International Journal of Home Science 2021; 7(2): 109-115

International Journal of Home Science

ISSN: 2395-7476
IJHS 2021; 7(2): 109-115

www.homesciencejournal.com
Received: 16-04-2021
Accepted: 20-05-2021

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Process and factor analysis in the manufacturing of woven polypropylene packaging textiles

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DOI: https://doi.org/10.22271/23957476.2021.v7.i2b.1155

Abstract
A study on manufacturing units of Polypropylene Woven fabric was taken up to obtain information regarding various aspects of Polypropylene packaging material such as products covered, setup of units, raw materials, manufacturing process and future plans. Information and data obtained from various units as per the set interview schedule was coded, tabulated and analyze. Polypropylene granules were used for making woven fabric. Woven fabric is use for making sacks, FIBC, leno bags and wrapping fabric. Fabric is sometimes sandwiched with plastic or metal film in order to make BOPP bags or wraps.

Keywords: Polypropylene, packaging textiles, manufacturing process

Introduction
The definition of textile is critical. Initially textile is defined as the fabric manufactured by weaving or knitting. Nowadays textile includes developing, processing, manufacturing and finishing of fiber, yarn and fabric. Change in lifestyle demands to mold the textile with new technology in order to fulfill not only aesthetic and overall apparel needs of humans but also technical and functional needs. One such field where textile is used to fulfill the technical and functional needs is packaging. Packaging includes any kind of material which is used for covering, transporting and protecting a variety of goods. The growing environmental need for reusable packages and containers is opening new doors for textile products in this market.
Packaging textiles can be made from natural or manmade fibers. The natural fibers used for Packaging Textiles are cotton, flax and jute which come from plants. They are durable and biodegradable. But the use of natural fibers alone was beset by problems of uncertain production volume and quality since it is an agricultural product. The synthetic fibers used for making packaging products are polyamide, polyolefin and polypropylene. Packaging materials made from synthetic textiles are stronger and withstand much higher impact loads.
Polypropylene fiber from numerous points of view can be viewed as the 'workhouse' among synthetic fibers. Despite its low cost, its key properties incorporate its high strength, high sturdiness and great resistance to chemical attack. Thus, it finds an extensive variety of uses from sacking and large industrial bags to high tech medical applications. Packaging materials made up of polypropylene are easy to clean and resist fungal attack. By 2017, the total annual world production of Polypropylene in textiles was well more than five million tons. Polypropylene accounts for over 90% of Polyolefin fiber production.
The PP packaging materials are cost effective, strongest, eco-friendly and good in appearance. These bags require less energy to manufacture than paper or jute bags. These bags are non-toxic, stain resistant and easy to clean. These bags are anti-bacterial, breathable or waterproof with a laminated film, have resistance to most alkalis, acids, organic solvents and degreasing agents resulting in less damage to bags & products. These bags can be reused by the consumer many times over, which is a big positive point. The raw material and process used for manufacturing these packaging textiles has a low impact on both energy consumption and on the environment.

Objectives
- To find out the raw material used.
- To acquire knowledge about the machinery used.

- To find out the steps involved in the manufacturing of Polypropylene fabric.

Methodology

Keeping the objectives in mind, the study was carried out in two phases.

Phase 1 - Exploratory phase

Locale of data, sample design, method selection, and development of research tools and collection of data were the different steps taken in an exploratory phase. For this study interview schedule cum an observation method was used.

Phase 2 - Compilation and analysis of data

Average and Percentage techniques were used to summarize the data.

Results and Discussion

1. Raw material used

Polypropylene granules were used for making woven fabric. Woven fabric is use for making sacks, FIBC, leno bags and wrapping fabric. Fabric is sometimes sandwiched with plastic or metal film in order to make BOPP bags or wraps. Polypropylene granules of different grades were used in the manufacturing of PP woven. These grades were given according to quality.

