Superior Processing Rubber Masterbatch

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Two processes are described for imparting superior processing characteristics to all grades of rubber. The first process, which makes use of a dry vulcanised rubber masterbatch, is best used in consuming areas to impart SP properties to RSS 2, 3, 4 and 5 grades. The second process, which makes use of the vulcanised rubber masterbatch coagulum, is best used in the producing areas to impart SP characteristics to the remilled grades.

THE ADVANTAGES OF SUPERIOR PROCESSING RUBBERS[1] in extruding, calendering, reworking and pan curing have all been accepted by the rubber manufacturing industry. Three hundred tons were sold to the industry in 1957 and, with the publication of a Technical Bulletin[2], more usage is expected in 1958. The process[3] which involves the admixture of 20 parts vulcanised rubber with 80 parts of unvulcanised rubber in latex form has some marketing disadvantages, the main one being that by this process SP rubber can only be made in No. 1 quality grade and cannot be prepared in any other grade. Lower grades of smoked sheet are mainly produced by smallholders. It would be extremely difficult to incorporate vulcanised latex into smallholders' latex in the same way that present SP rubbers are made. The lower grades of crepe are made from various kinds of wet scrap rubber. Mixing wet scrap with vulcanised latex does not result in a rubber with SP properties. Many goods in which the use of SP rubber would prove advantageous are made from lower grade rubbers and the advantages in processing offered by SP rubber cannot outweigh the additional cost of the higher grade. Efforts at the Institute were therefore directed towards finding a method of conferring superior processing characteristics upon all grades of rubber. This paper describes two successful processes developed for such a purpose; these are known as the Dry Masterbatch and the Wet Masterbatch processes respectively. Patent application has been made to cover them and is pending.

Dry Masterbatch Process

It is generally known that completely vulcanised rubber is incompatible with raw rubber on the mill. If it were not, the problem would have been simple. The reasons for the failure are crumbling of vulcanised rubber on the mill and the large differential between the raw Mooney viscosities of vulcanised and unvulcanised rubbers. In the standard SP rubber process, intimate blending of 80 parts of raw rubber with 20 parts of vulcanised rubber is achieved by mixing in the latex form. This SP rubber containing 20% of vulcanised rubber has been proved to be easily compatible with ordinary raw rubber on the mill. What is necessary then, is to determine the smallest proportion of unvulcanised rubber latex that has to be added to vulcanised latex to give a product that will knit well on the mill. If the vulcanised rubber proportion is sufficiently high in the product, then it should be possible to blend this material with any grade of rubber in appropriate quantities to impart SP characteristics to that grade of rubber. Investigations were therefore carried out by mixing different proportions of vulcanised and unvulcanised rubber latex, and studying the properties of the coagulated products obtained from such mixtures. The

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results obtained are summarised in Table 1 from which it is clear that as little as 10 parts of unvulcanised rubber mixed with 90 parts of vulcanised rubber in latex form imparts to the mixture sufficient tack to adhere together into a sheet on the open mill. The compatibility of these mixtures with further quantities of raw rubber on the open mill was then tested by blending the mixtures with appropriate quantities of raw rubber so that the final concentration of vulcanised rubber in the blend was in each case 20%. Typical results of tests of homogeneity, percentage extrusion swell, and scorch time, are given in Table 2.

TABLE 1. PROPERTIES OF DIFFERENT VULCANISED RUBBER MASTERBATCHES

Vulc/unvulc rubber ratio	Appearance of coagulum	Appearance of crepe	Behaviour on the mill when dry
98/2	Fine crumb	Powders	Does not knit
95/5	Slightly coarse crumb	Very brittle	Knits but brittle
90/10	Coarse crumb	Brittle	Knits satisfactorily
80/20	Coarse crumb	Brittle	Good
70/30	Brittle coagulum	Slightly brittle	
65/35	Brittle coagulum	Satisfactory crepe	
60/40	Hard coagulum	Good crepe	
50/50	Normal coagulum	Good crepe	
20/80	Normal coagulum	Good crepe	

