Avoid Remixing Step in Track Producing Extrusion Compound (ATR-6112) By Modification of Viscosity

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Abstract - Rubber compounding has mainly master batch mixing and final batch mixing. In some special cases, rubber compounding has additional re-mixing step to achieve specific viscosity standards in master batch mixing. This extra step increases the cost negatively affecting the profit of the rubber compounding industries. In this research, avoidance of remixing step in track producing extrusion compound was focused by modifying the viscosity. Thus, the properties and processability of said compound were tested by changing mastication phase rotor speed (25 rpm, 40 rpm, 55 rpm), mastication phase masticate time (80 s 100 s, 120 s), carbon black incorporation phase rotor speed (25 rpm, 40 rpm, 55 rpm) and dispersion phase rotor speed (25 rpm, 40 rpm, 55 rpm) separately. Furthermore, viscosity properties of the compound were analyzed by using Complete Randomized Design with 4 replicates per each treatment. Results revealed that, rotor speed and mastication phase masticate time have significant effect on viscosity of the compound. Better properties could be obtained at mastication phase 55 rpm rotor speed, mastication phase masticate time 120 s and 80 s, carbon black incorporation phase 55 rpm rotor speed, dispersion phase 55 rpm and 25 rpm rotor speed. These different best level were combined and the properties were tested again. The lowest viscosity value shown at mastication phase 55 rpm, mastication time 80 sec, carbon black incorporation phase 55 rpm and dispersion phase 25 rpm was taken as best combination and was selected as the new mixing cycle. In the selected mixing cycle, carbon black incorporation phase temperature was controlled at 150 0C well. The developed new mixing cycle of master batch mixing cycle could avoid the remixing step in track producing extrusion compound (ATR-6112) by modification of viscosity.

Key words: Master batch mixing cycle conditions, Re-mixing, Track producing extrusion compound, Viscosity modification

I. INTRODUCTION

Rubber track is a system of vehicle propulsion in which a continuous band of treads is driven by two or more wheels. This band is typically made of modular steel plates for military vehicles, or rubber reinforced with steel wires for lighter agricultural or construction vehicles which consists of three distinct parts; top profile, intermediate layer and metal piece [1]. There are many factors effecting the properties and processability of track producing extrusion compounds. Track profiles are formed by extrusion of uncured rubber compounds [2]. In this research, mixing parameters which affect the properties and processability of track producing extrusion compound were focused to find out the effect of mixing parameters on viscosity properties of the compound and to identify the optimum mixing parameters to reduce the rejection level of compound due to pre- vulcanization during extrusion. Camso Loadstar (pvt) Ltd. has experienced the quality reduction of rubber track producing extrusion compound due to high viscosity of master batch compound. Because, high viscosity rubber compound needs additional re-mixing step. It has caused high cost of production and they have not been able to achieve their demand also. Therefore, in this research the broader objective was to develop a new master batch mixing cycle for a track producing extrusion compound with lower rejection rate and the specific objectives were to find out the best combination of mastication phase rotor speed, mastication time, carbon black incorporation phase rotor speed and dispersion phase rotor speed.

II. MATERIALS & METHODS

1. Location of the study

The testings were conducted at the laboratory premises of Central Mixing Plant, Camso Loadstar (Pvt.) ltd, Opatha, Kotugoda during June to November 2017.

2. Materials and Equipment

The ingredients for manufacturing ATR-6112 track compounds were, Technically Specified Rubber (TSR 20), Stearin Butadiene Rubber (SBR 1502), Carbon black, Powder silica, Rubber processing oil, activators, accelerators, anti-oxidant and other compounding ingredients. The machinery used for the manufacturing track compounds (ATR-6112) are IM 320 intermesh, tangential mixer and 84 inches two roll mill. The equipment used to check the properties of rubber compound were Viscometer (ISO 289- 1, 2014), Rheometer (ISO 6502), Tensometer (ISO 4648), Durometer (ISO 7619), and Densimeter.

