

# A Review on Rubber Compound Mixing In Banbury Mixer at Tire Industries

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**Abstract:** In tire industries the formation of rubber is an important aspect for the manufacturing of tire. This formation is done in the Banbury mixer by adding various different compounds in the rubber. The rubber initially cut in the required proportion by Bale cutter and processed in the mixer. After process Rubber forwarded to the hot extruder and cold extruder for the formation of tread, bead, sidewall, ply etc. In this paper i have completely reviewed the formation of master and final rubber also discussed about the importance of compound added in the mixing of rubber.

**Keywords:** Mixing process, compound adding, Master rubber formation, final rubber formation, and Bale cutter.

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## 1. INTRODUCTION

In tire industries for making a tire mixing or compound formation of rubber is most important part. The two major ingredients in a rubber compound are the rubber itself and the filler, combined in such a way as to achieve different objectives. Depending on the intended use of the tire, the objective may be to optimize performance, to maximize traction in both wet and dry condition, or to achieve superior rolling resistance. Compounding is the operation of bringing together all the ingredients required to mix a batch of rubber compound. Each component has a different mix of ingredients according to the properties required for that component. The Mixing process was reviewed at APOLLO TYRES LTD, LIMDA (Gujarat) in which there are four major rubber used: styrene-butadiene rubber (SBR), Polybutadiene rubber (BR), and butyl rubber (along with halogenated butyl rubber). The first three are primarily used as tread and sidewall compounds, while butyl rubber and halogenated butyl rubber are primarily used for the inner liner, or the inside portion that holds the compressed air inside the tire.

This research paper includes brief introduction of compound formation, mixing of compound using Banbury mixer, cycle of Banbury mixer.

## 2. RUBBER COMPOUND FORMATION

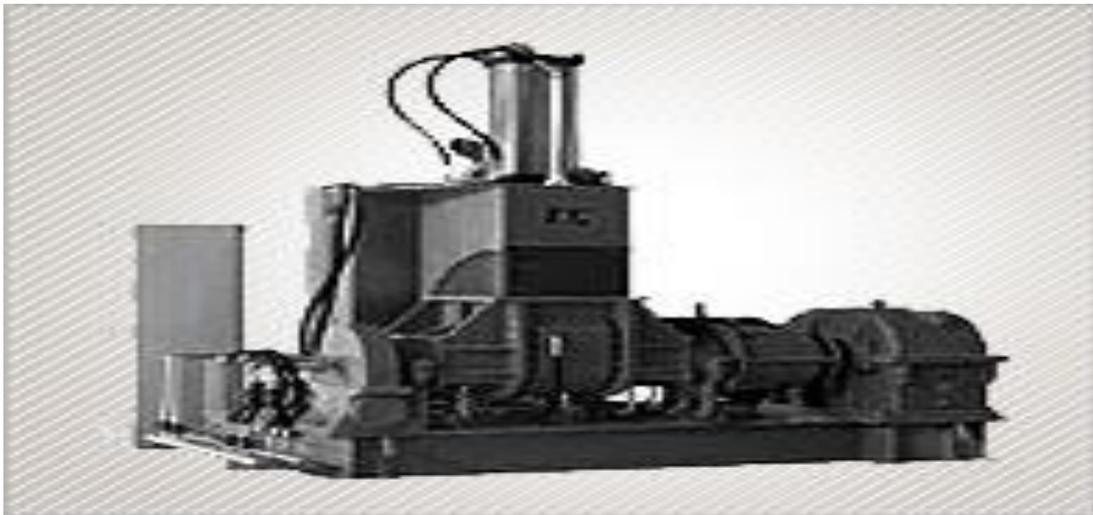
For the formation of the compound the main raw materials of a tire are natural rubber, synthetic rubber, carbon black and oil. The share of rubber compounds in the total weight of a tire is more than 80%. The rest consists of various kind of reinforcing materials. Approximately half of the rubber is natural rubber from a rubber tree and imported from Indonesia, srilanka, Thailand etc. Approximately one third of the compound consists of filler substances the most popular fillers are carbon black and silica. The selection depends on the performance requirements, as they are different for the tread, sidewall and apex. Other ingredients also come into play to aid in the processing of the tire or to function as anti-oxidants, anti-ozonants and anti-aging agents. In addition, the cure package- a combination of curatives and accelerators is used to form the tire and give it its elasticity.

In order to manufacturing a tire the major raw materials required are: Fabric (steel, polyester, nylon, or combination of these), Rubber (synthetic and natural types: hundred of different polymer), Reinforcing chemical (carbon black, silica, resins), Anti-degredants (ozonants, paraffin waxes), Adhesion promoters (cobalt salts, brass on wire, resins on fabric), Curatives (cure accelerators, sulphur) and processing oils (oils, trackfiers, softeners).

### 3. RUBBER COMPOUND MIXING

In rubber industry, mixing is the foundation step upon which every further step is dependent on. Mixing is the most critical component of rubber processing. The aim of mixing is to produce a product that has the ingredients dispersed and distributed sufficiently thoroughly that will process satisfactory in the next process, cure efficiently and give the required properties for the end application.