TABLE 2. EFFECT OF MASTERBATCH CONCENTRATION ON PROPERTIES OF THE FINISHED SP RUBBER

Vulc/unvulc rubber ratio	Wt of masterbatch (gm)	Wt of raw Yellow Circle rubber (gm)	Homogeneity of blend	% * Extrusion swell	Scorch † time in minutes
98 : 2	51	199	Poor	17.9	9
95 : 5	52.5	197.5	Slightly rough	15.0	8
90 : 10	55.5	194.5	Satisfactory	14.8	8
80 : 20	62.5	187.5	Good	13.8	7
70 : 30	71.5	178.5	Good	14.3	8
65 : 35	77	173	Good	15.9	7.5
60 : 40	83	167	Good	14.2	8
50 : 50	100	150	Good	14.6	10
20 : 80	250	—	Good	19.3	8
0 : 100	—	250	—	30.2	9

* The % extrusion swell[1] is the % increase in cross-sectional area of a tyre tread compound of the test rubber after extrusion through an orifice of known dimensions under controlled conditions. The cross-sectional area of the extruded rod is calculated from weight and density measurements.

† The scorch time is measured by the tangent method[4] described by J. M. Buist.

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By using a materbatch containing up to 90% vulcanised rubber and milling in the requisite amount of raw rubber to give a final concentration of 20% vulcanised rubber, the superior processing properties achieved in this experiment are, if anything, better than those obtained by conventional mixing in latex form. All grades of raw rubber can be used with such a masterbatch, as is shown in Table 3, in which the results obtained by blending the masterbatch with ADS, RSS and scrap crepe are shown.

TABLE 3. PROPERTIES OF SP RUBBERS PREPARED USING DRY MASTERBATCH

90 : 10 Vulc/unvulc rubber masterbatch (gm)	ADS	RSS	Bark scrap crepe	Homogeneity on the mill	% Extrusion swell	Scorch time (min)
50	175	—	—	Satisfactory	19	9
50	—	175	—	Satisfactory	14.2	10
50	—	—	175	Satisfactory	19	7
—	225	—	—	—	32	9
—	—	225	—	—	30.2	9
—	—	—	225	—	37.1	11

There is, however, a considerable difference in Mooney viscosity between the masterbatch and the raw rubber with which it is mixed. Blending on an open mill is satisfactory provided that the masterbatch is added to the raw rubber before any serious breakdown has taken place.

Recommended Procedure for the Dry Masterbatch Process

Ordinary field latex is well mixed with vulcanised latex in the proportion of 1:9 based on rubber content. The mixture is coagulated in the usual manner, creped, the crumbled crepe is put on trays and dried at 120°F. The drying rate of the masterbatch crepe is fast and normally a ½ to 1 inch layer dries in 24 hours. The dry crumbs are then passed once through a dry creping mill to convert into sheet. The recommended packing procedure is to compress the sheets into bales, bind them with steel tapes, and use sisalkraft paper as an outer wrapper. Such bales have been sent to the United Kingdom and arrived at their destination in a satisfactory condition.

Economics of the Dry Masterbatch Process

The operating cost of the process can best be worked out as the extra cost involved over the cost of producing RSS 1. The following analysis is applicable for the production of 1000 lb of dry 90/10 SP masterbatch per day.

1 *Chemical for 1000 lb of masterbatch.*

Chemicals	*lb*	*Price per lb ($)*	*Cost ($)*
Ammonia	12	0.64	7.68
Sulphur	18	0.16	2.9
Zinc oxide	6.75	0.58	3.92
Z.D.C.	1.8	2.25	4.05
M.B.T.	3.6	1.27	4.57
Dispersol LR	0.003	1.6	0.01
Extra formic acid for coagulation	7.7	0.41	4.92
		Total for chemicals	28.05

2 *Labour + electricity + steam for vulcanisation*—$8.84

3 *Drying and creping*—No additional operating costs for drying above the cost of making smoked sheets are envisaged. Indeed it is expected that there will be some saving in drying costs as the crumb dries faster than smoked sheets.