Table 1: Specifications of the PP granules

Grade	MFI (12)	Product
1030 RG	3	Woven sacks and wraps
1020 RU	2	FIBC
1030 FG or 1030 FGP	3	BOPP bags
3250 EG	25	Extrusion coating

Table 2: Type of raw material used

Form of raw material	PP granules	Woven fabric	Plastic film	Metal film
Image				
	Plate-1	Plate-2	Plate-3	Plate-4

Survey statistics-1

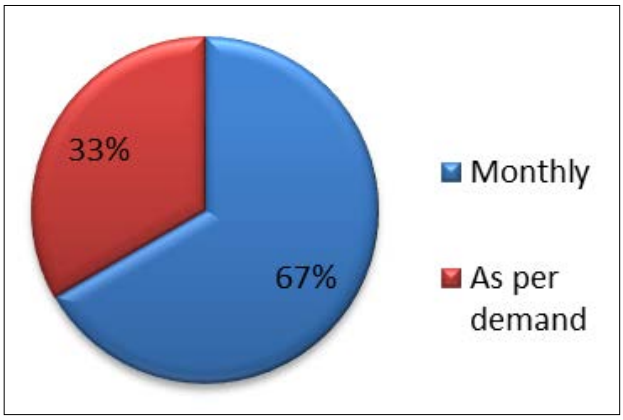


Fig 1: Frequency of buying raw material

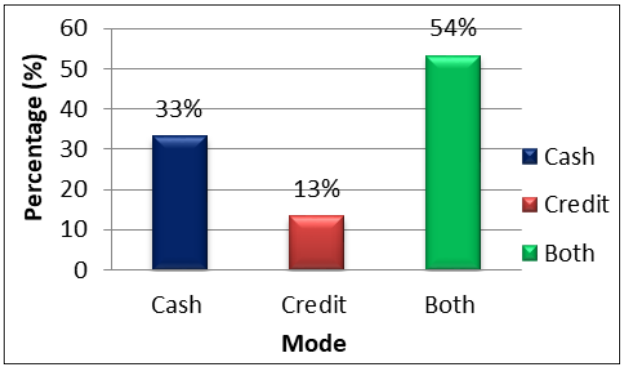


Fig 2: Mode of purchase of raw material

Most of the units i.e. 67% were buying raw material monthly and remaining 33% of units were buying raw material as per requirement. The raw material PP granules were purchased from Reliance, IOCL, and Exxon. Mobil., whereas PP woven fabric was purchased from Delhi, Uttar Pradesh, Panipat and kala Amb. Maximum number of the units i.e. 54% bought raw material through cash as well as credit, only 13% of units use credit mode to purchase raw material and 33% of the units bought raw material through cash. The raw materials were stored in storeroom or in separate go-down.

2. Machinery

The minimum number of machines required to set up the plant was in between the range of 10 to 20. The survey interpret that 53% of the units had number of machines in the range of 30-40, 33% of unit were having machines in the range of 10-20, whereas only 14% of the units were having 20-30 machines.

Table 3 (i): Machines used in packaging textiles

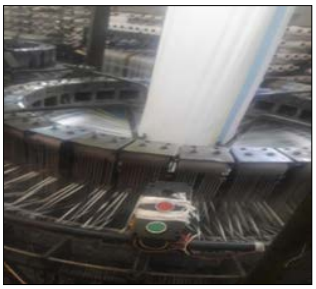
Name of the machine	PP/HDPE tape plant	Circular weaving looms	Laminating machine
Mode	Automatic	Automatic	Automatic
Purpose	Extrusion of PP granules in the form of yarns	Manufacture of PP woven fabric and leno bags	Used to laminate the fabric
Image	 **Plate-5**	 **Plate-6**	 **Plate-7**

Table 3 (ii): Machines used in packaging textiles

Name of the machine	**Flexo printing machine**	**9 roller or 8 roller printing machine**	**Cutting machines**
Mode	Automatic	Automatic	Manual, semi-automatic and automatic
Purpose	Used for printing PP woven and non-woven fabric	Used for printing plastic films	Used to cut the fabric
Image	 **Plate-8**	 **Plate-9**	 **Plate-10**

Table-3 (iii): Machines used in packaging textiles

Name of the machine	**Inspecting machine**	**Special packing and bale pressing machine**	**Sewing machines**	**Tubor**
Mode	Semi-automatic	Semi-automatic	Semi-automatic	Automatic
Purpose	Used to inspect the printing defects	Used to press the and pack the bundles	Used to stitch the fabric	Used to make BOPP bags
Image	 **Plate-11**	 **Plate-12**	 **Plate-13**	 **Plate-14**

