COMPARISON OF THE CARBON BLACK AND BIOCHAR IMPACT ON THE POWER CONSUMPTION DURING RUBBER MIXING

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ABSTRACT

A great attention, , from environmental point of view, has been directed toward reducing fossil fuel consumption and finding alternate, renewable sources of materials in the rubber industry. The dominant filler for rubber composites is carbon black (CB), the petroleum product, due to its exceptional reinforcement properties, purity and low cost. Recently, the major interest is made in replacement of CB with biochar because of its renewability and low cost. In order to compare CB and biochar impact on the power consumption of rubber mixer, two experiments were conducted: standard CB and the biochar made from woody waste feedstock were blended as filler with natural rubber commercial mixture. The experiments were conducted with 0, 10, 20, 30, 40 and 50 phr of CB and biochar. Power consumption of rubber mixer was the similar (around 44 Wh) for both mixtures with 0, 10 and 20 phr, and then started to increase using the CB, compared to biochar. Natural rubber blend with 50 phr of CB made a power consumption of 51 Wh, while the same share of biochar made 48 Wh. In addition to all its advantages, using biochar can contribute towards reducing energy consumption.

1. INTRODUCTION

Rubber products are widely used in a number of applications, and they are favoured when, compared to other materials, their greatly deformable characteristics are needed and their stronger attributes are desired. The most common recipe for obtaining rubber products contains Sulphur and necessary additives, by way of example reinforcement agents, commonly filler. Carbon black (CB) is a traditional filler, mostly used in natural rubber composites, because of its graphite crystal structure can significantly improve the characteristics of the final product. In the last decades, demand for energy is growing rapidly, while the reserves of fossil fuels are decreasing, it is necessary to find alternate sources, therefore, in the rubber industry, it is important to use environmentally friendly and sustainable fillers, such as biochar. In this work, the focus was on examining the impact of biochar content on power consumption used for rubber blend mixing. In order to make a comparison, the samples with CB as filler are prepared following the same recipe and procedure, as with biochar. During the mixing of components, current and voltage of the mixer are measured, and obtained data was used for calculating the consumed power for mixing, where voltage and power are necessary for the operation of the mixing motor.

2. MATERIALS AND METHODS

2.1. Components for rubber mixing

Natural rubber, accelerators and curing agents are constituents of used rubber blend. Accelerators, used in this work, are carbon black or biochar, N-isopropyl-N'-phenyl-p-phenylenediamine (IPPD), stearin and zinc oxide (ZnO). Curing agents are Sulphur and N-Cyclohexylbenzothiazol-2-sulphenamide (CBS). Carbon black is N330, Nhumo, Mexico, where the average particle size is 28-36 nm, and biochar is made by hardwood pyrolysis.

Table 1. Recipe for rubber mixing

COMPONENTS	phr					
Natural rubber	100	100	100	100	100	100
CB/Biochar	0	10	20	30	40	50
ZnO	4	4	4	4	4	4
Stearin	1	1	1	1	1	1
IPPD	1	1	1	1	1	1
Sulphur	2.5	2.5	2.5	2.5	2.5	2.5
CBS	0.5	0.5	0.5	0.5	0.5	0.5

Rubber mixing was performed with laboratory mixer HAAKE Rheomix (model 600) modified with drive unit HAAKE Rheocord EU-5, ammeter (HoldPeak HP-90EPC) and voltmeter (HoldPeak HP-90EPC).

2.2. Mixing procedure

Table 2. The mixing procedure

	Time mixing (min)	Rotor speed (min^{-1})	Description
I part	1	30	Mixer idle time
II part	3	100	NR addition
III part	3	60	NR mastification
IV part	5	60	Accelerators addition
V part	2	60	Curing agents addition

The mixer temperature was set to 90 °C. Ammeter and voltmeter are connected to electric motor of the direct current of the laboratory mixer drive part, as well as, with computer. It is used PC-LINK for recording the current and voltage during the mixing.

2.3. Power calculation

The current power for mixing was calculated following the Equation: $\mathbf{P = U \cdot I}$. Where the P is power [W], U voltage [V] and I current [A]. Power consumption is calculated as the power integral over the mixing time, i.e., the area below the curve power vs. time.

