Advisory Circular No.2016/12

Manufacture of Balloons

Rubber Research Institute
of Sri Lanka

Manufacture of Balloons

Dipped products such as gloves, balloons, teats, rubber bands, bathing caps, condoms, etc., are manufactured according to the dipping process which consists of immersing a clean, dry, former in a latex compound for an appropriate period and carefully withdrawing the former so that a uniform layer of latex is deposited on it. The thickness of the deposit can be increased by increasing the number of dippings. In the past, dipped goods were manufactured by dipping a former into a solution of milled rubber, but after the advent of concentrated latex (60% and above), solution technology has been replaced by the latex technology. Use of latex has various advantages over solutions such as high solids, non-inflammability, lower capital expenditure, non-toxicity, no solvent loss, hazard free operation and thicker deposits per dip.

Manufacture of dipped products such as balloons and rubber bands can be initiated at cottage level with a low capital expenditure.

Raw materials required

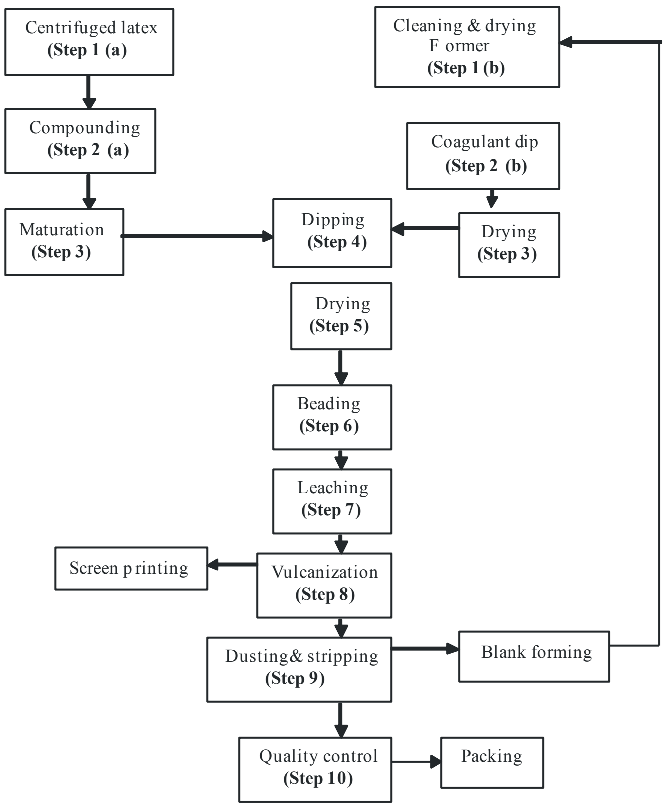
- 60% Concentrated latex
- Potassium hydroxide (KOH)
- Potassium laurate (or any other suitable surfactant)
- Sulphur
- Zinc diethyldithio carbamate (ZDC)
- Zinc oxide (ZnO)
- Antioxidant (phenolic type)
- Antiozonant (wax)
- Mineral oil
- Titanium dioxide and coloured pigments

Equipment required

- Ball mill, pearl mill or colloid mill
- Formers
- Drying chamber/oven
- Vulcanizing chamber/oven

Process flow chart

The following diagram represents the steps involved in the manufacture of balloons using the post-curing technique.



Compounding (Step 2 (a)

Centrifuged latex is the main raw material required for production of balloons. Balloons cannot be manufactured out of field latex as it does not have the required viscosity because of the low dry rubber content.

The latex compound for balloons should be such that it gives maximum elongation, easy inflation and adequate permanent set. A zinc-bearing accelerator such as ZDC is preferred and zinc oxide is kept at the minimum. Stabilizers are kept to the minimum so that coagulant could be most effective.

Typical formulation for balloons

60% Concentrated NR latex (centrifuged latex)	167 parts
10% Potassium hydroxide solution	0.5
10% Potassium laurate solution	1.5
50% Sulphur dispersion	1.0
50% ZDC dispersion	1.0
33% ZnO dispersion	0.5
50% Antioxidant SP (phenolic type) emulsion	1.0
25% Antiozonant (wax) emulsion	3.0
50% Vegetable oil (plasticizer) emulsion	6.0
50% Titanium dioxide/colourant dispersion	as required

Almost all the solid compounding ingredients listed in the above formulation are insoluble in water and hence the particle size should be reduced to that of the rubber in latex in order to get a uniform distribution of the ingredients in latex. Hence, all the water soluble solid ingredients are generally added into latex as dispersions.

The solid material is made to disperse in water, by grinding in the presence of a dispersing agent. The dispersing agent prevents the dispersed particle from reaggregation. For very fine particle size ingredients such as ZnO, the quantity of dispersing agent required is about 1% by weight, whereas for ingredients such as sulphur, 2-3% by weight is required. The grinding equipment used for the preparation of dispersions includes ball mills, pebble mills, colloid mills, *etc.* Formulations that can be used in preparing dispersions of the above ingredients are given below.

(1) <u>50% sulphur dispersion</u>

	pbw
Sulphur	50
Dispersol LR (dispersing agent)	2
Water	48

Ball milling time 48 hrs

(2) 50% zinc oxide dispersion

	pbw
Zinc oxide	50
Dispersol LR	1
Water	49

Ball milling time 24 hrs

The water insoluble liquids, oils or waxes are generally added as emulsions. The formulation used and the procedure employed in the preparation of a 50% emulsion of the liquid antioxidant are given below.