Since the dry crumb is passed once through the dry creping mill, there will be additional labour and operating costs which will be: $2.00

The production costs above RSS I thus amount to $38.89, which is 3.89 cents per lb.

4 *Depreciation of capital equipment*—In addition to the equipment required for vulcanisation, namely a boiler, a ball mill, a vulcanisation tank, bulking tank and stirrers, the following items are required:

Trays for holding the crumb,
modifications to existing drying sheds, and
one smooth roll creper.

Allowing ten year life, depreciation cost for all equipment above that used for RSS, approximates to 2.5 cents per lb.

5 *Packing charges*—The finished material occupies a 30% greater volume than normal sheet and therefore incurs additional freight charges which amount to about 1.2¢ per lb in shipment to the U.K. The total additional costs incurred in making 90/10 masterbatch thus amount to 7.59¢ per lb. A reasonable price including overheads and profits would be 11¢ over the price of RSS 1.

6 *Use of SP masterbatch*—Sufficient masterbatch is required to give 20% vulcanised rubber after mixing with raw rubber, that is, 2 parts of 90/10 masterbatch mixed with 7 parts of raw rubber. Assuming a differential of 3¢, 9¢ and 16¢ for RSS 2, RSS 3 and C Blanket respectively over the price of RSS 1, the increased cost of the final SP rubber in each case will be as follows:

SP RSS 2 $= \frac{(3 + 11)2}{9} = \frac{28}{9} = 3.1¢$ over the price of RSS 2

SP RSS 3 $= \frac{(9 + 11)2}{9} = \frac{40}{9} = 4.4¢$ over the price of RSS 3

SP C Blanket $= \frac{(16 + 11)2}{9} = \frac{54}{9} = 6¢$ over the price of C Blanket.

Wet Masterbatch Process

An alternative method of imparting SP properties to lower grades has been developed by using masterbatch coagulum before drying. The use of this method is confined to producing countries, i.e. the plantation factory or the remilling factory. The principle of the method is similar to that of the dry process. The compatibility of the wet masterbatch with scrap used for preparing remilled crepe was first ascertained to determine the highest concentration of vulcanised rubber masterbatch that could advantageously be used. Masterbatches containing various proportions of vulcanised rubber were blended with scrap crepe on a creping mill. Typical results obtained are given in Table 4, which shows that the highest percentage of vulcanised rubber in the wet masterbatch that can successfully be incorporated into wet scrap is 80%. Trials on a large scale were then carried out at a remiller's factory, milling 90/10, 80/20, 70/30 and 50/50 wet masterbatches separately with scrap so that the final concentration of vulcanised rubber in each blend was approximately 20%. The resulting rubbers were dried and tested for extrusion swell and scorch time. Results obtained are given in Table 5.

TABLE 4. COMPATIBILITY OF WET MASTERBATCHES WITH SCRAP RUBBER

Masterbatch	Observations on compatibility with wet scrap
95/5	Very poor and difficult
90/10	Compatible, but will cut down production rate to half. Final sheets are too brittle to be hung for drying
80/20	Satisfactory in all respects — no cut in production rate
70/30	Very satisfactory all round

TABLE 5. PROPERTIES OF SP LOWER GRADES PREPARED WITH WET MASTERBATCH

Wet masterbatch used vulc/unvulc ratio	Compatibility	% Extrusion swell	Scorch time (min)
90/10	Satisfactory but slow	19	7
80/20	Satisfactory	18.7	7
70/30	Good	17	8
50/50	Good	18.5	8
20/80	—	19.3	8
Control scrap used for blending	—	37.1	11

Recommended Wet Masterbatch Process

The wet process therefore consists in first preparing a blend of 80 parts of vulcanised rubber and 20 parts of unvulcanised rubber in latex form. This master-

batch latex is coagulated in the usual manner, resulting in a crumb coagulum, which is mixed without drying with sufficient scrap on the creping battery to give a final rubber mixture containing 20% vulcanised rubber. The dry rubber content of the wet masterbatch can be accurately ascertained during its preparation, but the d.r.c. of the wet scrap can only be estimated by visual methods normally used by re-millers. However, the experiments and trials carried out indicated that the visual estimation of the d.r.c. of wet scrap was sufficiently accurate to impart more or less uniform SP properties to the final rubber.

