Advisory Circular No.2016/14

Manufacture of Cast Products

Rubber Research Institute
of Sri Lanka

Manufacture of Cast Products

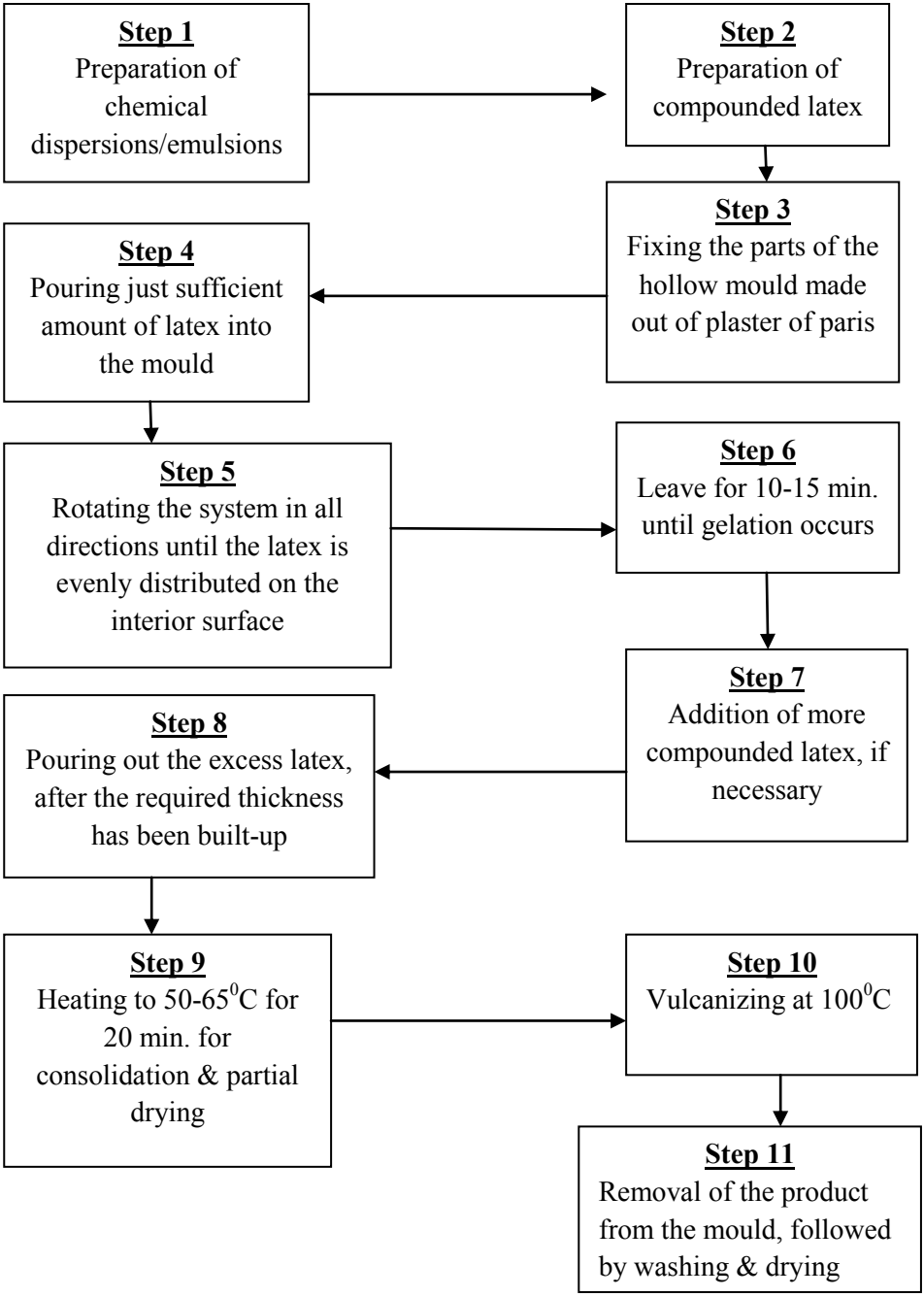
When a layer of rubber is deposited on the interior surface of a hollow mould, it is known as casting. The latex products obtained by the casting process are hollow and toys, masks, etc. are usually made by this process. Production of these articles according to the casting process can be initiated at cottage level.

An advantage of preparing a rubber toy by casting instead of dipping is that minute details of the mould will be reproduced on the outside of the finished article. Another advantage is that a round object like a ball can be made without having to patch the hole where the dipping former is withdrawn.

Slush moulding and rotational moulding techniques are used in producing articles. In rotational moulding technique (widely used technique), the mould is rotated to get a uniform thickness of deposit, after it has been filled with just sufficient amount of compounded latex. In slush moulding technique, the mould is filled with the latex compound and allowed to stand until the deposit with the required thickness is formed. Thereafter the excess latex is poured out, leaving in the mould a hollow deposit. A comparison of the two techniques is given below.

Rotational moulding technique	**Slush moulding technique**
1. Uniform thickness of deposit.	1. Articles have variations in wall thickness
2. Deposit thickness depends upon the amount of latex compound per unit area of the mould	2. Thickness of deposit depends upon stability of latex
3. Rotational casting equipment are required	3. No casting equipment is required
4. Thickness control is easy	4. Deposit thickness control is quite difficult

Process flow chart (Rotation moulding technique)



The complete manufacturing procedure giving each of the steps involved in the production of a casting using plaster of paris moulds according to the rotational moulding technique is shown in the above flow diagram.

