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Rubber Skill Development Council

Skill Gap Analysis across Sub-Segments (Tyre and Non-tyre) for Rubber Industry – Manufacturing process of Rubber products

ICRA Management Consulting Services Limited

Contents

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Introduction on Rubber Technology

Rubbers are loosely described as materials which show “elastic” properties. These materials with long chain molecules known as “polymers” and the combination of elastic and polymers have led to the alternative name of “elastomers”. Rubbers and elastomers are considered to perform similar function. Products made from rubber have a flexible and stable dimensional chemical structure and are able to withstand under force large deformations.

Rubber technology refers to the science involved in the process of transforming the rubber or elastomers into useful rubber products such as tyres, mats, etc. Rubber products can be broadly classified into two types such as raw rubber products and Latex products.

Overview of Rubber Product Processing:

The production process of rubber products can be compared with plastic products and some of them are similar. However, rubber product technology is different in many aspects. The basic technology involved in rubber product processing is mentioned below.

Before knowing the rubber product process, it would be helpful to know about different type of rubbers and processing of raw rubber which are sent to manufacturing units for product processing. Basically, there are two types of rubber namely: natural and synthetic rubber.

Natural Rubber

Natural rubber is tapped from rubber trees as latex. Latex is a colloidal dispersion of solid particles of the polymer polyisoprene in water. The latex is collected in large tanks, thus blending the yield of many trees together. The preferred method of recovering rubber from latex involves coagulation - adding an acid such as formic acid. This process is helpful in reducing the water content in the latex and they are drained out to form sheets. The sheets are then draped over wooden frames and are dried. The resulting rubber, now in a form called ribbed smoked sheet, is folded into large bales for sending it to the processor. It will be dark brown in color. There are different grades of rubber based on the quality such as pale creep rubber which is a better grade involving two coagulation steps.

Synthetic Rubber

Most synthetic rubbers are produced from petroleum by the same polymerization techniques used to synthesize other polymers.

Rubber is used as a name for 3 categories:

Raw Rubber – This is the prime raw material for any rubber product which determines the main characteristics of the final product.

Semi-manufactured product - The addition to raw rubber with chemicals and fillers, to impart desirable properties, is termed compounding. The material is however still malleable and plastic.

Final product – As a result of vulcanisation process, the rubber compound gets its elastic properties and gives shape to the final product.

Natural raw rubber and Synthetic rubber have similar characteristics and are alternatively used in the manufacturing process. However, for few product categories such as tyre, natural rubber is preferred for their product characteristics.

Product Processing:

There are many types of rubber products such as tyres, mats, moulded products, extruded products, etc. These rubber products have their unique specification of manufacturing. However, most of the rubber products are processed with four major steps and are listed below.

- Compounding
- Mixing
- Shaping
- Vulcanizing

Compounding

Rubber is always compounded with additives. Compounding adds chemicals for vulcanization, such as sulfur. Additives include fillers which act either to enhance the rubber's mechanical properties (reinforcing fillers) or to extend the rubber to reduce cost (non-reinforcing fillers). It is through compounding that the specific rubber is designed to satisfy a given application in terms of properties, cost, and processability.

Mixing

The additives must be thoroughly mixed with the base rubber to achieve uniform dispersion of ingredients. If vulcanizing agents were present from the start of mixing, premature vulcanization would result spoiling the product. To avoid premature vulcanization, a two-stage mixing process is usually deployed by the processing units:

1. carbon black and other non-vulcanizing additives are combined with the raw rubber. The term master batch is used for this first-stage mixture
2. after stage 1 mixing has been completed, and time for cooling has been allowed, stage 2 mixing is carried out in which vulcanizing agents are added

Shaping

This process helps in providing the shape to the product in the required form. Shaping and related processes for rubber products can be divided into four basic categories:

1. Extrusion
2. Calendaring

3. Coating
4. Moulding and casting

Some products require several basic processes plus assembly work such as tires which uses all of the basic shaping process to manufacture the final product.

Extrusion

Screw extruders are generally used for extrusion of rubber. The extruder is used to give shape to the rubber compound through the die fixed. The rubber is fed from one end it comes out with the preformed shaped as per the die used. The rubber has not yet been vulcanized. Some of the end product from this process includes hoses, rubber beadings, cables, etc.

Calendaring

Rubber roll is passed through a series of gaps of decreasing size made by a stand of rotating rolls. Rubber sheet thickness determined by final roll gap. Some of the end products include conveyor belts, bonding gum, etc.

Coating

This process is used when a fabric is coated with rubber. The equipment is similar to calendaring equipment. Some of the products made by this process are automobile tires, conveyor belts, inflatable rafts, and water proof cloth tents and rain coats.

Roller Die Process

This process involves a combination of extrusion and calendaring which results in better quality product than either extrusion or calendaring alone.

Moulding

Moulded rubber products include rubber mats, gaskets and seals, bush, chappal soles, straps and bottle stops. Also, many foamed rubber parts are produced by moulding. In addition, moulding is an important process in tyre Production as well.

There are different types of moulding processes followed. The major types are as follows:

- Compression moulding
- Transfer moulding
- Injection moulding

Compression moulding is the most followed technique for most of the moulded rubber product and it is used in tire manufacturing process as well. Curing (vulcanizing) is accomplished in the mould in all three processes. But for other shaping processes such as extrusion and calendaring, separate curing / vulcanization process needs to be performed.

Vulcanisation

Vulcanisation is generally a heating process that accomplishes cross-linking of elastomer molecules, so that the rubber becomes stiffer and stronger but retains extensibility. During the vulcanization process, the number of cross-links increases, the polymer becomes stiffer and behaves more and more like a thermosetting plastic (hard rubber).

These are the major standard steps followed in manufacturing of rubber products. However, each product has their own unique process specification and follows them during manufacturing.

Latex products:

Latex product processing:

Latex products are the products which are made from the latex tapped from the rubber trees. There are many products which are made from latex such as adhesives, gloves, balloons, foam mattress, thread, etc. The general processes followed in manufacturing of latex products includes:

- Compounding (Dispersion)
- Dipping
- Moulding
- Extrusion
- Vulcanisation

The function of compounding, moulding, extrusion and vulcanisation are similar to that of the process explained for rubber products. Compounding is a dispersion process which is done using a dispersion mill (ball mill, attritor mill, etc). Dipping is done to give a shape to the product in a former (mould) as per the end product specification.

1. Manufacturing Process of Rubber products

1.1 Latex based adhesives manufacturing process

Figure 1: *Manufacturing process of latex based adhesives*

Step 1: Raw Material incoming and weighing

Input	▪ Centrifuged Latex ▪ Chemicals such as zinc oxide
Process description	▪ The raw materials are procured from the supplier and are stocked in godown ▪ The quality of the raw materials are ensured by the certified test copies of the supplies from the supplier ▪ As per the defined proportion, the amount of different raw material to be used is weighed using a weighing machine
Output	▪ Raw materials as per the defined chemical formulation
Job role involved	Operator

Step 2: Mixing

Input	▪ Raw materials as per the defined chemical formulation
Process description	▪ Centrifuged latex and the other chemicals (as per the formulation) are mixed in a drum with a stirrer ▪ The mixing should be done properly that the compound is adequately mixed ▪ Then the compound is stored for a certain period (usually one week)
Output	▪ Latex solution
Job role involved	Operator

Step 3: Packing

Input	▪ Latex adhesive ▪ Packing materials
Process	▪ The adhesive is then weighed and then packed in bottles / packets

description	▪ The bottle is sealed and dispatched
Output	Packed end product
Job role involved	Supervisor and Helpers

Note: Some of the manufacturers may procure natural latex and do the creaming process by themselves. Creaming process is done to increase the dry rubber content (to around 55 to 60 per cent) in the latex. The adhesive tape process is similar. The only change is that the compounded latex is coated on fabric by operators and then cut to strips.

1.2 Beltings Manufacturing Process

Figure 2: Manufacturing process of V belts (Wrapped construction)

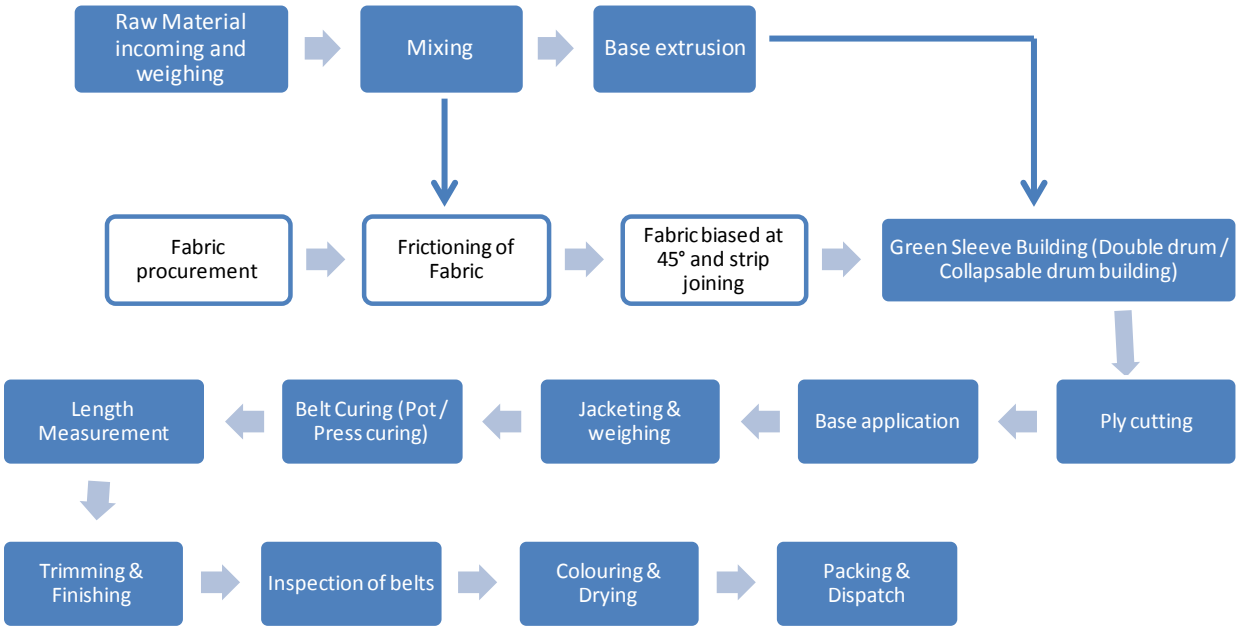
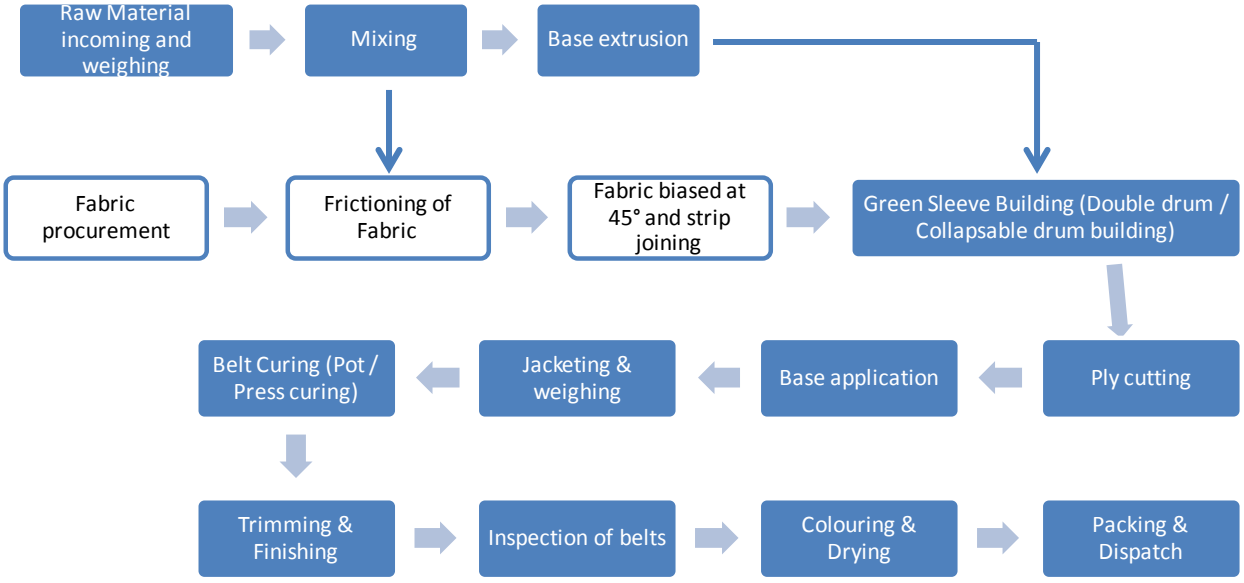


Figure 3: Manufacturing process of Fan belts



(The manufacturing process of wrapped construction V belts and Fan belts are mostly similar and is explained in detail below. The differences are pointed out wherever applicable)

Step 1: Raw materials weighing and mixing

Input	▪ Rubber : Natural and Synthetic Rubber ▪ Fillers ▪ Accelerators and Accelerators ▪ Process oils ▪ Curing agents
Process description	▪ Raw materials are procured from suppliers and are stored in the godown / storage place appropriately ▪ Quality of the raw materials are ensured by the testing certificates obtained by the supplier or through internal testing procedures ▪ Various raw materials are weighed according to formulation and are prepared as a batch for mixing process ▪ The raw materials are fed in the milling machine (kneader / open mixing mill) in a predefined sequence where mastication of rubber takes place ▪ The above chemicals are masticated in the mixing mill to form sheets ▪ Quality checks such as rheometric properties testing is done on the compound prepared
Output	Rubber compound in the form of sheets
Job role involved	Mixing Supervisor, Kneader operator, Mixing mill operator and Helper

Equipments Used

Kneader

Milling machine

Step 2: Extrusion (Base extrusion)

Input	▪ Rubber sheets from the milling process
Process description	▪ Extrusion machine is made ready for operation by fixing appropriate die and maintaining adequate temperature ▪ The rubber compound is warmed again in a supply mill for enabling extrusion (this process may be skipped in case of cold extruder) ▪ The rubber compound in the mill is cut into strips for extrusion purpose ▪ This strips of rubber compound passes through the extruding machine and comes out in a tube form

Equipments Used

Extrusion machine

	▪ The physical characteristics of the extruded rubber is as per the die fixed in the extruding machine ▪ The rubber compounded is extruded as per the size of the belt (output product) ▪ Temperature of the machine needs to be constantly monitored to prevent compound from getting cured
Output	Extruded rubber
Job role involved	Extrusion Operator and Helper

Step 3: Frictioning of Fabric

Input	▪ Rubber compound from mixing ▪ Fabric
Process description	▪ A rubbersied fabric would cover the outer part of the belts ▪ To prepare this outer cover, rubber compound from mixing and a fabric is taken to the calendaring section ▪ Rubber is coated into the fabric (on both weft and warp) on both sides and fractioning process takes place
Output	▪ Rubberised fabric
Job role involved	Calendaring Operator

Equipments Used

Calendaring machine

Step 4: Fabric bias cutting and strip joining

Input	▪ Frictioned Fabric
Process description	▪ The fractioned fabric is biased at 45 degrees for ▪ This is done for the purpose of strip joining ▪ This biased fabric will be used with the extrusion
Output	▪ Biased frictioned fabric
Job role involved	Ply cutting operator

Step 5: Building on mould (Green Sleeve Building)

Input	▪ Collapsable drum / Double drum

	▪ Rubber strips from extrusion process ▪ Rubberised fabric after calendaring process ▪ Polyester cord
Process description	▪ A collapasable drum is taken to build the belts and this is a critical process in belt manufacturing ▪ The rubberized fabric is cut as per the length of the belts and it forms the outer cover ▪ Rubber strip from extrusion process is placed in the mould ▪ Over the rubber strips, polyester cords are rolled. The count of rolls is as per the specification and it needs to be appropriately placed ▪ The cord provides the strength for the belt ▪ A thin rubber strip is placed over that for bonding purpose ▪ Then the rubberized fabric is used to cover the built belt
Output	▪ Uncured rubber belt
Job role involved	Building operator

Step 6: Wrapping

Input	▪ Uncured rubber belt
Process description	▪ The uncured belts in the collapsible drum is wrapped on the cloth ▪ Wrapping should be done appropriately without any wrinkle as that would affect the quality of the product ▪ This process is done with the help of a rolling machine
Output	▪ Wrapped Uncured rubber belt
Job role involved	Operator

Step 7: Curing (Pot/Press curing)

Input	▪ Wrapped Uncured rubber belt
Process description	▪ The wrapped belt in the drum is put in the vulcaniser chamber for certain period as per the specification ▪ Parameters such as pressure, temperature and curing time needs to be set appropriately in the vulcanising chamber ▪ Press curing process is followed for large belts where it cannot be cured with the drums

Output	▪ Cured belts
Job role involved	Vulcanising operator

Step 8: Unwrapping

Input	▪ Cured belts
Process description	▪ After the curing process, fabric is unwrapped and the belt is allowed to cool in the room temperature ▪ The belts are then removed from the collapsable drums
Output	▪ Unfinished belts
Job role involved	Operator and Helper

Step 9: Length measurement cutting & Trimming

Input	▪ Unfinished belts
Process description	▪ The length are measured and cut as per the specifications (this is applicable only for V belts) ▪ Trimming is done on the belts ▪ Other finishing process as per the requirement of the belt is also performed
Output	▪ Finished rubber belts
Job role involved	Helper

Step 10: Inspection of belts

Input	▪ Finished rubber belts
Process description	▪ Quality check such as tensile strength, endurance (elongation), etc are performed on the finished product ▪ They are also checked on parameters such as length and the specification mentioned by clients
Output	▪ Finished and QC passed belts
Job role involved	Quality check operator, Inspection operator and Helper

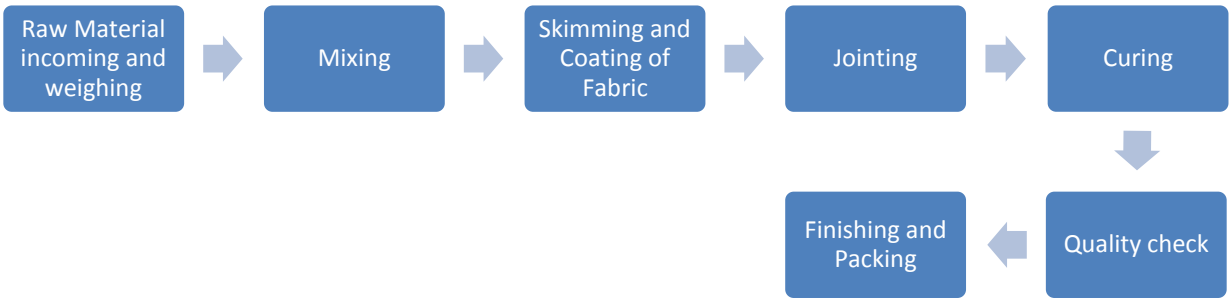
Step 11: Colouring & Drying

Input	▪ Finished rubber belts
Process description	▪ Post the quality check process, other finishing process such as colouring (paints / silicon emulsion) is done and then it is dried
Output	▪ Belts ready for dispatch
Job role involved	Operator and Helper

Step 12: Packing& Dispatch

Input	▪ Finished rubber belts
Process description	▪ Finished rubber belts are then packed and dispatched as per the delivery order
Output	▪ Belts ready for dispatch
Job role involved	Operator and Helper

Figure 4: Manufacturing process of Conveyor belts



Step 1: Raw materials weighing and mixing

Input	▪ Rubber : Natural and Synthetic Rubber ▪ Fillers ▪ Accelerators and Accelerators ▪ Process oils ▪ Curing agents	**Equipments Used** Kneader
Process description	▪ Raw materials are procured from suppliers and are stored in the godown / storage place appropriately	

	▪ Quality of the raw materials are ensured by the testing certificates obtained by the supplier or through internal testing procedures ▪ Various raw materials are weighed according to formulation and are prepared as a batch for mixing process ▪ The raw materials are fed in the milling machine (kneader / open mixing mill) in a predefined sequence where mastication of rubber takes place ▪ The above chemicals are masticated in the mixing mill to form sheets ▪ Quality checks such as rheometric properties testing is done on the compound prepared
Output	Rubber compound in the form of sheets
Job role involved	Mixing mill operator and Helper

Milling machine

Step 2: Skimming and Fabric Coating

Input	▪ Rubber compound from mixing ▪ Nylon fabric
Process description	▪ Rubber is coated into the nylon fabric through calendaring process ▪ The nylon fabric provides the strength to the belts (Alternatively Polyester or steel cords may be used depending on end user purpose) ▪ This rubberized nylon fabric (plies) would form the inner layers of the belt ▪ The ply passes through steel drums for uniform coating and these drums are steamed to remove any moisture in the plies ▪ This ply provides the strength for the conveyor belts to move the objects
Output	▪ Rubberised nylon fabric (plies)
Job role involved	Calendaring Operator and Helper

Equipments Used

Calendaring machine

Step 3: Calendaring (for outer top and bottom cover)

Input	▪ Rubber compound from mixing
Process description	▪ Rubber compound is calendared which will be used for the outer layer of the belt (both top and bottom side of the belt) ▪ The width of the ply and the calendared rubber sheet should be even ▪ The quality of the cover should be made as per end product requirement such as fire resistance belt, Oil and chemical resistance, cut resistance, etc.
Output	▪ Calendared rubber sheets of uniform width
Job role involved	Calendaring Operator

Equipments Used

Calendaring machine

Step 4: Jointing

Input	▪ Rubberised nylon sheet ▪ Rubber sheets
Process description	▪ The rubberized nylon sheet and calendared sheets are joined to make the belts ▪ The number of plies used is as per the specification of the belts (it may vary according to the end user requirement) ▪ The evenly joined plies are passed between two rollers so that they remain bonded. This is then rolled with cotton cloth so as to prevent joining between two adjacent layers of the roll ▪ This forms the carcass of the conveyor belts ▪ Calendared rubber sheets are placed at the top and bottom of the joined plies
Output	Uncured belt
Job role involved	Operator

Step 4: Curing

Input	▪ Uncured rubber sheet
Process description	▪ Before curing process, pricking process is done on the belts to remove any trapped air between the layers of the belt ▪ After pricking, the uncured belt is passed through the hydraulic press for curing ▪ If there is any minor defect in the belt like bubbles, it is rectified and fresh rubber is pasted over the defected area. It is then again passed through the press for curing
Output	Cured conveyor belt
Job role involved	Hydraulic press operator and helper

Equipments used
Hydraulic press

Step 4: Quality Test

Input	▪ Cured belts
Process description	▪ The cured belt is allowed to cool for certain period in the room temperature ▪ Quality check such as hardness test, elongation test, etc. are done to ensure quality ▪ Other lab test on abrasion and specific product testing is also done. For example: heat resistant belt is checked for temperature resistant check.
Output	▪ Packed belt
Job role involved	Helpers