Survey statistics-2

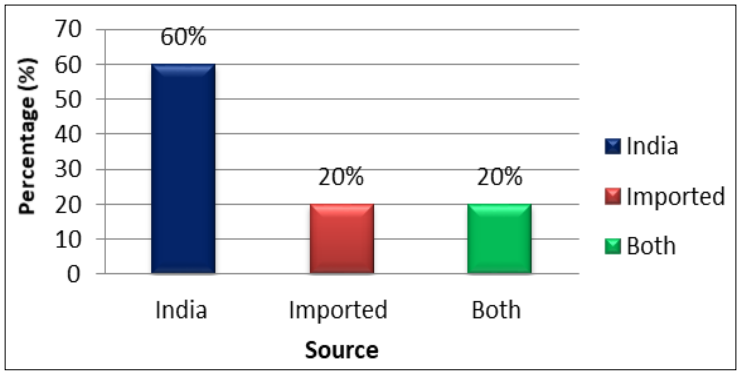


Fig 3: Source of machines

60% of the units had sourced their machines from India and 20% of units had imported machines from China, Taiwan and Italy. Remaining 20% had purchased their machines from India as well as from foreign country. The place of sourcing of machines in India was Ludhiana, Delhi, Ahmadabad and Kanpur. All the units used both the indigenous as well as imported machines but the use of imported machine was more due to technology up-gradation and efficiency of production.

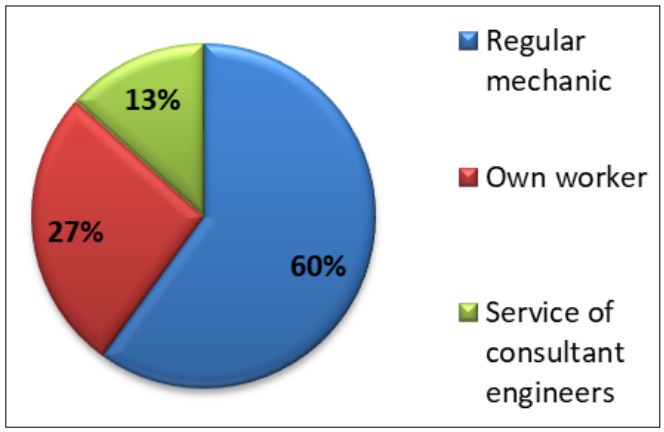


Fig 4: Maintenance of machines

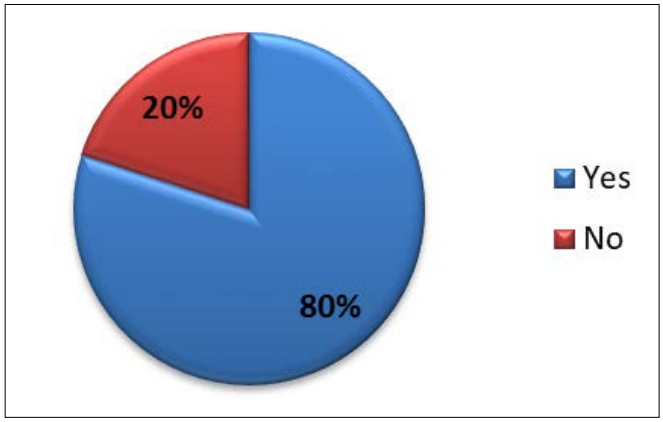


Fig 5: Change in machinery

60% of the units were having regular mechanic for the upkeep of machines, 27% of units had trained their own workers whereas only 13% of the units got service from the consultant engineers. The inspections of machines were done at regular intervals of 20-25 days.

Maximum number of the units i.e. 80% had changed their machinery. Industries changed or customized their machinery due to varied reasons such as advancement of technology, maintenance cost and in order to get better quality.

3. Manufacturing process

In this study, the manufacturing process of various pack-tech products were studied which included-PP woven fabric and sacks, FIBC, leno bags, polypropylene woven wrapping fabric, BOPP and shopping bags. Generally, all the pack-tech products were manufactured and printed as per the customer's demands. Different kinds of colour combinations and designs in the printing of these sacks are used to convey the message(s), characteristic(s), quantity & quality related details and handling instructions etc. All the units were certified by ISO 9001:2015-food grade certification and Hazard Analysis and Critical control Point (HACCP).