Raw materials required

- 60% Concentrated natural rubber latex
- Potassium laurate (or any other suitable surfactant)
- Sulphur
- Zinc diethyldithio carbamate (ZDC)
- Zinc oxide (ZnO)
- Antioxidant (phenolic type)
- China clay or whiting
- Colourants/pigments

Equipment required

- Ball mill, pebble mill or colloid mill
- Moulds (plaster of paris or metal)
- Rotational casting equipment (for rotational moulding technique)
- Drying chamber/oven
- Vulcanizing chamber/oven

Preparation of chemical dispersions (Step 1)

Most of the solid compounding ingredients 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 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. 50% dispersions can be prepared according to the following formulations.

(1)	50% sulphur dispersion	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	

Preparation of emulsions (Step 1)

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 is 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.

Preparation of compounded latex (Step 2)

Compounds containing china clay or whiting, deposits more readily than unfilled compounds as the latex particles tends to aggregate around the large mineral filler particles. With less filler the casting becomes more rubbery and with only 20 or 30 phr, squeeze toys, rubber face masks, *etc*. are made. If the filler is entirely excluded, the rate of build-up of the deposit is extremely poor, unless a sensitizer or a weak gelling agent is added.

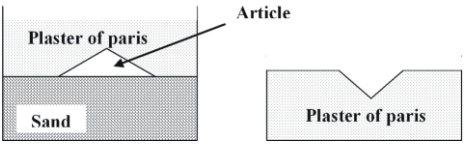
Pre-vulcanized latex tends to build-up better than vulcanizable compounds, but are only suitable for unfilled or lightly filled mixes. Vulcanizable mixes may be used for any type of product and are preferred for totally enclosed products. A latex compound suitable for production of hollow, rigid rubber toys is given below.

Formulation for hollow rigid rubber toys

60% Concentrated NR latex	167 parts
20% Stabilizer, e.g. potassium laurate solution	1-3
50% Sulphur dispersion	4
50% Accelerator (ZDC) dispersion	2
50% Zinc oxide dispersion	3
50% Antioxidant (phenolic type) dispersion	2
50% China clay or whiting dispersion	300
Pigment/colourant	as required

Moulds used for casting (Step 3)

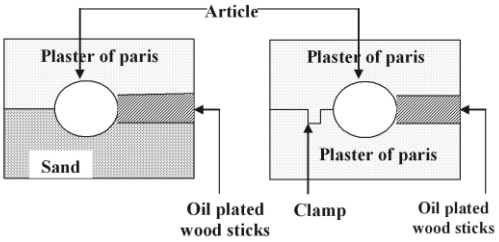
The moulds used for casting fall into two types namely, porous and non porous. Porous moulds are made of plaster of paris and non-porous moulds are made of light metal alloy. Plaster moulds have limited life (only about 30 castings can be produced with one mould) and are used for short production cycles, whereas metal moulds may be used for a long production cycle.



Place the article on sand and pour plaster of paris from the top

Plaster of paris mould

Schematic diagram showing the preparation of a one piece plaster of paris mould



Schematic diagrams showing the preparation of a two piece plaster of paris mould

Coarse plaster gives a higher rate of build-up of rubber deposit, but the surface of the mould soon deteriorates. The thickness of the mould wall also has an effect on the rate of deposition. When the wall is thin the capillary force pulling the water is less. The mould should be warm and damp when ready for use, to promote maximum surface evaporation. Further, the latex compound should be poured gently into the mould in order to avoid air trapping.

Aluminium or stainless steel moulds can also be used (copper, brass and iron should be avoided). These metallic moulds are chosen for lightness, thermal conductivity, strength, resistance to corrosion under alkaline conditions. Metal moulds are specially suitable for manufacturing hollow rubber articles by heat sensitized compounds as they can be heated easily.

Procedure for casting with porous plaster of paris moulds

Usually porous moulds **(Step 3)** are used for latex casting. The compounded latex is poured into the mould and the system is rotated in all directions until the latex is evenly distributed **(Steps 4 & 5).** Gelation occurs due to absorption of water by porous plaster and to the diffusion of Ca2+ ions into the latex from the plaster **(Step 6).** When water is absorbed by the plaster mould, the level of latex will fall and hence more latex should be added to fill the mould **(Step 7).** After the desired thickness has been built up, the excess latex is poured out **(Step 8)** and this latex can be re-used after mixing with freshly compounded latex.

The plaster mould containing the deposit of latex is kept inside an oven at 50-65^{o}C for several hours for consolidation and partial drying **(Step 9)**. Thereafter, vulcanization or curing is carried out at 100^{o}C **(Step 10).** After curing is completed, the article is carefully removed, washed and dried **(Step 11).**

Procedure for casting with metal moulds

In the rotational moulding technique, a measured volume of a compound containing a heat sensitizer or gelling agent such as an ammonium salt, e.g. ammonium acetate, is poured into a mould, which is then closed tightly and rotated at two different axes simultaneously at about 85-90^{o}C. The compound gets distributed evenly over the inner surface of the mould and gets gelled. Finally, the gel is removed, thoroughly washed with water and dried. Curing is completed during drying.

Rubber Technology & Development Dept.
Rubber Research Institute of Sri Lanka
Telawala Road
Ratmalana

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