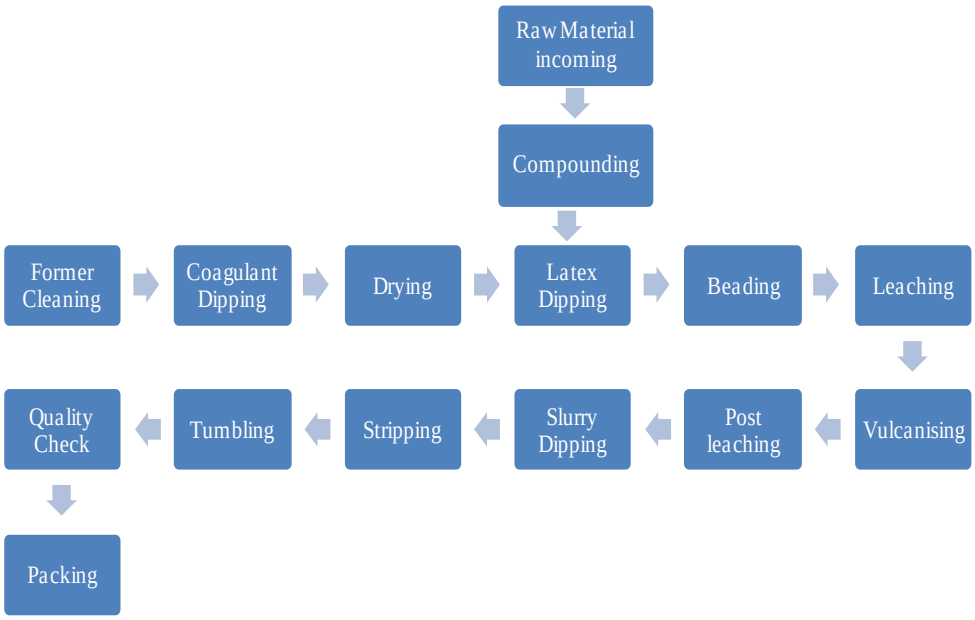
Step 5: Finishing and Packing

Input	▪ Cured belts
Process description	▪ The cured belt is allowed to cool for certain period in the room temperature ▪ Then finishing process such as trimming is done on the belts ▪ Quality check such as hardness test, etc. are done to ensure quality ▪ Once the end product is ready, it is being packed and dispatched as per the delivery
Output	▪ Packed belt
Job role involved	Helpers

1.3 Dipped Goods Manufacturing Process

1.3.1 Gloves Manufacturing Process

Figure 5*: Gloves manufacturing process*



Note:

1. The process steps from former cleaning to stripping happen automatically in the glove making machine (similar to an assembly line manufacturing process)
2. The process represented is for manufacturing surgical gloves. In case of industrial gloves, the number of dips may vary according to the thickness of the product and the manufacturing process remains more or less the same
3. The process is also applicable for balloon manufacturing process (automatic process)

Raw Material incoming and Compounding

Input	▪ Centrifuged Latex ▪ Accelerators such as ZDC, ZMBT, etc ▪ Activators such as Zinc Oxide ▪ Colouring agents ▪ Other chemicals	**Equipments Used** 1. Ball mills / attrition mills / stirrers etc. 2. Compound Mixer
Process description	▪ Raw materials are weighed according to the desired proportion and are kept ready for mixing ▪ The quality of the incoming raw materials are checked – this is done either internally or in external testing agencies or verified	

	with certified test copies from the supplier ▪ The raw materials are fed into the ball milling machine (It can contain porcelain balls / pebble balls / pearl balls) ▪ The water insoluble dry powdered chemicals are mixed in the ball milling machine to form the dispersion ▪ The liquid additives water insoluble agents are made into emulsions using a stirrer ▪ The water soluble ingredients are then made to a solution using a stirrer ▪ Then the centrifuged latex, dispersion, emulsion and solution are mixed in the desired proportion to form the compound ▪ Alternatively, the compound can also be procured from outside
Output	Output of this process will be the latex compound used for dipping
Job role involved	Compounding Operator; ball mill operator

Step 1: Former Cleaning

Input	▪ The Former (Moulds in hand shape made of Porcelain, Plaster of Paris, Metal, etc for manufacturing of gloves)
Process description	▪ The formers are attached to the assembly line of the Glove making machine ▪ Formers are then cleaned by dipping it into chambers in the glove making machine ▪ Cleaning consists of dipping the formers into chambers containing water, acid and alkali ▪ Then it will be dried in an oven (a chamber in the glove making machine)
Output	Clean and dry formers (moulds)
Job role involved	Operators and helpers

Equipments Used

Glove making machine

Step 2: Coagulant Dipping and Drying

Input	▪ Clean and dry formers (moulds) in the assembly line ▪ Coagulant solution
Process	▪ Coagulant solution is prepared as per the specification and

Equipments Used

Glove making machine

description	transferred to the coagulant chamber ▪ Formers are then dipped into coagulant tank ▪ The tank consists of chemicals such as Calcium Nitrate ▪ Coagulant dipping is done to build up the thickness of the gloves ▪ After Coagulant dipping, the formers are dried by passing through an oven in the machine line
Output	Formers ready for latex dipping
Job role involved	Operator

Step 3: Latex Dipping

Input	▪ Formers with a coating of the coagulant
Process description	▪ The formers after drying are then dipped into the latex compound, kept in the dipping tank ▪ Then the formers with latex are dipped in a coagulation tank to remove excess compound. This process is done for having an even glove surface ▪ Then the former is passed through a drying oven ▪ This process will remove the water
Output	Solid and sticky gloves on the formers
Job role involved	Operator

Equipments Used

Glove making machine

Step 4: Beading

Input	▪ Solid gloves on the former
Process description	▪ Part of the cuff portion in the glove is rolled to make beadings ▪ This process is done for easy insertion of gloves and to provide durability, by reinforcing the open edge.
Output	Gloves with beading on former
Job role involved	Operator

Equipments Used

Beading section in the glove making machine

Step 5: Pre-Leaching

Input	▪ Gloves with beading in former	**Equipments Used** Glove making machine 
Process description	▪ The formers (with sticky gloves) are then dipped in a hot water chamber ▪ Pre-leaching process is done to dissolve the water soluble residuals and other chemicals ▪ Leaching is an important process as it reduces the protein content on the gloves which would cause allergic reaction to some users	
Output	Gloves on the former ready for vulcanization	
Job role involved	Operator	

Step 6: Vulcanising

Input	▪ Gloves on the former	**Equipments Used** Vulcanising oven in the Glove making machine 
Process description	▪ The formers are then passed through main vulcanizing ovens ▪ The vulcanising process takes place ▪ The parameters such as temperature should be appropriately set to ensure proper vulcanization and realization of adequate strength for the film.	
Output	Vulcanized gloves on former	
Job role involved	Operator	

Step 7: Post-Leaching and Slurry dipping

Input	▪ Vulcanized gloves on former	**Equipments Used** Slurry dipping chamber in the Glove making machine 
Process description	▪ The gloves are then passed through another leaching process similar to the pre- leaching process ▪ This process is done to remove the additional residues present in the gloves ▪ Then the gloves go through slurry dipping process ▪ This process is done to provide a coating with a powder or other materials to remove the surface tack and thus to improve the donning of the gloves ▪ Then the formers pass through oven for drying process	

Output	Gloves ready for stripping
Job role involved	Operator

Step 8: Stripping

Input	▪ Solid and dry gloves in the former
Process description	▪ The solid gloves are stripped from the formers in this process ▪ This process is done manually by the helpers
Output	Gloves
Job role involved	Helpers

Equipments Used

Step 9: Tumbling

Input	▪ Gloves
Process description	▪ The gloves are then put into tumbling machine ▪ This process is done to remove the moisture in the gloves
Output	Moisture free gloves
Job role involved	Operator and Helpers

Equipments Used

Tumbling machine

Step 10: Quality Check

Input	▪ Unchecked gloves
Process description	▪ The gloves are then sent for Quality Check ▪ Some of the quality checks done here are for pin holes, black mark, beading bend, etc ▪ Pin holes test is done through air pumps ▪ Other test are done through visual examination ▪ Dimension test is also done by making measurements
Output	Defect free gloves suitable for packing
Job role involved	Lab- in- Charge and Lab Assistants

Equipments Used

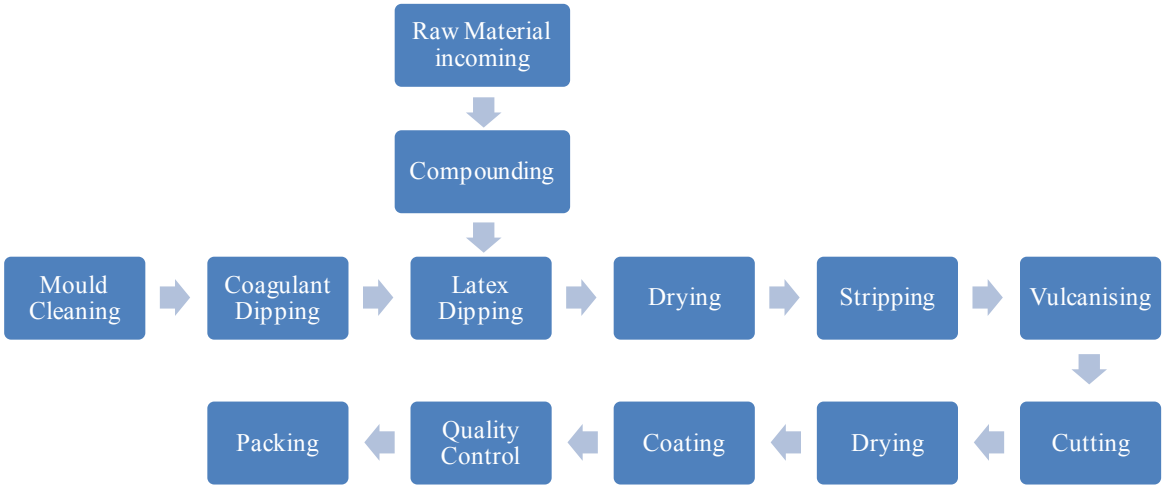
Air pumps

Step 11: Packing

Input	▪ QC passed gloves
Process description	▪ The Gloves are then weighed in a weighing machine ▪ Sterilization process is generally outsourced and so they are packed in bags and then stored ▪ The gloves are then dispatched according to delivery order
Output	▪ Packed Gloves
Job role involved	Helpers

1.3.2 Rubber Band Manufacturing Process

Figure 6: Rubber band manufacturing process



Raw Material incoming and Compounding

Input	▪ Centrifuged Latex ▪ Accelerators such as ZDC, ZMBT, etc ▪ Activators such as Zinc Oxide ▪ Colouring agents ▪ Other chemicals	**Equipments Used** Ball mill Compound Mixer

Process description	▪ Raw materials are weighed according to the desired proportion and are kept ready for mixing ▪ The Raw material are fed into the ball milling machine (It can contain of porcelain balls / pebble balls / pearl balls) ▪ The water insoluble dry powdered chemicals are mixed in the ball milling machine to form the dispersion ▪ The liquid additives water insoluble agents are made into emulsions using a stirrer ▪ The water soluble ingredients are then made to a solution using a stirrer ▪ Then the centrifuged latex, dispersion, emulsion and solution are mixed in the desired proportion to form the compound ▪ Alternatively, the compound can also be procured from outside
Output	Output of this process will be the latex compound used for dipping
Job role involved	Compounding Operator ; Ball mill operator (optional)

Step 1: Mould Cleaning

Input	▪ Moulds are mostly made of PVC pipes. The size (circumference) of the pipe determines the size (length) of the rubber band.	**Equipments Used** Moulds 
Process description	▪ The moulds are cleaned using a cloth and dust are removed ▪ The moulds are also cleaned using water and are wiped and dried before dipping is done	
Output	Clean and dry moulds	
Job role involved	Helpers	

Step 2: Coagulant Dipping and Latex Dipping

Input	▪ Clean and dry moulds	**Equipments Used** Automatic dipping machine / manual dipping the moulds in the latex and coagulant solution
Process description	▪ Moulds are then dipped into coagulant bath which has chemicals such as Calcium Chloride. This ensures thick and uniform latex coating ▪ After the coagulant dipping process, the moulds are then dipped into latex compound which is prepared during mixing process ▪ The process of Coagulant and Latex dipping are repeated around	

	3 – 6 times based on the thickness requirement of the rubber band
Output	Moulds with latex deposit
Job role involved	Dipping Operator; Helpers in the case of manual dipping

Step 3: Drying and Stripping

Input	▪ Moulds with latex deposit
Process description	▪ The moulds with rubber deposit are then made to dry under shade for around 2 days (Drying directly under sun would affect the quality) ▪ After the deposit is dried, it is stripped from the PVC moulds by pouring water into it ▪ The solid rubber deposit is in the form of tubes after stripping
Output	Unvulcanized rubber tubes
Job role involved	Helper

Step 4: Vulcanising

Input	▪ Unvulcanized rubber tubes
Process description	▪ The rubber tubes are then vulcanized ▪ The vulcanizer contains hot (boiling water and the tubes are put into it ▪ It is vulcanized by immersing boiling water for about one hour and then taken out ▪ This process is done to provide strength and other characteristics required for the rubber band
Output	Vulcanized rubber tube
Job role involved	Operator and helper

Equipments Used

Vulcaniser

Step 5: Cutting

Input	▪ Vulcanized rubber tube
Process description	▪ The rubber tube is then passed through the cutting machine to cut the tubes into rubber bands ▪ The cutting blade needs to be appropriately adjusted and fixed as per the width of the rubber band ▪ The rubber tubes need to be passed straight in the cutting machine to reduce wastage / rejections. Passing it diagonally will result in damage of product
Output	Unfinished rubber bands
Job role involved	Operator and helper

Equipments Used

Cutting machine

Step 6: Drying and Coating

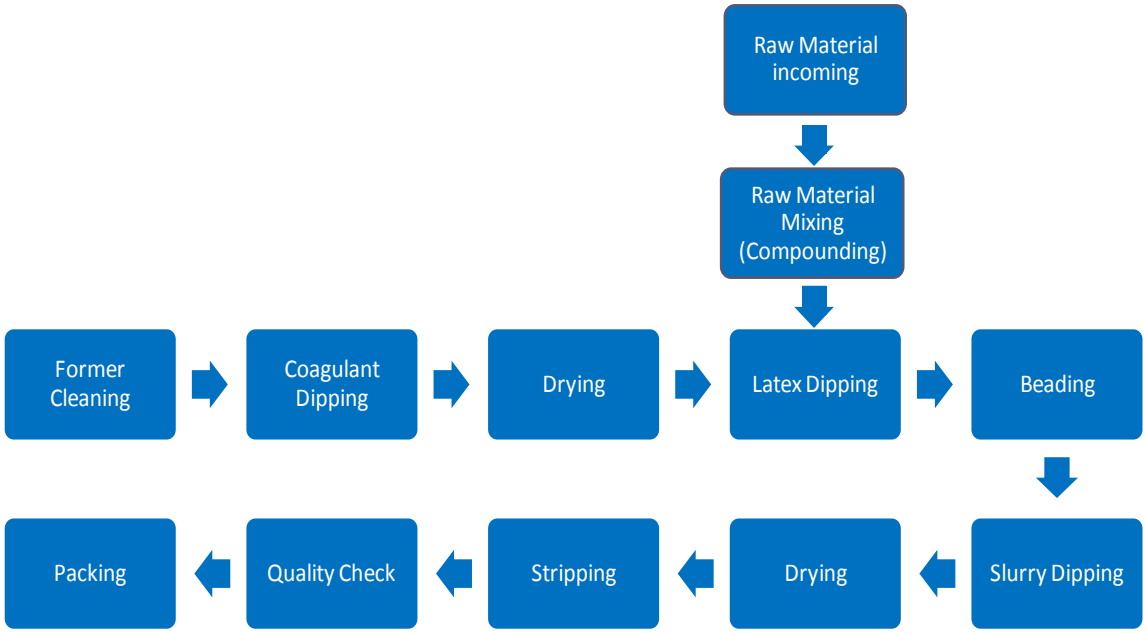
Input	▪ Unfinished rubber bands
Process description	▪ The rubber bands are then dried in a chamber / shade to remove the excess moisture in the rubber bands ▪ After drying, silicon emulsion is sprayed / applied on the rubber bands ▪ This is done to provide shining / glazing required for the rubber bands
Output	Finished rubber bands
Job role involved	Helper

Step 7: Quality check and Packing

Input	▪ Rubber bands
Process description	▪ In this process, the rubber bands which are defective are removed (using a tool which is in fork-like structure) ▪ The accepted rubber bands are packed in bundles as per the assortment
Output	Approved rubber bands ready for dispatch
Job role involved	Helper

1.3.3 Balloon Manufacturing Process

Figure 7: Balloon manufacturing process



Note: The automatic process of balloon manufacturing is similar to a glove manufacturing and the manual process is depicted above

This structure is depicted for a mini unit.

Step1: Raw Material incoming and Compounding

Input	▪ Centrifuged Latex ▪ Accelerators such as ZDC, ZMBT, etc, prepared as dispersions / emulsions / solutions. ▪ Activators such as Zinc Oxide, in the form of dispersion. ▪ Colouring agents ▪ Other chemicals
Process description	▪ Raw materials are weighed according to the desired proportion and are kept ready for mixing ▪ The dispersions / emulsions / solutions are prepared and mixed into compound ▪ Usually, the above process is outsourced and ready latex compound is procured
Output	Output of this process will be the latex compound used for dipping

Equipments Used

Compound Mixer

Job role involved	Compounding Operator

Step 2: Former Cleaning

Input	▪ Former (Moulds)
Process description	▪ The formers are attached to the trays of the balloon making machine ▪ Formers are cleaned by dipping them into tanks containing water, acid and alkali
Output	Clean and dry formers (moulds)
Job role involved	Operators and helpers

Step 3: Coagulant Dipping and Drying

Input	▪ Clean and dry formers (moulds)
Process description	▪ Formers are then dipped into coagulant tank ▪ The tank consist of chemicals such as Calcium Nitrate ▪ Coagulant dipping is done to ensure the appropriate thickness of the balloon
Output	Formers ready for latex dipping
Job role involved	Operator

Step 4: Latex Dipping

Input	▪ Formers after coagulant dipping
Process description	▪ The formers after drying are dipped into the latex compound ▪ Then the formers with latex are dipped in a coagulant tank to remove excess compound. This process is done for having an even balloon surface
Output	Solid and wet latex rubber film on the formers
Job role involved	Operator

Step 5: Drying (Vulcanization)

Input	▪ Wet rubber film on the former

Process description	▪ The wet film deposit on the formers are dried in the sun for vulcanization purpose ▪ The period of drying is extended, preferably at a higher temperature to vulcanize the film ▪ The above process is done with film on the former
Output	Dried and vulcanized balloons on former
Job role involved	Operator / Helper

**In case pre-vulcanized latex is used, this step can be avoided*

Step 6: Beading and slurry dipping

Input	▪ Dried balloons in the former
Process description	▪ The balloon tip is rolled manually to make the bead ▪ The bead reinforces the tip of the balloon and aids in blowing air into the balloon ▪ After rolling the beads, powder is applied on the balloons for ease of stripping
Output	Balloons with beading in former
Job role involved	Operator / Helper

Step 7: Stripping

Input	▪ Solid and dry balloons in the former
Process description	▪ The solid balloons are stripped from the formers in this process ▪ This process is done manually by helpers
Output	Balloons
Job role involved	Helpers

Step 8: Quality Check

Input	▪ Unchecked balloons
Process description	▪ The balloons are then sent for Quality Check ▪ Some of the quality checks done here are for pin holes, improper spread of colour, tears, etc ▪ These tests are done by passing compressed air through the balloons (for pin holes and tears) and visual checking (for improper spread of colour)

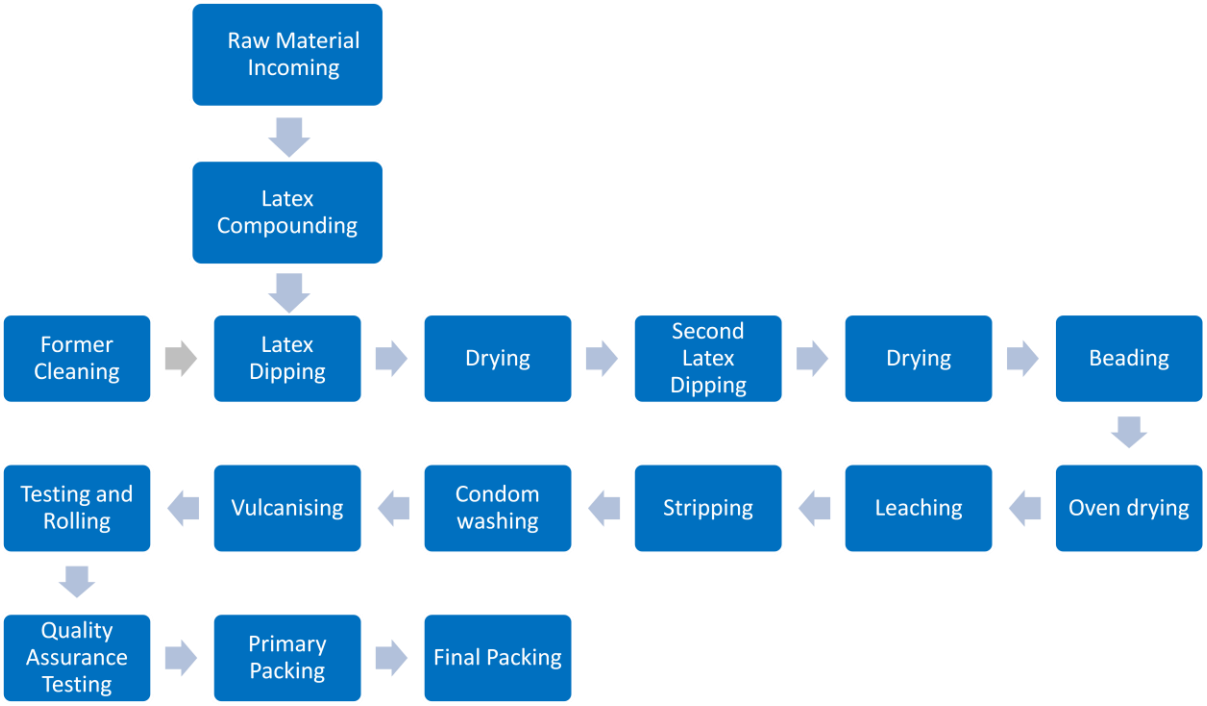
	▪ Other tests are done by visual examination
Output	Inspected and defect free balloons
Job role involved	Lab- in- charge and Lab Assistants

Step 9: Packing

Input	▪ QC passed balloons
Process description	▪ The balloons are sorted according to size and colour ▪ They are then weighed and packed
Output	▪ Packed balloons
Job role involved	Helpers

1.3.4 Condom manufacturing Process

Figure 8: Condom manufacturing process



Note: The process represented is the modern manufacturing method followed where the process of former cleaning to stripping happens in an automated machine.

