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RUBBER SKILL DEVELOPMENT COUNCIL

Participant Handbook

Sector
Rubber Industry

Sub-Sector
Tyre & Non-Tyre

Occupation
Calendering

Reference ID: **RSC/Q2701, Version 1.0**
NSQF Level 4

Rubber Calendering Operator

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> Skilling is building a better India. If we have to move India towards development then Skill Development should be our mission.

Shri Narendra Modi
Prime Minister of India

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COMPLIANCE TO
QUALIFICATION PACK – NATIONAL OCCUPATIONAL STANDARDS

is hereby issued by the

RUBBER SKILL DEVELOPMENT COUNCIL

for

SKILLING CONTENT : PARTICIPANT HANDBOOK

Complying to National Occupational Standards of
Job Role/ Qualification Pack: '**Rubber Calendering Operator'** QP No. '**RSC/Q2701 NSQF Level 4**'

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Authorised Signatory
(Rubber Skill Development Council)

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We are also grateful to the partner organizations for their efforts in reviewing and endorsing this participant handbook.

About this book

The participant handbook for 'Rubber Calendering Operator' is designed for participants to enable them to get trained and upgraded for the knowledge and basic skills of 'Rubber Calendering Operator' in 'Rubber Industry' sector. All the aspects of skills required by the participant, are covered in this handbook. This participant handbook is designed to enable training for the specific Qualification Pack (QP) drafted by Rubber Skill Development Council (RSDC) and ratified by National Skill Development Corporation (NSDC). It covers following National Occupational Standard (NOS) across Unit/s:

- RSC/N2704 - Perform pre rubber calendering activities
- RSC/N2705 - Perform calendering operation using 3 roll/ 4 roll calender
- RSC/N2706 - Perform post rubber calendering activities
- RSC/N5001 - Carry out housekeeping in rubber product manufacturing
- RSC/N5002 - Carry out reporting and documentation
- RSC/N5003 - Carry out quality checks
- RSC/N5004 - Carry out problem identification and escalation
- RSC/N5007 - Carry out health and safety

This handbook is designed to provide the necessary knowledge and skill to the participants to carry out their duties in an organized and disciplined manner by following safe working practices.

Key Learning Objectives for the specific NOS mark the beginning of the Unit/s for that NOS. The symbols used in this book are described below.

Symbols Used


Key Learning Outcomes


Steps


Time


Tips


Notes


Unit Objectives


Activity


Exercise


Summary

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1. Introduction to Rubber Calendering

Unit 1.1 – Introduction to Rubber Industry

Unit 1.2 – Rubber Calendering Basics

Unit 1.3 – Process of Rubber Calendering

Unit 1.4 – Job Role of a Rubber Calendering Operator

Key Learning Outcomes

At the end of this module, you will be able to:

1. Discuss about rubber industry.
2. Explain different sources of rubber.
3. Discuss about major Indian Rubber Associations.
4. Explain the rubber terminology.
5. Explain the basics of rubber calendering process.
6. Define material used in rubber calendering.
7. Explain equipment used for rubber calendering.
8. Define roles and responsibilities for rubber calendering operator.

UNIT 1.1: Introduction to Rubber Industry

Unit Objectives

At the end of this unit, you will be able to:

1. Discuss rubber and rubber industry.
2. Define types of rubber.
3. Explain about rubber manufacturing processes.
4. Explain different uses of rubber.
5. Discuss about various rubber bodies and associations in India.

1.1.1 The Rubber

Rubber is a polymer material, which has elastic properties. It is also called as 'Caoutchouc'. It normally has long chain molecules known as "polymers" . Rubber being elastic, is also called "elastomers". Products made from rubber have a flexible and stable – three-dimensional chemical structure and are able to withstand higher force and large deformations. For example: the material can be stretched repeatedly to at least twice of its original length and upon immediate release of the stress, will return with force, approximately to its original length. Under load, the product should not show creep or relaxation. Besides these properties, the modulus of rubber ranges from hundred to ten thousand times lower, as compared to other solid materials like steel, plastics and ceramics. This combination of unique properties, gives rubber its specific applications like seals, shock absorbers and tyres.

