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RESEARCHING ON THE USE OF ALTERNATIVE REDUCING AGENTS IN THE RECYCLING OF WASTE CONTAINING OXIDIZED COPPER COMPOUNDS

Xamdamov Muxtor Bekzod o‘g‘li
Almalyk State Technical Institute, 3
student of the "Metallurgy" department

Hojiyev Shohruh Toshpo‘latovich
Almalyk State Technical Institute, Associate Professor
of the Department of "Metallurgy", PhD

Xoliqulov Doniyor Baxtiyorovich
Almalyk State Technical Institute, Head of the
Department of "Metallurgy", DSc, Professor

Mutalibxonov Saida’loxon Saidolimxonovich
PhD student of the Department of Metallurgy,
Almalyk State Technical Institute
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Abstract. This study investigated the potential of using waste tire scrap as a reducing agent in copper slag recycling. The role of carbon, hydrogen, and sulfur, which are formed as a result of thermal decomposition of rubber materials at high temperatures, in the reduction of magnetite and copper oxides was analyzed. The experiments showed that the bulk oxidation rate of rubber scrap is higher than that of brown coal. It was also shown that the use of waste tire scrap reduces the amount of magnetite in the slag and accelerates the transition of copper to the matte phase.

Keywords: copper slag, waste tire scrap, magnetite, reduction, sulfidation, matte, oxidation rate, thermal decomposition.

Introduction. Laboratory from the furnace to a temperature of 1200 - 1240 °C has was slag to the crucible when poured crucible inside (before) put parked car tires waste parts with collides and in the system oxidation-reduction chemical reactions happened [1]. Temperature 1000 - 1240 ° C between unsuitable car tires waste rubbery in part there is was hydrocarbons carbon and hydrogen harvest to be with decomposes [2]:

$$(C_4H_6S_{0.25})_n \rightarrow 4nC + 3nH_2 + 0.25nS$$

(Rubber decomposition reaction)

Rubber thermal decomposition as a result return process for necessary was carbon, hydrogen and sulfur such as restorative substances harvest [3]. In the rubber macromolecule thermal decomposition on time initially sulfurous gardens interruption begins (Figure 1).

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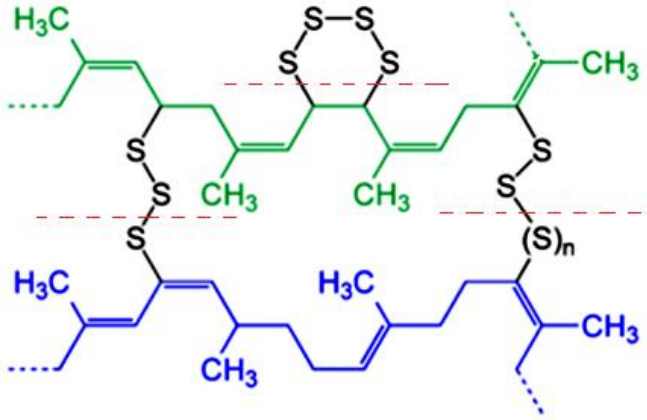
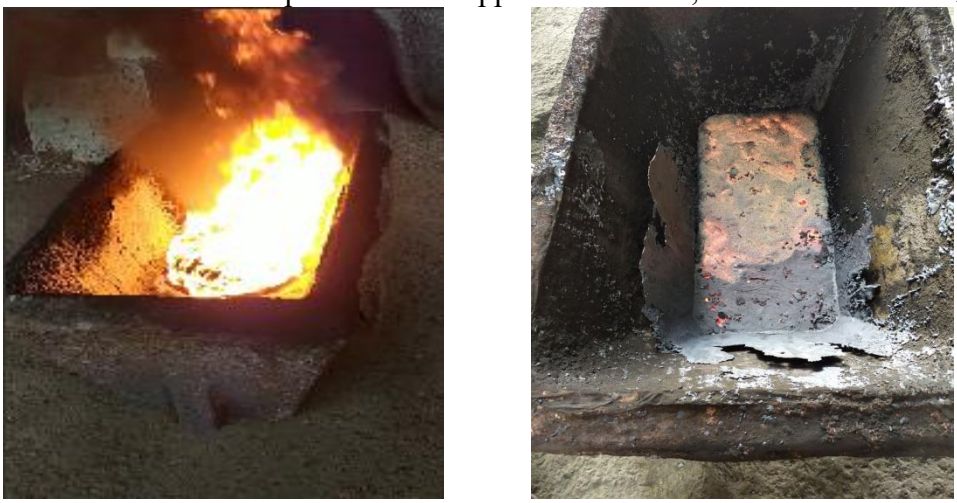