Step1: Raw Material incoming and Compounding

Input	▪ Centrifuged Latex ▪ Accelerators such as ZDC, ZMBT, etc ▪ Activators such as Zinc Oxide ▪ Colouring agents ▪ Other chemicals
Process description	▪ The quality of the incoming raw material are tested internally (raw latex testing and chemical treatment tests) / quality is ensured by the certificate of testing from the supplier ▪ Raw materials are weighed according to the desired proportion and are kept ready for mixing ▪ Raw material (such as chemicals) are then fed into the ball milling machine (It contains porcelain balls / pebble balls / pearl balls)

Equipments Used

Compound Mixer

	▪ The chemicals are grinded alternatively using a attritor mill and sand grinder ▪ The dispersion takes place and all the ingredients which are to be mixed with the latex are prepared as dispersion ▪ The liquid additives water insoluble agents are made into emulsions using a stirrer ▪ The water soluble ingredients are then made to a solution using a stirrer
Output	Dispersions for compounding
Job role involved	Compounding Operator

Step2: Latex Compounding and Maturation

Input	▪ Centrifuged Latex ▪ Dispersions ▪ Emulsions ▪ Solutions
Process description	▪ Then the centrifuged latex, dispersion, emulsion and solution are mixed in the desired proportion to form the compound ▪ The temperature in the mixer is maintained and the latex compound is kept in the mixer at around 20 degrees C for one day ▪ Then the compound is transferred to supply tanks where ammonia is added for better viscosity ▪ Then the latex compound is kept to mature for around 4 to 5 days (Maturation process)
Output	Output of this process will be the matured latex compound used for dipping
Job role involved	Compounding Operator

Equipments Used

Compound Mixer

Step 3: Former Cleaning

Input	▪ Glass formers (moulds)
Process description	▪ The glass formers are attached to the condom making machine (appropriate size needs to be selected)

Equipments Used

Condom making machine

	▪ Formers are cleaned by soap solution, brushing process and passing through hot water ▪ These are then dried before dipping through drying ovens ▪ It is to be noted that coagulant dipping is not required for condom because of the thin film and physical shape of condom
Output	Clean and dry formers (moulds)
Job role involved	Operators and helpers

Step 4: Latex dipping and Drying

Input	▪ Clean and dry formers (moulds)
Process description	▪ Formers then are passed through the latex compound tank (The speed of the mould movement is controlled) ▪ The formers then pass through an electronically controlled oven for drying ▪ The temperature in the oven is around 120 degrees Celsius.
Output	Formers with one dip of latex
Job role involved	Operator

Step 5: Second Dipping and Drying

Input	▪ Formers with thin latex deposit
Process description	▪ Formers then passed into the latex compound tank for second dipping ▪ Then they pass through an intermediate oven at a temperature of around 70 degrees Celsius for drying process
Output	Formers after latex dipping
Job role involved	Operator

Equipment used
Condom making machine

Step 6: Beading and Oven drying

Input	▪ Formers after latex dipping

Process description	▪ A brush rolls the latex film deposit in the former to form the bead in the condom ▪ Then the formers pass through main oven in the machine for drying where the temperature is around 85 to 90 degrees Celsius ▪ The condom gets a solid structure after this process
Output	Vulcanized condoms on the former
Job role involved	Operator

Step 7: Leaching and Stripping

Input	▪ Condoms in the mould
Process description	▪ Then the condoms are passed through a leaching tank with ammonia and other chemicals ▪ This process ensures that protein and residual (allergic) contents are removed ▪ Then silica water is forced through the formers which enables the condom to automatically strip from the moulds
Output	Stripped condoms
Job role involved	Operator

Step 8: Dehydration and Vulcanisation

Input	▪ Stripped condoms
Process description	▪ The condoms then undergo a dehydration process where the silica solution and condom is separated ▪ This process also ensures that condoms do not stick to each other (through an anti- sticking agent) ▪ Then the condoms are taken to the vulcanising chamber where it is treated at around 85 degrees Celsius for 40 minutes. Then it is left for 10 minutes to cool ▪ The condom after this process is called a half product
Output	Vulcanised condom (Half product)
Job role involved	Operator

Step 9: Testing and Rolling

Input	▪ Vulcanised condoms
Process description	▪ The half product is then taken for an electronic testing process ▪ The electronic testing is an important process and 100 per cent production undergoes this testing and is also a place where many persons are employed ▪ In this test, the condoms are manually inserted on a tube like structure made of steel ▪ They pass through a high voltage current (around 1200 volts) on both sides ▪ Since rubber is a bad conductor of electricity, it does not allow the current to pass through it for the steel mould ▪ If there is a fault in the condom, the current passes through and bad condoms are identified and rejected ▪ This test ensures that condoms with pin holes and weak resistance are rejected ▪ Then an inclined like structure automatically rolls the condom when it passes in the moulds (in the lane) and strips then from the mould ▪ Good condoms and rejected condoms are separated
Output	Good and electronic test passed condoms
Job role involved	Operators and helpers

Equipments Used

Electronic testing machine

Step 10: Quality Assurance testing and destructive testing

Input	▪ Electronic test passed condoms (samples)

Process description	▪ The condoms are then randomly picked from the electronic test passed lots for quality assurance tests
	▪ Visual check is done first. Some of the parameters to be checked for visual test are weak spot, bad edge roll, double twisted roll, sticking, wrinkle, lip cut, nipple weak, Oil stain, etc.
	▪ Dimension test is done for the size, width of beading, etc.
	▪ Destructive tests are also conducted such as:
	  ▪ Water leakage test: 300 ml of water is filled in the condom and is left to stand for one minute. The condom is squeezed with water to check for its strength
	  ▪ Inflation test: The condoms are inflated to burst and the pressure check is done in this process. This process ensures

Water Leakage test

Inflation test

	adequate shelf life of the product ▪ These above mentioned tests are done for products taken on samples from different stages of processing such as at half product level, after electronic testing and packed finished products ▪ After all these tests are performed at an Acceptance Quality Limit and the batch is declared as good and sent for packing ▪ Quality check is the most important process in condom manufacturing and maximum number of human resources are employed in this section
Output	▪ Quality check passed Condoms
Job role involved	Helpers

Step 11: Primary Packing

Input	▪ Quality check passed Condoms
Process description	▪ Packing is done through an auto feeding machine ▪ Before packing, condom is lubricated with silicone oils with / without fragrance ▪ They are then automatically packed individually in a foil packaging ▪ During packing, the foil and printing specification need to be appropriate as per standards
Output	▪ Condoms packed in foil
Job role involved	Packers

Equipments used

Automatic packing machine

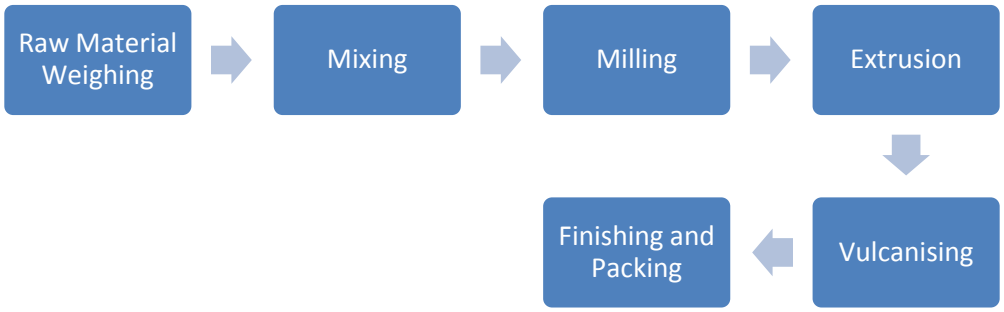
Step 12: Secondary Packing and dispatch

Input	▪ Condoms packed in a foil
Process description	▪ The condoms which are packed are then again packed in a small box ▪ Multiple pieces of condoms are packed in a box as per specification (example: 5 set pack) along with the details mentioned in the printed booklet ▪ These are then again packed in an assortment in a corrugated box for dispatch
Output	▪ Condoms packed in assortment for dispatch

Job role involved	Packers and Helpers

1.4 Extruded Rubber Goods manufacturing Process

Figure 9: Extruded Products manufacturing process



Step 1: Raw Material weighing and Mixing

Input	▪ Rubber : Natural Rubber/Synthetic Rubber ▪ Fillers such as China Clay, Crumb powder, Carbon black, etc. ▪ Process Oils ▪ Chemicals such as Stearic acid, Zinc Oxide, etc.

Process description	▪ Raw materials are procured from suppliers and are stored in the godown / storage place appropriately. Quality of the supplies are ensured by the certificates from supplier / internal testing
	▪ Raw materials are weighed according to the desired proportion and are kept ready for mixing
	▪ The Raw material are fed into the mixing mill machine (intermix machine/open mixing mill/kneader)
	▪ These raw material are put in the order (order of addition) as follows:
	  ▪ Mastication of Rubber (Natural and Synthetic)
	  ▪ Chemicals
	  ▪ Fillers (such as China clay, Crump, etc)
	  ▪ Process Oils
	▪ Rubber compound is formed after the mixing

Output	Output of this process will be in the form of uneven sized rubber sheets/ block of rubber compound
Job role involved	Mixing Supervisor, Mixing Operator, Helpers

Equipments Used

Kneader

Step 2: Milling

Input	▪ The sheet of rubber / block of rubber compound prepared from Mixing ▪ Curing agents such as Sulphur
Process description	▪ The compound is put into milling machine (open mixing mill) and is rolled to warm the compound ▪ Curing agents such as Sulphur is added in the milling process ▪ Measurement adjustor in the machine needs to be adjusted to get desired thickness in the sheet ▪ The sheets are cut into strips (for extrusion process) using knives
Output	Strips of rubber compound for extrusion process
Job role involved	Operators and helpers

Equipments Used

Milling machine (Open mixing mill)

Step 3: Extrusion

Input	▪ Strips of rubber compound made in the milling process
Process description	▪ Extrusion machine is made ready for operation by fixing appropriate die and maintaining adequate temperature ▪ The strips of rubber compound are inserted to the extrusion machine continuously ▪ The rubber pieces passes through the extruding machine and comes out through the die as a continuous strip (thread or rope like structure) ▪ The physical characteristics of the extruded rubber is as per the die fixed in the extruding machine ▪ Temperature of the machine and the size (width)of the tread extruded needs to be constantly monitored ▪ The rubber strip (as per the shape of die) coming out of the extruder is collected in a tray in such a way that it is not made to stick together ▪ Visual examination of the extruded rubber is done by the operator
Output	Extruded rubber collected from the extrusion machine
Job role involved	Extrusion Operator and Helper

Equipments Used

Extrusion machine

Step 4: Vulcanising

Input	▪ Extruded rubber for curing
Process description	▪ The extruded rubber is then placed into the vulcaniser for curing process ▪ Appropriate specification such as temperature, time, etc are set in the vulcaniser ▪ The vulcanized rubber product is then removed from the vulcaniser after the specified time and is allowed to cool at room atmosphere
Output	Vulcanised extruded rubber product
Job role involved	Operators and helpers

Equipments Used

Vulcaniser

Note: There are also now moving oven machine available for vulcanising process. The extruded rubber compound directly passes through the moving oven for vulcanization purpose. This is advancement in the curing process of extruded rubber products.

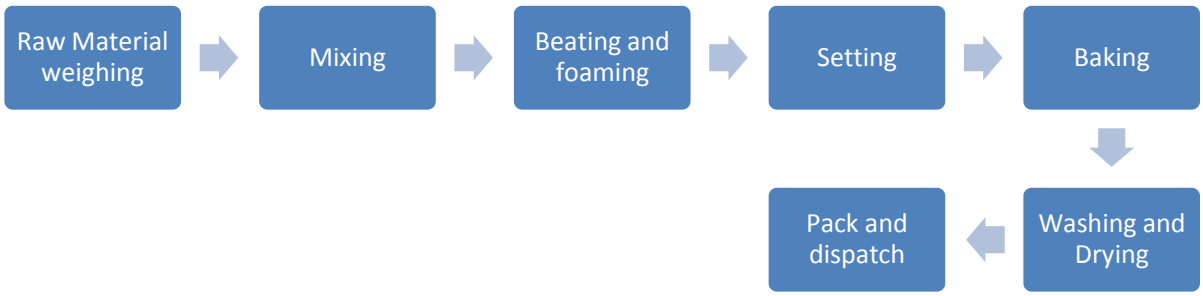
Step 5: Finishing and Packing

Input	▪ Vulcanised extruded rubber product
Process description	▪ Vulcanised product is then taken for finishing process ▪ Appropriate finishing process such applying paint, cutting the extruded product according to length requirement, applying silicon oil for glazing, sticking labels on the product, etc. are performed as per requirement ▪ Product is then packed according to assortment specifications ▪ Dispatch of products is done as per deliver order
Output	Finished extruded rubber product
Job role involved	Finishing Supervisor and helper

Note: The above process is applicable for the manufacturing of products such Cables, surgical and pharmaceutical and Rubber tubings. The difference arises only in the compounding formulation and the parameters set for the product finishing.

1.5 Foam Products - Latex foam manufacturing process

Figure 10: Latex foam manufacturing process



Step 1: Raw material weighing and mixing

Input	▪ Latex ▪ Accelerators such as ZDC, ZMBT, etc ▪ Activators such as Zinc Oxide ▪ Other chemicals
Process description	▪ Raw materials are tested for quality standards. ▪ Raw materials are weighed according to the desired proportion and are kept ready for mixing ▪ The Raw material are fed into the ball milling machine (It can contain of porcelain balls / pebble balls / pearl balls) ▪ The water insoluble dry powdered chemicals are mixed in the ball milling machine to form the dispersion ▪ The liquid additives water insoluble agents are made into emulsions using a stirrer ▪ The water soluble ingredients are then made to a solution using a stirrer ▪ Then the latex, dispersion, emulsion and solution are mixed in the desired proportion to form the compound ▪ Alternatively, the compound can also be procured from outside
Output	Output of this process will be the latex compound
Job role involved	Compounding Operator

Equipments Used

Compound Mixer

Note: Compounding for foam is carried out in three stages. In the first stage the latex is compounded with sulphur, a small part of the zinc oxide and soap solution, accelerator and antioxidant and then allowed to mature for a day or two. The maturation process is optional.

Step 2: Beating and foaming

Input	▪ Latex compound ▪ Foaming agent
Process description	▪ The latex compound which is prepared is taken for foaming process ▪ Latex compound and foaming agents are dumped in the beater ▪ This mixture is beat in the beater for about 15-20 minutes till it foams ▪ The foaming process takes place by blowing air below the surface of the latex (by beater) ▪ The final stage of beating is done at a slower speed allowing the foam to get refined
Output	Output of this process will be in the form of foamed latex
Job role involved	Supervisor, Operator, Helpers

Equipments Used

Note: The remaining quantity of soap is added just before beating. The remaining quantity of zinc oxide and the gelling agents and foam stabilizer are added when the desired level of expansion and refinement of foam has taken place.

Step 3: Setting / Gelling

Input	▪ Foamed latex ▪ Gelling agent such as sodium silicofluoride and secondary gelling agent Like zinc oxide, foam stabilizer etc.
Process description	▪ A gelling agent is added to the foamed latex to thicken the compound ▪ After adding the gelling agents, the latex foam needs to be quickly transferred to the mould ▪ The mould is prepared before the gelled foam is transferred. This usually entails cleaning of the moulds. ▪ The time required for gelling of the foam is critical. If it is delayed too long, foam may collapse. If it is too fast, solidification might start before it is transferred to the mould and hence affecting the shape of the product. Hence, the foam, after adding the gelling agent, should be transferred to the mould as soon as possible ▪ Some lubricants like silicones are applied in the mould prior to the contents are

	poured into it. This is done for easy removal of product from the mould after baking
Output	Foamed latex in mould with gelling agents
Job role involved	Supervisor, Setting operators, Helpers

Step 4: Baking

Input	▪ Solidified foam in the moulds
Process description	▪ In the moulds, cylindrical cores are attached to the lids of the mould to give a "honey comb" appearance to the underside of the moulded foam ▪ This is done to ensure adequate curing (baking) in the centre of the foam and also distributes shrinkage ▪ The mould, with the aid of lever system, is transferred into an oven ▪ For about 30 minutes (on an average) the mould is baked inside the oven at around 100 degree Celsius (general specification) ▪ The mould is removed from the oven after the baking is done
Output	Baked latex foam
Job role involved	Supervisor, Baking operator, Helpers

Step 6: Washing and Drying

Input	▪ Cured foam product
Process description	▪ After stripping the foam from the mould, flashes are trimmed ▪ The foam is then washed in water and passed through squeeze rollers to remove water and any residuals ▪ The foam is dried in an oven at around 60 to 70 degrees Celsius which allows good air circulation
Output	Finished latex foam product
Job role involved	Operator, Helpers

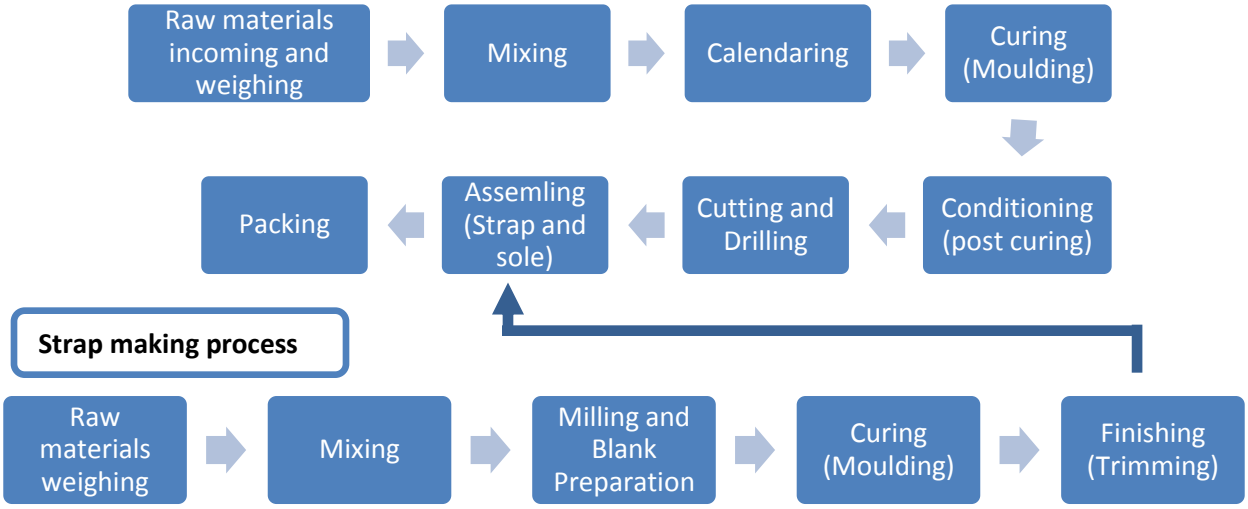
Step 7: Pack and dispatch

Input	▪ Finished latex foam product

Process description	▪ The final product is checked visually ▪ The product is provided with a cloth wrapping to protect the foam and to improve its appearance. This is usually done by a tailoring process. ▪ The product is packed in bundles based on customer's requirements and stored in the godown/storage area ▪ Finished products are dispatched to the customers
Output	Foam latex product ready for usage
Job role involved	Supervisor and Helpers

1.6 Footwear Manufacturing Process

Figure 11: Hawai chappal manufacturing process



- **Hawai Chappals**

Step 1: Raw material weighing and mixing

Input	▪ Rubber : Natural Rubber and Synthetic Rubber ▪ Fillers such as china clay, silica, crumb powder, etc. ▪ Process oils ▪ Accelerators, activators and antioxinants ▪ Blowing agents ▪ Vulcanising agent like sulphur	**Equipments used** Kneader
Process	▪ Raw materials are procured from suppliers and are stored	

description	in the godown / storage place appropriately. Quality of the supplies are ensured by the certificates from supplier / internal testing ▪ The raw materials are fed into the kneader in a predefined sequence where mastication and mixing of rubber take place
Output	Output is in the form of dough / block of rubber compound
Job role involved	Mixing Supervisor, operator, helper

Step 2: Milling and Calendaring

Input	▪ Dough from the kneader ▪ Curing agents such as Sulphur
Process description	▪ The dough and the curing agent (sulphur) are mixed in the mixing mill to complete the mixing process and to convert them into a sheet form ▪ The temperature in the mixing mill needs to be monitored and to be controlled as per specification. The quality of rubber compound may suffer if any of these parameters are not as per the required specification ▪ Thickness of the rubber sheet should be as per the requirement ▪ Then these sheets are put in the calendaring machine to get the sheets in the desired thickness and without air bubbles and defects. ▪ In case of double coloured soles (top and bottom), this process is important. In the upper layer of the calendaring machine, the top sole's compound is fed and in the lower layer of the machine, bottom sole's compound is fed. ▪ These two compounds are made into thin sheets and are then fixed into a single sheet (sole of chappal) through this calendaring process
Output	Calendared rubber sheets for curing process
Job role involved	Mixing mill operator, Calendar Operator and helper

Equipments used

Mixing mill

Step 3: Blank Preparation and Curing (Moulding)

Input	▪ Rubber Compound sheet
Process description	*Blank preparation* ▪ The long rubber sheets (from calendaring) are cut into specific size *Moulding* ▪ Appropriate moulds are taken and prepared for moulding process ▪ The mould is then fixed in the hydraulic press ▪ Dilute silicone solution is sprayed in the moulds before curing to ensure that compound do not stick to the moulds ▪ These sheets are then placed into the moulds of hydraulic press for pressing ▪ The curing process takes place here with the specified curing time, temperature and pressure ▪ The rubber compound sheet is then removed from the moulds after the curing time and are allowed to cool at room temperature
Output	Rubber sheet used for making soles of chappal
Job role involved	Moulding Press Operator, Helper

Equipments used

Hydraulic press

Step 4: Conditioning (Post- curing) and testing

Input	Cured rubber sole sheet

Process description	▪ Testing will done after the curing process to ensure the following:
	  ▪ The sheet is cured as per the specifications
	  ▪ There are no bubbles on the rubber sheet
	  ▪ There are no spots in the rubber sheet
	  ▪ Physical test (Tensile test, Elongation test, etc)
	▪ The rubber sheets are then stored / kept in the room temperature for around 10 – 12 days before further processing
	▪ The cured rubber sheets usually shrink after curing process. Keeping them for 10 to 12 days allows for adequate shrinking and no further shrinking will take place.