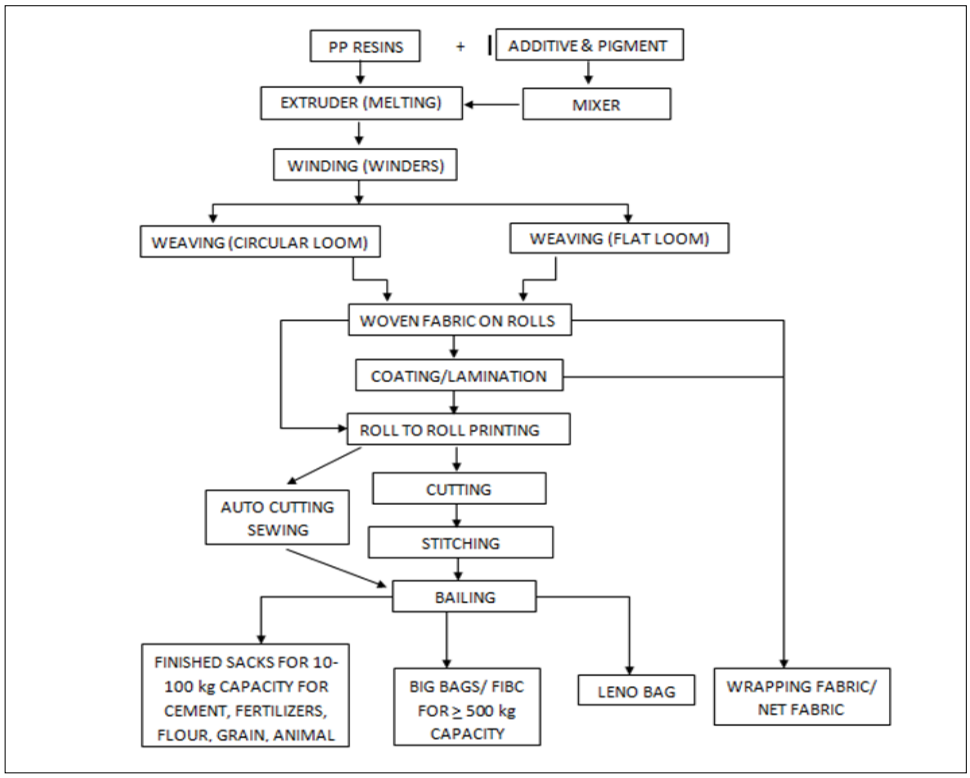


Fig 6: Flow chart-1 manufacturing process of woven polypropylene fabric and sacks

The process of manufacturing PP Woven fabric and sacks, FIBC, leno bags, wrapping fabric involves following steps:

a. Extrusion
b. Weaving
c. Finishing & Stitching

a. Extrusion

The raw material mix (PP & filler) is prepared in a tray adjacent to the feed hopper. These granules form is fed to raffia tape manufacturing plant to obtain the tapes of PP. The prepared mix is sucked in to the hopper by vacuum. The raw material mix is fetched to the extruder of the plant; where the same is melt by applying controlled external heat on the barrel. PP resin is heated with feeler of $CaCO_3$ and pigment.

The molten mass is forced out through a dye head into a cooling tank, in the form of sheet/film. The sheet received from the plant was allowed to cool slowly, in order to remove internal stress and to toughen it. The cooled & solidified sheet/film is then slit into tape yarn (2.5 mm wide) by the slitting unit. The tapes received from the plant are stretched and annealed.

Next, a take-up winder winds the heat oriented tape yarn onto a bobbin. The take up winder consists of 110-310 pieces of winders. The yarn tension is controlled electronically. The winding speed of plant is in between 100-270 m/min depending upon the capacity of PP tape yarn manufacturing plant. The capacity of plant varies from 160-520 kg/hr.