3. Procedure

Literature survey was done & historical data were analyzed to find the major three steps of mixing compound. Different experiments were designed to test the properties of extrusion compounds. Mastication phase rotor speed (25 rpm, 40 rpm, 55 rpm), mastication phase masticate time (80 s 100 s, 120 s), carbon black incorporation phase rotor speed (25 rpm, 40 rpm, 55 rpm) and dispersion phase rotor speed (25 rpm, 40 rpm, 55

rpm) on the properties and processability of said compound were tested and the best level of each treatment was selected the to develop a new master batch mixing cycle for a track producing extrusion compound. Furthermore, Minitab- 16.2.3 statistical software and Complete Randomized Design with 4 replicates per each treatment were used to test the viscosity properties of the compound and mean comparison was done by using Tukey method. After selecting the best treatment combination, the temperature controller (1600C, 1500C) was added to the carbon black incorporation phase for the reduction of Moony final of the master batch compound.

III. RESULTS AND DISCUSSION

As this research was mainly focused on the modification of the viscosity in master batch compound, the moony final data and the physical properties were considered mainly.

1. Experiment 01- Moony viscosity changes with rotor speed in mastication phase

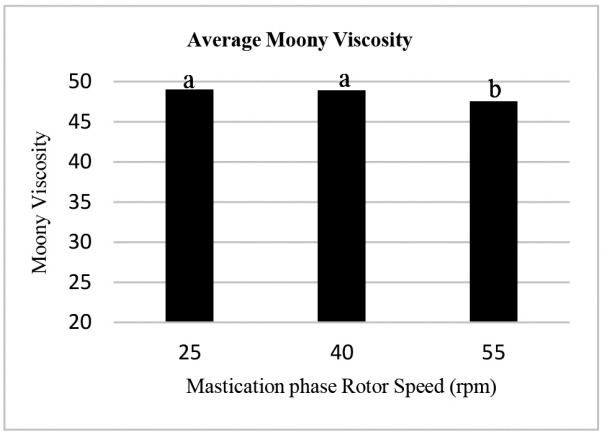

Fig.1: Mean values of the Moony Viscosity in different mastication phase rotor speed

Effect of mastication phase rotor speed for Moony final of track producing extrusion compound is shown in Figure 1. It should be noted that there is no any significant difference between 25 rpm and 40 rpm mastication phase rotor speed. However, 55 rpm rotor speed is statistically different and also shows the lowest Moony final value. Therefore 55 rpm can be selected as the best treatment of this experiment.

2. Experiment 02- Moony viscosity changes with masticate time of mastication phase

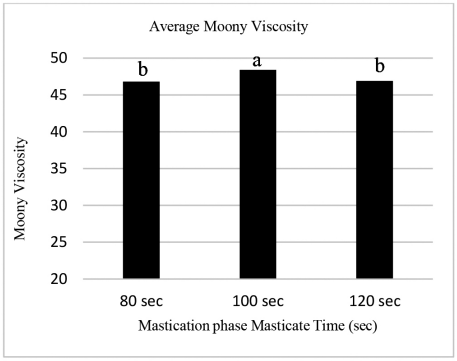

Fig. 2: Mean values of the moony viscosity in different mastication phase masticate time

Effect of mastication phase masticate time for Moony final of track producing extrusion compound is shown in Figure 2. There is no any significant difference in between 80 s and 120 s. However, 100 s mastication time is statistically different. Further, both 80 s and 120 s show the lower Moony final values. Therefore, both 80 s and 120 s selected as best treatments of this experiment.

