RUBBER

Objectives:

At the end of this session trainees should be able to know:

- Introduction about the rubber
- Different types of rubbers used in IR
- Application of rubbers in IR
- Selection of rubbers
- Storage of rubbers
- Conclusion

RUBBER

- **Rubbers** (also known as **elastomers)** are high polymers, which have elastic properties in excess of 300%.
- Can be stretched to 4 to 10 times its original length & as soon as the stretching force is released, it returns to its original length.
- Why ?
- Elastomer molecule is not straight chained (as in the case of plastic, fiber etc)

NATURAL RUBBER:

- Natural Rubber is obtained from certain types of plants, which yield a white milky substance known as latex.

- **Hevea brasiliensis** is the most important commercial source of plant from which natural rubber comes from.

- Areas in which it is found: Kerala,TN west Garo Hills & Amazon section in South America.

Crude natural rubber

Collection & Coagulation of Latex: -

- White syrupy liquid known as **Latex** collected.
- By cutting at an angle through the bark of the rubber tree.
- The more the Latex is removed more the plants regenerate it.
- **Latex contains 30-36% rubber hydrocarbon, 0.3-0.7% ash, 1-2% proteins, 2% resin and 0.5% quebrachitol.**
- Rubber is formed in the tree from the lower polymerizing element, which is C_5 H_8 group, by a **bio-chemical reaction**, in which a particular type of **enzyme** acts as a catalytic agent.
- Latex is diluted to contain between 15 to 20% of rubber and filtered or stained to eliminate any dirt present in it.
- **Acetic acid or Formic acid (about 1kg per 200 kg of rubber material) is then added.**
- When rubber is so coagulated to **soft white mass**, then it is treated for further processing after washing.

Latex being collected from a tapped rubber tree

Crepe Rubber:

- The coagulum is allowed to drain for about 2 hrs.
- Then the coagulum is passed through a creeping machine, which consists essentially of two rollers with longitudinal grooves, upon which water is sprayed.
- When the sheet comes out as, It has an uneven rough surface resembling crepe paper..

Smoked Rubber:

- Coagulator is carried out in a long tanks (about 1m wide and 30cm deep) having sides with vertical grooves (about 4cm apart) fitted with metal plates.
- Diluted Latex is poured into the tanks with plates removed.
- Then dilute Acetic acid / Formic acid is added and the mixtures stirred thoroughly.
- The partition plates are then inserted into the grooves.
- The tanks are kept undisturbed for about 16 hrs.
- The tough slabs of coagulum so formed, between the partition plates are removed.
- The slabs are then passed through a series of smooth rollers, with decreasing clearance in between them, and water is sprayed simultaneously at the center of the rollers.
- The final roller has a clearance of such a design so as to give ribbed pattern to the final rubber sheet.
- The sheets are then hung for about 4 days in a **smokehouse,** which maintained between **40 to 50^0 C**

DRAWBACKS OF RAW RUBBER

- Plastic in nature i.e., soft at high temperature & too brittle at low temperature.
- It is weak – tensile strength 200 kg/cm^2.
- It has large water absorption capacity.
- It is non-resistant to non-polar solvents like vegetable and mineral oils.
- Oxidizing agents like Nitric acid, conc. H2SO4, attacks it.
- It perishes due to oxidation in air.
- It swells in organic solvents and gradually disintegrate.
- It possesses marked tackiness.
- It has little durability.
- When stretched to a great extent, it suffers permanent deformation.

VULCANIZATION

To improve the properties of rubber, it is compounded with some chemicals like sulphur, hydrogen sulphide, benzoyl chloride etc.

Most important of all the processes of vulcanizing is addition of sulphur.

The process consists in heating the raw rubber with sulphur to 110 – 140^0 C thereby the added sulphur combines chemically at the double bonds of different rubber springs.

Vulcanization thus serves to stiffen the material by a sort of anchoring and consequently preventing inter-molecular movement of rubber springs.

The extent of stiffness of vulcanized rubber may contain 3 to 5% sulphur but a battery case rubber may contain as much as 30% sulphur.

VULCANIZATION:

Vulcanized rubber possesses the following superior properties over the unvalcanised rubber.