Based on the source of raw material, there are two kinds of rubber, Natural Rubber (NR) and Synthetic Rubber (SR). However, there is third type of rubber - reclaimed rubber, which is produced by recycling scrap rubber.

Fig. 1.1.1. Rubber

Natural rubber

Natural rubber is mainly harvested from rubber plants. There are many plant species that generate natural rubber and there are many other plants that contain rubber latex. For quality and economic considerations, rubber plant is a major source of natural rubber.'Latex' is a sticky, milky white, liquid material. The process used for extracting latex is called 'tapping'.

Fig. 1.1.2. Rubber Plant

Fig. 1.1.3. Collection of rubber by tapping process

This latex is further processed for making rubber, which can be used for making some useable products. Latex is processed in following ways –

1. Sheets
2. Creps
3. Block rubber
4. Preserved latex concentrates

Most of the natural rubber is sold in the form of sheets, creps and block rubber.

Sheets

This form is most easy to produce; hence it is the most saleable form of natural rubber. There are 2 types of sheets –

1. Ribbed Smoked Sheets (RSS)
2. Air Dried Sheets (ADS)

Out of above types, Ribbed Smoked Sheets are more common in market. There are five grades of Ribbed Smoked Sheets based on quality. These grades are established by International Rubber quality and packing conference. Only completely dried sheets are allowed to be sold in this category. Based on different conditions, these ratings are called as RSS1, RSS2, RSS3, RSS4 and RSS5

Fig. 1.1.4. Rubber sheets

Crepes

Crepes are derived from coagulated latex / field coagulam after getting rolled many times between rollers and then dried in Air. There are many types of crepes, namely – pale latex crepes, estae brown crepes, thin brown crepes, thick blanket crepes, flat blanket crepes, standard flat bark crepe and pure smoked blanket crepe.

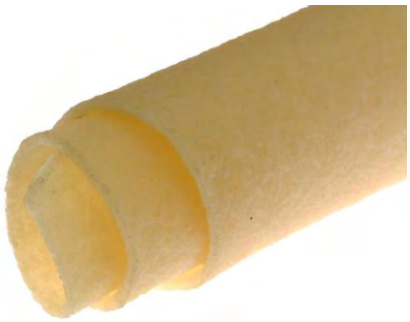

Fig. 1.1.5. Rubber crepes

Technically specialized Natural Rubber

Natural dried rubber is graded based on technical specification. It was initially proposed by ISO (International Standard Organization) and then Malaysia adopted it in 1965. Later on all natural rubber producing countries adopted the system. In this system, two letters of the countries name used for making code. For ex - Indian natural rubber is coded as ISNR (Indian Standard Natural Rubber)

Fig. 1.1.6. TSR rubber

Synthetic Rubber

As the name suggest, it is man made rubber, which is derived from petroleum, coal, oil, natural gas and acetylene. It has more than 10 major classes, many of these are copolymers i.e. polymers consisting more than one monomer. Initially, Styrene-butadiene copolymers (SBR) synthetic rubbers were invented. Which is one of the widely used elastomer. Synthetic rubber is used as a replacement for natural rubber in many cases, especially when improved material properties are needed. Common used Synthetic rubber are –

1. Emulsion Styrene Butadiene (ESBR)
2. Butadiene Rubber (BR)
3. Solution Styrene Butadiene (SSBR)
4. Isobutylene Isoprene Butyl (IIR)
5. Acrylonitrile Butadiene (NBR)
6. Ethylene Propylene diene monomer (EPDM)

Fig. 1.1.7. Synthetic rubber

Used or Reclaimed Rubber

Used or reclaimed rubber is the product, which is recovered from the processing of vulcanized scrap rubber tyres, tubes and miscellaneous waste rubber goods. The process includes use of heat and chemical agents. The process also includes heavy mechanical working. This reclaimed rubber has plasticity which is near to the original plasticity. This rubber can be compounded, processed and re-vulcanized as fresh rubber. During the process of reclamation the molecular weight of the elastomeric component is substantially reduced.

