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Sustainable Manufacturing Process in Crepe Rubber

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ABSTRACT

Hevea Brasiliensis is a tree which discharge white colored latex that is utilized to produce natural rubber. Among the different types of Natural Rubber (NR), crepe rubber holds a significant position, as it is used to produce pharmaceutical and surgical rubber products, and also articles that are in contact with food materials. At present, the crepe rubber manufacturing has been challenged by low productivity, rising cost of production, and environmental issues. Therefore, this study was aimed to assess the feasibility in the adoption of sustainable manufacturing practices in the crepe rubber production. They are used for the production of huge end products like tyres, condoms, surgical gloves, balloons, adhesive, rubber band, carpet backing etc. It is produced by applying few steps named as latex collection by tapping process, preservation, coagulation, sheet formation and smoke drying process. Thus this study explains the formation of various types of crepe rubber.

Keywords**:** Natural Rubber production, Rubber products, Crepe Rubber

INTRODUCTION

Crepe rubber is coagulated latex that is rolled out in crinkled sheets and commonly used to make soles for shoes and boots but also a raw material for further processed rubber products. Crepe rubber is processed from fresh latex coagulum or cutting of Ribbed Smoked Sheets (RSS). These materials are passed through a set of crepe making machines, to get crinkly, lace- like rubber. This when dried is called Crepe rubber. Processing into crepe rubber was one of the method to upgrade low quality field coagulum materials such as earth scrap, shell scrap and tree lace. Materials selected from different types of field coagulum are blended in appropriate proportion to make crepe rubber of desired quality thorough soaking, agitation, cleaning and machining are required to produce good quality crepe from field coagulum materials. Processing of low quality field coagulum into crepe rubber is now replaced by Technically Specified Rubber (TSR) because it yields a better quality material.

Crepe Rubber Processing

Colloidal latex is first mixed with formic acid to causes coagulation. The coagulum is processed in a "creping battery", a series of machines that crush, press and roll the coagula. The sheets are hung in a heated drying shed and then sorted by grade and packed for shipping.

Grades of crepe rubber

Grades of crepe rubber depends on quality of crepe rubber sheets. Quality of sheets depends on several factors such as quality of latex, amount of formic acid added, during coagulation time, washing quality and drying time.

Crepe Rubber Manufacturing

Crepe rubber manufacturing is long process. It takes around 4 days to finish one bulk of sheets. Crepe rubber should be manufactured very cleanly, because they are used to prepare pharmaceutical products. Usually crepe rubber takes white colour. As much as **non rubber constitutes** should be removed to get more clean and pure crepe rubber. Most clean and pure rubber will get higher price in the market.

Types of Crepe Rubbers

There are several types and grades of rubber crepe, mainly distinguished by the grade and pre-processing of the latex used in their manufacture.[1]

- Pale latex crepe (PLC) is a premium grade, made from raw field latex.
- Estate brown crepe (EBC) is made from "cup lump" (raw, naturally coagulated rubber from the collection cup) and other coagulum.
- Re-milled crepe is made from "wet slab coagulum" (cured latex, still wet from the coagulation tanks), latex sheets (unsmoked) and cup lump
- Smoked blanket crepe is made from thick sheets of latex that have been processed in a smoker.
- Flat bark crepe is made from scraps and other poor quality raw product**.**

Processing of Natural Rubber

Fresh latex, as it comes out of the tree is slightly alkaline or neutral. Micro-organisms may contaminate it. They metabolise the non-rubber constituents of the latex and produce volatile fatty acids such as formic, acetic and propionic acids. These acids neutralise the negative charge on rubber particles and the latex gradually thickens and gets coagulated within 6 to 12 hours of its collection[7]. Therefore, anticoagulants (or preservatives) like ammonia, sodium sulphite or formalin (depends on the type of processing) are added to keep it for longer periods before it is processed[7, 8]. Among the various chemicals used as preservatives, ammonia is of prime importance. Natural Rubber(NR) latex harvested from plantations needs to be processed soon after harvesting to maintain its quality. Processing of this latex is essential also for easy storage, transportation, better uniformity in quality and utilization by manufacturing industries. A large number of rubber processing units (RPUs) have been established in Kerala for the processing of latex and the field coagulum into different marketable forms of Natural Rubber .

