EFFECT OF HIGH STYRENE RESIN ON FLOW TIMES INSTEAD OF KAOLIN USED AS ADDITIVES IN RUBBER COMPOUND

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Abstract - In this study, it is aimed to reduce the injection time of the injection machine by using high styrene resin (HSR) instead of kaolin used in rubber compounds. A reduction of close to 50% was observed in the injection times.

Index Terms - HSR, Kaolin, Natural Rubber, Rubber Injection

I. INTRODUCTION

For reduce injection times in the Rubber injection process; increase fluidity in the Rubber composition by using HSR instead of kaolin in the rubber composition.

II. RUDIMENTS

A. Styrene Butadiene Rubber (SBR)

Styrene-butadiene rubbers (SBR) are copolymers of styrene and butadiene. They are of the most commonly used rubbers. Their properties are influenced not only by micro- and macrostructure of polymer chains but also by styrene content. Butadiene structural units can be arrangement as cis-1.4, trans-1.4 or 1.2 (vinyl) units. SBR is an amorphous structure so that is prevents crystallization. It is produced by solution and emulsion polymerization. [1]

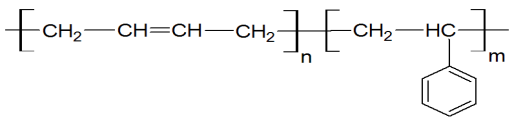


Figure 1 SBR Polymer Structure

SBR Specifications

- Resistant to non-polar solvents, dilute acids and bases.
- Not resistant to fuel and oil.
- SBR with 25% styrene are used in the parts of the vehicle tires that touch the road.
- Requires reinforcing fillers to ensure mechanical properties.
- Ozone and atmospheric strength are good.

B. High Styrene Resin (HSR)

HSR are styrene and butadiene polymers, used as an additive in rubber. Mechanically more durable properties are obtained by replacing fillers with partial or complete. HSR eliminates errors in the process using high fill. It is used instead of carbon black because it does not increase the process viscosity up to carbon black. In addition, the mixture with a high HSR ratio in the same shear stress exhibits lower viscosity. [2,3] As the resin ratio increases in the elastomers, a gradual increase in the modulus and a gradual decrease in the elongation at break are observed. As the resin level increases, the tensile strength increases first, then falls to the optimum, and then a lower value than the optimum level is observed. This is due to the disintegration of the rubber and resin interface. High styrene resins can be used in polychloroprene, styrene butadiene copolymers and natural rubber. [3,4].

C. Kaolin

Al2O3.2SiO2.2H2O chemical structure of kaolin rubber mixtures are used because of their hardness, cost reduction. It has a particle size of 0.1-1 microns. Used in parts that require robustness at low cost. Kaolin-containing rubber mixtures are used in the manufacture of products such as shoe sole, mechanical parts, cable. [5]

D. HSR and Kaolin Similarities-Differences

- HSR in the mixture is mechanically stronger than kaolin.
- The main purpose of both is to give hardness to the rubber compound.
- The use of HSR in injection and extrusion processes is more costly compared to kaolin but produces fewer defect.
- In vulcanization of the rubber compound, both have a delaying effect on vulcanization.

III. EXPRIMENTAL

In this study 70 Shore hardness rubber formulation used by HD Rubber Company was used. Experiments on this rubber formulation;
In the first experiment; we used that 22% HSR instead of 22 Phr kaolin. The injection process with this formulation showed a 55% reduction in injection times, but the hardness value of which was 70 shore measured as 77 shore.

In the second formulation experiment; HSR was used at a rate of 15% considering the first trial. The hardness value of which was 70 Shore measured as 74 Shore. Injection time decreased by 50%.
In the third and final experiment, HSR was added to the rubber formulation by 10% according to data obtained from the output of the first and second experiments. 71 Shore hardness values were reached and the injection time decreased from 105 seconds to 55 seconds.

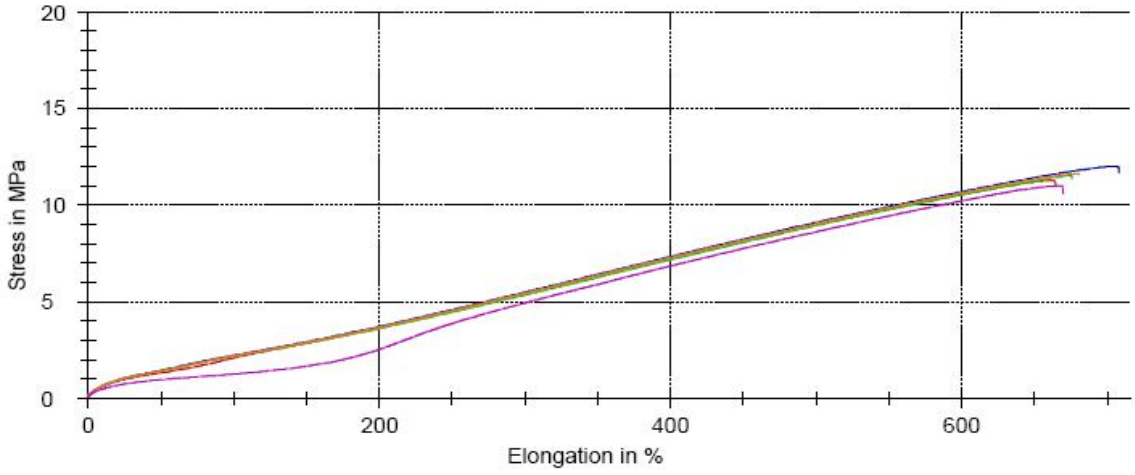
Chart 1 – Compound Formulations

Materials	Compound 1 (Phr)	Compound 2 (Phr)
Natural Rubber (SMR 5)	75	75
SBR 1502	25	25
FEF 550	65	65
HSR(%83 Styrene)	-	10
Kaolin	22	-
Paraffinic Oil	10	10
ZnO	4,5	4,5
Stearic Acid	1,5	1,5
Sulfur (%80)	1,75	1,75
CBS-MBTS (%80-%75)	1,2	1,2