Fig. 1.1.8. Reclaimed rubber

1.1.7 Uses of rubber

Rubber is a widely used product now a days. It is used in automobiles, household and industrial applications. Some of the most common uses are as following -

- Tyres and Tubes - Automobile and agriculture tyres and tubes are the largest consumers of rubber. This category consume around three fourth of total rubber consumption.
- 'Under the bonnet' products for automobile - It includes, Door and window profiles, noses, bells, matting, flooring and dampeners (anti-vibration mounts).
- Conveyor Belt – for various industrial use.
- Hoses and pipes – for air and water circulation.
- Medical equipment - Gloves (medical, household and industrial), toy balloons, rubber bands, etc.
- Adhesives – Many manufacturing industries and products also use rubber product as adhesives. It is mostly used in paper and the carpet industry.
- Textile industry – Rubber is also widely used in textile industry.
- Shock absorbers – Impact absorbing property of rubber is very useful in shock absorber application.
- Machine mounting pads – it is widely used as a machine mounting mount, which helps in reducing vibration transfer to floor from machine.

Fig. 1.1.9. Rubber products

1.1.8 Rubber industry

Initially rubber industry started in South America during 19th century. Where it was restricted for a long time from export. In 1876, English brought it to India, Sri Lanka and other parts of Asian countries. Initially rubber trees were planted in Kolkata and then later it was grown in coastal areas of Kerala, Tamil Nadu and Karnataka.

Rubber products manufacturing started in India, in the year 1920. Now, Rubber industry is one of the key industries of the Indian economy.

Following are some of the facts on rubber industries –

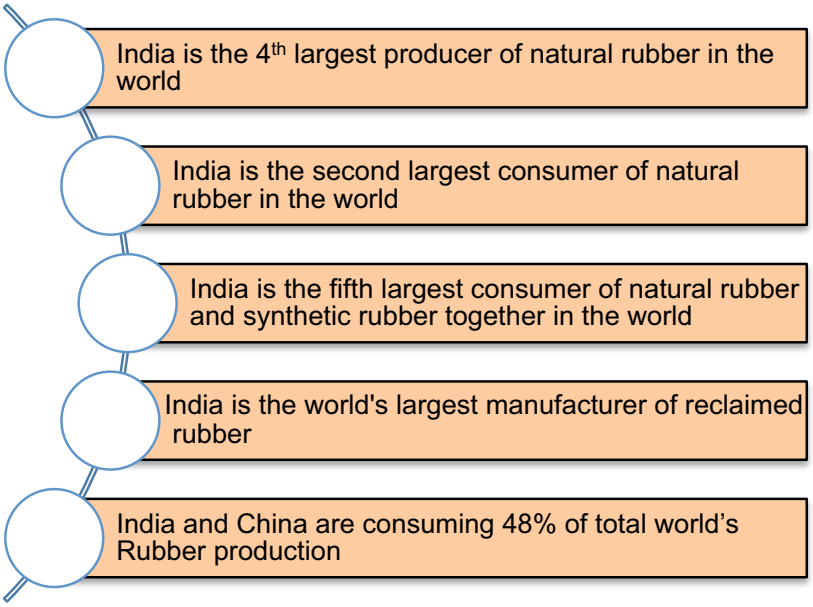

Fig. 1.1.10. Rubber industry facts

Overview of India Rubber Industry

India produces approx. 7 Lakh tons of rubber, annually . In India there are approximately 6000 rubber product companies. Out of these some 35 large scale companies, 320 medium scale and more than 5000 small scale industries. These companies do total turnover of around Rs. 12,000 Crore. These units are manufacturing more than 35000 rubber products, employing four Crore people, which also includes 22000 technically qualified support personnel. India's rubber industry has growth rate of 8-9% per annum.