The major categories of processed rubber are:

- (a) Ribbed smoked sheets (RSS)
- (b) Pale latex crepe (PLC)
- (c) Technically specified rubber (TSR)
- (d) Preserved field latex and latex concentrate (PFLR).

PROCESSING METHODS

(a)Ribbed Smoked Sheets (RSS)

It is the oldest and simplest method of processing latex into a marketable form. Latex collected from the field is first sieved to remove foreign materials. It is then bulked for uniform property and diluted to standard dry rubber content (DRC) of 12.5 per cent to improve the quality of coagulum. Chemicals like sodium bisulphite and paranitrophenol are added to prevent discolouration /mould growth. They also act as preservatives. The latex is then coagulated using formic acid or acetic acid. After completion of coagulation, the serum is drained out and the coagulum is obtained in the form of blocks. Washed coagulum is then rolled to sheets using a pair of plain rolls and another set of grooved ones. The sheets are then allowed to drip in shade and dried in smoke houses for producing ribbed smoked sheet.

Water is used in the process for diluting the latex and washing the coagulum during sheeting operations. This water forms part of the effluent. The water consumption is in the range of 20-30 litre /kg of dry rubber.

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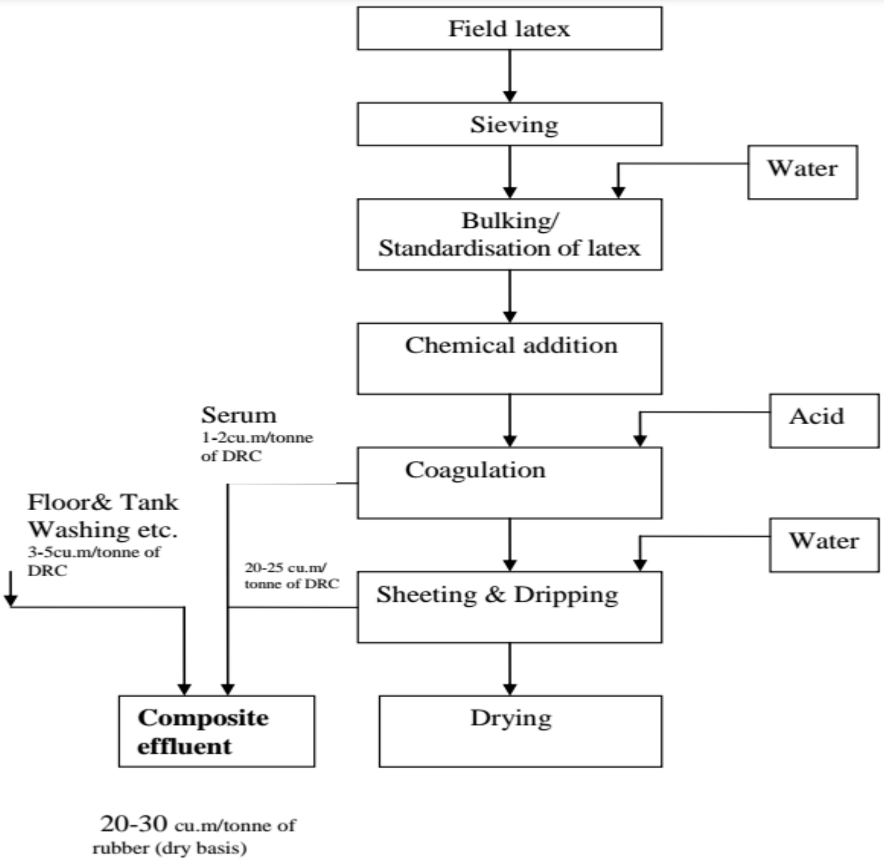

Fig.1.1. Process flow chart for ribbed smoked sheet manufacture

Pale latex crepe (PLC)

When coagulated latex or any form of field coagulum or RSS cuttings, after necessary preliminary treatments, are passed several times through a set of creping machines, lace-like rubber is obtained. This lace like rubber when air-dried is called crepe rubber

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Different stages in the manufacture of pale latex crepe (PLC) are shown in Fig.1.2.