- It has good tensile strength, it can bear a load of 2000 kg/cm^2.
- It has excellent resilience, article made from it returns to the original shape after removing of deforming force.
- Possesses low water absorption tendency.
- It has higher resistance to oxidation and to abrasion.
- It has much higher resistance to wear and tear.
- It is better electrical insulator.
- It is resistant to organic solvents.
- It is very easy to manipulate the desired shape.
- Useful temperature range is –40 to 100^0 C.
- Its tackiness is only slight.

  Its elasticity is low.

COMPOUNDING

- Compounding means the mixing of raw materials for the manufacture of rubber compound at the lowest possible cost.
- The service condition to which the item is to be exposed must be known to the compounder.
- This will show the combination of properties required for the successful functioning of the rubber compound.
- In compounding, another factor which is kept in view is the ease of manufacturing the item from the rubber compound.
- Taking into view the properties required, such raw materials are mixed so that the processing methods like mixing, calendearing, extruding are neither difficult nor unnecessarily.

MATERIALS USED IN COMPOUNDING

The following are the materials, which are used in compounding of a rubber compound:

- 1) Elastomers.The following list shows some of the rubber or vulcanizable elastomers available to the compounder:
- Natural Rubber.
- Reclaimed rubber.
- Styrene rubber.
- Nitrile rubber
- Butyl rubber.
- Neoprene rubber.
- Polysulphide rubber or Thiokols.
- Silicone rubber.
- Urethane rubber.

MATERIALS USED IN COMPOUNDING

- **2) Vulcanizing Agents.**

- **Sulpher, Sulpher Monochloride, Selenium, Tellurium, Zink Oxide, Magnisium Oxide, Benzyal peroxide etc.**

3)Accelerator:

They are used to increased the rate of cure, improve physical properties and improve the aging of rubber compound.

Using this type of accelerator or combination of this, it is possible to vulcanize rubber within any desire time and at any temperature.

Many important properties can be controlled to a great extent by the choice of the accelerator.

4)Accelerator activator:

Most of the accelerator require Zink-oxide and fatty acid in order to develop the best result in the compound.

The other ingredients are antioxidant, pigment and softner.

SYNTHETIC RUBBER:

- The term applies to that group of high polymers, which possesses to a greater or lesser extent the physical properties of **natural rubber.**
- According to another definition synthetic rubber is a substance that will stretch repeatedly to 300% or more of its original length & will return rapidly to its approximate original shape.
- This definition will hold good only after **vulcanization.**
- None of the **synthetic rubbers** produced up to now posses all the properties of natural rubber, such as chemical structure, molecular weight etc.
- Some of the experts call these as **rubber substitutes** or elastomers or **elastroprenes**.

Application of Rubber in IR

INTRODUCTION

Indian Railways are facing many troubles with rubber products since long.

- **Quality Problem to improve the performance of rubber products .**
- **Knowledge is required for upgrading purchase system.**
- **Training to Railway staffs.**
- **Awareness on rubber properties.**
- **Their manufacturing & applications.**

POLYMERS

POLYMERS are compounds formed by a more or less regular repetition of a large number of the same and different atomic groupings that are joined by chemical bonds into long chains.

MONOMERS are those repeating atomic groupings to form Polymer.

$$-CH_2-CH_2-CH_2-CH_2-CH_2-$$

POLYMER

	RUBBER	PLASTIC	FIBRE
INTRA.MOLECULAR FORCE OF ATTRAC.	LESS	MEDIUM	MORE
CHAIN FLEXIBILITY	HIGH	LOW	VERY LOW
Tg	-ve	+ve	++ve

WHAT IS RUBBER

RUBBER is a substance termed as “Polymer” having high Molecular Weight Compounds, predominantly organic, consisting of long-chain molecules made up of repeating units usually backbone of carbon atoms.

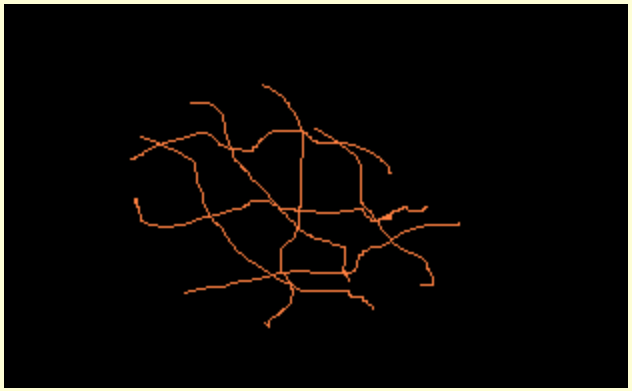
IT IS ALSO KNOWN AS ELASOMER.