India consumes nearly 20 lakh tones of rubber (including natural, synthetic and reclaim) annually (as per the data of 2018-19) for producing a wide range of rubber products. Tamil Nadu (3.7 lakh tones), Maharashtra (2.09 lakh tones) and Kerala (2.02 lakh tones) are the top three rubber consuming states in the country (as per the data of 2018-19).

Trend of Rubber Consumption in India

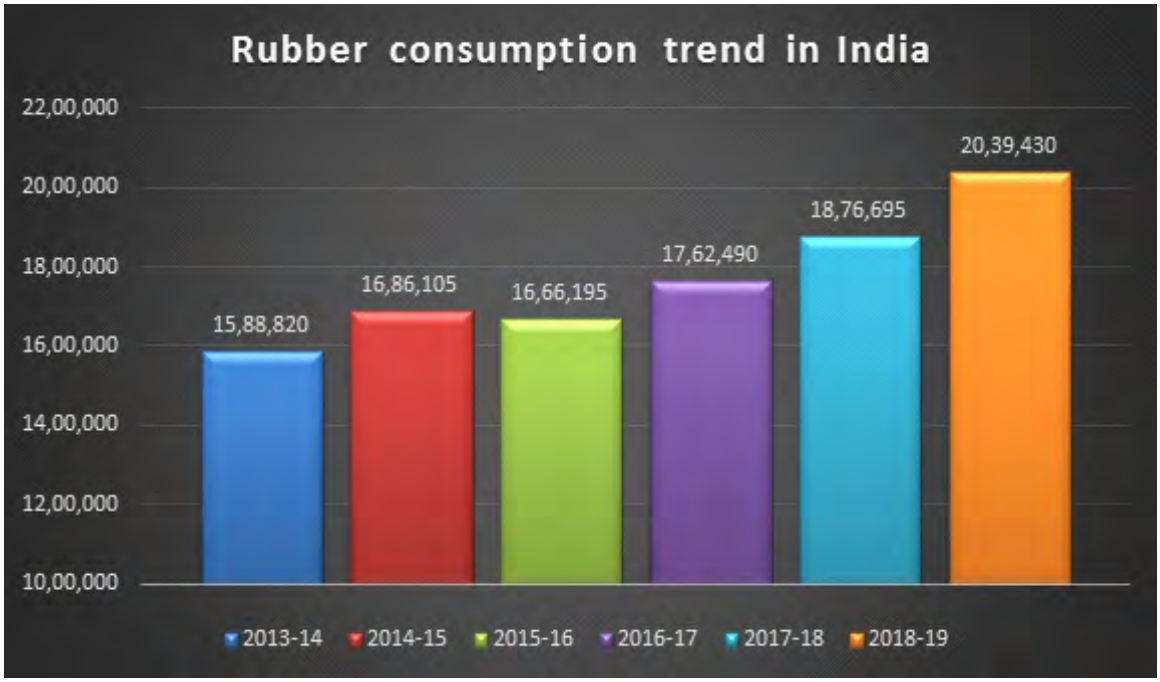

Fig. 1.1.11. Trend of rubber consumption

Rubber Consumption in India

The major rubber consuming sectors in India are as follows:

1. Automotive tyre sector
2. Bicycles tyres and tubes
3. Footwear
4. Camelback and latex products
5. Belts and hoses
6. Rest of products