Output	Post-cured and tested sole rubber sheet
Job role involved	Quality Supervisor, Helper

Step 5: Cutting and drilling

Input	▪ Post-cured and tested rubber sheet ▪ Dies as per the size of the sole ▪ Cutting presses
Process description	▪ Soles are cut from the sheet with the help of a cutting machine ▪ After cutting, holes are drilled in the appropriate position in the sole of the chappal
Output	Soles for chappals
Job role involved	Finishing Supervisor and Operator

Step 6: Assembling (Sole and strap)

Input	▪ Soles after cutting and drilling ▪ Straps from the strap making section
Process description	▪ The straps are fitted into the sole of the slipper using a machine ▪ The stickers and tags are fixed in the chappals ▪ The chappals are then stacked in racks according to size, style, model number, etc.
Output	Finished Chappal
Job role involved	Finishing Operator

Step 7: Packing

Input	Finished Chappals
Process description	▪ The chappals are first packed in a small carton box ▪ Appropriate labels (with color, size, price, etc) are stuck into the box ▪ Then these small boxes are then assorted and put into a large corrugated box as per assortment (The assortment will have mix of size and different models and the operator needs to pack accordingly)
Output	Packed chappals ready for dispatch
Job role involved	Helper

Note: The process of making micro cellular sheet is similar to the process of making sole sheets for the chappals.

- **Strap making process**

Step 1: Raw materials weighing and mixing

Input	▪ Rubber: Natural Rubber ▪ Fillers such as china clay, precipitated calcium carbonate and silica ▪ Process oils ▪ Activators and Anti oxidants ▪ Pigments and colours

Process description	▪ Raw materials are weighed according to the desired proportion and are kept ready for mixing
	▪ The raw material are fed into the mixing mill machine (intermix machine/open mixing mill/kneader)
	▪ The following raw material are put in the machine for mixing:
	  ▪ Rubber (Natural and/or Synthetic)
	  ▪ Chemicals
	  ▪ Fillers
	  ▪ Oils
	▪ Rubber compound is formed

Output	Output of this process will be in the form of uneven sized rubber sheets/ block of rubber compound
Job role involved	Mixing Supervisor, Operator, Helper

Equipment used

Kneader

Step 2: Milling and Blank preparation

Input	▪ Uneven sized rubber sheets /block of rubber compound (dough) ▪ Vulcanising agents such as sulphur and accelerators ▪ Strap moulds

Equipments used

Open mixing mill

Process description	*Milling* ▪ The dough/sheets from the above process and the accelerators are mixed in the mixing mill to convert them in a sheet form/ to warm them up. ▪ The temperature in the mixing mill needs to be monitored and to be controlled as per specification. The quality of rubber compound may suffer if any of these parameters are not as per the required specification. *Blank preparation* ▪ The long rubber sheets (from milling) are cut into specific size *Mould preparation* ▪ Moulds used for making straps are procured from outside and they are then fixed in the hydraulic press for the moulding process ▪ Dilute silicone solution is sprayed in the moulds before curing to ensure that compound do not stick to the moulds
Output	Pieces of rubber compound sheet and moulds
Job role involved	Mixing Mill Operator and Helper

Step 3: Curing (Moulding)

Input	▪ Pieces of rubber compound sheet ▪ Moulds (which converts the rubber compound to strap shape)
Process description	▪ Pieces of rubber compound sheets are placed in the moulds kept in the hydraulic press ▪ Control charts are used by the operator to set the curing time (parameters considered – temperature, pressure and input weight) in the machine ▪ Curing process takes place in the machine and also the compound gets the form of the mould in this process ▪ The cured straps are then removed from the moulds after the curing time
Output	Cured, unfinished rubber straps
Job role involved	Moulding Operator, Helper

Equipments used

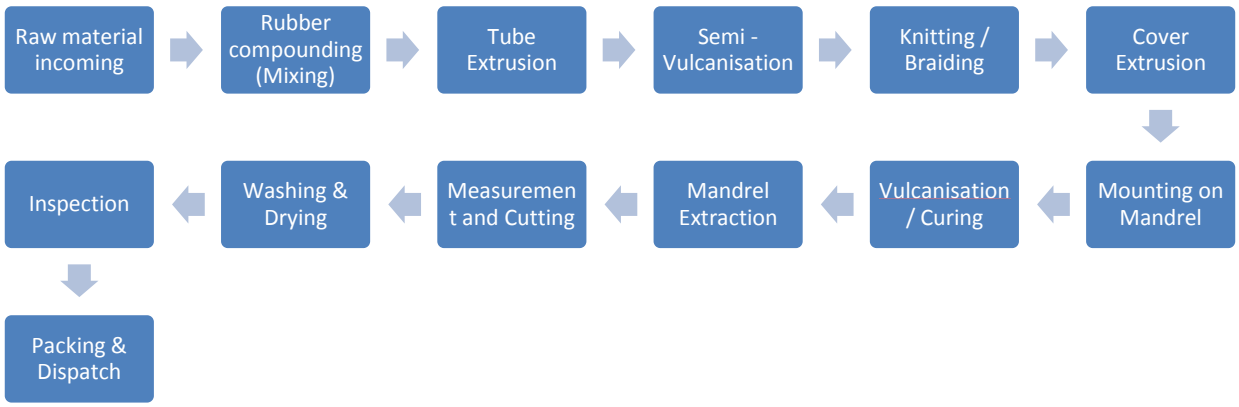
Hydraulic press

Step 4: Finishing (Trimming)

Input	Cured, unfinished rubber straps
Process description	▪ The cured rubber straps will have additional flashes which needs to be removed ▪ These are trimmed using scissors / knives and are removed ▪ A visual examination of the strap is done checking for any physical flaws ▪ The straps are then taken to finishing section
Output	Finished Straps
Job role involved	Helpers

1.7 Hoses Manufacturing Process

Figure 12: Manufacturing process of Braided / Knitted Hoses (Smooth finished)



Step 1: Raw materials weighing and mixing

Input	▪ Rubber : Natural and Synthetic Rubber ▪ Fillers ▪ Accelerators and Accelerators ▪ Process oils ▪ Curing agents such as Sulphur	**Equipments Used** Kneader
Process description	▪ Raw materials are procured from suppliers and are stored in the godown / storage place appropriately ▪ Quality of the raw materials are ensured by the testing	

	certificates obtained by the supplier or through internal testing procedures ▪ Various raw materials are weighed according to formulation and are prepared as a batch for mixing process ▪ The raw materials are fed in the milling machine (kneader / open mixing mill) in a predefined sequence where mastication of rubber takes place ▪ The above chemicals are masticated in the mixing mill to form sheets ▪ Quality checks such as rheometric properties testing is done on the compound prepared
Output	Rubber compound in the form of sheets
Job role involved	Mixing mill operator and Helper

Milling machine

Step 2: Extrusion (inner tube)

Input	▪ Rubber sheets from the milling process
Process description	▪ Extrusion machine is made ready for operation by fixing appropriate die and maintaining adequate temperature ▪ The rubber compound in the mill is cut into strips for extrusion purpose ▪ This strips of rubber compound passes through the extruding machine and comes out in a tube form ▪ The physical characteristics of the extruded rubber is as per the die fixed in the extruding machine ▪ Temperature of the machine needs to be constantly monitored to prevent compound from getting cured ▪ This extruded product forms the inner tube of the hose
Output	Extruded rubber collected from the extrusion machine
Job role involved	Extrusion Operator and Helper

Equipments Used

Extrusion machine

Step 3: Vulcanisation of inner tube

Input	▪ Inner tube from the extrusion process

Process description	▪ The inner tube is then sent for curing process ▪ The Inner tube of hose is vulcanised under steam pressure for three to four hours in vulcanising chamber
Output	▪ Vulcanised inner tube
Job role involved	Vulcanising Operator

Step 4: Braiding

Input	▪ Inner tube from the extrusion process ▪ Yarn
Process description	▪ The inner tube is passed through the braiding machine where it is reinforced with yarn ▪ This yarn forms the outer cover for the inner tube and provides strength for the hose
Output	▪ Braided inner tube
Job role involved	Braiding machine operator

Equipments used

Braiding machine

Step 5: Cementing

Input	▪ Braided inner tube ▪ cementing solution
Process description	▪ The braided inner tube is passed through a cementing solution which increases the tube's strength
Output	▪ Cemented inner tube
Job role involved	Helper

Step 6: Drying in steam chamber

Input	▪ Cemented inner tube
Process description	▪ The compounded tube is dried in the steam chamber for three to four hours ▪ This process id done to dry the cementing solution
Output	▪ Finished inner tube

Job role involved	Operator and Helper

Step 7: Extrusion (outer tube)

Input	▪ Finished inner tube (with braiding) ▪ Rubber compound
Process description	▪ The dried inner tube is again passed through the extruder to cover it with an outer layer of rubber compound ▪ The rubber compound is fed into the extruder which forms the outer cover of the rubber hose ▪ Parameters such as temperature, time and pressure needs to be monitored and ensure that they are as per the specification
Output	▪ Rubber hose (With uncured outer cover)
Job role involved	Extruder operator and helper

Equipments used

Extrusion machine

Step 8: Mounting on Mandrel

Input	▪ Rubber hose (With uncured outer cover)
Process description	▪ The uncured hose (green hose) is cut as per the required length and is mounted on the mandrel
Output	▪ Wrapped hose
Job role involved	Operator and Helper

Step 9: Vulcanisation / Curing

Input	▪ Wrapped hose
Process description	▪ The hose in the mandrel is put in the vulcaniser chamber for certain period as per the specification ▪ Parameters such as pressure, temperature and curing time needs to be set appropriately in the vulcanising chamber
Output	▪ Cured hose
Job role	Vulcanising operator

involved	

Step 10: Demandrelling and Quality Check

Input	▪ Cured hose
Process description	▪ The cured tubes are dismantled from the mandrels ▪ The hose is then cut as per the measurement mentioned in the specification of the product ▪ Quality checks such as dimension, hardness test, etc. are performed on the finished hose
Output	▪ Finished hose
Job role involved	Operator

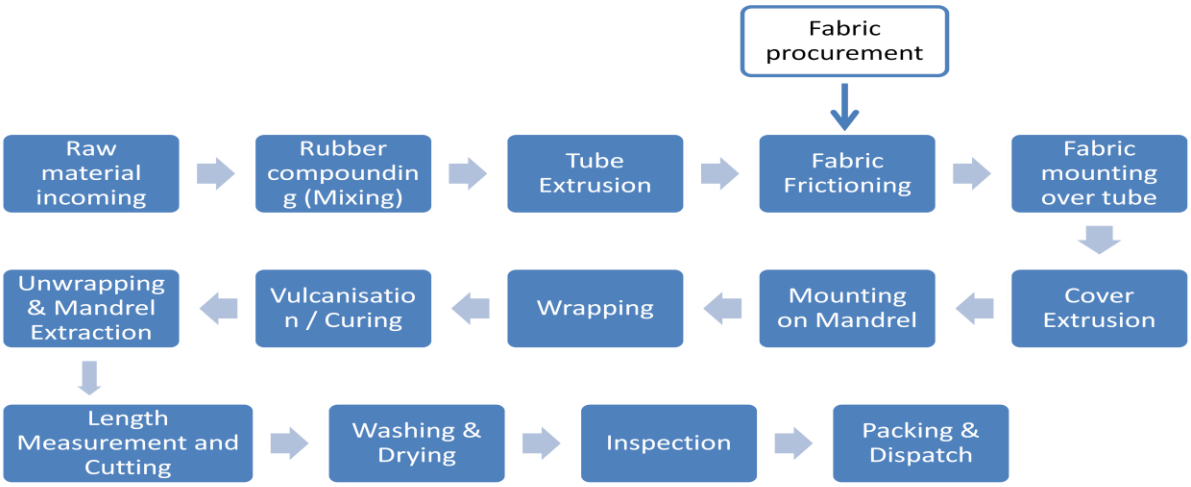
Step 11: Cutting and Packing

Input	▪ Finished hose
Process description	▪ The inspected product is then measured, cut and packed as per customer's requirement
Output	▪ Packing
Job role involved	Supervisor and helper

Note: The above mentioned manufacturing process is widely followed by most of small and medium sized players. However, there have been technological advancement and continuous manufacturing of hoses are available. It involves extrusion of inner tube, then curing in a continuous oven, braiding, extrusion of outer tube, continuous oven curing and finishing. This process follows similar to an assembly / moving process and this reduces time and human intervention to a good extent.

Also, the manufacturing of fuel hose is similar to braided / knitted hose manufacturing process.

Figure 13: Manufacturing process of Radiator Hoses (Wrapped)



Step 1: Raw materials weighing and mixing

Input	▪ Rubber : Natural and Synthetic Rubber ▪ Fillers ▪ Accelerators and Accelerators ▪ Process oils ▪ Curing agents such as Sulphur
Process description	▪ Raw materials are procured from suppliers and are stored in the godown / storage place appropriately ▪ Quality of the raw materials are ensured by the testing certificates obtained by the supplier or through internal testing procedures ▪ Various raw materials are weighed according to formulation and are prepared as a batch for mixing process ▪ The raw materials are fed in the milling machine (kneader / open mixing mill) in a predefined sequence where mastication of rubber takes place ▪ The above chemicals are masticated in the mixing mill to form sheets ▪ Quality checks such as rheometric properties testing is done on the compound prepared
Output	Rubber compound in the form of sheets
Job role involved	Mixing mill operator and Helper

Equipments Used

Kneader

Milling machine

Step 2: Extrusion (inner tube)

Input	▪ Rubber sheets from the milling process	**Equipments Used** *Extrusion machine* 
Process description	▪ Extrusion machine is made ready for operation by fixing appropriate die and maintaining adequate temperature ▪ The rubber compound in the mill is cut into strips for extrusion purpose ▪ This strips of rubber compound passes through the extruding machine and comes out in a tube form ▪ The physical characteristics of the extruded rubber is as per the die fixed in the extruding machine ▪ Temperature of the machine needs to be constantly monitored to prevent compound from getting cured ▪ This extruded product forms the inner tube of the hose	
Output	Extruded rubber collected from the extrusion machine	
Job role involved	Extrusion Operator and Helper	

Step 3: Frictioning of Fabric

Input	▪ Rubber compound from mixing ▪ Fabric	**Equipments Used** *Calendaring machine* 
Process description	▪ A rubbersied fabric would cover the outer part of the hose ▪ To prepare this outer cover, rubber compound from mixing and a fabric is taken to the calendaring section ▪ Rubber is coated into the fabric (on both weft and warp) on both sides and frictioning process takes place ▪ This frictioned fabric is then coated to the extruded tube	
Output	▪ Rubberised fabric	
Job role involved	Calendaring Operator	

Step 4: Fabric mounting over tube

Input	▪ Extruded tube ▪ Frictioned fabric

Process description	▪ The frictioned fabric is then coated / mounted over the extruded tube (inner tube) ▪ The mounting has to be proper in a way that they are adequately bond and of same size
Output	▪ Tube mounted with fabric
Job role involved	Calendaring Operator and Helper

Step 5: Cover extrusion (outer tube)

Input	▪ Fabric mounted inner tube ▪ Rubber compound
Process description	▪ The fabric mounted tube is again passed through the extruder to cover it with an outer layer of rubber compound ▪ The rubber compound is fed into the extruder which forms the outer cover of the rubber hose ▪ Parameters such as temperature, time and pressure needs to be monitored and ensure that they are as per the specification
Output	▪ Rubber hose (With uncured outer cover)
Job role involved	Extruder operator and helper

Equipments used

Extrusion machine

Step 6: Mounting on Mandrel and Wrapping

Input	▪ Rubber hose (With uncured outer cover)
Process description	▪ The uncured hose (green hose) is cut as per the required length and is mounted on the mandrel ▪ The hose is put through the wrapping machine where cotton cloth is wrapped

	around the hose ▪ This is done to improve the quality of the hose and it is as per customer specification
Output	▪ Wrapped hose
Job role involved	Operator and Helper

Step 9: Vulcanisation / Curing

Input	▪ Wrapped hose
Process description	▪ The wrapped hose is put in the vulcaniser chamber for certain period as per the specification ▪ Parameters such as pressure, temperature and curing time needs to be set appropriately in the vulcanising chamber
Output	▪ Cured hose
Job role involved	Vulcanising operator

Step 10: Unwrapping & Demandrelling

Input	▪ Cured hose
Process description	▪ The wrapped cloth is then removed after the curing process ▪ The cured tubes are dismantled from the mandrels
Output	▪ Finished hose
Job role involved	Operator

Step 10: Cutting and Washing & Drying

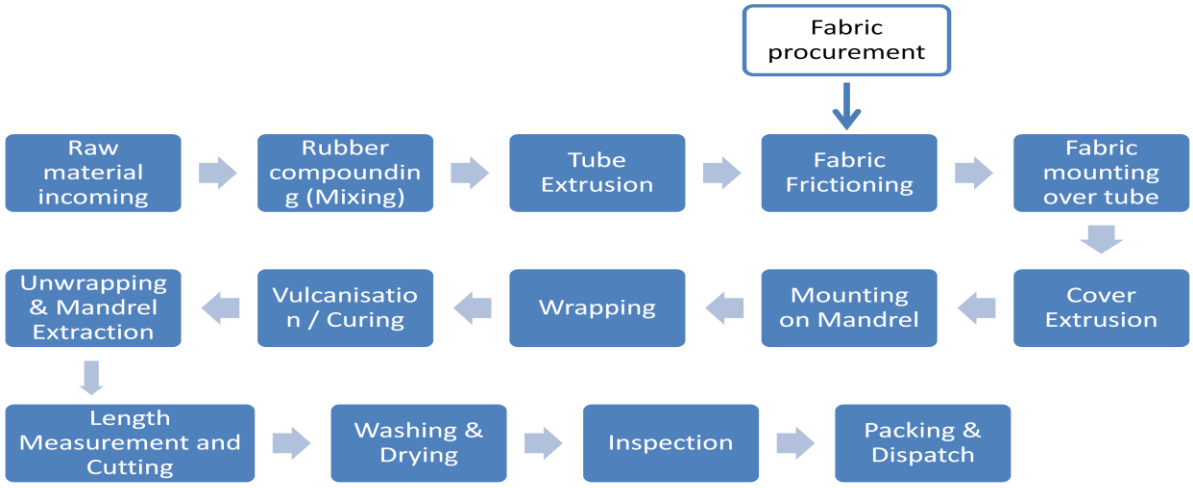
Input	▪ Cured hose
Process description	▪ The inspected product is then measured and cut as per customer requirement and specification ▪ These hoses are then washed and dried
Output	▪ Finished hose

Job role involved	Operator

Step 11: Inspection and Packing

Input	▪ Finished hose
Process description	▪ Quality checks such as dimension, hardness test, etc. are performed on the finished hose ▪ The inspected product is then packed and dispatched as per customer's requirement
Output	▪ Packing
Job role involved	Quality in-charge, inspection operator, Finishing supervisor and helper

Figure 14: Manufacturing process of Radiator Hoses (Wrapped)



Step 1: Raw materials weighing and mixing

Input	▪ Rubber : Natural and Synthetic Rubber ▪ Fillers ▪ Accelerators and Accelerators ▪ Process oils ▪ Curing agents such as Sulphur	**Equipments Used** Kneader

Process description	▪ Raw materials are procured from suppliers and are stored in the godown / storage place appropriately ▪ Quality of the raw materials are ensured by the testing certificates obtained by the supplier or through internal testing procedures ▪ Various raw materials are weighed according to formulation and are prepared as a batch for mixing process ▪ The raw materials are fed in the milling machine (kneader / open mixing mill) in a predefined sequence where mastication of rubber takes place ▪ The above chemicals are masticated in the mixing mill to form sheets ▪ Quality checks such as rheometric properties testing is done on the compound prepared
Output	Rubber compound in the form of sheets
Job role involved	Mixing mill operator and Helper

Milling machine

Step 2: Extrusion (inner tube)

Input	▪ Rubber sheets from the milling process
Process description	▪ Extrusion machine is made ready for operation by fixing appropriate die and maintaining adequate temperature ▪ The rubber compound in the mill is cut into strips for extrusion purpose ▪ This strips of rubber compound passes through the extruding machine and comes out in a tube form ▪ The physical characteristics of the extruded rubber is as per the die fixed in the extruding machine ▪ Temperature of the machine needs to be constantly monitored to prevent compound from getting cured ▪ This extruded product forms the inner tube of the hose
Output	Extruded rubber collected from the extrusion machine
Job role involved	Extrusion Operator and Helper

Equipments Used

Extrusion machine

Step 3: Frictioning of Fabric

Input	▪ Rubber compound from mixing ▪ Fabric
Process description	▪ A rubbersied fabric would cover the outer part of the hose ▪ To prepare this outer cover, rubber compound from mixing and a fabric is taken to the calendaring section ▪ Rubber is coated into the fabric (on both weft and warp) on both sides and frictioning process takes place ▪ This frictioned fabric is then coated to the extruded tube
Output	▪ Rubberised fabric
Job role involved	Calendaring Operator

Equipments Used

Calendaring machine

Step 4: Fabric mounting over tube

Input	▪ Extruded tube ▪ Frictioned fabric
Process description	▪ The frictioned fabric is then coated / mounted over the extruded tube (inner tube) ▪ The mounting has to be proper in a way that they are adequately bond and of same size
Output	▪ Tube mounted with fabric
Job role involved	Calendaring Operator and Helper

Step 5: Cover extrusion (outer tube)

Input	▪ Fabric mounted inner tube ▪ Rubber compound
Process description	▪ The fabric mounted tube is again passed through the extruder to cover it with an outer layer of rubber compound ▪ The rubber compound is fed into the extruder which forms the outer cover of the rubber hose ▪ Parameters such as temperature, time and pressure needs to be monitored and ensure that they are as per the specification
Output	▪ Rubber hose (With uncured outer cover)

Equipments used

Extrusion machine

Job role involved	Extruder operator and helper

Step 6: Mounting on Mandrel and Wrapping

Input	▪ Rubber hose (With uncured outer cover)
Process description	▪ The uncured hose (green hose) is cut as per the required length and is mounted on the mandrel ▪ The hose is put through the wrapping machine where cotton cloth is wrapped around the hose ▪ This is done to improve the quality of the hose and it is as per customer specification
Output	▪ Wrapped hose
Job role involved	Operator and Helper

Step 9: Vulcanisation / Curing

Input	▪ Wrapped hose
Process description	▪ The wrapped hose is put in the vulcaniser chamber for certain period as per the specification ▪ Parameters such as pressure, temperature and curing time needs to be set appropriately in the vulcanising chamber
Output	▪ Cured hose
Job role involved	Vulcanising operator