VULCANISATION

Rubber is a high viscous liquid in nature. The long molecular chains are nonuniformly distributed in the rubber matrix and is in plastic state. These chains can be cross-linked with specified vulcanizing agent and heat, to convert the rubber from plastic state to elastic state.

Before Vulcanisation

After Vulcanisation



VULCANISED RUBBER VS RAW RUBBER.

S.NO	PROPERTY	RAW RUBBER	VULCANISED RUBBER
1.	TENSILE STRENGTH	200KG/CM2	2000KG/CM2
2.	RESILIENCE	GOOD	VERY GOOD
3.	USEFUL TEMPERATURE RANGE	10-60°C	-40 TO 100 °C
4.	RESISTANCE TO MOISTURE OXIDATION AND ABRATION	POOR	GOOD
5.	RESISTANCE TO ORGANIC SOLVENTS	POOR	LARGE BUT LIMITED.
6.	TACKINESS	MARKED	SLIGHT
7.	ELASTICITY	VERY HIGH	LOW(DECREASES WITH EXTENT OF VULCANISATION)
8.	% ELONGATION AT BREAK	1200	800

WHY RUBBER IN ENGINEERING APPLICATI0NS

1. RUBBER IS TOUGH, FLEXIBLE AND INCOMPRESSABLE.
2. RUBBER CAN STORE 150 TIMES HIGHER ENERGY (J/KG) COMPARED TO TEMPERED STEEL OF EQUAL WEIGHT.
3. ELASTICITY IS A MATERIAL PROPERTY OF RUBBER AND CAN BE CHANGED EASILY.
4. IT CAN WITHSTAND NORMAL EXPANSION AND CONTRACTION OF METAL STRUCTURE.
5. RUBBER ABSORBS SHOCK LOAD & PROTECTS THE SYSTEM.
6. NO RUSTING & NO LUBRICATION IS REQUIRED.
7. LIGHTER IN WEIGHT AND EXTREMELY ECONOMIC.

Important Rubber used in IR

- Natural rubber.
- Synthetic rubber.
  - **SBR(Styrene- Butadine rubber)**
  - **NBR (Acrylonitrile Butadiene rubber)**
  - **CR (Polychloroprene rubber)**
  - **MQ (Silicon rubber)**
  - **IIR (Butyl Rubber)**
  - **EPDM**
  - **PU (Polyurethane rubber)**
  - **FKM (Fluorocarbon rubber) VITON Rubber**

DIFFERENT APPLICATION OF RUBBER IN THE RAILWAYS

- SHOCK ABSORBER
- AIR BRAKE COMPONENT
- EXTRUDED PROFILES
- CALENDERED SHEETS
- GASKET, SEALS, 'O'RING, WASHER,
- ADHESIVES
- INSULATORS
- RUBBER IN TRACK
- CELLULAR / SPONGE
- DIAPHRAGMS

APPLICATION OF RUBBER IN IR PRODUCTS.

1.Shock Absorber & Dampers **(NR & CR)**

2.Gaskets, O-Rings, Seals, Rollers etc. **(NBR,CR,MQ,FKM)**

3.Diaphragms (CR,NBR)

4. Piston Packing Cups (NBR)

5.Weather Strips (EPDM, NBR,NR)