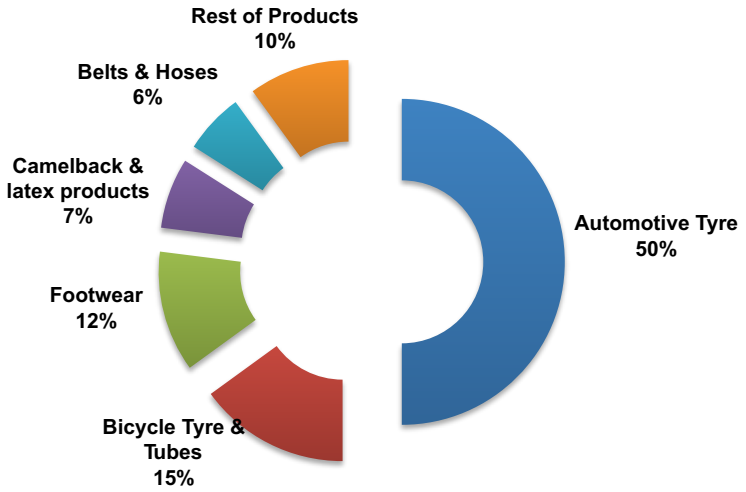

Fig. 1.1.12. Rubber consumption details

UNIT 1.2: Rubber Calendering Basics

Unit Objectives

At the end of this unit, you will be able to:

1. Describe common terminology used in rubber industry.
2. Explain what is calendering.
3. Describe the constituent material of a calendered part.
4. Define the types of calendering.

1.2.1 Basic terminology

Before studying calendering, we will learn basic rubber terminology which is commonly used in rubber industry. These are as follows –

Accelerator- Chemicals which are used for accelerating vulcanization or curing process, called Accelerator.

Autoclave- An equipment used for vulcanization of rubber with heat and pressure.

Compression moulding- It is a process of rubber moulding by heat and pressure. Due to heat rubber softens and flows in mould.

Compound- A homogeneous mixture of many polymers and other chemicals like - zinc oxide, carbon black and oil etc.

Co-Polymer- This is polymer which is made by mixing two different monomers. Some of the examples are EPDM, NBR and SBR etc.

Cure- A chemical reaction activated by heat and pressure in rubber compound which enables rubber compound to change from semi-plastic stage to elastic stage and provide useful properties such as good tensile strength, hardness, resistance to ageing and resistance to swelling in oil.

Elasticity- It is a property of rubber, due to which it comes back to its original shape after leaving from a pulled or pressed condition.

Elongation- This is a ratio of original length of rubber and maximum elongated length.

Extrusion- Extrusion process is pushing or pulling a material through a pre-designed die for creating a desired shape for the extrudate. The extrudate to desired lengths after extrusion. This could be any material, such as steel, aluminum and rubber.

Flashes- This is extra rubber which comes out from various exit points and joints of mould, like - air vent or mould closing surfaces.

Fillers- Fillers are of three kinds namely reinforcers, semi reinforcers and fillers. They improve physical properties such as strength, tear resistance, enhance durability and help cost savings.

Hardness- This is way of measuring rubber's relative resistance towards pre-defined indentation.

Injection moulding- A type of moulding in which soft rubber under heat and pressure fed to mould.

Master batch- It is basic rubber mixture made for making various type of compounds.

Moulding- It is a process of making usable rubber parts by using moulds.

Polymer- A material which has a molecular structure built up chiefly or completely from a large number of similar units bonded together, e.g. many synthetic organic materials used as rubber, plastics and resins.

Shelf life- Safe period of storage for any rubber compound or finished product of rubber other material, during which the product can be used without losing any of its key properties.

Shrinkage- Decrease in rubber volume during moulding and due to prevailing environment.

Swell- Increase in rubber volume due to oil, liquids and other things.

Vulcanization- This is another term used for cure.

1.2.2 What is a Calender

The word calender is derived from the Greek word "kylindros" also the source of the word "cylinder". Calender is a big, heavy machine used to produce:

- a blemish free rubber sheeting with uniform thickness and width.
- rubberized fabric coated with rubber compounds.