Step 10: Unwrapping & Demandrelling

Input	▪ Cured hose
Process description	▪ The wrapped cloth is then removed after the curing process ▪ The cured tubes are dismantled from the mandrels
Output	▪ Finished hose
Job role	Operator

involved	

Step 10: Cutting and Washing & Drying

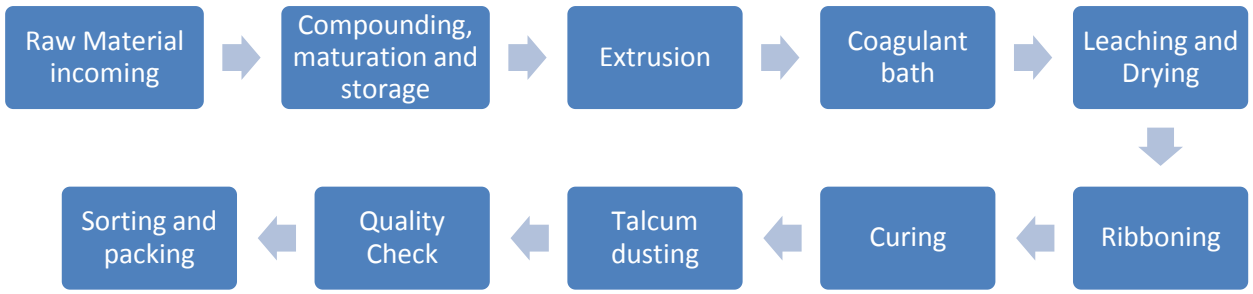
Input	▪ Cured hose
Process description	▪ The inspected product is then measured and cut as per customer requirement and specification ▪ These hoses are then washed and dried
Output	▪ Finished hose
Job role involved	Operator

Step 11: Inspection and Packing

Input	▪ Finished hose
Process description	▪ Quality checks such as dimension, hardness test, etc. are performed on the finished hose ▪ The inspected product is then packed and dispatched as per customer's requirement
Output	▪ Packing
Job role involved	Quality in-charge, inspection operator, Finishing supervisor and helper

1.8 Latex thread – Manufacturing Process

Figure 15: Manufacturing process of latex thread



Step 1: Raw material incoming and ingredient preparation

Input	▪ Latex ▪ Raw materials for dispersion / emulsion / solution
Process description	▪ Raw materials are tested for quality standards. ▪ Raw materials are weighed according to the desired proportion and are kept ready for mixing ▪ The Raw material are fed into the ball milling machine (It can contain of porcelain balls / pebble balls / pearl balls) ▪ The water insoluble dry powdered chemicals are mixed in the ball milling machine to form the dispersion ▪ The liquid additives water insoluble agents are made into emulsions using a stirrer ▪ The water soluble ingredients are then made to a solution using a stirrer
Output	Output of this process will be ingredients of compounding
Job role involved	Compounding Operator

Equipments Used

Compound Mixer

Step 2: Compounding maturation and storage

Input	▪ Latex ▪ Stabilizing agents like potassium hydroxide ▪ Vulcanizing agent like sulphur ▪ Accelerator and activator like ZDC, ZMBT and Zinc Oxide ▪ Antioxidant like phenol compounds ▪ Dispersion / emulsion / solution prepared

Process description	▪ The latex is de-ammoniated to reduce the ammonia percentage ▪ This is transferred to the compounding tank which is fitted with mechanical stirrer ▪ Then, the latex is compounded by adding pre-determined quantities of the ingredients ▪ This compound is made to mature for certain period of time ▪ They are then transferred to a constant head tank (In the constant head tank, the latex quantity is always constant to ensure equal force of latex outgoing for the extrusion process)
Output	Compounded latex
Job role involved	Supervisor, Compounding operator, Helpers

Step 3: Extrusion

Input	▪ Compounded latex in the constant head tank
Process description	▪ The latex compound is then passed for extrusion process from constant head tank (through gravitational force) ▪ The latex compound is passed through an extruding head which distributes the compound into capillaries through flexible tubes
Output	Extruded rubber compound (in liquid thread form in capillaries)
Job role involved	Operators and Helpers

Step 4: Coagulant bath and Leaching

Input	▪ Extruded latex thread ▪ Coagulant solution
Process description	▪ Coagulant solution is prepared as per the specification and transferred to the coagulant chamber ▪ The latex thread is given a coagulant bath with acetic acid solution ▪ This is then transferred to hot water bath at a temperature of around 70 degrees centigrade
Output	Coagulated and washed latex thread
Job role involved	Operators, Helpers

Step 5: Drying and Ribboning

Input	▪ Coagulated and washed latex thread
Process description	▪ The latex thread then passes through a drying chamber and the moisture is removed ▪ The individual threads then passes through a ribboning roller to form the threads in a ribbon form
Output	Uncured latex thread in ribbon form
Job role involved	Operator, Helpers

Step 6: Curing

Input	▪ Uncured latex thread in ribbon form
Process description	▪ The latex thread is then cured in oven chamber at about 90-95 degrees centigrade ▪ This is usually done by the thread moving on a canvas belt system inside the chamber
Output	Cured latex thread
Job role involved	Supervisor, Curing Oven Operator, Helpers

Step 7: Talcum dusting and Winding

Input	▪ Cured latex thread
Process description	▪ The latex thread is then dusted with talc ▪ The talc dusted thread is wound into bobbins.
Output	Latex thread
Job role involved	Supervisor and Helpers

Step 8: Quality check

Input	▪ Final latex thread

Process description	▪ The final latex thread is tested across various property parameters like count, tensile strength, elongation at break, etc ▪ In addition to the property parameters, the defects like blobbing, bright spots are checked
Output	Quality check passed latex thread
Job role involved	Supervisor and Helpers

Step 9: Sorting and packing

Input	▪ Quality check passed latex thread
Process description	▪ The final product is checked visually ▪ They are packed in bundles based on customer's requirements and stored ▪ Finished products are dispatched to the customers
Output	Latex thread package ready for dispatch
Job role involved	Supervisor and Helpers

1.9 Leather board

Figure 16: Manufacturing process of leather board

Step 1: Raw Material incoming, weighing and beating

Input	▪ Raw materials are procured from suppliers and are stored in the godown / storage place appropriately. Quality of the supplies are ensured by the certificates from supplier / internal testing ▪ The primary raw material used is leather which is brought from tanneries
Process description	▪ Raw materials are weighed according to the desired proportion and are kept ready for beating ▪ Leather and other chemicals are fed into the beating machine ▪ The beating machine transforms the above raw material in the form of pulp
Output	Output of this process will be in the form of pulp
Job role involved	Supervisor and Beating machine operator

Step 2: Moulding

Input	▪ The pulp prepared through beating process ▪ Latex
Process description	▪ The leather pulp is put into a mould ▪ Latex and other chemicals are added into this mould as per the specification ▪ The moulding machine sucks the liquid out of the compound by applying a vacuum force
Output	Solid form of the compound

Job role involved	Supervisor and moulding machine operator

Step 3: Curing

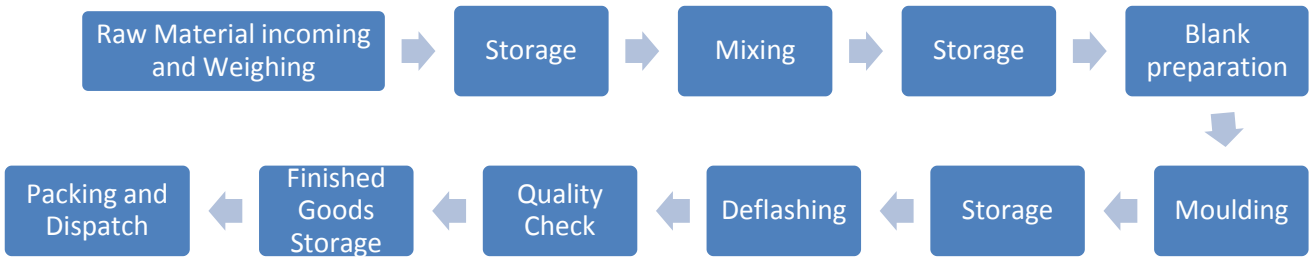
Input	▪ Leather board compound from moulding process
Process description	▪ The leather board compound is cured in hydraulic press ▪ The process of curing takes place as per the specified duration and temperature ▪ The cured finished product is kept under the sunlight for certain period of time
Output	Leather board
Job role involved	Supervisor and hydraulic press operator

Step 4: Packing and Dispatch

Input	Leather board
Process description	▪ The leather board is cut as per the required size and are packed in bags
Output	Packed finished product.
Job role involved	Supervisor and helper

1.10 Moulded Rubber Products Manufacturing Process

Figure 17: Manufacturing process of moulded rubber product



Step 1: Raw Material incoming, weighing and mixing (Master batch preparation)

Input	▪ Raw materials are procured from suppliers and are stored in the godown / storage place appropriately. Quality of the supplies are ensured by the certificates from supplier / internal testing ▪ Rubber (Natural and/or Synthetic) and Chemicals (Zinc Oxide, Stearic Acid, etc) are used. There are around 30-40 different chemicals that are being used on a need basis. ▪ Fillers (Carbon, Calcium Carbonate, Clay, Silica, etc) are used to provide hardness ▪ Oils (Aromatic types, Naphthenic types) are used to improve the dispersion of filers and flow characteristics of compound during processing ▪ Tolerance level (E.g. +/- of 2 grams for chemicals and +/- of 20 grams for rubber, filler and oil) is considered while quantifying the inputs for mixing.

Process description	▪ Raw materials are weighed according to the desired proportion and are kept ready for mixing
	▪ The Raw material are fed into the mixing mill machine (intermix machine/open mixing mill/kneader)
	▪ The following raw material are used for mixing:
	  ▪ Mastication of Rubber (Natural and/or Synthetic)
	  ▪ Chemicals
	  ▪ Fillers
	  ▪ Oils
	▪ Master batch (Compound) is prepared
	▪ This is stored for approximately 16 hours before final batch preparation

Equipments Used

Kneader

Output	Output of this process will be in the form of uneven sized rubber sheets/ block of rubber compound
Job role involved	Lab In charge, Mixing Supervisor, Mill man, Helpers

Step 2: Mixing (Final Batch Preparation) and Storage

Input	▪ The sheet of rubber / block of rubber compound prepared through mixing process ▪ Curing agents
Process description	▪ The compound is put into milling machine (with rollers) and are rolled to get desired thickness ▪ Curing agents such as sulphur is added during this process ▪ Nip adjustor in the machine needs to be adjusted to get desired thickness in the sheet ▪ Samples of rubber are tested in lab for hardness, specific gravity, rheological properties, aging test, special test based on customer's requirement (ozone testing, cold resistance test, etc) ▪ In case of rejections during the lab test, the batch is sent for rework i.e, for correcting the chemical composition in milling machine ▪ The final batch compound is then stored
Output	Rubber Compound (Final batch)
Job role involved	Mixing Supervisor, Mill Man, Lab In charge
*Other equipments used for testing includes Low temperature test chamber, Electronic tensile testing machine, Mooney viscometer, Melting point apparatus, Compression set apparatus, etc	

Equipments Used*

Milling Machine

Oscillating disc Rheometer

Air and oil aging oven

Step 3: Blank preparation

Input	▪ Rubber sheets from mixing process
Process description	▪ The sheets from the milling are cut in a desired shape (as per moulds) using knives (Preformer) ▪ The remaining part of the sheet (which is left out after cutting) is again loaded into the milling machine and is used for making further sheets.
Output	Blanks for moulding

Job role involved	Mixing Supervisor, Operator

Step 4: Moulding (Curing)

Input	▪ Rubber compound and Mould for curing process
Process description	▪ Moulds are generally procured from outside as per specifications ▪ The pieces of rubber blanks are placed in between the moulds ▪ Control charts are used by the Operator to set the curing time (parameters considered – temperature, pressure and input weight) in the machine ▪ Curing process takes place in the machine and also the compound gets the form of the mould in this process ▪ On completion of curing time, the moulds are removed from the machine and the moulded rubber products are extracted from the moulds ▪ Quality of the product is checked through visual examination ▪ Products with defects such as short fills/cut marks/air pockets are identified and corrective actions are taken
Output	Moulded rubber products
Job role involved	Supervisor, Moulding Operator and Helpers

Equipments Used

Hydraulic press

Note: If products require functions such as sand blasting, surface preparation, etc. (metal to bonded rubber products), they are performed before moulding process

Step 5: Deflashing

Input	▪ Deflashing/trimming – Moulded rubber products
	  ▪ Manual Trimming – Knives, Scissors, etc
	  ▪ Cryogenic machine – This process uses liquid nitrogen and media (selected based on the hardness of the flash)

Process description	The process of trimming can be done manually/by using machine such as cryogenic machine
	a. Manual trimming – Flashes are trimmed using knives, scissors, etc.
	b. Deflashing using cryogenic machine
	  ▪ Selected products (usually small moulded rubber products) undergo Deflashing process.
	  ▪ Deflashing is done in Cryogenic machine. It is a high speed

Equipments Used

Cryogenic machine

	shot blast deflashing process used to remove flashes in moulded products. ▪ Liquid nitrogen is injected into the insulated chamber in Cryogenic machine, in which the moulded rubber parts will be tumbled and blasted. The chamber will be rotated at a high speed and medias will be thrown at the tumbling parts, which will split the brittle flash on impact. ▪ Average time taken for deflashing is 3 to 5 minutes ▪ Cryogenic process is preferred as it is economical, highly precise and time saving
Output	Deflashed moulded rubber products, media and debris (flash and dust)
Job role involved	Operator/Supervisor

Step 6: Quality Check

Input	Trimmed moulded products and magnifying glass
Process description	▪ Physical inspection of moulded rubber products are done using magnifiers to check for cut marks, shot mould, air pockets, foreign matters (such as dust, thread, pin, etc) ▪ Other tests such as tensile test, hardness test, dimension test, abrasion test, etc are performed to ensure the quality of the product ▪ Most of the moulded products are customer specified products and quality heck is done as per the specification described by the customers and the ensure the parameters are met
Output	Final moulded rubber products available for dispatch
Job role involved	QC Inspectors/Quality In-charge

Equipments Used

Tensile testing machine

Abrasion tester

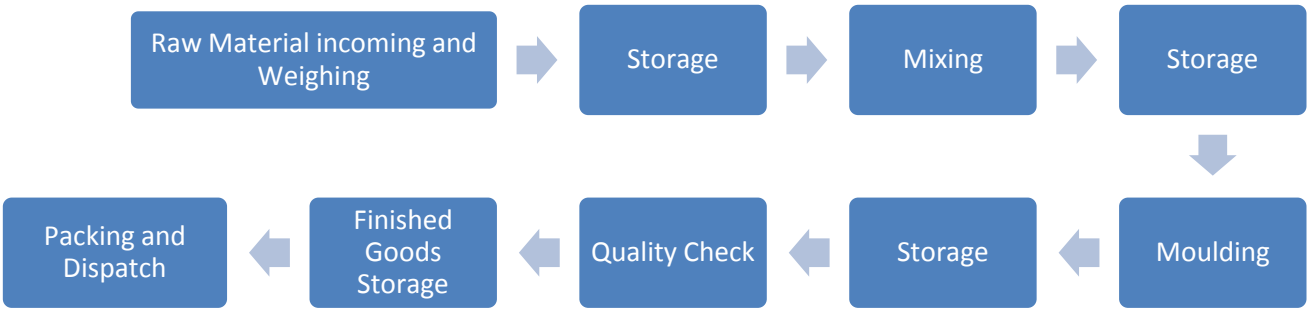
Step 7: Packing and Dispatch

Input	Moulded rubber products after inspection
Process description	Weighing and packing of the moulded rubber product as per the dispatch schedule issued
Output	Packaged moulded rubber products, ready for delivery to the customers

Job role involved	Dispatch assistant/ Dispatch In-charge

Note: The process represented is for compressor moulding process which is widely followed by the industries currently. The above process is applicable for the manufacturing of products such Auto and Cycle products, Ebonite products, solid tyres, Tyre flaps and Sports goods.

Figure 18: Manufacturing process of moulded rubber product (injection moulding process)



Step 1: Raw Material incoming, weighing and mixing (Master batch preparation)

Input	▪ Raw materials are procured from suppliers and are stored in the godown / storage place appropriately. Quality of the supplies are ensured by the certificates from supplier / internal testing ▪ Rubber (Natural and/or Synthetic) and Chemicals (Zinc Oxide, Stearic Acid, etc) are used. There are around 30-40 different chemicals that are being used on a need basis. ▪ Fillers (Carbon, Calcium Carbonate, Clay, Silica, etc) are used to provide hardness ▪ Oils (Aromatic types, Naphthenic types) are used to improve the dispersion of filers and flow characteristics of compound during processing ▪ Tolerance level (E.g. +/- of 2 grams for chemicals and +/- of 20 grams for rubber, filler and oil) is considered while quantifying the inputs for mixing.
Process description	▪ Raw materials are weighed according to the desired proportion and are kept ready for mixing ▪ The Raw material are fed into the mixing mill machine (intermix machine/open mixing mill/kneader) ▪ The following raw material are used for mixing:

Equipments Used

Kneader

	▪ Mastication of Rubber (Natural and/or Synthetic) ▪ Chemicals ▪ Fillers ▪ Oils ▪ Master batch (Compound) is prepared ▪ This is stored for approximately 16 hours before final batch preparation
Output	Output of this process will be in the form of uneven sized rubber sheets/ block of rubber compound
Job role involved	Lab In charge, Mixing Supervisor, Mill man, Helpers

Step 2: Mixing (Final Batch Preparation) and Storage

Input	▪ The sheet of rubber / block of rubber compound prepared through mixing process ▪ Curing agents
Process description	▪ The compound is put into milling machine (with rollers) and are rolled to get desired thickness ▪ Curing agents such as sulphur is added during this process ▪ Nip adjustor in the machine needs to be adjusted to get desired thickness in the sheet ▪ Samples of rubber are tested in lab for hardness, specific gravity, rheological properties, aging test, special test based on customer's requirement (ozone testing, cold resistance test, etc) ▪ In case of rejections during the lab test, the batch is sent for rework i.e, for correcting the chemical composition in milling machine ▪ The final batch compound is then stored ▪ They are then cut into strips as per injection moulding screw size
Output	Rubber Compound (Final batch)
Job role involved	Mixing Supervisor, Mill Man, Lab In charge
*Other equipments used for testing includes Low temperature test chamber, Electronic tensile testing machine, Mooney viscometer, Melting point apparatus, Compression set apparatus, etc	

Equipments Used*

Milling Machine

Oscillating disc Rheometer

Air and oil aging oven

Step 3: Moulding (Curing)

Input	▪ Rubber strips for moulding process
Process description	▪ The rubber strips are placed in the injection (screw) on the top ▪ Control charts are used by the Operator to set the curing time (parameters considered – temperature, pressure and input weight) in the machine ▪ The rubber strip is then injected into the machine ▪ The screw pre - heats the compound before moulding ▪ The heated compound is filled in the cavity and it reduces the flashes ▪ Curing process takes place in the machine and also the compound gets the form of the mould in this process ▪ On completion of curing time, the moulded rubber is taken out from the machine ▪ Quality of the product is checked through visual examination ▪ Products with defects such as short fills/cut marks/air pockets are identified and corrective actions are taken
Output	Moulded rubber products
Job role involved	Supervisor, Moulding Operator and Helpers

Equipments Used

Injection moulding machine

Note: If products require functions such as sand blasting, surface preparation, etc. (metal to bonded rubber products), they are performed before moulding process

Step 4: Quality Check

Input	Moulded products and magnifying glass
Process description	▪ Physical inspection of moulded rubber products are done using magnifiers to check for cut marks, shot mould, air pockets, foreign matters (such as dust, thread, pin, etc) ▪ Other tests such as tensile test, hardness test, dimension test, abrasion test, etc are performed to ensure the quality of the product ▪ Most of the moulded products are customer specified products and quality heck is done as per the specification described by the customers and the ensure the parameters are met
Output	Final moulded rubber products available for dispatch
Job role involved	QC Inspectors/Quality In-charge

Equipments Used

Tensile testing machine

Abrasion tester

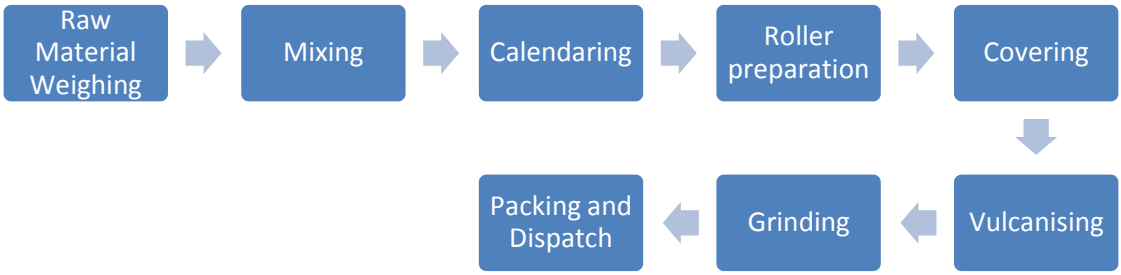
Step 5: Packing and Dispatch

Input	Moulded rubber products after inspection
Process description	Weighing and packing of the moulded rubber product as per the dispatch schedule issued
Output	Packaged moulded rubber products, ready for delivery to the customers
Job role involved	Dispatch assistant/ Dispatch In-charge

Note: Injection process is useful for mass production of small size products and this process ensures less wastage of materials.

