Investigation of Mechanical Behavior Of Fiber Reinforced Tire Rubber Composite

Hanan Mohsin Saadoon*, Abbas A. Alassadi1, Nadhum Mejbil Faleh1
1Al-Mustansiriyyah University, Mechanical Engineering Department, Iraq
*hanan.muhssen@gmail.com

Abstract. This paper consists of the recipe preparation of passenger tire tread, the recipe formula, properties of the materials (matrix rubbers and reinforcement), the technology of rubber processing, compression modulus, vulcanization, mechanical tests. The rubber that used in this work were created from natural (SMR-20) and styrene-butadiene (SBR-1502) rubber. Fifteen carbon black (N375) versus load level (10-30-50-70-90) filled recipes with other compounding materials such as filler; vulcanizing agent (sulfur) and accelerator were formulated with the compound formulations. In this paper we improve mechanical properties through selection of suitable rubber blends and through selected carbon black.

Keywords: Natural rubber_ NR (SMR_20 ), Styrene_butadiene_rubber (SBR_1502), carbon black (CB N_375).

1. Introduction
Modern fast transportation and advanced machine development have become possible because of the use of rubber products like tires, belts, seals, springs and mounts. Typical examples for dynamically loaded components are (rubber springs, engine mounts and tires). Globally, The transfer is about 60% of people by moving vehicles on rubber tires [1]. Rubber wheel have main function to balance of tire performance, while sidewall rubber is main function to resist tire fatigue [2]. Especially during the past decades, enormous progress has been happen in chassis engineering and driveability [3].

2. Tread compound
The recipe for the fittings used in this work is based on the basic formula of the passenger tire itinerary shown in Table (1).
Table 1. Tread compound

| Item | Material                     | Loading Level (pphr) |
|------|------------------------------|----------------------|
| 1    | SBR                          | 75,50 and 25         |
| 2    | NR                           | 50                   |
| 3    | Zinc oxide (activator)       | 1.5                  |
| 4    | Stearic acid (activator)     | 1                    |
| 5    | Antioxidant (TMQ)            | 0.5                  |
| 6    | Antiozonant (6PPD)           | 1                    |
| 7    | Carbon black (N375)          | 10,30,50,70 and 90   |
| 8    | Process oil                  | 18.35                |
| 9    | WAX                          | 1                    |
| 10   | CBS                          | 1                    |
| 11   | Sulphur                      | 1.75                 |
| 12   | CTP-100                      | -                    |

3. Objectives
The main goals of this study are:
- To improve the prescription properties of tread tires by adding carbon black reinforcement filler at different loading levels in addition to the additive materials to styrene butadiene (SBR) rubber and (NR) natural rubber.
- Improve mechanical properties through selection of suitable rubber blends and through selected carbon black type (N375).
- To optimize the effect of the blending and loading in pphr of NR with SBR.
- To optimize the effect of loading level of carbon black (N375).

4. Compression Test
Compression coefficient obtained at a given stress by a compressing a cylindrical test specimen between flat parallel planes lubricated with oil to facilitate slippage of the rubber at the contact faces, because constraining slippage will lead to a high apparent compression modulus [4 and 5].

Figures (1,2 and 3) shows the Compression without Thermal. Figures (4,5 and 6) shows the Compression with Thermal 2h.

![Figure 1. Compression without Thermal Pastes( A).](image-url)
Figure 2. Compression without Thermal Pastes (B).

Figure 3. Compression without Thermal Pastes (C).

Figure 4. Compression without Thermal Pastes (A).

Figure 5. Compression without Thermal Pastes (B).
5. Wear Test

We can be defined as corrosion resistance by rubbing or sliding the rubber surface against abrasives material that led to the removal of surface materials. Pin-on-disk test was used, which relies on the production of relative movement between the rubber and an abrasive. The standard test adopted in this work is that the rubber cylinder blocks are mounted in a vertical stand and pressed against a rotating abrasive paper disc at specific force, time, temperature, and velocity.

Figures (7,8 and 9) shows the corrosion rate versus the carbon black load level of (75/25_ SBR/NR), (50/50_SBR/NR) and (25/75_SBR/NR) respectively. This fig. display the corrosion rate of all prescriptions inversely proportional to the load level of black carbon and non-linear relationship.

Figure 6. Compression without Thermal Pastes( C).

Figure 7. Wear test Pastes(A).

Figure 8. Wear test Pastes(B).
6. Tensile (Test)

Include that test axial tensile applied for curves (Stress - Strain). Maximum tensile strength at elongation (100%) and elongation ratio at break can be seen from this curve. To find (stress) and best pasta we used the following equations:

\[
\sigma = \frac{F}{A} \quad [6]
\]

\[
E = \frac{\sigma}{\varepsilon} \quad [7]
\]

\[
\sigma = k \cdot \varepsilon^n \quad [8]
\]

\[
n = \frac{(n_1 + n_2 + \ldots + n_i)}{i} \quad [9]
\]

\[
\log k = \frac{\sum \log \sigma_i - n \sum \log \varepsilon_i}{n_0} \quad [10]
\]

\[
E = k \cdot \varepsilon^{(n - 1)} \quad [11]
\]

Where:

- \(\sigma\): Stress, \(F\): Force, \(A\): Area, \(E\): Modules at x\% Elongation, \(\varepsilon\): Strain, \(k\): Constant, \(n\): Constant, \(i\): Reading of one test, \(n_0\): All reading summation of one test.

Figures (10) and Figures (11, 12 and 13) illustrate the relationship between stress and strain in SBR mixing with natural rubber (NR) in different compositions (25, 50 and 75) pphr respectively. When (NR) increases (SBR) will decrease in the same composition.

Each one of these recipes is reinforced with carbon black type (N375) at different loading levels (10, 30, 50, 70 and 90) pphr, respectively. We can understand from that the (Strain) increases with (Stress) increase at different recipes. In another way it can be increased elasticity of rubber chain segments by adding external force.
The Figure (10) illustrate that, the stress increases with the increase of carbon black until the addition ratio 70 pphr, and then the stress is decreased. The reasons behind such behaviour is that the mechanism of reinforcing filler (CB_carbon black), the amount of filler particles impeding the slip of chain rubber. The chains need high stress to bending in narrow space between the particles.

![Graph A](image.png)

**Figure 11. Tensile test Pastes (A)**

![Graph B](image.png)

**Figure 12. Tensile test Pastes (B)**

![Graph C](image.png)

**Figure 13. Tensile test Pastes (C)**

Strengthening increases to be reach maximum values at the ratio of 70 pphr. Increased (CB) leads to a fracture between the particle and the matrix so that it leads to slippage in tension. The join between the matrix net molecules will increases the bond strength.

So the rubber composite require high stress to break its physical bonding. Carbon black until 70 pphr, the interface area between the matrix net and carbon_black represents strengthening area. The interface area will be increase its disconnection between the matrix net and filling material increases by the [low wettability],
Therefore, materials composite will be fracture their physical bonding [12]. So, the interface area will be increase its discontinuity between the matrix net and the filler material due to the decrease in [low wettability], so that the material composite needs low stress to break its physical bonding [12]. While Figure (10) shows that, the stress increases with increasing carbon black without decreasing, and the maximum value achieved at 90 pphr carbon black.

7. Conclusion

It can notice that from Figure (11), the curve (stress strain) increases with the increase of the level of NR to SBR. The best pasta (A4) compound formulation values at the ratio of CB is 70 pphr , (NR_25) and (SBR_75).

8. References

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