What is Calendering

Calendering is the process by which a rubber compound or plastic formulation is given a definite continuous smooth, uniform sheeting or to coat or friction textiles. Note the terms "definite" and "continuous" –Definite because the nip or the roll profile decide the shape of the article and Continuous because the product can be taken to very large lengths. Examples of calendered items are Hospital sheeting, PVC sheeting, calendered NTCF etc.

In calendering, textile fabric or steel cord is coated with a film of rubber on both sides and into the material. Calendered textiles are used for casing and cap plies and chafers. Calendered steel cord is used for belts. Because the adhesion of rubber to the fabric or steel is important to final performance, the calendering process is an important step. Especially important are the tension, temperature and humidity of the fabric to be calendered. The temperature of the rollers is controlled via steam and water. The rubber that coats the fabric is different from the one used to make the tread or that which coats the bead cords.

Calendering processes green rubber compound by forcing the material softened by heat into the center of two to five counter-rotating rollers. The rollers compact the sheet as it passes through them. The thickness of the resulting product gets determined by the gap between the rolls, called the nip. After that the sheet passes over cooling rollers and is often spooled as a finished product.
Calendering is a popular process because of its ability to precisely adjust the product thickness. Finishing textures and coatings can also be applied to the product. Calendering was originally developed to process rubber, but today is widely used to make thermoplastic films, sheets, and coatings. Calendering is used most frequently in the production of vinyl products, primarily plasticized PVC (polyvinyl chloride).
Rubber coating is an important process of manufacturing i.e. tyres, conveyor belts, hoses and footwear.
For any industrial rubber manufacturing business, calendered rubber products are the cornerstone. Calendered rubber products comprises a wide range of rubber products used in various industries, with each application having its own specific requirements. These rubber products are formed by the process of calendering.
Sheet preparation is used for the same products as above and for all kind of technical rubber sheeting. Perfect sheets up to 2 mm thickness can be produced without air inclusions. For thicker sheets a combination of an extruder and a calendar is used and is called roller head calender.

What is Calendered Rubber

Rubber that is formed by using a method known as calendering is known as calendered rubber. Such type of rubber is used to produce different products like rubber sheets, rubberized fabric, elastomeric films etc. Calendering is a mechanical process in which rubber or plastic is pressed.

It is a finishing process which is applied to textiles and paper. During the process, fabric and rubber or plastic material pass through heated rollers to flatten, smooth and forms a sheets which creates a shiny, flat and smooth surface. The final surface characteristics depend on the pressure exerted by the rollers, on their composition, temperature, surface designs, type of coating or glaze initially applied to the material to be calendered. Coated material are often wound with liner in between layers to facilitate usage for further processing. Liner used are off different materials such as cotton, nylon, PVC, ILMS, etc.

Fig. 1.2.1. Calendered rubber

Calender Operating Mechanism

The roller temperature is controlled via steam and water. The roll no. 3 is maintained in fixed position in the calendar frame and is driven from the output shaft of a gear reducer. The roll no. 1 & 2 and bottom roll 4 is moveable for gage adjustment and for cleaning purposes. It is driven from the fixed roll by a set of connecting gears. Roll no.1 and 4 are adjusted for top rubber coating feed and roll no. 4 is adjusted for bottom coating feed. Similarly, roll no. 2 is used for nip gap adjustment. Through nip gap adjustment we can adjust the rubber coating thickness on the material. The rolls can be with core type cooling system or drilled for effective and quick heating or cooling of rolls .The roll gap or the space between the rollers is a very important parameter. It is adjusted either by two motor driven screw down devices or two hydraulic cylinders on the top roll.