Table 4: Plate No. - 15 Extrusion

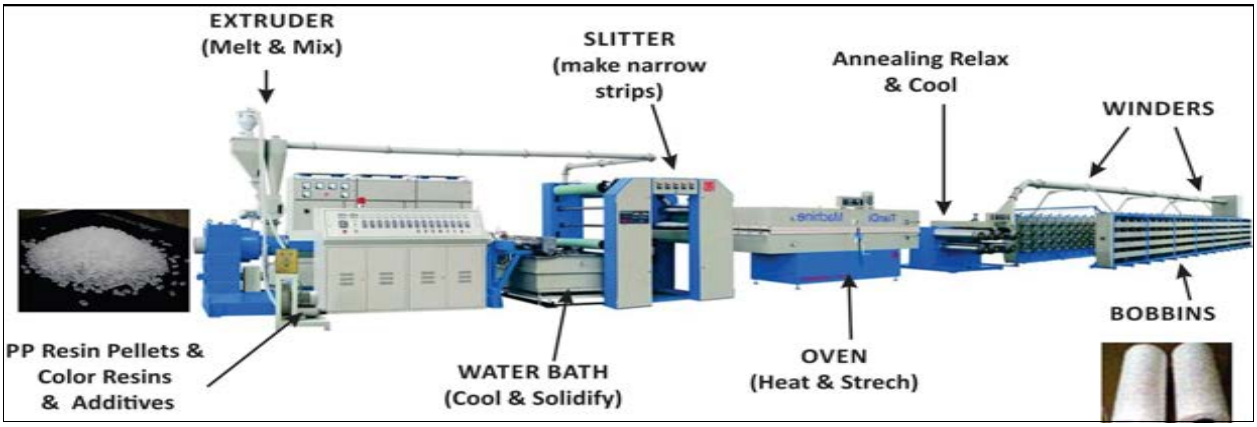


Plate No. - 15 Extrusion

Plate No.-16 Extruder

Plate No.-17 Melting and filtration

Plate No.-18 Water bath

Plate No.-19 Heat and stretch

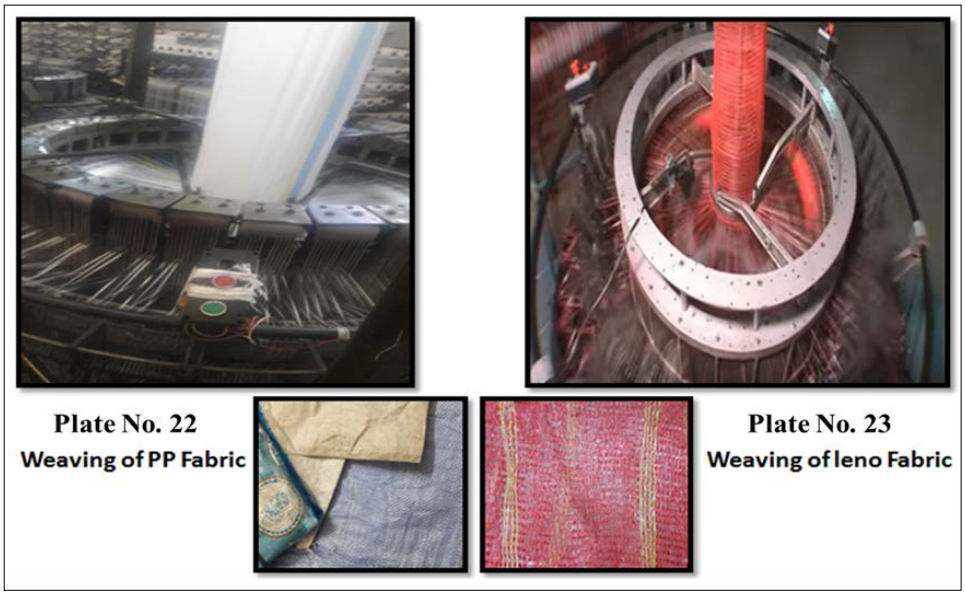
Plate No.-20 Slitting unit

Plate No.-21 Winding

b. Weaving

The weaving of PP woven fabric is carried out in circular looms, which produce circular cloth of desired width. The process of weaving is automatic and continuous in nature. Numbers of circular looms are installed so as to match the effective output of the PP tape manufacturing plant. The cloth produced by each loom is continuously wound on rotating pipes.