Chart 2 – MDR, Hardness and Denstiy Results (160^{o} C)

	Compound 1	Compound 2
T_2(min:sec)(TS 2009-2 ISO 289-1)	3:27	3:09
T_{90}(min:sec)(TS 2009-2 ISO 289-1)	4:08	4:10
ML (dNm)(TS 2009-2 ISO 289-1)	7.24	5.41
MH(dNm)(TS 2009-2 ISO 289-1)	9.91	8.39
Shore A (TS EN ISO 868)	70	71
Density (g/cm3) (TS EN ISO 1183-1)	1,224	1,172

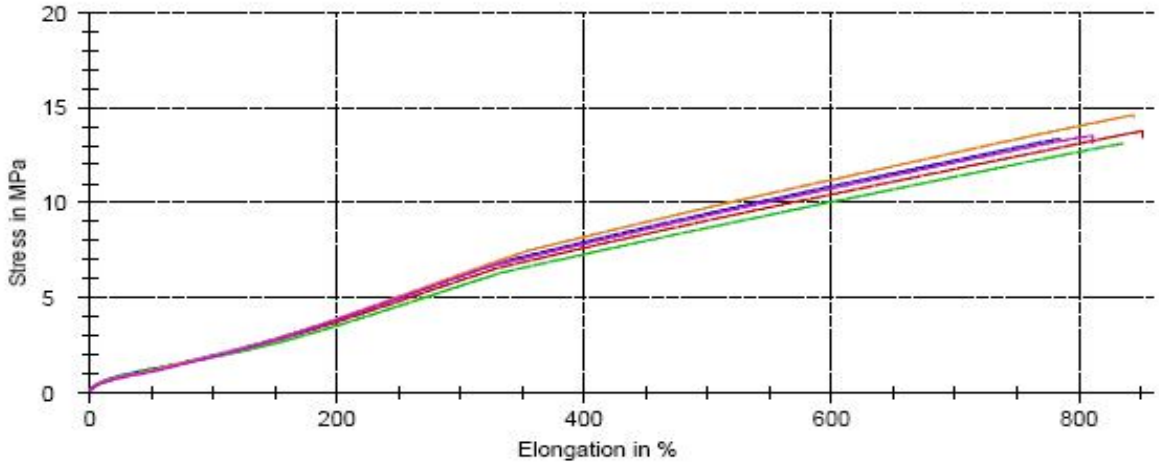
After the appropriate hardness value of the newly formed formulations of HSR containing rubber have to be compared with the tensile strength values of the kaolin containing formulation.



Statistics:

Series	σ_{max}	ε_R	σ_{50}	σ_{100}	σ_{200}	σ_{300}	σ_{500}	a	b	A_0
n = 5	MPa	%	MPa	MPa	MPa	MPa	MPa	mm	mm	mm²
x	11,5	677	1,3	2,0	3,4	5,3	8,9	1,81	4,61	8,34
s	0,4	17	0,2	0,4	0,5	0,2	0,2	0,000	0,000	0,00
ν [%]	3,30	2,52	15,45	20,71	14,73	4,20	2,15	0,00	0,00	0,00

Graph 1 Tensile test results of Compound 1 (DIN 53504)



Statistics:

Series	σ_{max}	ε_R	σ_{50}	σ_{100}	σ_{200}	σ_{300}	σ_{500}	a	b	A_0
n = 5	MPa	%	MPa	MPa	MPa	MPa	MPa	mm	mm	mm²
x	13,7	825	1,2	1,9	3,8	6,0	9,2	2,17	5	10,85
s	0,6	27	0,1	0,0	0,1	0,2	0,4	0,000	0,000	0,00
V [%]	4,22	3,33	5,16	2,32	3,96	4,04	4,34	0,00	0,00	0,00

Graph 2 Tensile test results of Compound 2 (DIN 53504)

Chart 3 – Injection Machine Control Panel-Parameters

Injection Counter	Injection Time (sec)
186	147,14
187	161,6
188	199,08
189	97,54
190	100,51
191	105,26
192	95,37
193	103.08
194	91,61
195	103,02
196	89,18
197	92,56
198	68,62
199	58,76
200	50,47

IV. RESULTS

Kaolin, which is used to reach the desired hardness and reduce the cost of rubber, increases the injection time and slow down the process. HSR is used as a substitute for kaolin because it reduces the process viscosity. When the temperatures of the mixture increases, the solubility of HSR in the elastomer phase increases and the shear friction decreases. When the machine parameters in the table are examined; injection 198,199,200 belong to injection times of the compound made with HSR. It was observed that up to 50% time saving was achieved in the mixture using HSR. In addition, when the results of the tensile test given in the graphs were evaluated, the increase in tensile strength of the mixture used in HSR was observed.

A. Abbreviations

HSR: High Styrene Resin
SBR: Styrene Butadien Rubber
MDR: Moving Die Rheometer

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