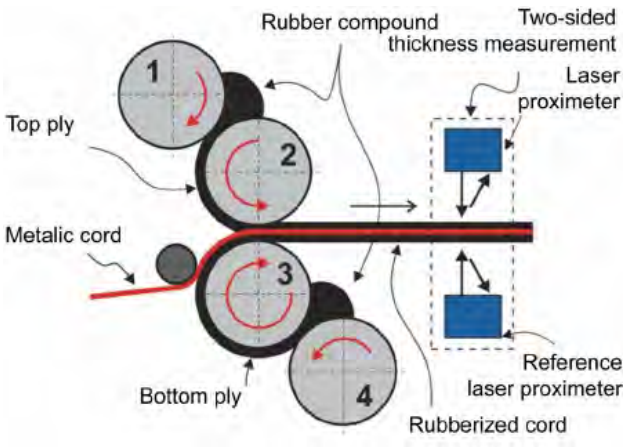

Fig. 1.2.2. Calender operating mechanism

Product made through rubber calendering process

- Rubber sheets
- Conveyor belting
- Expansion joints
- Brake lining
- Rolled roofing
- Pinch valves
- Roll covering
- Industrial hose
- Tire patches
- Gaskets
- Seals
- Rubberized fabric
- Graphic arts

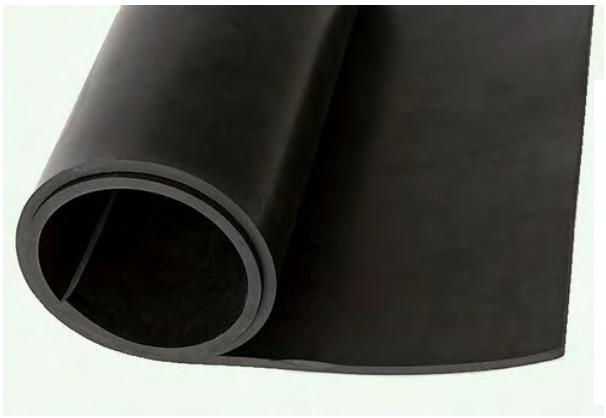

Fig. 1.2.3. Calendered rubber sheet

Fig. 1.2.4. Calendered rubber rolls

Fig. 1.2.5. Calendered rubber sheet

1.2.3 History of Rubber Calendering

Calendering is one of the oldest rubber processing technologies.

In 1836 Edwin M. Chaffee, of the Roxbury India rubber company, invented a four-roll calender to make rubber sheet. He worked with Charles Goodyear with the intention to “produce a sheet of rubber laminated to a fabric base”. Despite this development, calendering as a process became popular only after the 1930's.

As we know calendering is a mechanical process by which rubber is pressed into textiles (cloth, fabric, tire cord) forming composite sheets. In this process, you pass pre-selected fabric and rubber through a series of rolls to flatten, smoothen and sandwich the materials.

Depending on the end-use, the calendered sheets could have multiple layers “sandwiched” together.

A rubber calender can produce both 'supported' or 'unsupported' calendered sheets.

'Unsupported' sheets contain only layers of rubber that has been joined. While a 'supported' sheet has textile fabric or steel cord coated with a film of rubber on both sides and into the material. Supported rubber sheets give you higher strength or tear resistance.

Coating of fabrics has been in practice for almost 200 years now. Steel cord and fabric cord coating is a process in tyre manufacturing. Specifications and tolerances for calendered cords are very narrow. So, it is difficult to maintain the thickness variation across the calendered ply and the cord density.

The calender were not very popular when it was first invented mainly because it was difficult to adjust the desired gap between rolls. Consequently, it was difficult to get an accurate rubber sheet thickness.

Hence, the process did not become popular till the calender machines became easier to adjust until the 1930's. Since then, features have evolved. Modern calenders can achieve tolerances around ±0.005mm and their lines are adaptive for most sophisticated precision requirements of products.

Fig. 1.2.6. Rubber calender

1.2.4 Types of Calender

Calender classification based on what is being calendered.

1. Rubber calendering
2. Fabric calendering
3. Steel cord calendering

Rubber Calendering

A very common product formed out of the calendering process is calendered rubber sheets. They can have multiple layers of both the elastomeric and polymer "combined" together.