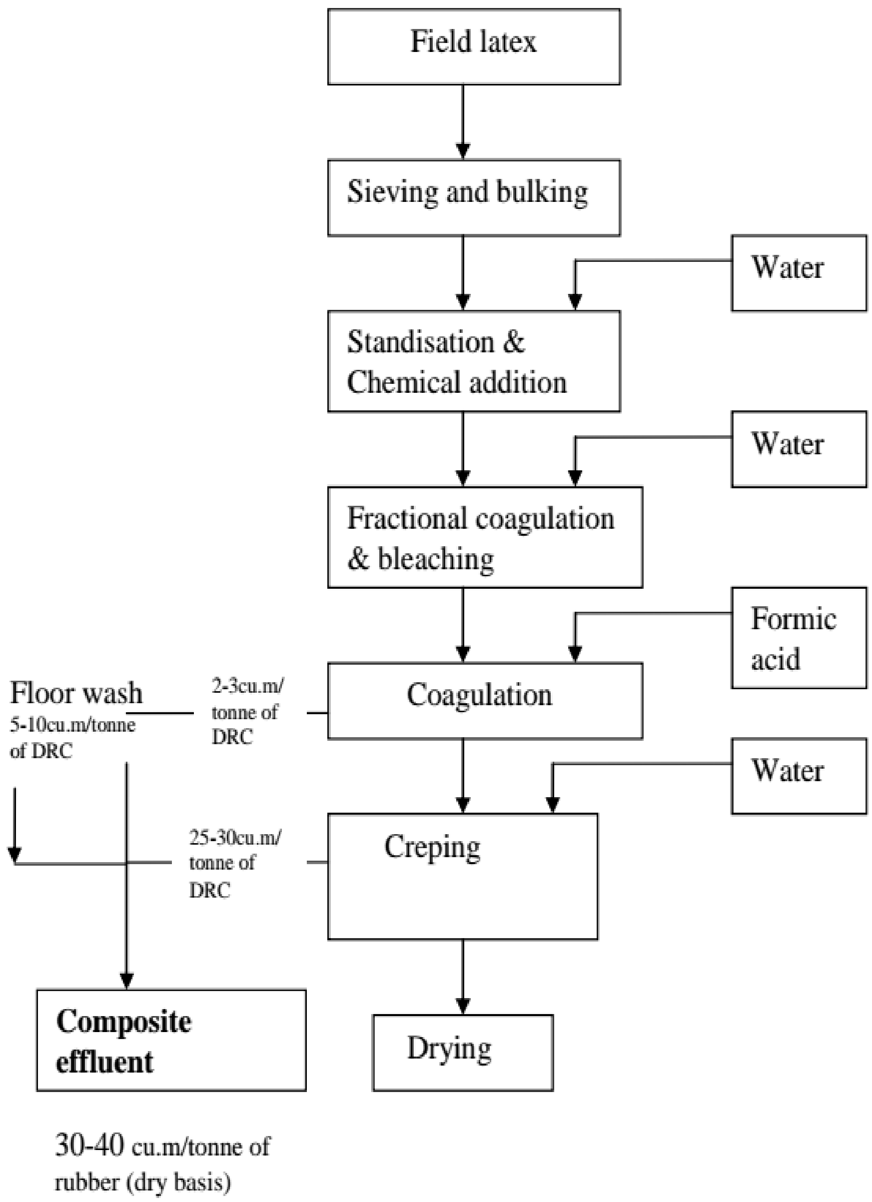

Fig.1.2. Process flow chart of pale latex crepe unit.

The field latex containing anticoagulants like sodium sulphite is received. The latex is then sieved, bulked, standardised by dilution and chemically treated. The chemically treated latex is then subjected to fractional coagulation using acetic acid for removing colouring materials[9]. It is then sieved through a 60 mesh sieve. The latex after fractional coagulation and bleaching is coagulated using formic acid. About 4 ml of formic acid per Kg of dry rubber is used. The coagulum obtained in the form of block is milled in creping machines. Water is used for washing coagulum during milling to wash out the serum and other non-rubber materials. The crepe is then dried at ambient or slightly elevated temperature in drying sheds and packed.

In a pale latex crepe unit, water is required for diluting the latex, washing the coagulum and for cooling the rollers. Wastewater is released from the latex coagulation section and crepe milling section[10]. Water consumption per Kg of DRC is about 35-50 litres. The effluent discharged marginally exceeds the quantity of water consumed, because of the addition of serum in the process of coagulation.