6.Electrical Insulation **(EPDM,CR,NR).**

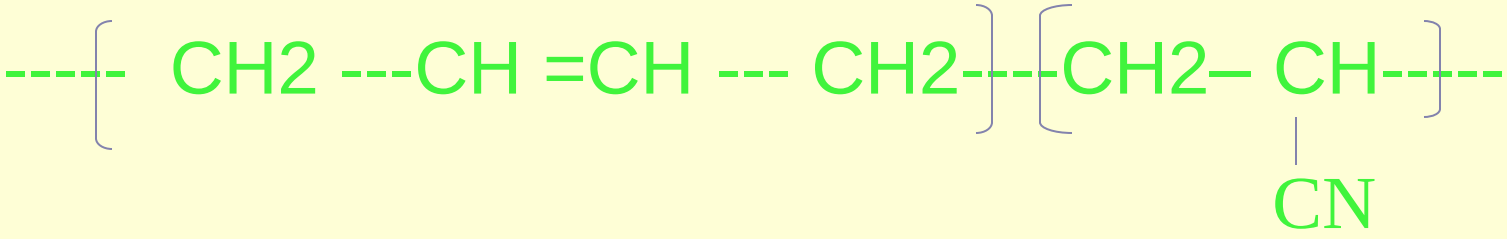
7.Cellular products **(NR,CR,NBR)**

8.Transmission Coupling **(CR,NR)**

9. Rubber adhesive **(CR)**

Nitrile rubber or NBR GR-A(BUNA-N):

Copolymer of Butadine and Acrylonitrile.



Properties: Outstanding resistance to oil & fuel at both normal & elevated temperature.

Possesses excellent resistance to heat,sunlight, oils, acids and salts but less resistant to alkali than Natural Rubber because of presence of Cyano(-CN) group.

Uses:

- **Used for making conveyor belts,**
- **high altitude aircraft components,**
- **tank linings, hoses, gaskets,**
- **printing rollers, adhesives,**
- **oil resistant foams,**
- **automobile parts etc.**

(BUNA-S) or SBR:

- Copolymer of 75% Butadiene & 25 of Styrene.
- **Properties:**
- It resembles Natural Rubber in processing characteristics as well as quality of finished products.
- It possesses high abrasion resistance, high load bearing capacity and resilience.

(BUNA-S) or SBR:

- **It gets readily oxidized, especially in presence of traces of Ozone in the atmosphere.**
- **It swells in oil and solvents.**

Uses:

- Used for manufacture of motor tyres, f
- loor tiles, shoe soles,
- gaskets, foot wear components,
- wire and cable insulator,
- carpet backing, adhesive,
- tank lining etc.

Different types of Synthetic rubbers are:

(I) Synthetic Rubber (BUNA-S) or SBR:

Copolymer of 75% Butadiene & 25% of Styrene.

Properties:

- It resembles Natural Rubber in processing characteristics as well as quality of finished products.
- It possesses high abrasion resistance, high load bearing capacity and resilience.
- However it gets readily oxidized, especially in presence of traces of Ozone in the atmosphere.
- Moreover it swells in oil and solvents.

Uses:

- Used for manufacture of motor tyres, floor tiles, shoe soles, gaskets, foot wear components, wire and cable insulator, carpet backing, adhesive, tank lining etc.

Different types of Synthetic rubbers are:

(ii) Nitrile (BUNA-N): Copolymer of Butadine and Acrylonitrile.

Properties:

- Possesses excellent resistance to heat, sunlight, oils, acids and salts but less resistant to alkali than Natural Rubber because of presence of Cyano(-CN) group.

Uses:

- Used for making conveyor belts, high altitude aircraft components, tank linings, hoses, gaskets, printing rollers, adhesives, oil resistant foams, automobile parts etc.

Different types of Synthetic rubbers are:

iii) Neoprene (GR-M): Polymerization of Chloroprene.

Properties:

Closely related chemically to Natural Rubber.

It is superior resistant to vegetable and mineral oils, ageing and temperature but has greater solubility in polar solvents.

Uses:

- Used for making hoses, gaskets and tubing for carrying corrosive gases and oils. Used for making sponges, conveyor belts, lining of reaction vessels, adhesive etc.

Different types of Synthetic rubbers are:

- (iv) **Butyl Rubber (GR-I): Copolymer of isobutylene with 1 to 5% of isoprene.**

Properties:

- Possesses outstanding low permeability to air and other gases less than 1/10th of Natural Rubber.
- Excellent resistant to heat, abrasion, ageing, chemicals, polar solvents like alcohol & acetone but soluble in hydrocarbon solvents.
- High resistant to Ozone and good electrical insulating properties.

- **Uses :**
- For making cycle & automobile tubes, automobile parts, hoses, conveyor belts for food and other materials, tank linings, insulation for high voltage wires and cables.

Different types of Synthetic rubbers are

- (V)**Poly Sulphide Rubber (Thiocol):** Made by the reaction between Sodium Polysulphide and Ethylene dichloride.