Circular looms range from four shuttle for open mesh (leno weave) packaging fabric for fruits & vegetable, to six shuttle for a vast range of packaging applications such as cement, fertilizer, polymer granules, chemicals, grains, animal feed, seeds and husk; to eight & ten shuttle for the production of wide width fabric for Jumbo bags (FIBC's), tarpaulins. The output of the machine is 2800 to 3000 m/day.



c. Finishing and stitching

The rolls of woven cloth are carried out to the finishing & stitching section of the unit. The fabric is first printed and then cut into desired size. Then, these cut pieces are sent for stitching.

Single colour, four colour and six colour flexo printing machines were used for printing. The printing speed of machine varies from 70-90 m/min. Both manual and mechanical method was used by the unit to cut and sew the fabric.

The woven sacks passed through the quality control test, where each sack is examined manually. Then, these sacks are bundled in 500 or 1000 nos. and pressed on a bailing press. The pressed Woven Sacks are wrapped, bundled, packed and dispatched. The quality control checks are carried out at each and every step to avoid rejections.

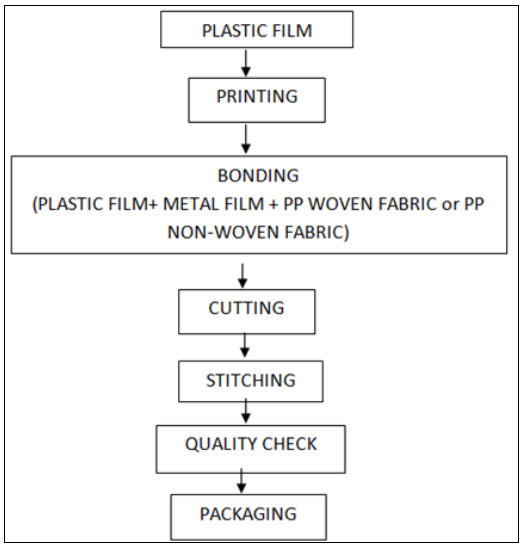


Fig 8: Flow chart-2 manufacturing process of biaxillary oriented polypropylene bags

For laminated wrapping fabric or sacks the PP woven fabric is laminated with melted PP granules or plastic film.

Eight colour and nine colour rotogravure printing machine was used to print plastic film. After printing, the plastic film was checked manually under proper light. After printing's quality check, the plastic film was bonded with metal film with the help of ethyl adhesive. The bonded fabric was then stored in hot room where temperature is controlled.

PP woven fabric was laminated with bonded metal sheet & plastic sheet or only with printed plastic sheet. These sheets were passed through hot rollers, no adhesive is used.

The laminated fabric is then passed through automatic cutting & sewing machine where slitters cut the fabric into pouches and side seams are sewn. Different shapes, sizes and types of bags can be produced from latest pouching machine. These machines can produce approximately 150,000 bags per day. Manual sewing machine is used to sew the bottom and handle of bags.

For making BOPP tapes bonded fabric was passed through slitting machine.

4. Future plans

The size of the market for packaging textile was growing. All the respondents were satisfied with their business and some of them were planning to increase their production to cater to the growing market demand of packaging textiles.

Conclusion

Polypropylene Woven sacks (excluding FIBC) represent around half of the technical textiles utilization under Packaging textiles. Woven polypropylene fabric is used for making sacks, FIBCs, BOPP, leno bags and (UN) laminated wrapping fabric. Polypropylene woven fabric manufacturing units was medium scale units using PP/HDPE tape plant and Circular weaving loom. Packaging textile industry manufacturing PP woven was a combination of textiles and plastic industry. The automatic cutting and sewing machines aided with computer numerical control can produce huge quantity of bags with variation in size; with a tremendous speed and efficiency in short period. A common testing facility center should be setup by the Government for manufacturing units to provide necessary testing and certification to meet international demand. The increasing demand for these products ensured a bright future for this industry which had plans to expand and compete in the international market.

The demand for packing material is directly proportional to economic growth, industrial production and trade as goods are produced and then distributed both locally and internationally. The growing environmental need for reusable packages and containers is opening new doors for textile products in this market.

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