3. RESULTS AND DISCUSSION

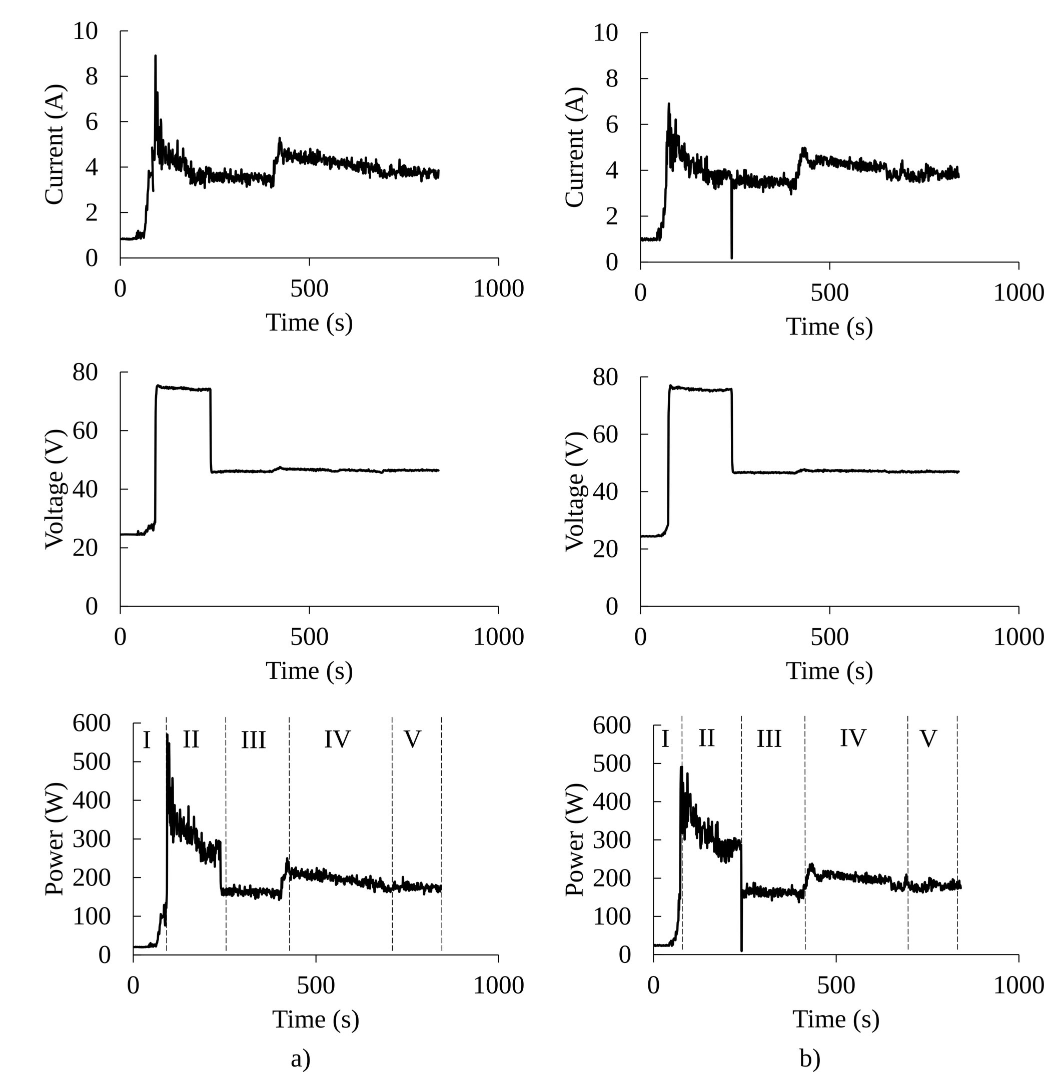

Figure 1. The example of current, voltage and power results for 20 phr of a) CB and b) biochar during the rubber blend mixing

From Figure 1. can be observed the baseline at the very beginning of the mixing process. In next step (from Table 2), where the natural rubber is added into the mixer there is a peak in power for both mixtures (CB and biochar). During this second part, where the bonds of natural rubber are breaking, there is a decreasing in power consumption with time, and it gets stabilized. When the accelerators are added, the small peak is detected. Curing agents are not casing peak in power.

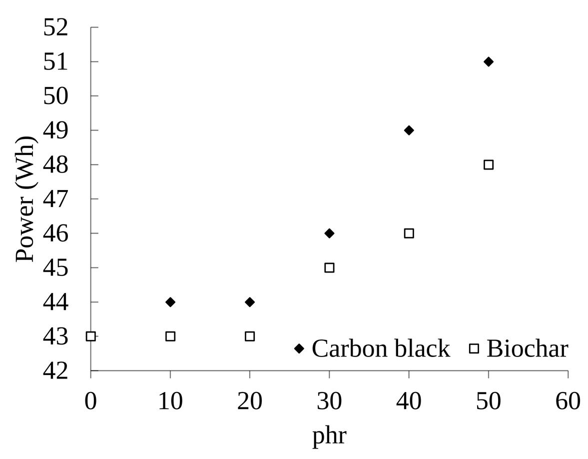

Figure 2. Consumed power for mixing the rubber blend with CB and biochar

From Figure 2 it can be observed that with higher share of CB and biochar, the power consumption is increasing, especially for blend with CB, which can be explained with CB smaller particle size, purity and higher interaction with natural rubber. Higher power consumption for mixing can be related to the better mixing and homogeneity of the final rubber product. In order to investigate the differences in the power consumption, it is necessary to conduct more experiments related to particle size and activity of both materials.

4. CONCLUSIONS

The aim of this work was comparing the impact of biochar and CB share in rubber blend on the power consumption during mixing. The components for mixing were measured following the recipe and mixed according to the procedure, where the share of biochar and carbon black were 0, 10, 20, 30, 40 and 50 phr. The current and voltage were measured during the mixing, and based on their results, the mixer power consumption was calculated. It can be concluded that power consumption is increasing with higher share of CB and biochar in the rubber blend, while the power is higher with blends with CB. This can be explained with greater CB purity and interaction with natural rubber, resulting in more homogeny final material, although it has to be done more research for precise conclusion, which is the plan for the future work.

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