1.11 Rubber covered roller manufacturing process

Figure 19: Manufacturing process of Rubber covered roller



Step 1: Raw Material Weighing and Mixing

Input	▪ Natural Rubber/Synthetic Rubber /Reclaimed Rubber ▪ Fillers such as Carbon black, etc. ▪ Process oils ▪ Chemicals such as Stearic acid, Zinc Oxide, etc. ▪ Accelerators and Anti oxidants
Process description	▪ Raw materials are procured from suppliers and are stored in the godown / storage place appropriately. Quality of the supplies are ensured by the certificates from supplier / internal testing ▪ Raw materials are weighed according to the desired proportion and are kept ready for mixing ▪ Raw materials are fed into the mixing mill machine (open mixing mill/kneader) ▪ The raw materials are fed into the machine in a predefined sequence ▪ Rubber compound is formed after the mixing ▪ The quality check for rubber compound is done by the tests such as hardness test, rheo test, etc.
Output	Output of this process will be in the form of uneven sized rubber sheets/ block of rubber compound
Job role involved	Mixing Supervisor, Mixing Operator, Helpers

Equipments Used

Kneader

Open mixing mill

Step 2: Calendaring

Input	▪ Rubber compound from mixing process
Process description	▪ The sheet of rubber compound is then fed into a calendaring machine

Output	Rubber sheet with desired width
Job role involved	Calendaring Operator and Helper

Step 3: Roller Preparation

Input	▪ Rollers made of steel
Process description	▪ The metal rollers that is to be used for covering with rubber is procured from outside ▪ Alternatively, large companies have their own tool room to make this rollers ▪ Then the roller needs to be prepared for rubber covering ▪ The roller is cleaned and then is roughen for bonding agent application using methods such as sand blasting ▪ Then adhesive / bonding agent is applied over the roller to enable the rubber sheet to be covered on it
Output	Metal roller for rubber covering
Job role involved	Operator and Helper

Step 4: Covering

Input	▪ Rubber sheet from calendaring process ▪ Metal roller with adhesives
Process description	▪ The rubber sheets from the calendaring process is covered by rolling over the metal roller ▪ The width of the rubber covering is measured with the gauge to ensure that it is as per the specification ▪ The operator needs to ensure that the rubber covering is proper without any issues such as air pockets and adequately bonded with the roller
Output	Roller covered with uncured rubber
Job role involved	Operators and Helpers

Step 5: Vulcanising

Input	▪ Roller covered with uncured rubber
Process description	▪ The roller with uncured rubber may be wrapped with cloth before vulcanization process for better quality output ▪ The roller is then put in the vulcanising chamber for the curing process ▪ Specification for vulcanising process such as temperature, pressure and time is appropriately set as per the product
Output	Cured rubber covered roller
Job role involved	Curing / Vulcanising Operator and Helpers

Equipments Used

Vulcaniser

Step 6: Grinding

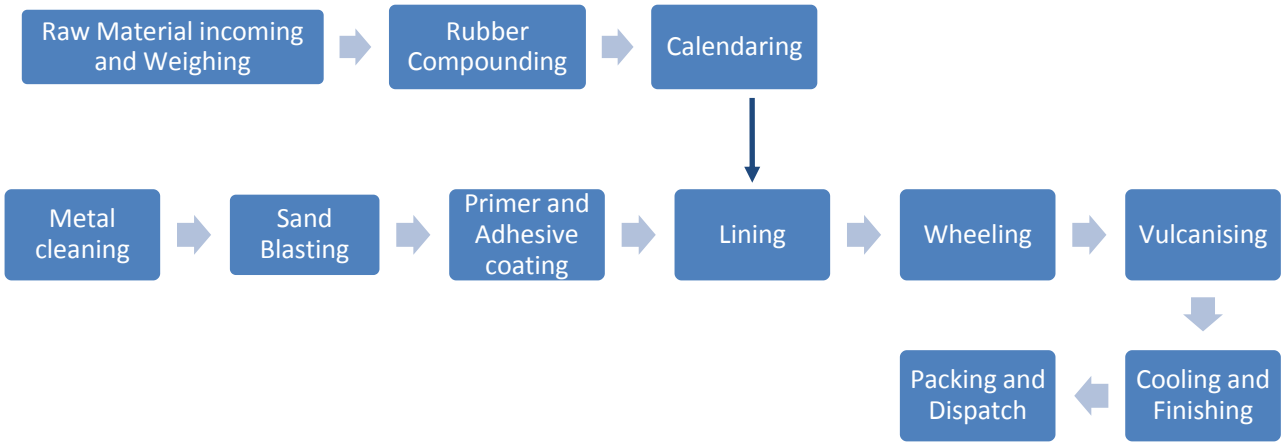
Input	▪ Cured rubber covered roller
Process description	▪ The cured rubber covered roller then undergoes a grinding process ▪ This process is done to ensure the finishing of the roller as per the specification ▪ Final inspection of the roller is done after this process ▪ Various tests such as dimension test, hardness test is done to check the quality of the product
Output	Finished rubber covered rollers
Job role involved	Operator and Helpers

Step 7: Packing and dispatch

Input	▪ Finished rubber covered rollers
Process description	▪ The final inspected rollers are then sent for packing ▪ Packing is done as per the customer requirement ▪ Then the packed roller is then dispatched as per the deliver order
Output	Finished rubber covered rollers
Job role involved	Helpers

1.12 Rubber lining manufacturing process

Figure 20: Manufacturing process of rubber lining



Raw Material incoming, weighing and Compounding

Input	▪ Rubber : Natural or Synthetic Rubber ▪ Fillers ▪ Accelerators and Accelerators ▪ Process oils ▪ Curing agents such as Sulphur & accelerators
Process description	▪ Raw materials are procured from suppliers and are stored in the godown / storage place appropriately ▪ Quality of the raw materials are ensured by the test certificates obtained from the supplier and also through internal testing procedures for essential properties, shelf life, viscosity etc ▪ Various raw materials are weighed using calibrated weighing machine according to formulation and are prepared as a batch for mixing process ▪ The raw materials are fed in the mixing machine (kneader / open mixing mill) in a predefined sequence where compounding of rubber takes place ▪ The above rubber and chemicals are compounded in the mixing mill to form sheets / dough form in case of a kneading machine for further sheeting by open mill ▪ Quality checks such as rheometric properties testing is done on the compound prepared for viscosity, cure characteristic, specific gravity etc
Output	Rubber compound in the form of sheets
Job role involved	Compounder ,Dosing operator, Mixing mill operator and Helper

Equipments Used

Kneader

Milling machine

Calendaring

Input	▪ Rubber compound
Process description	▪ The sheet of rubber compound is then fed into a calendaring machine ▪ The calendar converts the rubber compound into a sheet of 1mm to 1.5 mm thickness by passing the compound into rollers which rotates in opposite directions ▪ Quality check performed on the compound includes visual check , specific gravity, thickness, width, length etc ▪ Re-warming , addition of accelerator as case may be done before feeding to calendar
Output	Calendared rubber sheets of standard thickness
Job role involved	Mixing mill operator , calendar operator, handling workmen and Helper

Equipments Used
Calendaring Machine

Step 1: Metal cleaning and grit blasting

Input	▪ Metal to be rubber lined
Process description	▪ All metal surfaces should be inspected prior to blasting for contamination such as grease and other foreign matters. Such foreign matter should be removed by burning, buffing, washing with solvent. ▪ The metal to be lined is cleaned with copper slag/steel grits at high pressure to SA 2 ½ white metal finish ▪ All surfaces are to be grit blasted to a clean grey white metal surface for a proper metal to rubber bonding. ▪ This is done to keep the metal clean from rust, oil and grease ▪ This process is known as grit / sand blasting ▪ The sandblasted metal thus is devoid of rust and sharp edges and this enhances adhesion of coatings and adhesives ▪ Visual check is done after the process to ensure that the surface is clean, no moisture, no contamination and the metal has a near white appearance ▪ Surface roughness is checked with roughness gauge or press'O film ▪ After completion of blasting , cleaning by compressed air, brush is recommended to clean the surface to remove blasting material contaminants
Output	Blasted metal
Job role involved	Supervisor, blasting operator and Helpers

Step 2: Primer and Adhesive coating

Input	▪ Blasted metal ▪ Bonding agents like chemlok and rubber solution ▪ Adhesives
Process description	▪ The bonding agents of correct viscosity are applied on the metal surface as a primer coat ▪ Multiple layers of coat of correct viscosity with periodical intervals are applied ▪ After the primer coating, adhesive is applied over it to enable the sticking process ▪ Some of the quality checks done on the primer coating includes checking viscosity of the coating, humidity, temperature of surface etc ▪ Minimum interval between coat is approximately 4 hours
Output	Adhesive coated metal
Job role involved	Coating operator and Helpers

Step 3: Lining

Input	▪ Adhesive coated metal ▪ Calendared rubber compound/sheet
Process description	▪ The calendared rubber sheets are bought to the lining section ▪ The rubber compound is made to stick (lined) in the metal. The sheet surface may require solvent wiping before application ▪ Adhesives coated in the metal helps to hold the rubber compound which is fixed ▪ Quality checks is done for the parameters such as pin hole, thickness, joints, overlapping , poor bonding, non blisters and appearance
Output	Rubber lined vessel/equipment
Job role involved	Supervisor, lining operator and Helpers

Step 4: Wheeling

Input	▪ Rubber lined metal
Process description	▪ The rubber lining that is stuck into the metal undergoes a process called wheeling ▪ In this process, the air particles (if any) present in between the rubber lining and the mild steel tank is removed ▪ The rubber sheet should be applied without stretching/ tension ▪ This process is very important as if there are any air particles in between the metal and the rubber lining, it will cause damage to the rubber lining when it undergoes the process of curing
Output	Rubber lined metal
Job role involved	Supervisor and Operator

Step 5: Vulcanising

Input	▪ Rubber lined metal
Process description	▪ Then the metal is put into an auto clave/vulcanizer for the curing process. The other methods of curing are i) hot water curing ii)low pressure curing iii) exhaust steam curing iv)hot air vulcanization ▪ Curing parameters such as temperature, pressure and time according to curing cycle
Output	Cured rubber lining in the metal
Job role involved	Supervisor and autoclave operator

Equipments Used

Autoclave Vulcanising Machine

Step 6: Inspection and Finishing

Input	Cured rubber lined metal
Process description	▪ Cured rubber lined metal is allowed to cool at room temperature for certain period of time ▪ Then the additional flaps in the rubber line are cut using trimming equipments such as scissors, knives, etc. ▪ Quality check tests performed on the finished products include visual check (for smooth lining and rough surface), hardness test, spark test, tap test, bond strength, delamination and air blisters

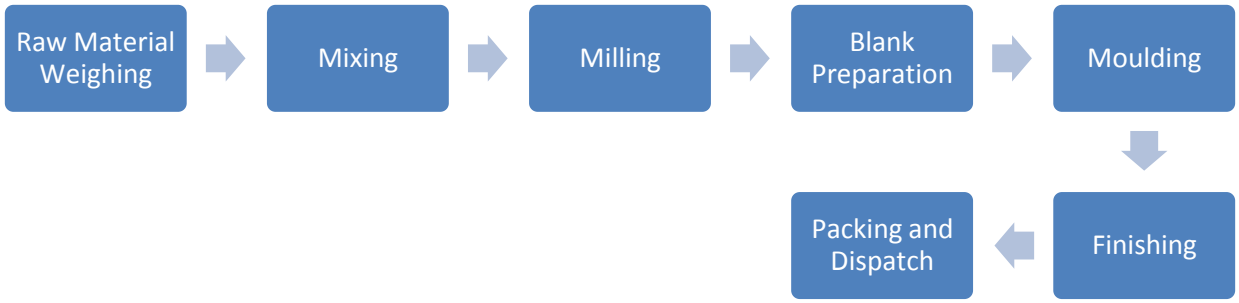
Output	Inspected rubber lined metal
Job role involved	▪ Finishing helpers , inspection technician & supervisor ▪ Quality In-charge

Step 7: Packing and Dispatch

Input	▪ Inspected rubber lined metal
Process description	▪ The rubber lined metal is packed as per the customer specification and is dispatched
Output	Packed rubber lined metal
Job role involved	Dispatch assistant/ Dispatch Incharge , packing technicians

1.13 Rubber matting manufacturing Process

Figure 21: Manufacturing process of rubber mats



Step 1: Raw Material Weighing and Mixing

Input	▪ Natural Rubber/Synthetic Rubber /Reclaimed Rubber ▪ Fillers such as china clay, crumb powder, etc. ▪ Process Oils ▪ Activators such as Stearic acid, Zinc Oxide, etc. ▪ Accelerators and Anti oxidants chemicals
Process description	▪ Quality of the raw materials are ensured by the test certificates obtained from the supplier and also through internal testing procedures for essential properties, shelf life, viscosity etc ▪ Various raw materials are weighed using calibrated weighing machine according to formulation and are prepared as a batch for mixing process ▪ Raw materials are fed into the mixing mill machine (Intermix

Equipments Used

Kneader

	machine/ kneader /open mixing mill) ▪ The following raw material are used in the mixing process: ▪ Mastication of Rubber (Natural and Synthetic) ▪ Activators ▪ Accelerators and Anti oxidant chemicals ▪ Fillers (Carbon black) ▪ Rubber compound is formed after the mixing
Output	Output of this process will be in the form of uneven sized rubber sheets/ block of rubber compound
Job role involved	Mixing Supervisor, Mixing Operator, Helpers

Step 2: Milling

Input	▪ The sheet of rubber / block of rubber compound prepared through mixing process ▪ Curing agents
Process description	▪ The compound is put into milling machine (with rollers) and are rolled to get desired thickness ▪ Curing agents such as sulphur is added during this warming process ▪ Nip in the mill machine needs to be adjusted to get desired thickness in the sheet
Output	Sheet of rubber compound with required thickness
Job role involved	Operators and helpers

Equipments Used

Milling machine (Open mixing mill)

Step 3: Blank preparation

Input	▪ Rubber sheets from mixing process
Process description	▪ The sheets from the milling are cut in a desired shape (as per moulds) using knives (Preformer) ▪ The remaining part of the sheet (which is left out after cutting) is again loaded into the milling machine and is used for making further sheets.
Output	Blanks for moulding
Job role	Mixing Supervisor, Operator

involved	

Step 4: Moulding

Input	▪ Blanks for moulding
Process description	▪ Diluted Silicon solution is sprayed in the moulds before curing to ensure that compound do not stick to the moulds ▪ The sheets of rubber compound are placed in between the moulds ▪ Curing process takes place in the machine and also the compound gets the form of the mould in this process ▪ The temperature and curing time is set in the machine and the mould is pressed automatically in the Hydraulic machine ▪ After the specified time, the mould is opened and then the mat is removed ▪ General specification : Temperature 150 – 160 degrees and curing time of 3 to 4 minutes (But may vary according to desired quality and output) ▪ Quality of the product is checked through visual examination
Output	Rubber mats as per desired shape with flashes and additional flaps
Job role involved	Moulding Supervisor, Moulding Operator and Helpers

Equipments Used

Hydraulic pressing machine

Step 5: Finishing

Input	▪ Rubber mats with flashes and additional flaps
Process description	▪ Flashes are trimmed using knives, scissors, etc. ▪ If any punching is required for mats, punching machines are used ▪ Visual examination of the mats for flaps and finishing are done as a part of quality check
Output	Finished rubber mats
Job role involved	Finishing Supervisors, Moulding Operators and helpers

Step 6: Packing and Dispatch

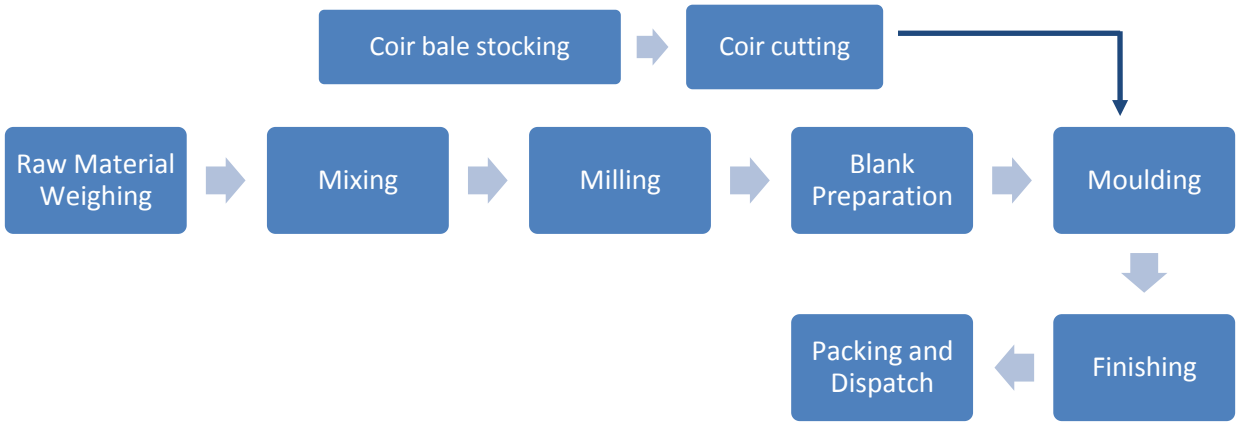
Input	▪ Finished rubber mats

Process description	▪ Flashes are trimmed using knives, scissors, etc. ▪ If any punching is required for mats, punching machines are used ▪ Visual examination of the mats for flaps and finishing are done as a part of quality check
Output	Packed rubber mats ready for dispatch
Job role involved	Finishing Supervisor and helpers

Note: The same process is followed for rubber sheeting manufacturing process

1.14 Rubberised Coir, Jute and Woolen products manufacturing Process

Figure 22: Manufacturing process of rubberized coir products



Coir bale stocking and Coir cutting

Input	▪ Coir bale
Process description	▪ Coir bale is received from outside as a lot and is stored in the godown ▪ Then they are rolled out and cut as per the finished product shape using scissors ▪ The same process is followed for jute and other product as well
Output	Output of this process will be the coir cut in the shape of the mould / end product
Job role involved	Helpers

Step 1: Raw Material Weighing and Mixing

Input	▪ Natural Rubber/Synthetic Rubber /Reclaimed Rubber ▪ Fillers such as china clay, crumb powder, etc. ▪ Process Oils ▪ Activators such as Stearic acid, Zinc Oxide, etc. ▪ Accelerators and Anti oxidants chemicals
Process description	▪ Raw materials are weighed according to the desired proportion and are kept ready for mixing ▪ Raw materials are fed into the mixing mill machine (Intermix machine/ kneader /open mixing mill) ▪ These raw material are put in the order (order of addition) as follows: ▪ Mastication of Rubber (Natural and Synthetic)

Equipments Used

Kneader

	▪ Activators ▪ Accelerators and Anti oxidant chemicals ▪ Fillers (Carbon black) ▪ Rubber compound is formed after the mixing
Output	Output of this process will be in the form of uneven sized rubber sheets/ block of rubber compound
Job role involved	Mixing Supervisor, Mixing Operator, Helpers

Step 2: Milling

Input	▪ The sheet of rubber / block of rubber compound prepared through mixing process ▪ Curing agents
Process description	▪ The compound is put into milling machine (with rollers) and are rolled to get desired thickness ▪ Curing agents such as sulphur is added during this warming process ▪ Measurement adjustor in the machine needs to be adjusted to get desired thickness in the sheet
Output	Sheet of rubber compound with required thickness
Job role involved	Operators and helpers

Equipments Used

Milling machine (Open mixing mill)

Step 3: Blank preparation

Input	▪ Rubber sheets from mixing process
Process description	▪ The sheets from the milling are cut in a desired shape (as per moulds) using knives (Preformer) ▪ The remaining part of the sheet (which is left out after cutting) is again loaded into the milling machine and is used for making further sheets.
Output	Blanks for moulding
Job role involved	Mixing Supervisor, Operator

Step 4: Moulding

Input	▪ Blanks for moulding

Process description	▪ Diluted Silicon solution is sprayed in the moulds before curing to ensure that compound do not stick to the moulds
	▪ The compound that needs to be moulded is prepared as follows:
	  ▪ In the bottom, rubber compound is placed and over that the coir which is cut in the mould shape is placed
	  ▪ Then above that a rubber compound (which is thin) is placed to protect the coir from damage during moulding process
	▪ The sheet prepared is placed in between the moulds
	▪ Curing process takes place in the machine and also the compound gets the form of the mould in this process
	▪ The temperature and curing time is set in the machine and the mould is pressed automatically in the Hydraulic machine
	▪ After the specified time, the mould is opened and then the mat is removed
	▪ General specification : Temperature 150 – 160 degrees and curing time of 3 to 4 minutes (But may vary according to desired quality and output)
	▪ Quality of the product is checked through visual examination

Output	Rubberised coir mats as per desired shape with flashes and additional flaps
Job role involved	Moulding Supervisor, Moulding Operator and Helpers

Equipments Used

Hydraulic pressing machine

Step 5: Finishing

Input	▪ Rubber mats with flashes and additional flaps
Process description	▪ Flashes are trimmed using knives, scissors, etc. ▪ There will be flashes on the top of mat to cover the coir product. They need to removed as well in the process ▪ If any punching is required for mats, punching machines are used ▪ Visual examination of the mats for flaps and finishing are done as a part of quality check

Output	Finished rubberized coir product
Job role involved	Finishing Supervisors, Moulding Operators and helpers

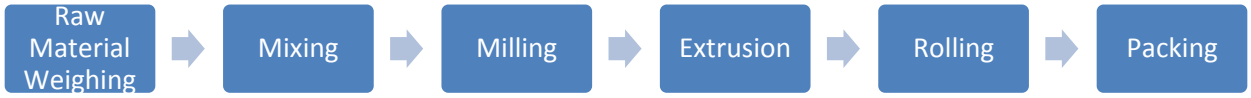
Step 6: Packing and Dispatch

Input	▪ Finished rubberized coir product
Process description	▪ Flashes are trimmed using knives, scissors, etc. ▪ If any punching is required for mats, punching machines are used ▪ Visual examination of the mats for flaps and finishing are done as a part of quality check
Output	Packed rubberized coir product ready for dispatch
Job role involved	Finishing Supervisor and helpers

Note: The depicted process is for rubberized coir mats. Similar process is followed for other rubberized jute and woolen product as well.