(c) Technically specified rubber (TSR)

TSR or crumb rubber is mostly produced from field coagulum11. The stages in the process are collection of field coagulum, soaking and precleaning, blending, milling and size reduction, drying, pressing and packing. When crumb rubber is produced from field latex, the additional stages required are bulking, coagulation and pre-machining. Sodium bisulphite at the rate of 1 g/Kg of DRC rubber is added as 1 % solution to the bulking tank to prevent surface darkening of the coagulum. Coagulation of latex is done using either formic or acetic acid. Individual slabs of latex coagula are cut into smaller pieces before feeding to an extruder or one or two passes are given through a creper before feeding to a hammer mill for final size reduction. Water is required for scrap soaking, milling, size reduction and crumb collection. The water consumption and effluent generation is estimated to be 35-55 litres per Kg of DRC. The flow diagram of the process is shown in Fig.1.3.

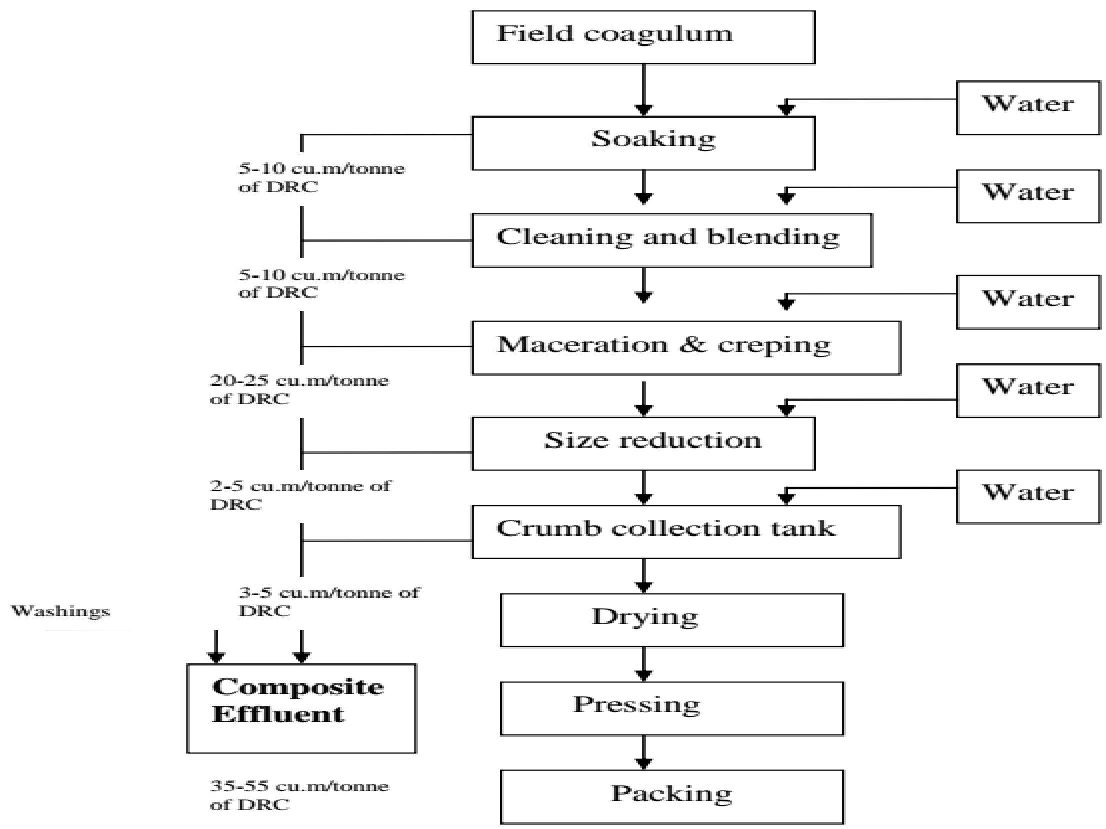

Fig.1.3. Process flow chart for technically specified rubber factory

(d) Preserved field latex and latex concentrate

Field latex preserved with suitable preservatives is termed as preserved field latex. Processing into preserved field latex consists of adding the preservative, bulking, settling and blending into consignments of suitable size for despatch.

Latex concentrate is an important raw material having wide uses. The process of latex concentration removes substantial quantity of serum from field latex, thus making the cream richer in rubber content. The major processes in a latex concentrating unit are ammoniation, desludging, latex concentration and skim recovery.

