1600, 2800 D air textured yarns. The products of Rajasthan Petro Synthetics are used in Hosiery, Industrial and upholstery sector while that of Gujarat Filaments goes in industrial and carpet sector.

Gujarat filament have one step, slow speed spinning line and have twisting and draw texturising facility. They manufacture limited range of products suited to specific applications. The technology of production is simple.

Rajasthan Petrosynthetics have high speed POY and in line Spin draw spinning process. They are producing a wide product range, including manufacturing polypropylene partially oriented yarn (POY) at spinning speed exceeding 2500 m/min. which is draw textured by the company and sold as textured yarn. The company has air texturising machines also. The spinning equipment is set up in conventional 3 storey building.

For PP fibre, high speed on line with speed of upto 500 m/min and, high speed spinning followed by fibre draw line with speeds of upto 1500 m/min is not yet practised in the country. On the other hand for PPFY slow speed with speed of 350 m/min, high speed spinning for POY with speeds of about 2500 m/min is being practised in the country.

Technology gap in PPSF is generated because of only one unit working on polypropylene fibre in India though for filament processing various technologies have been adopted depending upon product range/plant size/project cost. In the filament manufacture technology gap exists in the bulk continuous filament manufacture as this technology has not so far come in India.

0.8 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Polypropylene is today regarded equivalent to other synthetic fibres in manufacture of filter and other industrial fabric, tufted and woven carpets, upholstery, carpet backing, hosiery and knitwears, ropes, fishnets, cardages and twines and other textile application. It even offers superior feature due to its lowest specific gravity resulting into better relative coverage, high dimensional stability, excellent recovery properties namely elasticity and resiliency, low thermal conductivity, lowest static charge and its inertness to chemicals. Its unique feature of lowest moisture absorption amongst textile fibres provides desired comfort for undergarment use.

- The raw material in the manufacturing of polypropylene staple fibre and filament is polypropylene resin. The essential steps in the spinning process for fibre and filament production cover melting of polymer chips, mixing of additives for mass dyeing, uniform distribution of melt to spinneret, followed by quenching and finishing.

- The fibres hereonwards are taken up for further processing like drawing, crimping, heat setting. In case of filaments further process would be to produce drawn yarns (DY), Fully Drawn Yarns (FDY), Partially Oriented Yarn (POY), Fully Oriented Yarns (FOY) and Bulk Continuous Filament Yarns (BCF). The drawing, spin drawing, high speed spin winding and draw -texturising processes are employed to produce these yarns in single step or in two steps. The noted recent development in manufacturing process are:-

- High speed in line process for polypropylene fibre,

- High speed partially oriented yarn process for Polypropylene filament

- One stage process for manufacture of BCF filament yarn

- Compact spinning process

- For the production of final finished product, drawing, draw twisting and texturising are employed as secondary operations depending upon their applications.

- The various processes employed for the manufacture have their relative merits. However, high speed in line process though capital intensive could be considered as a state of art in the fibre manufacture. In case of filaments high speed POY spinning and spin draw texturising (BCF) though capital intensive could be considered state of art.BCF has gained wide popularity for production of carpet yarn due to its cost effectiveness.

- Since polypropylene has poor dye-affinity various mass colouring technologies like mixing of pigments with polypropylene powder, mass-compounding, mixing of masterbatch, injection

system and volumetric/gravimetric proportionate mixing have been developed. Volumetric/Gravimetric proportionate mixing by adopting special equipments, which provide better shade uniformity and brightness is considered best for textile denier and BCF yarn manufacture, though it is capital intensive.

Present annual consumption of polypropylene resin in the country is in the region of 81,000 M.T. , about 50% of which is met from imports. IPCL is the only manufacturer and their present installed capacity is in the region of 55,000 M.T. per annum, out of which 25,000 M.T. per annum capacity plant has only been commissioned in 1988. In addition, LI's have been issued for a plant capacity of 60,000 M.T. per annum in favour of IPCL's MGCG plant and 50,000 M.T. per annum in favour of PICUP. Recently NOCIL has acquired Letter of Intent for 1,00,000 M.T. per annum PP plant. This shows that at present India is self sufficient as regards the installed capacity of Polypropylene; however, filament grade Polymer suitable for high speed spinning would continue to be imported till an alternate is developed or it is produced at MGCG plant of IPCL.

- The licensed and installed capacities, present production, projected production and status of LI's issued in case of PP filament and fibre are:-

In M.T.

		PPS Fibre	PP Filament
i)	Licensed capacity	6,000	8,000
ii)	Installed capacity		
	- Organised Sector	4,300	2,500
	- Small Scale Sector	-	2,080
iii)	Present Prod-1989	1,760	2,950
iv)	Projected Prod-1995	9,200	18,200
v)	LI's issued	16,000	1,60,000

From the above data it could be concluded that capacity utilisation has been particularly low in case of PP fibre, which has been attributed to low market demand. In case of PP filament, the demand has lately picked up and with the introduction of textile denier it has a bright future ahead.