1.15 Tread Rubber products - Manufacturing Process

Figure 23: Manufacturing process of conventional / hot tread rubber



Step 1: Raw Material Weighing and Mixing

Input	▪ Natural Rubber/Synthetic Rubber /Reclaimed Rubber ▪ Fillers such as Carbon black, etc. ▪ Process Oils ▪ Activators such as Stearic acid, Zinc Oxide, etc. ▪ Accelerators and Anti oxidants chemicals

Process description	▪ The quality of raw material is ensured by internal testing procedures. Various testing is done for different raw material. Visual test is done for natural rubber to spot impurities. Ash and moisture test are conducted for carbon black
	▪ Quality of supplies is also ensured by the testing certificate offered by the supplier
	▪ Raw materials are weighed according to the desired proportion and are kept ready for mixing
	▪ Raw materials are fed into the mixing mill machine (Banbury mixer ®/intermix machine/open mixing mill/kneader)
	▪ The following raw material (not exhaustive list) are used for mixing process:
	  ▪ Rubber (Natural and Synthetic)
	  ▪ Activators
	  ▪ Accelerators and Anti oxidant chemicals
	  ▪ Fillers (Carbon black)
	▪ Rubber compound is formed after the mixing
	▪ Then the compound is kept in a storage place for a specified time (ageing process)

Output	Output of this process will be in the form of uneven sized rubber sheets/ block of rubber compound
Job role involved	Mixing Supervisor, Mixing Operator, Helpers

Equipments Used

Banbury Mixer ® / Intermix / Kneader

Kneader machine

Step 2: Milling

Input	▪ The sheet of rubber / block of rubber compound prepared from Mixing ▪ Curing agents such as Sulphur
Process description	▪ Rubber compound is taken and warmed using open mixing mill ▪ The temperature in the milling machine needs to be controlled appropriately that the compound is not over heated ▪ Curing agents such as sulphur is added in this process ▪ The rubber compound which are warmed are taken in a sheet form which are then fed into an extrusion machine
Output	Sheet of rubber compound from milling process
Job role involved	Operator and helpers

Equipments Used

Open Mixing Mill

Step 3: Extrusion

Input	▪ Strips of rubber compound made in the milling process
Process description	▪ Extrusion machine is made ready for operation by fixing appropriate die and maintaining adequate temperature at various parts of extruder ▪ The strips of rubber compound are inserted to the extrusion machine continuously ▪ The rubber pieces passes through the extruding machine and comes out through the die as a continuous strip (tread) ▪ The physical characteristics of the tread is as per the die fixed in the extruding machine ▪ Temperature of the machine and the size (width)of the tread extruded needs to be constantly monitored ▪ The tread coming out of the extruder is passed through water for cooling ▪ Visual examination of the tread is done by the operator
Output	Hot Tread Rubber
Job role involved	Extrusion Operator and Helper

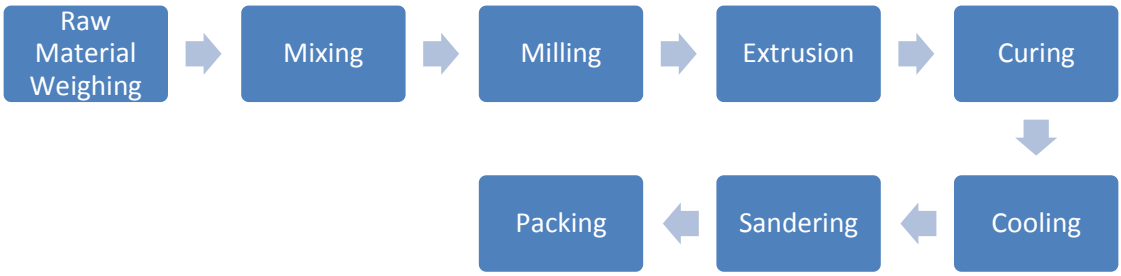
Equipments Used

Extrusion Machine

Step 6: Rolling and Packing

Input	▪ Hot Tread Rubber
Process description	▪ The tread rubber is then rolled automatically or manually ▪ They are with plastic sheets to ensure that treads do not stick to each other while rolling ▪ Visual examination of the tread is done during packing ▪ Specified number of treads are rolled and are then packed as per the assortment ▪ The package is dispatched as per the order sheet
Output	Packed Hot Tread Rubbers
Job role involved	Helpers

Figure 24: Manufacturing process of precured / cool tread rubber



Step 1: Raw Material Weighing and Mixing

Input	▪ Natural Rubber/Synthetic Rubber /Reclaimed Rubber ▪ Fillers such as Carbon black, etc. ▪ Process Oils ▪ Activators such as Stearic acid, Zinc Oxide, etc. ▪ Accelerators and Anti oxidants chemicals
Process description	▪ The quality of raw material is ensured by internal testing procedures. Various testing is done for different raw material. Visual test is done for natural rubber to spot impurities. Ash and moisture test are conducted for carbon black ▪ Quality of supplies is also ensured by the testing certificate offered by the supplier ▪ Raw materials are weighed according to the desired proportion and are kept ready for mixing

Equipments Used

Banbury Mixer ® / Intermix / Kneader

Kneader machine

	▪ Raw materials are fed into the mixing mill machine (Banbury mixer ®/intermix machine/open mixing mill/kneader)
	▪ The following raw material (not exhaustive list) are used for mixing process:
	  ▪ Rubber (Natural and Synthetic)
	  ▪ Activators
	  ▪ Accelerators and Anti oxidant chemicals
	  ▪ Fillers (Carbon black)
	▪ Rubber compound is formed after the mixing
	▪ Then the compound is kept in a storage place for a specified time (ageing process)

Output	Output of this process will be in the form of uneven sized rubber sheets/ block of rubber compound
Job role involved	Mixing Supervisor, Mixing Operator, Helpers

Step 2: Milling

Input	▪ The sheet of rubber / block of rubber compound prepared from Mixing ▪ Curing agents such as Sulphur
Process description	▪ Rubber compound is taken and warmed using open mixing mill ▪ The temperature in the milling machine needs to be controlled appropriately that the compound is not over heated ▪ Curing agents such as sulphur is added in this process ▪ The rubber compound which are warmed are taken in a sheet form which are then fed into an extrusion machine
Output	Sheet of rubber compound from milling process
Job role involved	Operator and helpers

Equipments Used

Open Mixing Mill

Step 3: Extrusion

Input	▪ Strips of rubber compound made in the milling process
Process description	▪ Extrusion machine is made ready for operation by fixing appropriate die and maintaining adequate temperature at various parts of extruder

Equipments Used

	▪ The strips of rubber compound are inserted to the extrusion machine continuously ▪ The rubber pieces passes through the extruding machine and comes out through the die as a continuous strip (tread) ▪ The physical characteristics of the tread is as per the die fixed in the extruding machine ▪ Temperature of the machine and the size (width)of the tread extruded needs to be constantly monitored ▪ The tread coming out of the extruder is passed through water for cooling ▪ Visual examination of the tread is done by the operator
Output	Hot Tread Rubber
Job role involved	Extrusion Operator and Helper

Extrusion Machine

Step 4: Curing / Moulding

Input	▪ Extruded rubber
Process description	▪ The length of the tread is then cut according to the standard length (specification as per tyre size) and is ready for curing process ▪ Moulds are procured from outside according to the desired requirements (shape and size) of the customers. These moulds are used in the hydraulic press machines ▪ Diluted Silicon solution is sprayed in the moulds before curing to ensure that compound do not stick to the moulds ▪ The temperature and curing time is set in the hydraulic press ▪ The sheets of hot rubber are placed in between the hot moulds ▪ The mould when closed, the press moulds the rubber into the mould pattern ▪ The temperature and curing time is set and the mould is pressed automatically in the hydraulic machine ▪ The temperature and pressure needs to be set and monitored during the curing process ▪ After curing, the tread needs to be removed safely from the press without damaging it
Output	Precured Tread Rubber with flashes

Equipments Used

Hydraulic press

Job role involved	Moulding Operators and helpers

Step 5: Buffing

Input	▪ Precured Tread Rubber with flashes
Process description	▪ The additional flashes in the tread is then removed using knives ▪ Then these precured treads are then cooled in the room temperature ▪ The tread then undergoes a process called buffing ▪ In this process, the back side of the tread (without the pattern) is roughened using a sandering machine ▪ The machine has steel spokes in a roller form which roughens the surface of the tread when it passes through it ▪ This process is done to ensure that the tread sticks well to the cushion gum compound during retreading process
Output	Finished precured tread rubber ready for packing
Job role involved	Finishing operator and helpers

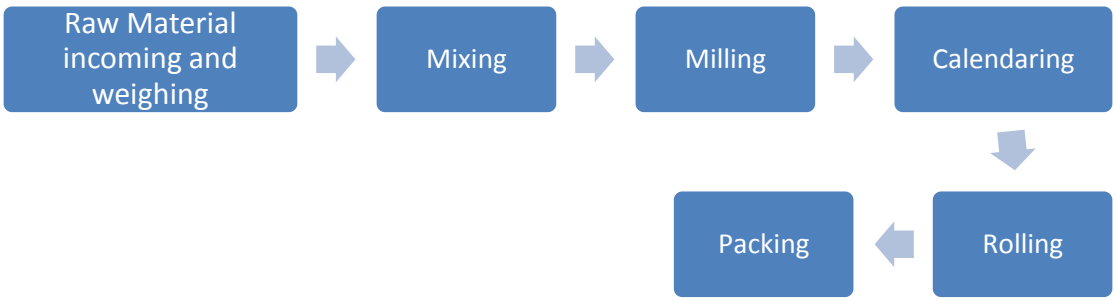
Equipments Used

Buffing machine

Step 6: Packing

Input	▪ Precured Tread Rubber
Process description	▪ The tread rubber is then rolled manually ▪ Visual examination of the tread is done during packing ▪ Specified number of treads are rolled and are then packed as per the assortment ▪ The package is dispatched as per the order sheet
Output	Packed precured Tread Rubbers
Job role involved	Helpers

Figure 25: Manufacturing process of bonding gum compound



Step 1: Raw Material Weighing and Mixing

Input	▪ Natural Rubber/Synthetic Rubber /Reclaimed Rubber ▪ Fillers such as Carbon black, etc. ▪ Process Oils ▪ Activators such as Stearic acid, Zinc Oxide, etc. ▪ Accelerators and Anti oxidants chemicals

Process description	▪ The quality of raw material is ensured by internal testing procedures or the testing certificates issued by suppliers
	▪ Raw materials are weighed according to the desired proportion and are kept ready for mixing
	▪ Raw materials are fed into the mixing mill machine (intermix machine/open mixing mill/kneader)
	▪ The following raw material (not exhaustive list) are used for mixing process:
	  ▪ Rubber (Natural and Synthetic)
	  ▪ Activators
	  ▪ Accelerators and Anti oxidant chemicals
	  ▪ Fillers (Carbon black)
	▪ Rubber compound is formed after the mixing
	▪ Then the compound is kept in a storage place for a specified time (ageing process)

Output	Output of this process will be in the form of uneven sized rubber sheets/ block of rubber compound
Job role involved	Mixing Supervisor, Mixing Operator, Helpers

Equipments Used

Intermix / Kneader

Kneader machine

Step 2: Milling

Input	▪ The sheet of rubber / block of rubber compound prepared from Mixing

Equipments Used

	▪ Curing agents such as Sulphur ▪ Tackifiers (to improve the stickiness)
Process description	▪ Rubber compound is taken and warmed using open mixing mill ▪ The temperature in the milling machine needs to be controlled appropriately that the compound is not over heated ▪ Curing agents such as sulphur and tackifiers are added in this process ▪ The rubber compound which are warmed are taken in a sheet form which are then fed into a calendering machine
Output	Sheet of rubber compound from milling process
Job role involved	Operator and helpers

Open Mixing Mill

Step 3: Calendering

Input	▪ Sheet of rubber compound from milling process
Process description	▪ The sheet of rubber compound is then fed into a Calendering machine ▪ The Calendering converts the rubber compound into a thin sheet with desired width by passing the compound through rollers which rotates in opposite direction ▪ The gap between the rollers are set such that the output sheets meet the requirement of specification ▪ A semi embossed film is attached to the thin sheet which ensures that the compound does not stick during rolling process ▪ The compound passes through a set of cooling drums to obtain better properties
Output	Bonding Gum Compound
Job role involved	Calendering Operator and Helper

Equipments Used

Calendering Machine

Step 4: Rolling and Packing

Input	▪ Bonding gum compound
Process description	▪ The bonding gum compound along with the film is then rolled manually

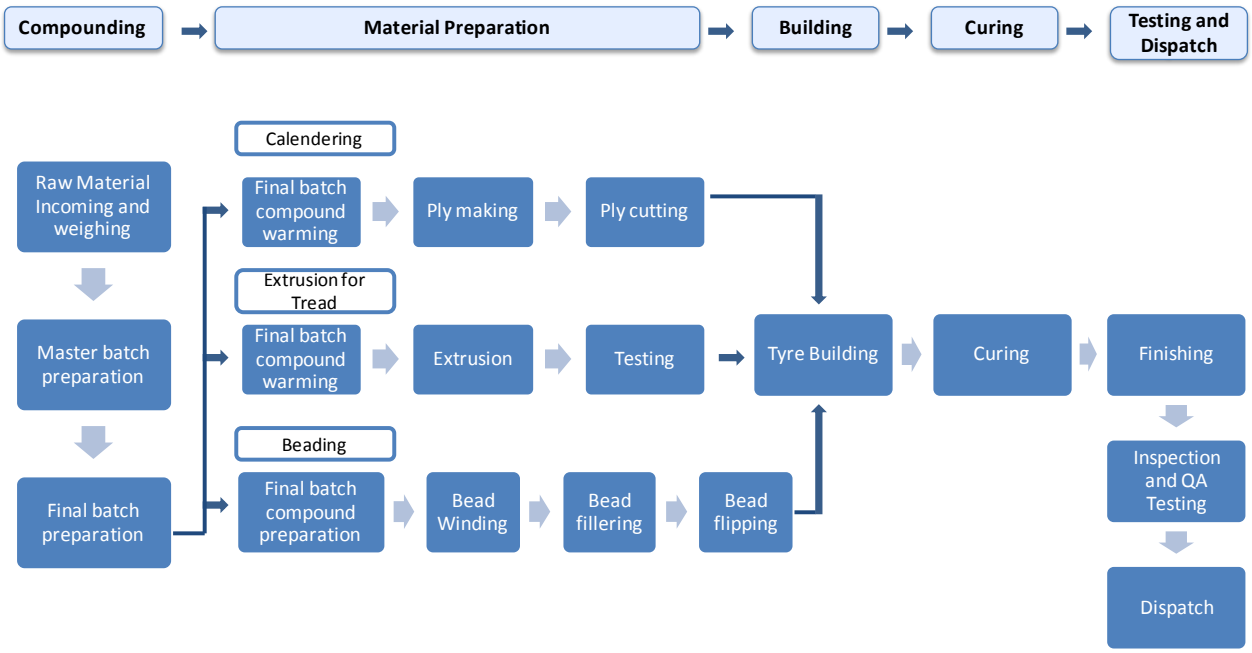
	▪ Visual examination of the product is done during the rolling process. Some of the parameters checked here are wrinkles in the compound, dust particles, gauge, etc. ▪ After rolling, the bonding gum compound is weighed and packed ▪ The package is done as per the assortment
Output	Packed cushion gum compound
Job role involved	Helpers

Note: The process of making cushion gum compound is also prepared similarly. Cushion gum is used for conventional treads and bonding gum is used for precured tread rubber retreading.

There are other retreading materials such as retread solution which is prepared through chemical mixing (similar to adhesive process) and balloons for retreading process which is prepared through moulding process.

1.16 Tyre Manufacturing Process

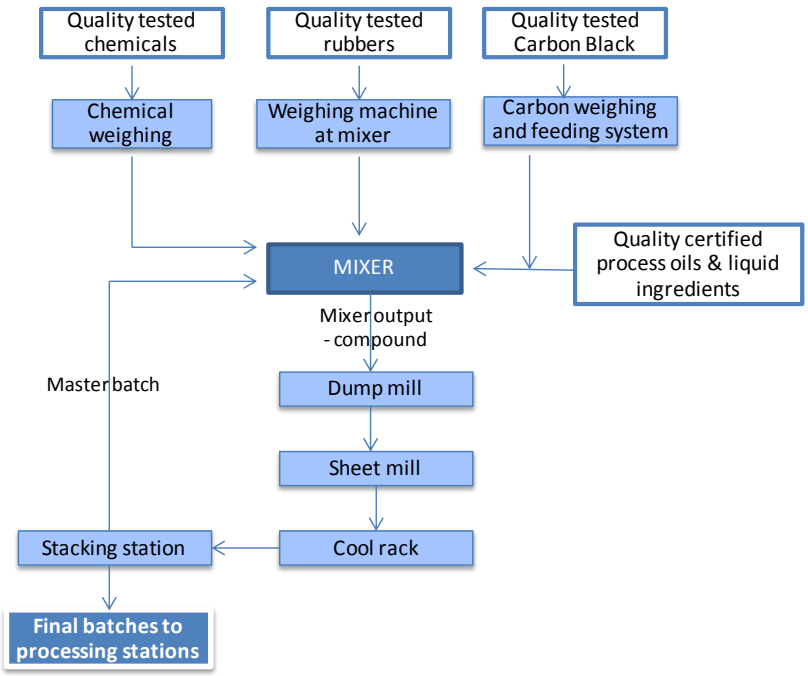
Figure 26*: Basic Tyre manufacturing process*



I. Material Preparation:

1. <u>Compounding Mixing:</u>

Figure 27*: Compound mixing Process flow chart*



Step 1: Rubber Material Incoming and Weighing

Input	Raw Materials for compounding includes natural rubber, synthetic rubber, carbon black, antioxidants, antiozonants, retarders, pigments, plasticizers, reinforcing agents, etc.
Process description	▪ The raw material are stored in a desired place for each chemicals ▪ The quality of raw material is ensured by internal testing procedures. Various testing is done for different raw material. Visual test is done for natural rubber to spot impurities. Ash and moisture test are conducted for carbon black. ▪ Quality of supplies is also ensured by the testing certificate offered by the supplier. The tyre manufacturers usually procure from authorized suppliers who supplies only quality product ▪ Various ingredients are then weighed according to formulation and are placed as a batch for mixing
Output	Ingredients in desired proportion as per formulation
Job role involved	Compounding Expert, Chemists, Mixing Mill Supervisor, Mixing Mill Operator, Helpers

Step 2: Master batch preparation

Input	Ingredients for compounding in desired proportion as per formulation
Process description	▪ The mixing is done usually in a Banbury mixer ®(mixing machine) where the raw material feeding can be done in two layers and the output is collected at the bottom ▪ Carbon black is loaded in the top storey (separate floor) to avoid the dust generated from carbon black in mixing with other chemicals ▪ In the middle layer, other materials such as rubber and other chemicals are loaded and passed into the mixer through a conveyor system ▪ Process parameters like temperature, pressure and time are set by the operator based on pre determined specifications ▪ The mixing process combines rubber stock, carbon black and the weighed chemicals to produce the master batch of rubber compound ▪ The master batch is checked for quality through specific gravity and viscosity test

Equipments used

Banbury Mixer

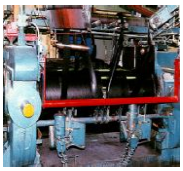
Output	Rubber compound (Master batch)
Job role involved	Compounding Expert, Supervisor, Mixing Operator (Compounder), Helpers

Step 3: Final batch Preparation

Input	Rubber compound (Master batch)
Process description	▪ After the completion of the mixing cycle, the rubber compound is dropped onto a drop mill ▪ From the mill, the compound is sheeted out in the form of a continuous strip of rubber compound ▪ It is then cooled immediately by passing through a slurry and hanged in a place of a series of fans (for drying of slurry) ▪ These sheets are again sent to the second storey (Banbury machine ®) for final batch preparation ▪ Sheets of various batches are mixed to have a good blending and also to reduce the variations ▪ During final batch, vulcanising agents such as sulphur is added and the temperature is less than that of master batch to ensure that the compound does not gets cured in the process ▪ The final batch compound is also collected in a milling machine where compounding sheets are formed ▪ The master batch is checked for quality through specific gravity and rheology test
Output	Sheets of rubber compound
Job role involved	Mixing Operators (Compounders) and Helpers

Equipments used

Milling machine

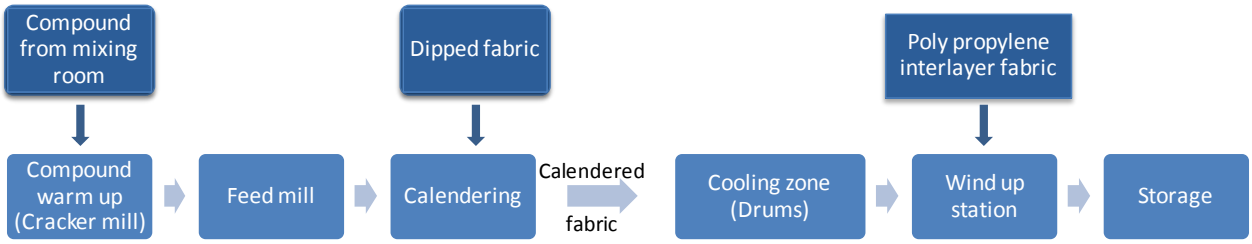


Banbury mixer

Note: The same process is followed to prepare rubber compound which goes as material for different process such extrusion, calendaring and bead coating. The formulation of the compound differs for each process.

2. Calendering

Figure 28: Calendering Process flow chart



Step 1: Raw Material incoming and Calendering

Input	▪ Rubber compound formed in the mixing process ▪ Latex coated fabric (procured from outside)
Process description - calendaring	▪ Rubber compound is warmed up using a series of mills before taking into calendering section ▪ The calendaring machine generally consists of four rollers and three passages between them ▪ On the top and bottom nips, rubber compound is fed and in the middle passage, fabric is admitted thus forming a sandwich of fabric in between layers of rubber compound in a single pass ▪ The calendared rubber sheets are wound on drums with a fabric to prevent the sticking of the calendared sheets ▪ Quality of the calendered fabric is checked through tests such as adhesion test, moisture test, Part Load Elongation test, etc.
Output	Calendered fabric
Job role involved	▪ Calendaring Supervisors, Operators and Helpers

Equipment used

Calendaring machine

Step 2: Ply cutting

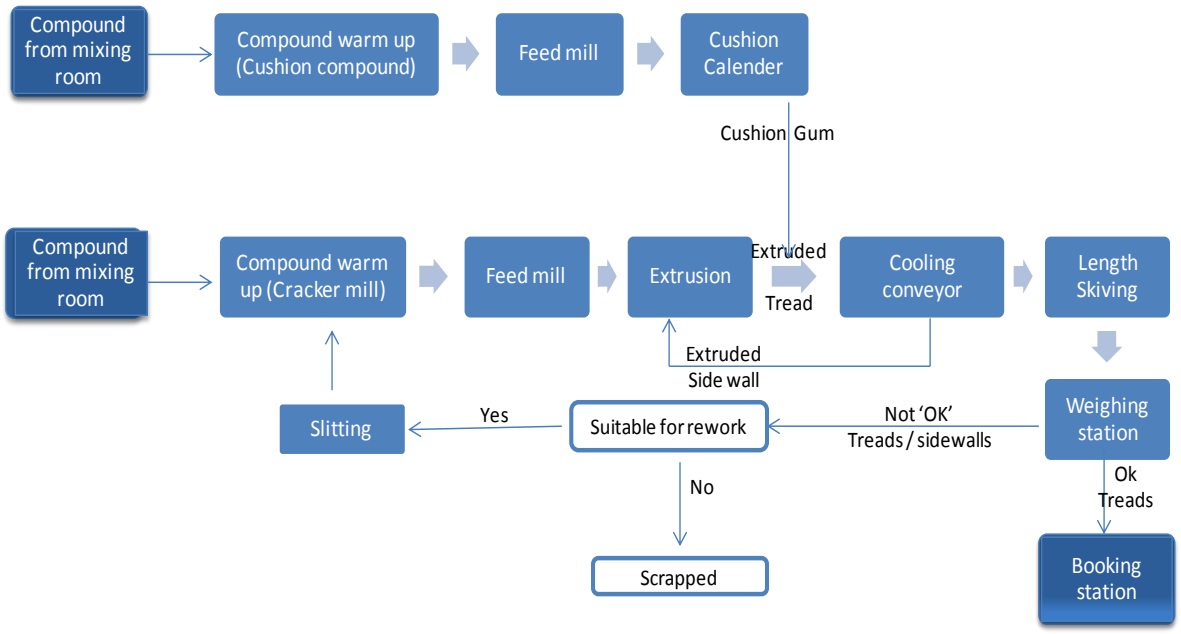
Input	▪ Rubberised fabric (or calendered fabric)
Process description	▪ After the calendaring process, the rubberised fabric sheet is then cut ▪ The cutting is called a bias cutting which is a angled cut done by a machine fixed at an angle as required ▪ The cut fabric is called a ply. The angled cut is a key characteristic and place a critical role in building process ▪ The sheet is taken by the operator manually and is spliced correctly over the

	edges (width to length transformation) ▪ The spliced cut plies are rolled with a poly propylene inter layer fabric to prevent sticking
Output	Output of this process will be the cut ply rolls used in tyre building process
Job role involved	▪ Calendaring Supervisors, Operators (Bias cutting operators, Splicer) and Helpers

Note: The plies made from this process are used in tyre building and in beading (flipping) process.