The latex from the field is sieved and bulked and ammonia is bubbled through it so as to get a concentration of 0.7 to 1.0 per cent by weight of latex. Ammonia inhibits bacterial growth, acts as an alkaline buffer and raises the pH and neutralises the free acid formed in latex[12]. The degree of ammoniation depends on the period, which has elapsed since collection and ranges from 0.25% for immediate centrifuging to 0.8% for two days or more. Only the minimum required quantity of ammonia should be added since most of it goes to the skim which makes coagulation of the skim difficult. Ammonia deactivates some metal ions which tend to coagulate latex by forming insoluble compounds or complexes with them. For the complete precipitation of magnesium as magnesium ammonium phosphate, calculated quantity of diammonium hydrogen orthophosphate is added if the phosphate ions already present in the latex are not sufficient.

After ammoniation, latex is left undisturbed for about 15-20 minutes to allow separation of sedimentable impurities and reaction product (magnesium ammonium phosphate).

Preserved field latex is unsuitable for most latex applications as its rubber content is low. For most product manufacture, latex of minimum 60 per cent dry rubber content is essential. The important methods for the concentration of preserved field latex are (i) centrifuging and (ii) creaming. These methods involve partial removal of non-rubber constituents. The particle size distribution of the concentrate differs from that of the initial latex. A portion of the smaller particles escapes to the serum. At present, more than 90 percent of the latex concentrate is obtained by centrifuging.

Main stages in the Manufacturing Process

1. Centrifuging

Different types of centrifuging machines are used for concentration of latex. In the centrifuging process of latex, the centrifugal force brings about separation of rubber particles from the serum. The rotating mass of ammoniated field latex is broken up into a number of thin conical shells within the bowl rotating around 6000 rpm whereby individual rubber particles tend to separate into a layer surrounding the axis of rotation leaving behind an outer layer (skim) having a comparatively lower rubber content. The DRC of the centrifuged latex is around 60 percent. About 85 to 93 percent of the total rubber in the field latex will be separated into the cream or concentrated fraction. The cream is separately collected in a bulking tank, its ammonia content estimated and made upto 0.7% on latex and packed in drums.

LATZ latex

Centrifuged latices are commercially available as high ammonia (HA minimum 0.6% ammonia), and low ammonia (LA- maximum 0.3% ammonia), types. The former is preserved solely with ammonia and the latter contains one or more preservatives in addition to ammonia and the most popular LA type latex is low ammonia-TMTD-Zinc oxide(LA-TZ) which contains 0.2% ammonia, 0.013% tetramethyl thiuran disulphide (TMTD), 0.013% ZnO and 0.05% lauric acid. Major advantages of LATZ are reduced cost of production through, savings in preservatives, acid and effluent treatment and improvement in the quality of output. It also ensures better working environment in the factory.

Double centrifuged latex is a purer form of concentrated latex obtained by a second stage of centrifuging ordinary centrifuged latex after dilution to 60% DRC.

Skim latex and serum effluent

When field latex is centrifuged /creamed, in addition to the concentrate containing most of the rubber, an equal fraction in volume, containing a very small proportion of rubber is also obtained. This is known as skim latex. 3.5 to 6 per cent rubber will be lost into the skim fraction. It contains about two thirds of the total serum from the field latex. To recover the rubber in skim latex, it is coagulated with sulphuric acid and the serum left out is drained off and is known as skim serum effluent.

In-depth study conducted in RPUs reveal that the volume of water consumed by latex concentrating units is much less when compared to that of other processes. The water requirement in centrifuging process is in the range of 3.5 to 6.0 litres per Kg of dry rubber as latex concentrate. The quantity of effluent generated is found to vary widely from unit to unit and depends on the processing capacity of the unit. Apart from the water consumed for processing, the serum left out after coagulation of the skim latex is also discharged from industries which have adopted centrifuging process. Hence, the quantity of effluent discharged is much higher than that of the water consumed[13]. The water requirement is mainly for cleaning the latex storage tanks once a week, washing the barrels and floor, washing the bowls of the centrifuging machine twice in a shift and coagulation of skim latex. Apart from the skim serum, all the water used in the process comes out as effluent.

The flow diagram of the process with effluent generation is shown in Fig.1.4.