Mixing requires deciding the formulation, what equipment to use, and the time, speeds, pressures, temperatures. The aim should be to minimize the labour, energy and equipment cost per unit volume of product. Due to the partly elastic nature and very high viscosity of rubber, power intensive, sturdy machinery like mixing mills and internal mixers are necessary.



**Fig. 1**

The internal mixers are termed as Banbury mixer used for mixing rubber and plastics. Mainly two different type of Banbury mixer are used in Apollo tyres named as Farrel 270 and Farrel 440. Farrel 270 has a mixing capacity of 220 litres and Farrel 440 has a mixing capacity of 370 litres. The rubber used for mixing in Banbury is in weight pack of 35kg of natural rubber and 50 kg pack of synthetic rubber.

The Banbury mixer works on the different principle as all have a different ram pressure before and after oil addition in the process of mixing the ram pressure as per the operation are listed below:

**Table: 1**

| Operation Listed                           | Ram pressure  |
|--|---|
| Energy based operation                     | 5.5 kg/cm <sup>2</sup>  |
| Single stage mixing (Time based operation) | 4.4 kg/cm <sup>2</sup>  |
| Temperature based operation                | 6.6 kg/cm <sup>2</sup> (before oil addition) to 4.5 kg/cm <sup>2</sup> (after oil addition) |

The Banbury mixer is a tangential type internal mixing machine, in which two slightly spiralled rotors revolve side by side towards each other within a chamber shaped like two short cylinders lying together with adjacent sides open. The chamber has a top opening called hopper, which can be closed by pneumatic means for inserting the material and a bottom gate, which can be hydraulically opened, to drop out the contents after mixing.

The Banbury is charged by raising the ram completely out of hopper and dropping in bales of rubber weighed up properly to fill the chamber. The ram is then lowered under pressure and the rubber forced and held in the chamber while it is needed and blended by the rotors. Breakdown of rubber is accomplished by shearing action between rotor blade tips and rotor walls and between rotor-rotor, with one rotor running slightly faster than the other to prevent sticking to the blades.

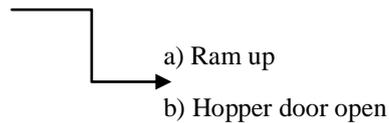
Banbury mixer combines rubber stock, carbon black and other chemical ingredients. Compounding and Banbury mixing create a homogeneous rubber material. Time, heat and raw material are factors utilized to engineer material composition. The ingredients are generally provided to the plant in pre-weighed packages or are prepared and weighed by Banbury operator from bulk quantities. Measured ingredients are placed onto a conveyer system, and the Banbury is charged to initiate the mixing process.

Hundreds of compounds are combined to form rubber utilized to form tyre manufacturing. The components include a compound which acts as an accelerators, anti-oxidants, anti-ozonants, extenders, vulcanizers, pigments, plasticizer, reinforcing agent and resins.

#### 4. BASIC OPERATION CYCLE OF BANBURY MIXER

1. Start operation

2. Discharge door closed



3. Compound inputted

4. Mixing started (Rubber + Chemical powders)

5. Close hopper door

6. Carbon is charged

7. Mixing for given period

8. Ram up

9. Oil injection

10. Ram down

11. Ram up/down

12. Ram float

13. Open discharge door

14. Start the next cycle

The temperature in each step changes simultaneously initially the temperature is 35<sup>0</sup>c and the mixer speed is set at 55 rpm and the ram pressure is at 135 bar then the mixing starts and the temperature goes to 105<sup>0</sup>c and the ram pressure decreases to 110 bar after the mixing completes the temperature in the mixer is 130<sup>0</sup>c and discharge time after the ram float is 10 to 12 sec.

#### 5. CONTROLLABLE FACTORS AT BANBURY MIXER

1. Batch size

2. Sequence of addition

3. Ram cylinder pressure

4. Rotor speed

5. Mixing time

6. Temperature of the finished mix, chamber, rotors, discharge door top

7. Energy for mixing

In Banbury two different type of product can be made as a final product and master product. The final product is further sent to the extrusion and the master product is again gone through the cycle once. Initially the bale cutter is used to cut the rubber from batch as per the requirement. The bale cutter is hydraulically operated with a pressure of 90 kg/cm<sup>2</sup>. After making the master compound it is further sent to the extrusion for the further processes to be done on it.

## **6. RESULT AND DISCUSSIONS**

1. Approximately 120 different materials are added for the formation of rubber compound.
2. The maximum ram pressure in the Banbury mixer is 6.6 kg/cm<sup>2</sup>.
3. The Banbury mixer is of capacity 220 and 370 litres of Farrel Corporation.
4. The operation of Banbury is of energy type (35.5 kWh), temperature type (165°c) and time based (120 sec).

## **7. CONCLUSION**

From my research i have concluded that the formation of rubber for a tire is an process of mixing different compound as per the required result of tire and distributing the compound for the further process by which the single cycle master compound are send to the bead and ply formation and final compound is sent to the extrusion department for the manufacturing of tread the is division is done for reduce of cost as proceeding master compound to the bead formation further. This distribution of master and final compound make a reduce of 4.5 % price of overall tire.

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