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# MONITORING SYSTEM OF THE CARBON BLACK DISPERSION IN A RUBBER BLEND

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**ABSTRACT:** The paper deals with the alternating current parameters of measurement in a mixer for preparation of rubber blends. The mixing process was continuously monitored through the changes of impedance $Z$ and $\varphi$. Very good repetition ability of the mixing process was achieved.

**KEY WORDS:** rubber, electrical properties

## 1. INTRODUCTION

The process of carbon black mixing is assumed in the following steps [1,2]. After the addition of the filler, agglomerates of the size up to 10-100 micrometers are created. In the blend, the rubber shells are created around the filler particles followed by filling up the voids within the filler agglomerates. Under stretching deformation caused by shearing forces, aggregates of 100 nanometers up to 0.5 micrometer appear after the breaking of the agglomerates. Primary particles, as a final product of mixing, have the dimension of approximately 20 nm. Smaller aggregates and primary particles appear at the expense of larger aggregates and agglomerates. It is necessary to underline that the whole process of mixing in the period of mastication and plasticization is accompanied by changes of rheological properties, where the viscosity decrease is caused by both the polymer breakdown and temperature rise respectively. The viscosity fall reaches the plateau with the smallest particle size (aggregates) in the structural point of view. Further mixing spreads the particles homogeneously in the blend volume only.

The change of conductivity and carbon black dispersion are determined by a very complex behavior of the mass in a mixing chamber. Corresponding change of the online conductivity, the rubber infiltration into the carbon black agglomerates, and the carbon black dispersion value in all the systems investigated have been observed on a large scale of rubber mixtures. A linear chain structure, as well as a low molecular weight of the matrix rubber accelerates the infiltration process and hence the carbon black dispersion process takes place faster.

In this paper we present the results of an electronic „in situ" test of a rubber blend mixing. It has tested changes of *AC* electric parameters such as impedance, capacity, and phase angle caused by addition of chemical components to the natural rubber.

## 2. EXPERIMENTAL PROCEDURE

Rubber blends were mixed in two steps. In the first step, we started with mixing natural rubber, then we added *ZnO*, then carbon black and finally oil. We have used carbon black *N660 Cabot* as a filler. The temperature of the Brabender plasti-corder *PLV 151* chamber was maintained at *80 °C*.

In the second step, sulfur as a vulcanization agent was added to the mixture. The vulcanization temperature was *150 °C*.

Mixing process has been continuously monitored by a capacity probe located in the mixing chamber of the mixer. The sensor was connected to *RLC bridge Fluke* Pm 6306 controlled by a computer. Values of $Z^*$, and phase angle $\varphi$ were monitored continuously. $Z^*$, and $\varphi$ changes displayed continuously on the computer screen as a function of mixing time. Cylindrical capacitor, as a sensor, was located in the middle of the chamber, near the mixing blade in order to obtain the continuous contact of the blend with the sensor.

## 3. EXPERIMENTAL RESULTS AND DISCUSSION

Fig. 1 displayes the time dependence of the impedance *Z* versus time for mixing of the blend with carbon black *N660*. Fig. 1 also shows the impedance falling to zero after the addition of carbon black. The influence of described ingredients on *AC* conductivity coarse is marked in attached frames. This zero level is caused by carbon black interception on the surface of the sensor. In Fig. 1 it is possible to see the sensor response on the addition of components present in the blend. The *ZnO* influence is negligible. On the other hand, it is possible to see a huge impedance change after introducing carbon black as expected. Incorporation (dispersion) of carbon black in the blend takes approximately more than *700s*. After this time, the „oil peak" is observed. Dispersion of carbon black is characteristic by a zig-zag signal and good dispersion by nearly flat signal. In Fig. 2, the time dependence of a phase angle $\varphi$ is presented. In comparison with Fig. 1 it is clear that the dependence of phase angle practically copies the shape of the impedance time dependence.