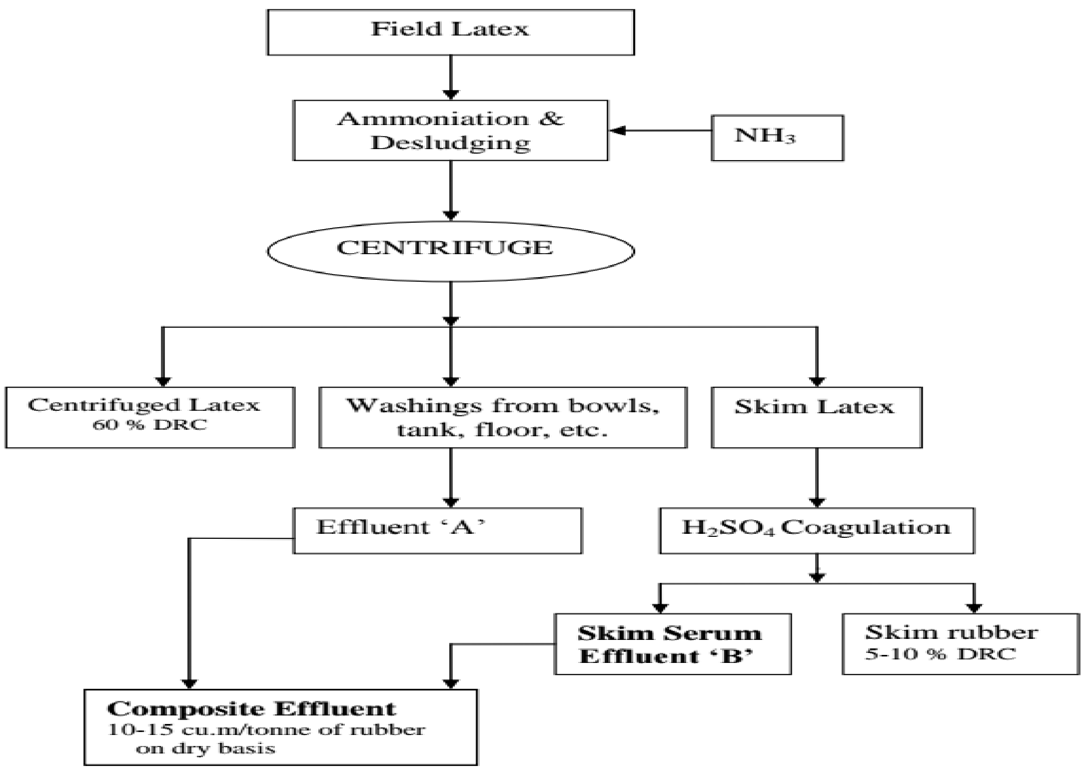

Fig.1.4. Process flow chart of latex centrifuging unit

2. *Creaming*

Field latex is ammoniated to 1 % and kept for a few days for ageing. Ammonium alginate or cooked tamarind seed powder is usually used as the creaming agent. A 3% solution of the seed powder is prepared by boiling the required quantity in water. The calculated quantity of the creaming agent solution which has been sieved to remove uncooked materials and a 10 percent soap solution is added to latex in order to get a final concentration of 0.3 per cent in latex. The latex is stirred for one hour. After stirring, the latex is allowed to remain undisturbed for a minimum period of 48 hours to obtain the desired level of creaming[11].

Although a minimum period of 48 hours is usually required for creaming, fixed time can be set for all conditions. After the creaming agent is added there is an induction period of several hours before any creaming is visible. For the first 24 - 40 hours, creaming is rapid and then it becomes slower. The gravitational force brings about the separation of rubber particles during creaming. When the desired level of creaming is obtained, the skim layer is drained off. Latex with 55-58 percent of DRC is obtained by the creaming method. The skim serum left behind will contain 2-3 per cent rubber. The water requirement in a latex creaming unit is for operations like cleaning the reception tanks and floor of the factory. This water goes out as effluent.

CONCLUSION

As per the above discussion, it has been concluded that, out of the four types of crepe rubbers, the Ribbed Smoked Sheet (RSS) is referred as the better quality product which are highly used when compared to TSR, PLC and PFLR. Ribbed Smoked Sheet is also considered to be easily obtainable and cheapest with reference to other types of Crepe Rubbers.

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