Figure 1. Thermal heating on time rubber macromolecule one how many to links until decomposition

This of substances oxidation process various features to know separately importance [4]. Polymers most of them burning when it goes, the flame The temperature reaches 1500-1700 ° C, which fat, brown coal such as wide widespread materials for suitable coming from the value noticeable at the level high [5]. Fire is the most synthetic polymers when burning, strong heat to radiation has was bright is smoke [6]. Synthetic polymeric materials of combustion again one feature many in quantity poisonous and thick black smoke harvest This is illustrated in Figure 2. experience See also: possible [7].

Research object and Methodology. When rubber burns black smoke harvest as of combustion main the reason is this of oxygen This is a deficiency. In this case, heat under the influence decomposition as a result of substances harvest to be speed of oxygen reaction to the zone from diffusion high [8]. From this except for hydrocarbons how much unsaturated gardens many if this hydrocarbon in the fire so much many in quantity black smoke harvest to be in experiments the resulting " black smoke " is airborne not oxidized remaining carbon nanoparticles (Figure 2, a). In the air carbon nanoparticles harvest to be and Boudoir reaction reverse towards departure with happened becomes, that is : $2CO = CO_2 + C$.



a) **b)**

Figure 2. Liquid slag with large rubber of the branches each other effect: a) hot slag on top of floating came out rubber air with contact as a result combustion; b) oxidation - reduction reactions face from giving then remaining product

Fragmentation as a result harvest was carbon little oxidation as a result initially carbon monoxide - CO is produced becomes: $2C + O_2 = 2CO$. Then temperature 570 Celsius from the level carbon monoxide when decreasing molecules between disproportion reaction happened

will be, that is, 2 greenhouse gases in the molecule carbon from atoms one oxidizing agent, the second and returner (restorer) function having done reaction as a result carbonate anhydride and atomic carbon harvest [9]. Atomic carbon particles together black colored from nanoparticles consists of smoke harvest will be:

570 ˚C from the level high at temperature : $CO_2 + C = 2CO$;

570 ˚C At temperatures below zero : $2CO = CO_2 + C$.

Rubber for oxidation process only one how many quantitative characteristics known. Rubber oxidation heat known, this is ~33 MJ/kg, which is wide widespread combustible material - oil hungry - 14 MJ / kg oxidation from the heat noticeable at the level increases. Rubber oxidation temperature his/her to spread very dependent. The usual in case rubber oxidation temperature 275°C, crushed without and 112 ° C. Rubber oxidation process such important feature his/her mass oxidation speed every kind kind of rubbers for wide varies in the range (0.4 - 0.9) kg / (m 2 ˙ min) stands.

This of the research purpose car tires working issued rubber samples public oxidation speed experimental accordingly is to determine. In the CIS countries the most many used from tires one Rosava company by working issued car tires waste experience for sample as this the company offers 155/70R13 BTs-10 tubeless, radial tires selected.

Rubber in the air burning to leave against features determining the most important from the features one this slag in phase magnetite and oxidized copper compounds with oxidation process This is the speed of heat. release or swallowing intensity and that's why for oxidation speed determines. Car tires waste rubbery part of oxidation reaction speed usually phases separation of the area per unit hint is done :

$$V=\frac{1}{v}\cdot\frac{1}{S}\cdot\frac{dn}{d\tau}$$

Here: *v* is stoichiometric coefficient, S - interphase area, n - of the substance amount (in moles) expressed), t - time.