In case of sole manufacturer of PPSF, M/s Neomer had the foreign collaboration with M/s James Mackie of U.K. and has an installation of short gap slow speed spinning plant. In case of PPFY, M/s Rajasthan Petro Synthetic Ltd. had technical knowhow from M/s Cora Engineering of Switzerland and has spin draw process technology in addition to high speed spinning for POY. The other major manufacturer viz. Gujarat Filaments Ltd have acquired technology, as well as, plant and machinery from M/s Fare of Italy for a slow speed warp stretching process for production of industrial denier. The other small scale unit of PPFY have acquired technology, as well as, plants mostly from Korean manufacturers and are equipped with conventional two stage process of spinning and stretching. As such technology of high speed spinning for fibre and spin draw -texturizing for production of BCF have not yet been introduced in the country.

- The technology of short gap slow speed fibre manufacture has been partly absorbed in the country by the existing user whereas the technology for filament production appears to be marginally absorbed as the users are comparatively new.

- The world polypropylene yarn and fibre production in 1988 stands at 8 lakh tons which is roughly 12% of the total synthetic fibres and filaments production. The average yearly production capacities of the PPFY and PPSF units are 1700 tons and 4500 tons respectively. Contemporary technologies of various suppliers are having similar manufacturing process. The differences are mostly in design of plant and equipment resulting into product range, efficiency in terms of consumption of utilities and incidence of wastages and overall quality of the product, which could be manufactured. There are over 20 suppliers of technology and another over 20 suppliers of plant and machinery mostly from USA, Europe and Japan.

- The development, at international level, is mostly concentrated at polymers the use of high yield catalyst in its manu-

facturer high speed compact spinning and in product development for more suitable structure of fibre and filaments.

- The technology absorption efforts has been achieved to an extent by M/s Neomer in production of PPSF except for the part of technology related with hardware design of the plant and equipment. It has added two more lines. It has also developed new shades for fibres, suitable products for working on cotton and woollen system and Geotextiles. In case of PPFY, National Rayon Corporation have developed technology on their pilot plant indigenously from the experience derived from production of nylon industrial yarn/tyre cord production and can be considered as pioneer in filament production.

- The technology absorption efforts by other two PPFY manufacture viz. M/s Rajasthan Petrosynthetics and Gujarat Filament have been limited, being new in the field and the development works taken up are directed towards optimisation of production parameters and products modification.

Research and Development activities at the National level research institutions like IIT need to be organised to match with the latest technology on international level. Research and Development activities do not exist with the local manufacturers except IPCL. These institutes are rather engaged in general and specific research works on improving the operating conditions of Polypropylene resins improving the dyeability and texturisability, trouble shooting for the problems referred by industry, etc. and not on the development of basic technology. SASMIRA which has an installation of pilot plant for high speed in-line process has not carried out research work on development of polypropylene fibres.

Indigenous manufacturers of plant and equipment have not been able to develop equipment for the PP filament and staple fibre industry due to lack of demand and the intricacies of design involved. Except for the availability of capital equipment and experienced man power because of industry being new, no other constraints in the availability of raw materials, demand of products, etc., have been found in technology absorption though initially the market for polypropylene fibre had to be created. Indian industries have been established basically to meet the local demand and not to cater for

export markets. The volume and cost of production and limited product range till recently are the main constraints in developing export.

- Technological gaps do exist between Indian and International level particularly in technology of high speed spinning for fibre, high speed spin draw process, compact short spin process, production of BCF, production of fine deniers for apparel industry which are still to come to India. These gaps can be filled up if import of latest technologies is allowed to the new entrants which are rushing to establish plants looking at the rush of LI's issued.

Recommendations

- The latest technology of high speed on-line spinning process, and high speed spinning followed by stretching process should be introduced. The benefit of these processes shall be lower production cost, fine denier fibre production and wide denier range of fibre.

- Similarly in case of PP filament, the target should be to import high speed spinning and take up units for production of POY as is existing with one unit. The spin -draw process for manufacture of fully drawn yarn should also be emphasised. The thrust shall also be to import one stage as well as 2-stage B.C.F. process technology. The minimum capacity of such plants shall be 1000 MT per annum.

- After upgradation of technology as suggested above the thrust area of R&D should be to improve it further by import of latest knowhow on product development. Another important area of development should be to develop master batches for coloration and spin finish and stabilisers suitable for high speed spinning and fine denier production.

- As regards manufacture of plant, the development of extruders, spinning beam and air quenching system can be taken up by import of certain key components, as manufacturing facilities for the same exist in the country. Development of high speed winders, spin draw machines, spinnerets polymer pumps etc. could be taken later at second phase.

Industry and Government should ensure that all the new collaborations are based only on import of latest and cost effective technology. Further collaboration agreements approved should be active for a suitable period for proper absorption and development of technology so that both technical know-how and product know-how are made available. Moreover, intending companies of large sizes should be asked to put up their own R&D Centre, and if necessary, with suitable tie-up with a competent research institute.

National level Research Institutes should carry out more concentrated research on technology development. Their efforts shall be to remove the gap in technology and product development. More stringent monitoring of R&D work of industry and liberal policy to spend reasonable amount of their earnings on R&D should go a long way to bridge the technological gap.

A very cautious and rational approach to R&D efforts and import of technology is imperative considering the costs involved versus saving in foreign exchange; and policy should not be averse to import of technology where inescapable.