3. Experiment 03- Moony viscosity changes with rotor speed in carbon black incorporation phase

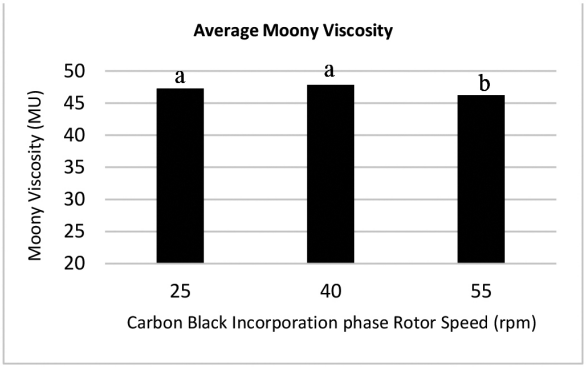

Fig. 3: Mean values of the Moony Viscosity in different carbon black incorporation phase rotor speed

Effect of mastication phase rotor speed for Moony final of track producing extrusion compound is shown in Figure 3. It should be noted that, there is no any significant difference between 25 rpm and 40 rpm carbon black incorporation phase rotor speed. However, 55 rpm rotor speed is statistically different from other two speeds. And also 55 rpm shows the lowest Moony final value. Therefore, 55 rpm was selected as the best treatment of this experiment.

4. Experiment 04- Moony viscosity changes with rotor speed in dispersion phase

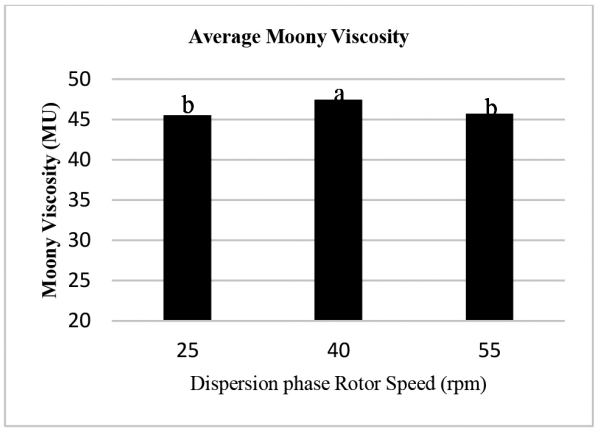

Fig. 4: Mean values of the Moony Viscosity in different dispersion phase rotor speed

Effect of dispersion phase rotor speed for Moony final of track producing extrusion compound is shown in Figure 4. There is no any significant difference between 25 rpm and 55 rpm dispersion phase rotor speed. But 40 rpm rotor speed is statistically different from other two. And also both 25 rpm

and 55 rpm show the lower Moony final values. Therefore, both 25 and 55 rpm were selected as best treatments of this experiment.

5. Experiment 05- Selection of the best treatment combination of all experiments

Mastication step rpm - 55 rpm, Mastication time – 120 s and 80 s, Carbon black incorporation phase rpm – 55 rpm and Dispersion phase rpm – 55 and 25 rpm were selected as the best treatment combinations to develop four new master batch mixing cycle for the track producing extrusion compound. By using selected best treatments of each 01 to 04 experiments, four different new master batch mixing cycles were developed as appeared in Table 1.

Table I
New Master Batch Mixing Cycles

Parameters	Combination 01	Combination 02	Combination 03	Combination 04
Mastication step rpm	55 rpm	55 rpm	55 rpm	55 rpm
Mastication time	120 sec	120 sec	80 sec	80 sec
Carbon black incorporation phase rpm	55 rpm	55 rpm	55 rpm	55 rpm
Dispersion phase rpm	55 rpm	25 rpm	55 rpm	25 rpm

Among these new mixing cycles, the lowest Moony final viscosity showing mixing cycle was selected to develop the new master batch mixing cycle to avoid remixing step in ATR-6112 track producing extrusion compound.