		Wet wt.
Component A	Antioxidant SP	50
	Oleic acid	5
Component B	KOH	1.5
	Water	43.5

The emulsifying agent (potassium oleate soap) is produced *in-situ.* Components A and B are mixed with agitation. Subsequently, the mixture is sheared in an emulsifier, at high speed stirring.

In the compounding step, all the required ingredients as dispersions or as emulsions are incorporated into the latex, while stirring.

Maturation (Step 3)

After incorporation of the ingredients into the latex, the latex compound thus prepared is generally left to stand with slow speed of stirring for a period of 24 hours. This brings about an equilibrium state called the matured state, to the latex compound which is required for production of good quality balloons.

Formers

Various types of porous and non-porous types are available. The material may be either aluminium, wood, porcelain (ceramic) or glass. The size and shape of the former should correspond to the article desired. The choice of material will be governed by the size and shape of the product and also the volume of production.

Preparation of coagulant solution (Step 2(b)) and dipping procedure (Step 4)

Balloons can be manufactured either by the straight dipping process or the coagulant dipping process. Straight dipping process is used for cheaper balloons, while good quality balloons are manufactured generally by the latter process. Coagulant dipping process can be divided into wet coagulant dipping and dry coagulant dipping. Wet coagulant dipping is not widely used as there are several disadvantages.

Dry coagulant dipping

This is the most widely used coagulant dipping method. Metal salt solutions of calcium nitrate $Ca\ (NO_3)_2$, calcium chloride ($CaCl_2$) or their mixtures are recommended as coagulants. Strength of coagulant solution depends on the work in hand. For balloons, a dilute solution of its is suitable. Calcium salts absorb moisture on storage. When using more concentrated solutions, washing of deposit is required to remove soluble calcium salts, otherwise these would cause the finished article to become damp on storage. Leaching or washing of deposit is not necessary when using dilute solutions of 5% or less. Small amounts of ingredients such as clay, talc, *etc*. may be added to the coagulant solution. To ensure complete wetting of the former by the coagulant solution, a wetting agent is included in the formulation.

Typical formulations
Formulation 1

Anhydrous calcium chloride	10 parts
Calcium nitrate tetra hydrate	10
Wetting agent *	0.05 - 0.25
Water	upto 100

*Wetting agent methyl alcohol, acetone, cetrimide, *etc.*

Formulation 2

Calcium nitrate	15
Industrial alcohol	10
Wetting agent	0.1-0.2

Sometimes finely divided talc is added in the coagulant solution to serve as a stripping aid.

The former is initially dipped in the coagulant solution. Thereafter the solvent is allowed to evaporate leaving either a dry deposit or one which is in the form of a very viscous concentrated solution. The former is then dipped in the latex and allowed to dwell for a predetermined time. The thickness depends on the time of dwell and upon the stability of latex towards the coagulant used.

Drying (Step 5)

The wet latex deposit on the former is first dried at below 100oC and when the water has evaporated the drying temperature of the hot air oven should not exceed 60^{o}C.

Beading (Step 6)

Dipped rubber products are generally required with "bead" around the open end. This is made by rolling the edge of the deposit back upon itself until adequate thickness of bead or ring is formed. This operation is done after full or partial drying. This "beading" is usually done by hand, but numerous mechanical devices exist which can efficiently perform this operation.

Leaching (Step 7)

The dipped dry rubber deposit contains some water soluble materials which are undesirable as they absorb moisture during storage making the article wet. These materials are removed by extraction with water. Extraction is carried out by dipping the formers with unvulcanized deposits, in a tank (aluminium or galvanized iron) containing fresh water at about 60-80^{o}C. The water should be continuously replaced by fresh water and the dipping time could vary from 1 min. to 1 hour according to the thickness of the article.

Vulcanization (Step 8)

Post curing or pre-vulcanization technique can be applied for vulcanization. Post curing is carried out using hot air, steam or hot water. Hot water vulcanization is considered to be the best. The bath temperature is maintained at 80-85^{o}C. Hot air vulcanization is also popular due to its simplicity and low capital cost. Higher temperatures are used for rapid vulcanization and in this case the equipment used is an air oven.

Balloon compounds are generally unfilled compounds for easy inflation and hence pre-vulcanized mixes are the most suitable. Pre-vulcanization can be carried out by heating the mix at a temperature of 70^{o}C for about one and a half to two hours with gentle stirring. Generally, the latex compound is heated in a hot water/steam jacketed stainless steel tank. The extent of cross-linking can be assessed using the chloroform coagulation test or the Modified Swollen Diameter test. After pre-vulcanization, the mix should be sieved through a 80-100 mesh nylon or stainless steel gauge before being fed to the dipping tank.

Dusting and stripping (Step 9)

Fully vulcanized and finished articles are then stripped off the formers. Prior to or during this operation, a dusting powder is applied to the rubber surface to remove its harsh feel and to ensure free movement upon itself. Zinc stearate, ground mica and French chalk are some of the important dusting powders. When stripping is carried out using water, the dusting powder is incorporated in the liquid as a suspension.

The method of stripping depends upon the type and quantity of the article. Toy balloons are often stripped by hand, sometimes using water or compressed air, but for handling very large quantities, numerous mechanical methods are employed.

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