3. Extrusion (for tread rubber)

Figure 29: Extrusion Process flow chart



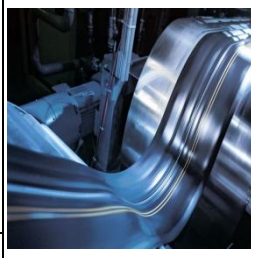
Step 1: Raw Material incoming and Extrusion

Input	▪ Rubber compound formed in the mixing process	**Equipment used** Extruder 
Process description	▪ Rubber compound from the mixing is taken to the extrusion section ▪ The die is fixed appropriately in the extruder as per the size of the tread required ▪ Rubber compound is fed into the extrusion machine ▪ Temperature in the extrusion machine needs to be set as per the specification and needs to be monitored ▪ Tread rubber comes out of the extruder as per the shape of the	

	die and colour lines are marked in the tread for identification purpose ▪ Tread rubber passes through water for cooling
Output	Extruded treads
Job role involved	▪ Extrusion Operators and Helpers

Step 2: Testing

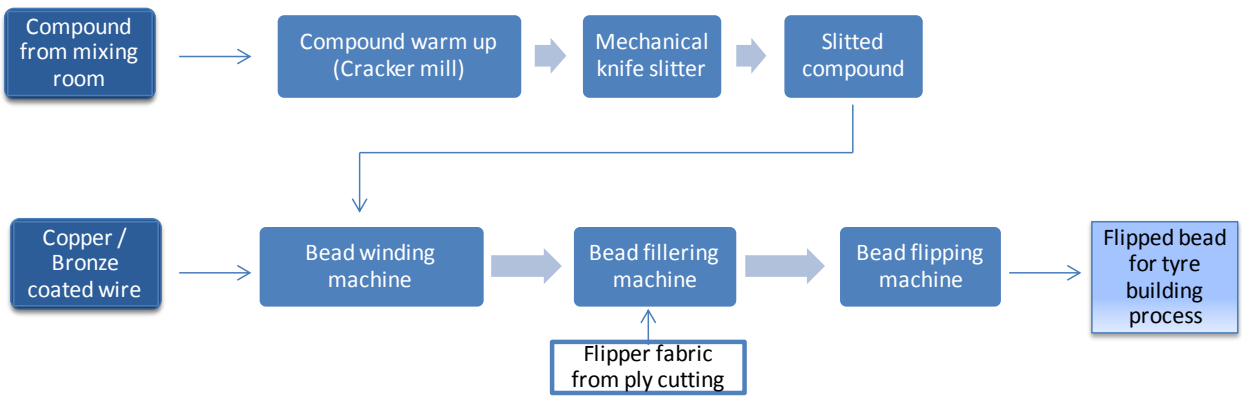
Input	▪ Extruded treads
Process description	▪ The tread rubber is cut as per the size of the tyre ▪ Then the tread is checked automatically in the conveyor for weight and length ▪ If there is a variation in length / weight / width, the tread is rejected ▪ QC passed tread is taken for the next process
Output	Treads meeting requirements of dimension and weight
Job role involved	▪ Extrusion Supervisors, Extruding Operators and Helpers



Note: Side wall, rubber compound (breakers) and bead fillering compound making is also made similarly (through extrusion process).

4. <u>Beading</u>

Figure 30: Bead room Process flow chart



Step 1: Bead Winding

Input	▪ Tempered steel wires with bronze / copper coating ▪ Rubber compound formed in the mixing process in the extrusion ▪ Solution of rubber compound in a hydrocarbon solvent
Process description	▪ Rolls of tempered steel wire with copper coating are fixed in the winding machine. Bronze / Copper coating ensures the bonding of the metal with rubber ▪ Bead winding is done and the beads are formed in a shape of tape ▪ Coating is done using a cross head extruder where a bunch of bead wire is coated with the rubber compound to form a bead tape ▪ Then this rubberised beads pass through rubber compound solution ▪ Enough length of the tape is concentrically wound (layer over layer) on a circular former of desired diameter to form the wound bead bundle
Output	Wound beads
Job role involved	▪ Bead winder operators and Helpers

Equipment used

Bead winding machine

Step 2: Bead Fillering

Input	▪ Wound beads ▪ Rubber compound strips
Process description	▪ A triangular extruded rubber compound is prepared in the extruder ▪ This compound is placed on the bead bundle's full periphery as an exterior strip
Output	Fillered bead
Job role involved	▪ Beading(fillering) operators and Helpers

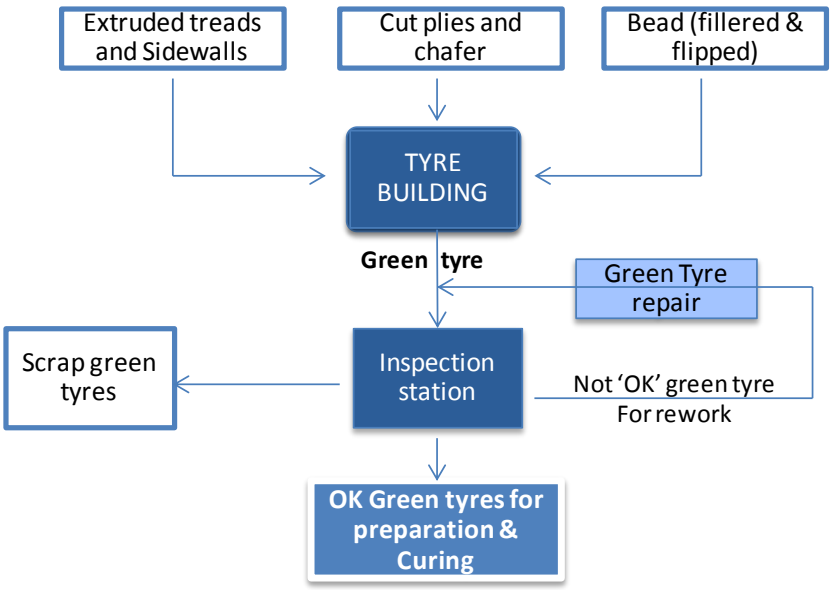
Step 3: Bead Flipping

Input	▪ Fillered bead ▪ Rubberised fabric

Process description	▪ The rubberised fabric is bought from the bias cutting process as rolls of fabric cut to the desired widths ▪ The flippering machine makes the flipper fabric to cover the full circumference of the fillered bead ▪ The flipper fabric is cut to length when the full bead is covered and spliced ▪ The flipping machine consolidates the flipper with the fillered bead in the cover process ▪ This process is done to provide additional strength to the tyre as the bead comes to contact with the rim of the wheel
Output	Output of this process will be the bead used in the tyre building process
Job role involved	▪ Beading operators and Helpers

II. Building

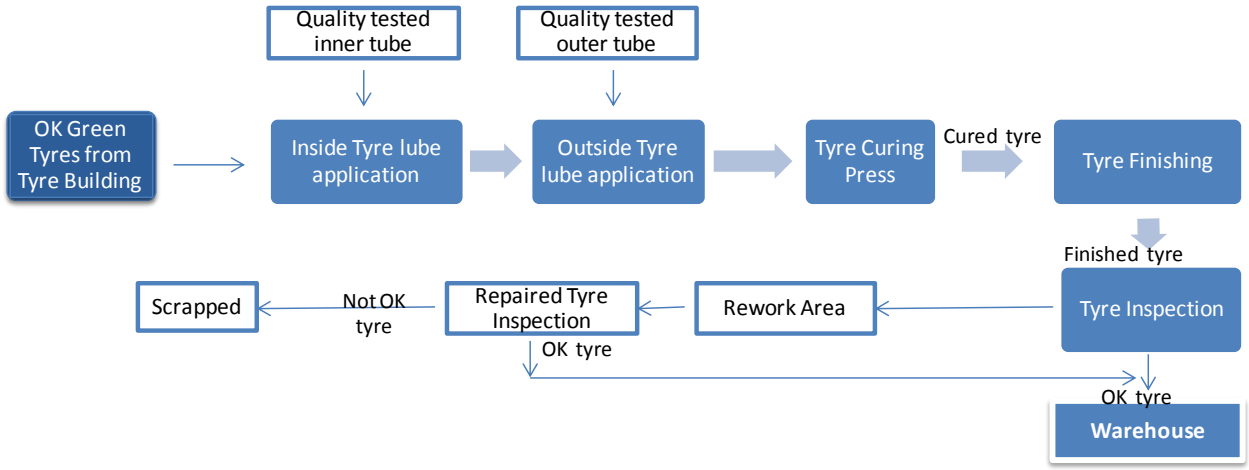
Figure 31: Building Process flow chart



Input	Ply, breaker, Side wall, flipped bead and Tread
Process description	▪ Tyre building can be a highly automated process or a series of manual processes ▪ In case of the automated tyre assembly, the first stage is to begin with an unsupported rubber sheet called inner liner, the beads, body plies, treads and sidewalls being placed on the building drum. The correctly-positioned beads rings are then attached, which results in the automatic wrapping of the ply edges around the

	bead core, and the simultaneously movement of the sidewalls into position ▪ After this, the tyre is shaped by inflating the rubber and applying side tread rubber, and plies ▪ In the case of manual building, the building operator manually, sequentially builds the tyre with ply, breakers, beads and then the tread ▪ During manual building, the building operator needs to ensure the alignment of the tyre (centering) ▪ Tyre building is the most critical process and it needs to be built as per specification without any wrinkles and air pockets ▪ The number of plies and breaker (and side walls) varies according to the tyre category and it needs to be built accordingly ▪ All the materials need to be intact and after building it is called a green tyre
Output	Green tyre
Job role involved	Building Operator and Helper

Figure 32: Curing and Finishing Process flow chart



III. Curing

Input	Green tyre	**Equipment used**
Process description	▪ The tyre is applied with a lubricant inside the tyre to facilitate easy laying and removal of bladder inside the tyre during curing process ▪ Then the green tyre is taken to the curing press and is placed	Curing Machine

	inside the curing machine ▪ Temperature, pressure and time parameters are set in the machine by the operator and the tyre is cured based on predetermined specifications ▪ After the curing time period, the tyre is removed from the machine ▪ It is then placed in a machine called post cure inflation machine depending on the tyre design and construction ▪ The tyre gets the physical properties and shape as required
Output	Cured tyre
Job role involved	Curing Operator and Helper

IV. Testing and Dispatch

Step 1: Finishing

Input	Vulcanized tyre
Process description	▪ Post Curing Inflation process is done to retain the shape of the tyre and to add strength of the tyre. This is an optional process ▪ Excess rubber remains on the tyre from vents in the curing mould. The finishing operation trims flash or excess rubber from the tyre ▪ Additionally, excess layers of rubber may need to be ground from the side walls or raised lettering on the tyre (only for radial tyres having balancing specifications)
Output	De-flashed tyre
Job role involved	Finishing Operator and Helper

Step 2: QC and inspection

Type of testing	**Testing parameters** (Except a few, tyre test are destructive in nature. Destructive testes are carried out on sampling basis)
Tensile test	A specimen cut from the tyre is clamped in a tensile testing apparatus under a defined pre-tension and subjected to constant rate of extensions until rupture. It is a test of the mechanical properties of the rubber compound.
Abrasion test	This is for determination of the resistance of tyre for wear and tear. The finished product is rubbed, ground and scraped against material to test the point of it

	rupturing (destructive test)
Elongation test	The extent to which the tyre compound elongates when it ruptures is tested
Breaking load test	The tyre is loaded gradually with the weights to find a point (load / weight) at which the tread breaks
Rheological test	The rheological test determines the characteristics of the compound. Analysis of the characteristics will help QA and compounding experts take action on the compounded rubber
Viscometer test	The viscometer test will map the change in rubber properties from the initial state to the cured state, thereby offering the QA and compounding experts analysis of the properties change
Dispersion test	This test evaluates the extent to which the carbon black is dispersed. The dispersion pattern is studied to glean the impact on the properties
Job role involved	Quality Check Supervisor, Quality Inspector

Step 3: Dispatch

Input	Inspected tyre
Process description	▪ If there is a problem in the tyre and if it can be fixed, it is sent to the repair section, else they are rejected ▪ The inspected and QC passed tyres are moved to godown for storage ▪ Tyres are dispatched as per order
Output	Tyres ready for dispatch
Job role involved	Helper

Common physical testing methods of raw rubber products

The below listed are some common physical testing methods of raw rubber products:

Type of testing	Testing Purpose	Apparatus used
Tensile test	This is done to evaluate the strength of the vulcanised and degree of the cure of the vulcanised. It is a test of the mechanical properties of the rubber compound.	Tensile testing machine
Hardness test	Measure hardness of master batch / product	Rubber hardness tester
Tear test	Tear tests give an indication of the behavior of the vulcanized rubber in tear initiation and tear propagation	Tensile testing machine
Abrasion test	This is for determination of the resistance of rubber product for wear and tear. The finished product is rubbed, ground and scraped against material to test the point of it rupturing	Abrader
Elongation test	The extent to which the rubber compound elongates when it ruptures is tested	Tensile testing machine
Leak test	Testing for joint hose leakage	Leak test machine
Rheological test	The rheological test determines the characteristics of the compound.	Rheometer
Viscometer test	The viscometer test will map the change in rubber properties from the initial state to the cured state.	Viscometer
Dispersion test	This test evaluates the extent to which the carbon black is dispersed. The dispersion pattern is studied to glean the impact on the properties	Dispersion tester
Aging resistance test	Measure heat aging resistance of product	Aging Oven Tester
Vibration test	Measure vibration resistance of product	Vibration Testing Machine
Burst strength testing	Measure burst strength of products	Burst Pressure Testing Machine

Trends and technological impact in rubber product manufacturing processes

Rubber product manufacturing is a technological process. Technological impact has been high in this industry and has improved the manufacturing process aiding the industry to a greater extent. Though there has not been a drastic change in the basic processes mentioned above, technology and advanced equipment have led to increase in productivity, less human intervention in the process, shorten the manufacturing time and increase in the quality of finished goods.

Indian rubber product industry has also adapted the technological changes in the manufacturing process and have implemented in their system. Technology impact has majorly come through changes made in the machines used for manufacturing process. Rubber products are machine oriented and any improvements in the machine used leads to improvement in productivity and quality. However, most of the changes have occurred by importing advanced machines from countries such as China, Japan, etc. and there have very little contribution by Indian companies in developing advanced manufacturing machines.

There have been advancements in manufacturing process of all types of rubber products. The below table gives a snapshot on some of the technological changes witnessed in some of the products' processes and its impact. As mentioned, the impact is due to installing advanced machineries and the impact is referred by parameters such as productivity, human resource requirement, operational cost, quality and process time.

Table 1: Impact of advanced system and machinery in rubber product manufacturing (Illustrative)

S. No	Process	Product	Traditional system / machine	Advanced system / machineries used	Impact
1	Compounding / Mixing	Raw rubber based products such as moulded, extruded, belts, etc	2 roll mill	Internal Mixer, Kneader	Increase in productivity, less process time
2	Moulding	Moulded products	Hand Press	Compressor Moulding, Injection moulding	Increase in quality, Less wastage, Increase in productivity, Precision product making
3	Extrusion	Extruded rubber products, Tread rubber	Hot extruder	Cold extruder	Less process time, Less operational cost
4	Vulcanisation	Extruded rubber products, Hoses	Vulcaniser / Auto clave machine	Moving oven	Less process time, Less human intervention

S. No	Process	Product	Traditional system / machine	Advanced system / machineries used	Impact
5	Deflashing	Moulded products	Trimmer, knives (Manual process)	Cyrogenic machines	Less process time, Less human intervention
6	Building	Tyre	Manual tyre building	Automatic Tyre Building machine	Increase in productivity, Less human effort
7	Tyre making	Tyre	Manual movement of tyres (to different sections)	Automatic movement (robotics) system for tyres to different section	Increase in productivity, Less human intervention
8	Dipping	Latex dipped goods (Rubber band)	Forms / moulds mounted in a stand (Manual process)	Automatic dipping machine	Increase in productivity, Less human intervention
9	Stripping	Latex dipped goods (Gloves, Condoms, balloons)	Manual stripping from moulds	Automatic stripping (in the assembly machine)	Increase in productivity, Less human intervention
10	Dipping, Vulcanisation	Latex dipped goods (Gloves, Condoms, balloons)	Forms / moulds mounted in a stand, Vulcanisation chamber	Assembly line machine for gloves / balloons / condoms	Increase in productivity, Less human intervention

The table is only illustrative and only some of the process is captured. In the above table, for example, compounding done in a 2 roll mill for 60 kg of compound takes 40 minutes approximately, whereas the same process takes around eight minutes in an internal mixer. In dipped goods such as gloves and condoms, the complete manufacturing process (former cleaning, dipping, leaching, vulcanization) is done by an automatic assembly line machine which has addressed the human resource shortage issue and increased the productivity as well.

However, in India, only large and medium sized companies have adopted for modern manufacturing processes and advanced machines. This is mainly due to the high cost of machines and the affordability to buy.

Global trends in Rubber Product Production

Rubber industries across the globe are constantly involved in R&D activities to enhance the manufacturing process. With the increasing awareness on the quality of the product, all the manufacturing companies are following best practices to deliver quality product. Innovations are made at machine level to produce more products, combine two or more processes and reduce the human intervention. There manufacturing processes followed for select rubber products across the globe are given below to understand the advancement in the processes.

Rubber hoses:

Traditionally, rubber hoses are manufactured by following sequential process of inner tube extruding, vulcanising, braiding, outer tube extruding and vulcanising. In all these steps, the rubber needs to be manually moved to different equipment and process cycle was time consuming. Innovations are made in this process and the entire manufacturing process is now automated. Rubber companies in china follows this system where the rubber compound is automatically fed into the extruder as per the process speed, the extruded rubber is collected in a moving oven (for curing), then it is passed through braiding (knitting) machine, again it is passed through extruder (for outer cover) and it passes through moving oven (for outer cover curing). The cured hose is also automatically cut and the product is collected at end. This assembly line automatic process has reduced significantly the cycle time and the human intervention involved in the process.

Rubber band:

In rubber band manufacturing, there are innovations made to improve the processes. Rubber band is a mass production product and the company would want to increase the productivity in the manufacturing. Thailand is a major rubber band manufacturer in the world and they export rubber bands globally. The process of extruding, vulcanising and cutting are major steps in rubber band manufacturing. These processes are automated in a single assembly line machine and the productivity is increased to a greater. This also resulted in reducing the operational cost and reduces the labour involved in rubber band manufacturing.

Dipped goods - Gloves:

Malaysia is one of the leading rubber product manufacturing countries. It is one of the top exporters of rubber gloves. Given below is a case study[1] of how innovation in manufacturing process helped them to improve their productivity in manufacturing.

In the late 1980s, glove manufacturers made use of glove production lines that were mainly imported from Taiwan. Soon after, local engineering companies started building “Made in Malaysia” lines. Glove manufacturers working with engineering companies improved the lines in several stages and today, the country has become the leading supplier of dipping line technology to other countries. An example to

[1] Source: http://www.innovation.my/pdf/innovating_formulation_of_nis/Rubber%20Products%20Innovation.pdf

illustrate how innovation has contributed to the industry is well reflected in the sharp increase in the speed of the production lines in different time period (given in years).

1988: Imported lines from Taiwan produce about 3,000 gloves/hour
1992: Malaysian Built Lines produce 6,000 gloves/hour
1997: Malaysian Built Lines produce 12,000 gloves/hour
2002: Major Innovation using double formers resulting in production of 20,000 gloves/hour
2007: Further improvement resulting in 30,000 gloves/hour
2010: Improved this to 36,000 gloves/hour

Innovation and process improvement is a continuous process and there are research done to improve further.

This is a case where engineering technology has helped improved the productivity of rubber gloves. Many rubber industries are coordinating engineering companies to improve their processes, adjust their production line so as to minimize the cost and increase the productivity.

Moulded products:

Most of the rubber moulding companies across the countries now prefers injection moulding as they are useful in manufacturing high volume of products with less wastage. Countries such as China and other European countries are using Liquid Silicone Rubber (LSR) for moulding. This would increase the quality of the end product. Also, it has been proved that usage of LSR has resulted in easier processing, faster cycle time and better end products. Automobile industry is a major consumer of the moulded rubber products and they require high quality and performance products. So, these innovations at raw material and compounding help them to achieve the desired quality of end product.

Also there are precision and engineering rubber products manufactured where technology is involved at high level. Rubber to metal bonding, rubber with plastic bonding, mesh inserts, fabric inserts and tuflon coating with rubber are some of the engineering products required by manufacturers. These are engineering products which requires precision manufacturing techniques. Unlike general rubber products, the manufacturing of technical rubber products requires more sophisticated equipment for production and for quality evaluation of the products. Very often, this requires highly automated processing facilities. The manufacturing practices and processes for engineering rubber products may require the utilization of advanced manufacturing technologies, which involve new manufacturing techniques and machines combined with the application of information technology, micro-electronics and new organizational practices within the manufacturing process. Computer-aided design (CAD) and rapid prototyping are used to shorten the development time for testing and designing new products. These automated machines are designed by coordinating with precision equipment making engineering company and are used for manufacturing these technical rubber products.

Tyres:

Tyre is an engineering and technology product. Research and Development is a constant activity in tyre industry to improve the performance of tyres. Innovations are taking place to make permanent tyre and eco-friendly tyres for future. Tyre manufacturing process has also undergone major changes time to time. One of the major changes was the automatic tyre building machine development. Traditionally, tyre building was a laborious activity and the productivity is dependent on the tyre builders' ability to build tyres. Also, the quality is dependent on the efficiency of the employee to build the tyre which required immense physical effort. Automated tyre building machine has helped the tyre manufacturers to constantly maintain the quality of tyre and increasing the productivity. Tyre manufacturers in United States and European countries have almost fully automated the tyre manufacturing process. The process is automated through robotics and conveyor system is deployed and the tyre is carried automatically to different sections of processing (extrusion, building, curing and inspection) and the efficiency and productivity have increased significantly

These are some of the cases where best case manufacturing process is currently followed in the mentioned countries. Rubber industries in India are also adopting some of the best manufacturing process and are competitive with global manufacturing companies. These practices can be followed by most of the firms to increase their productivity and quality of the product manufactured.