Economics of the Wet Masterbatch Process

Chemicals for 1000 lb of wet masterbatch of 80/20 vulc/unvulc composition

Chemicals	lb	Price/lb ($)	Cost ($)
Ammonia	12	0.64	7.68
Sulphur	16	0.16	2.57
Zinc Oxide	6	0.58	3.49
Z.D.C.	1.6	2.25	3.6
M.B.T.	3.2	1.27	4.06
Dispersol LR	.0027	1.6	0.01
Extra formic acid	6.84	0.41	4.92
		Total for chemicals =	26.33
		Labour, electricity and steam for vulcanisation =	8.33
		Total extra manufacturing cost =	34.66
		Total =	3.47¢ per lb.

There are no other additional operating charges because the masterbatch is not dried but is mixed on the creping mill with wet scrap rubber and dried in the usual way.

Depreciation of capital equipment—: 1.5¢ (as with normal grades of SP rubber for extra equipment over RSS).

Thus, the total additional costs incurred in making 80/20 masterbatch amount to 4.97 cents per lb above RSS 1. A reasonable price including profit would be 7 cents per lb above the price of RSS 1.

Use of Wet SP Masterbatch

One part of 80/20 masterbatch is mixed with 3 parts of scrap rubber to produce 4 parts of SP brown crepe. Assuming a price differential of 16 cents between RSS 1 and scrap crepe, the additional cost of SP brown crepe must therefore be $\frac{7 + 16}{4} = 5.75$ cents over the equivalent scrap crepe. There is, however, an additional factor to be taken into consideration. Since there is approximately 1 part of good quality rubber mixed with 3 parts of scrap crepe, the final blended crepe is of improved colour over its equivalent grade of crepe. In other words, a part of the increased cost, say 0.75 cents/lb, can be compensated for by the improvement in price because of the better colour. This leaves 5 cents/lb as the final premium for imparting SP properties to the scrap grades by employing the wet masterbatch process.

CONCLUSION

Two processes have been developed for imparting SP properties to low grades of rubber. The dry masterbatch process, which aims at selling a masterbatch as a compounding aid to manufacturers, can be blended with any grade of rubber, using normal mixing equipment. The wet process, however, is suitable only in producing areas. Although with the dry masterbatch any grade of rubber can be given SP properties the wet process can be used only to prepare SP remilled or scrap grade rubbers. The cost analyses that have been given in this paper favour the wet process for remilled grades. On the other hand the flexibility of the dry process and its utility with all grades of rubber makes it attractive. However, both processes are necessary to cover economically the entire range of rubber grades below RSS 1. The dry process should be used when SP RSS 2, 3, 4 and 5 are required, the wet process when SP remilled or scrap grades are required. Thus by a combination of the normal, dry and wet processes, it is now possible to produce SP rubbers in all grades.

At first sight the additional cost of SP lower grade rubbers may appear high. There are, however, several hidden advantages which cannot be estimated without actual experience of using SP lower grades in a factory. For example, an SP lower grade contains a proportion of first quality rubber and therefore has better physical properties than the normal material of that grade. The rate of mill breakdown is improved. In addition to this factor, the SP lower grades will contain appreciably less dirt and also will be of improved appearance and colour.

Although it is clear that the dry masterbatch can be also used for RSS 1, the advantage of obtaining the finished material without having to process it further to make it superior processing, by the manufacturers should be considered. In other words, where SP No. 1 grades are involved, it will be preferable to use the normal SP process. The two processes outlined in this paper are not therefore developed to compete with the existing process, but are a result of an attempt to meet the demands for lower grade superior processing rubbers.

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