Fabric Calendering

The tension, temperature and humidity are critical before the fabric cords are calendered with the rubber compound. That is why the fabric cord is kept in a temperature – and – humidity-controlled room once it arrives in the shop floor.

The textile is arranged in a flat parallel manner. Under proper tension, they are continually pressed through two steel rollers, and simultaneously the rubber compound is added to the opening area between the rollers. A thin layer of rubber is applied into, on top of and the bottom of the fabric. A continuous sheet of cord – rubber composite goes through many more subsequent rollers to ensure proper penetration of rubber between the cords and desired adhesion between rubber and the fabric.

Quality is assessed in terms of thickness of the sheet, spacing between cords, number of cords and penetration of rubber into the space in between cords. The sheets are cut at required angles, so that the cords are set at predetermined angles across the sheet.

Inner liners are calendered the same way into sheets of required thickness and then cut into appropriate widths for use in tyre construction. The calendered fabric is made into rolls with interleaving layers of woven fabric liner to prevent them from sticking together.

Steel Cord Calendering

High tensile brass coated steel cords (multi strand) are used in the construction of tyre belts. The brass coating is done to make rubber adhere to the steel. The steel cords come in various arrangements such as in cross section of pairs, triplets and so on.

The storage of these brass coated steel cords should be in a temperature and humidity-controlled environment (the creel room). Even the distance between the creel room and the calender must not be too large. Otherwise, corrosion due to moisture may cause the steel belts to lose adhesion with rubber. The steel wire passes from the creel room on rollers through aligning combs into the calender where the wires are coated with a thin sheet of skim stock rubber.

A pre – set number of steel cords under proper tension are continually pressed through two steel rollers, and simultaneously the rubber compound is added to the opening area between the rollers. A thin layer of rubber is applied into, on top of and the bottom of the fabric. A continuous sheet of cord – rubber composite goes through many more subsequent rollers to ensure proper penetration of rubber between the cords and desired adhesion between rubber and the fabric.

As above here also quality is quantized in terms of thickness of the sheet, spacing between cords, number of cords and penetration of rubber into the space in between cords. The rubber should also penetrate the gaps within and between the steel cords for maximum adhesion. Maximum adhesion also means least rusting. Then the steel cords are cut at specified angles and widths for use in tyre building.

1.2.5 Calender classification

Calender classification based on calender construction, i.e.

1. The number of rolls.
2. The position or orientation of the rolls.

2 - roll calender vertical type

It is the simplest calender and can be used only for production of gum sheets.

Fig. 1.2.7. 2 roll calender vertical type

3 - roll calender

It is also called the Universal Calender. It is the most flexible and reliable machine even today.

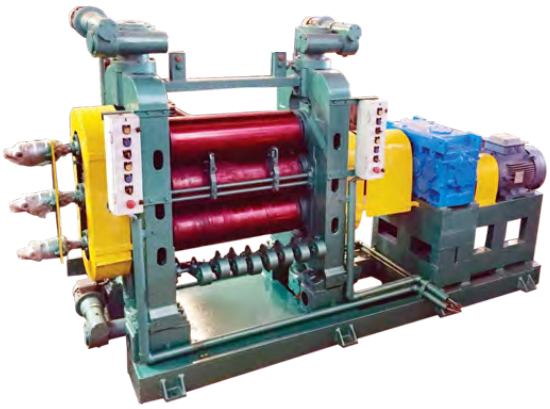

Fig. 1.2.8. 3 roll calender

3 - roll calender vertical stack

It is the oldest and most common configuration of calender. In this type of calender reactive forces are in a single vertical plane.

Fig. 1.2.9. 3- roll Calender Vertical Stack

3 - roll Calender off set Stack

In this type of calender reactive forces are not in a single vertical plane. Deflection of only the top roll acts on the bottom roll. Gauge is not affected by the weight of the top roll. Deflection of the top and middle acts on the bottom roll. Weight of the top roll affects the gauge.

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