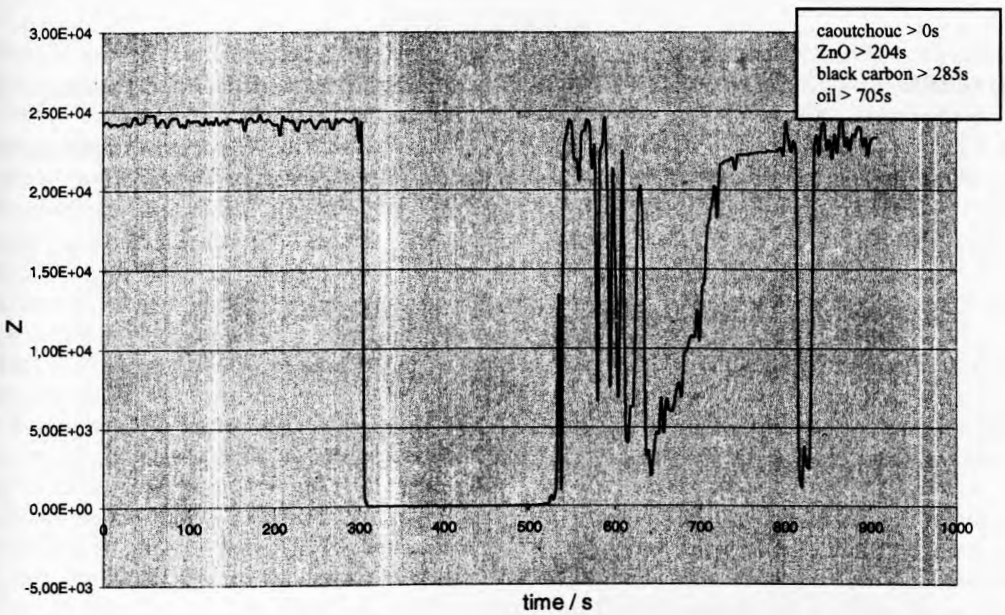


**Fig. 1:** The time dependence of the impedance *Z* versus time for the carbon black N660

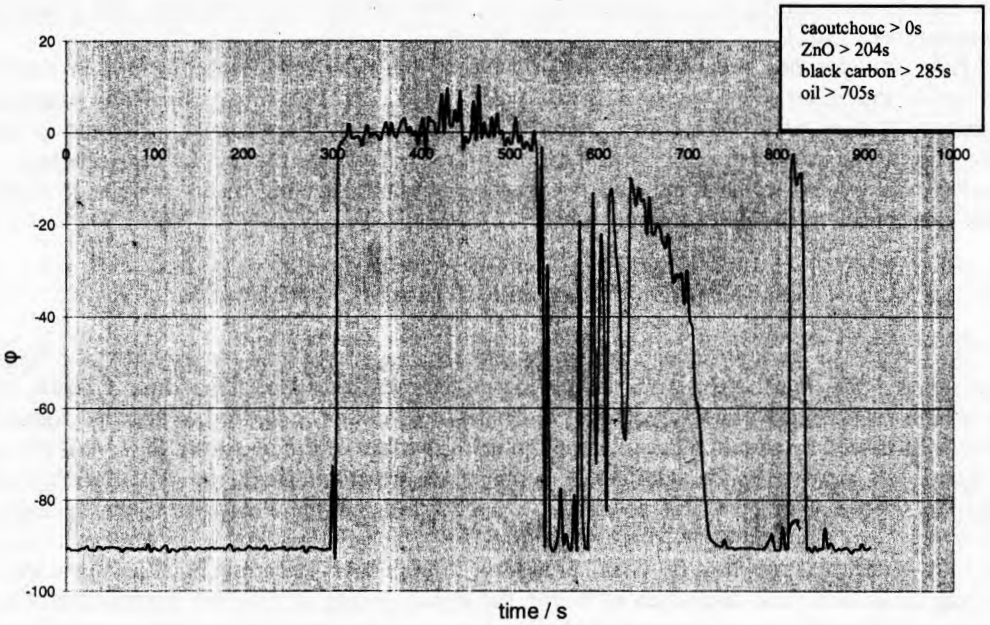


**Fig. 2:** The time dependence of the phase angle $\varphi$ versus time for the carbon black N660

## 4. REFERENCES

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