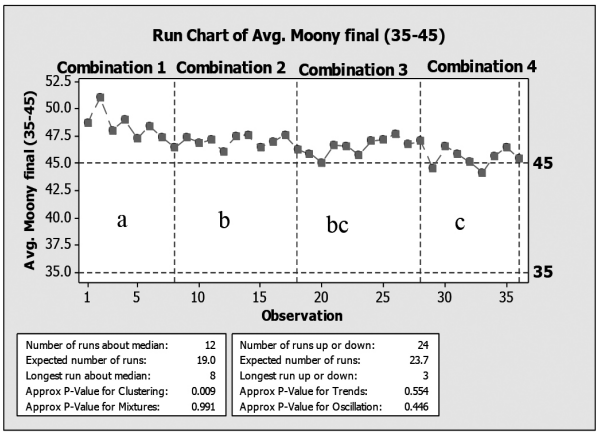

Fig. 5: Final viscosity behavior of newly develop mixing cycles

The Moony final behavior of newly developed four different master batch mixing cycles moony is shown in figure 5. According to the mean comparison of the Moony final behavior of newly develop mixing cycle combination 01, 02, and 04 are different from each other and it should be noted that there is a no any statistical different on combination 03 with combination 2 and combination 03 with combination 04. Therefore, the lowest Moony final showing combination 04 was selected as the best mixing cycle for further experiments. Although the best treatment combination of each experiment has also not achieved the company standard level, for further reduction of Moony final value of the master batch, temperature controller to the carbon black incorporation phase was added. Hence 1500C and 1600C were two levels of temperature applied to the selected best combination. By using chiller system of the intermesh this temperature controller was added to the newly developed master batch mixing cycle.

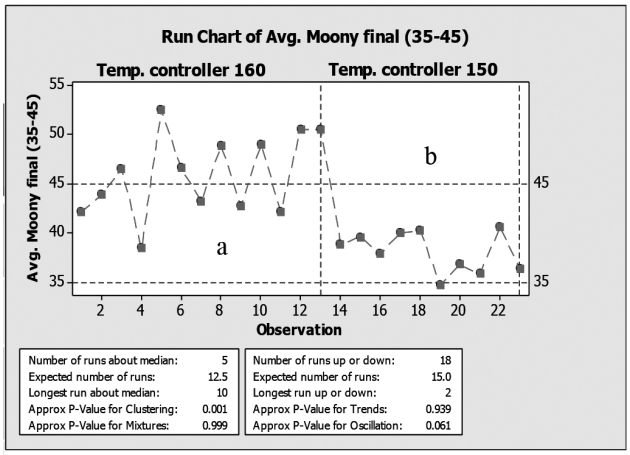

Fig. 6: Final viscosity behavior of after applying temperature controller to selected best combination

According to figure 6, two levels of temperature show two different levels of moony final behaviour. Here, 1500C was selected as the temperature controller of this newly developed master batch mixing cycle, as it shows lower Moony final behaviour. Hence, using 1500C temperature controller newly developed master batch mixing cycle can be used to avoid the remixing step of ATR-6112 track producing extrusion compound.

IV. CONCLUSION

Viscosity property is significantly affecting on the performances of track producing extrusion compound since standard range of viscosity of the compound help avoid the pre-vulcanization during manufacturing track profiles by extrusion. Different parameters viz mastication phase rotor speed, mastication phase mastication time, carbon black incorporation phase rotor speed and dispersion phase rotor speed directly affect the properties of track producing extrusion compound.

Among those parameters, mastication phase rotor speed 55 rpm, mastication phase masticate time 80 second, carbon black incorporation phase rotor speed 55 rpm and dispersion phase rotor speed 25 rpm were selected as the best treatment combination for a new master batch mixing cycle. Further, 1500C temperature controller can be used to carbon black

incorporation phase in order to achieve better performances of viscosity and physical properties.

Newly developed master batch mixing cycle can be developed as a new mixing cycle to avoid re-mixing step of track producing extrusion compound (ATR-6112).

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References

1. Kimmich, E. G. (1956). General Engineering Properties of Rubber. New York: Reinhold Publishing Corporation.
2. Nobuyuki, N. (2000). Science and Chemistry of solid tire processing. United Kingdom: PAPRA Technologies.
3. Morton. (1987). Rubber Technology (1st edition ed.). Wokingham: Van Nostrand Reinhold company co, Molly Millars Lane, Wokingham.