Properties:

- Possesses extremely good resistance to mineral oils, fuels, solvents, oxygen, ozone and sunlight.
- Impermeable to gases.
- It does require sulphur for vulcanization and hence does not form hard rubber.
- However it possesses poor strength and abrasion resistance.

Uses :

- For making hoses, gaskets, cable coverings, oil tank linings and a solid propellant fuel for rocket motors.

Different types of Synthetic rubbers are

vi) Chlorosulphonated Polyethylene Rubber (HYPALON):

Produced by reactingPolyethylene with Chlorine and Sulphur di-oxide.

Properties:

- It shows high oxidation resistance and high chemical resistance.

Uses:

- In chemical Industry.

Different types of Synthetic rubbers are

- **vii) Polyurethane Rubber (Isocyanate Rubber):** Produced by reacting with Di-isocyanates.

- **Properties:**

- Highly resistant to oxidation, many organic solvents but attacked by acids & alkalies, especially concentrated and hot.

- Polyurethane foams are light, tough and resistant to heat, abrasion, chemicals and weathering.

- Uses for surface coatings and manufacture of foams and fibre.

Different types of Synthetic rubbers are

- (viii) **Silicon Rubber:** Produced by polymerization of Di-methyl Silicon Hydroxide.

Properties:

- Exceptional resistance to prolonged exposure to sunlight, weathering, most common oils, boiling water, dilute acids and alkalies. Remain flexible in the temperature range 90-250^{0}C.

Uses:

- As a sealing material in search lights and in air-craft engines for manufacture of tyres for fighter air-crafts.
- For insulating the electrical wiring in ships.
- In making lubricants, paints and protective coatings for fabric finishing and water proofing.
- As adhesive in electronics industry etc.

Neoprene (GR-M):

Polymerization of Chloroprene.

Properties:

Closely related chemically to Natural Rubber.

- It is superior resistant to vegetable and mineral oils, ageing and temperature .
- It has greater solubility in polar solvents.

SELECTION OF ELASTOMER

- To identify application conditions correctly. (Polarity, Heat, Weathering etc.)
- To identify the need of minimum service life.
- To select proper grade of elastomer.
- To honour the availability of elastomer.
- To consider price of elastomer

GENERAL PROPERTIES OF RUBBER

	NR	SBR	EPDM	CR	IIR	NBR	HNBR	CPE	PU
Price / Kg	60	80	130	180	150	130	200	160	1500
Resilience	E	G	P	E	P	F	F	F	G
TS/Tear	E	G	F	E	G	G	G	G	G
O2/O3/UV	P	P	E	G	E	G	VG	E	G
Heat Rest	P	P	E	G	G	G	VG	E	G
Low Temp	F	F	G	G	G	F	VG	G	G
Flame R	P	P	P	GE	P	P	P	GE	P
Oil Rest	P	P	P	G	P	GE	E	G	F
Acid/Basei	P	P	E	F	E	F	E	G	F
Dielectric	G	F	E	G	G	F	G	G	F
Permeablty	P	P	G	G	E	F	F	F	F
C. Set	E	G	F	GE	G		G	G	G
Dyn. Prop	E	P	P	E	F	P	G	P	G
Damping	P	G	E	F	E	G	F	P	P

STORAGE OF RUBBER COMPONENT:

- **All rubber products are more or less affected by Weathering.**
- **Hence proper proper storage (as per IS: 6713) is to be maintained when not in use.**
- **Should avoid direct sun light.**
- **Ambient temperature should be less than 30 ºC**
- **Special care for unsaturated elastomers as they are very much prone to be attacked by weathering.**
- **Should avoid moisture for metal component.**
- **Any loose electrical connections should be avoided.**

They should be stored away from contact with materials containing Cu & Mn (which act as poising agents & resulting in their further degradation).

- Any contact with grease or oil should be avoided (as these causes swelling, softening and deterioration of rubbers)
- French chalk or soapstone or mica should liberally be applied on the surface of rubber components.
- Great care taken so that the material is used in the order of their receipt in the stores

"FIRST-CUM-FIRST OUT BASIS".

CONCLUSION

1. **Online developmental cell is required to modify or upgrade drawing & specification and to do trouble shooting.**

2. **The faculties should have good experience & should come from railways and others sectors.**

3. **Better to have own small manufacturing set up or on contract basis.**

4. **Training to people involved in quality**

5. **Coordination between Manufacturers & Customers required.**

Thanks.