Rubber polymeric is a substance, *and* and n values usually unknown. O' z in turn, the following from the relationship used:

$$n = m/M$$

Here: M is the rubber molar mass, m - its experienced mass, from this reaction speed is proportional to dm/dt will be said to the conclusion arrival possible.

$$V=\frac{k}{S}\cdot\frac{dm}{d\tau}$$

Here: k - proportionality coefficient, that is including burning rubber reaction for constants, n and M values. In such cases, k together accepted as equal will be done.

$$V_m=\frac{1}{S}\cdot\frac{dm}{d\tau}$$

V_m value public oxidation is called the speed of the rubber mass. oxidation speed determination for time passing with burning substance of mass change determination enough.

Received results and their discussion. In the experiment taken rubber hot liquid slag in the content magnetite and oxidized copper compounds with influenced oxidation reaction speed time unit inside restorative substance as used rubber of mass decrease with is determined (Figure 3).

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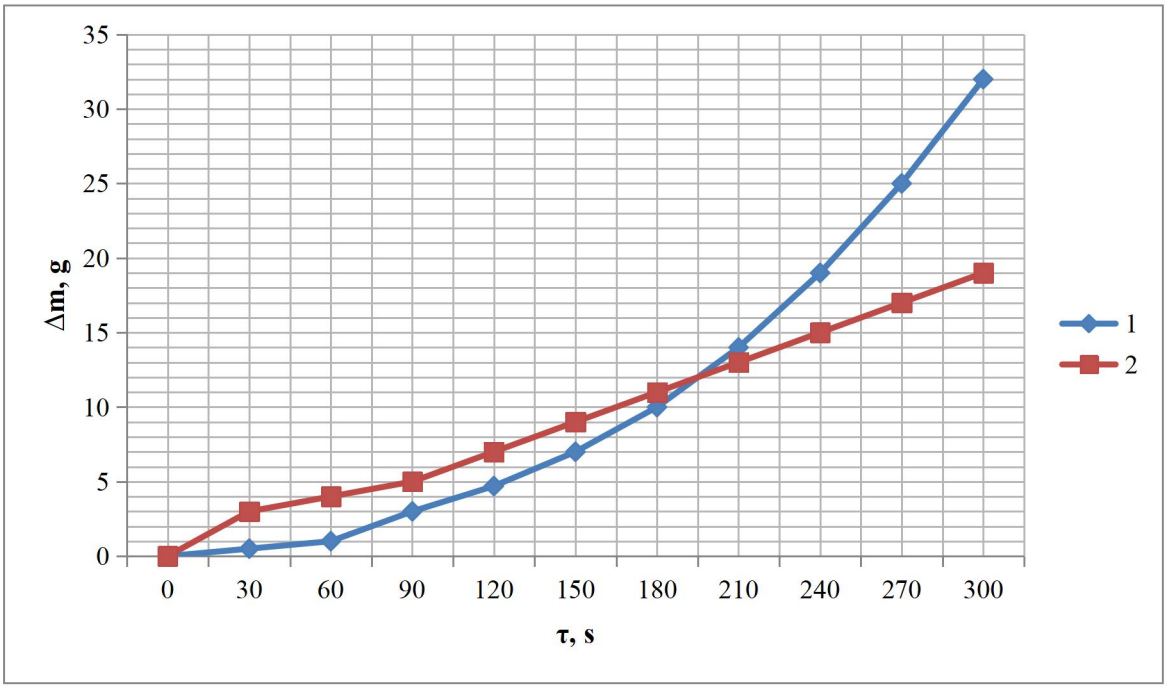

Figure 3. Rubber (1) and brown coal (2) samples mass (Δm) of slag components with to be affected time dependence (τ)

Shown in Figure 3 on the graph straight away oxidation under the influence rubber ~ 1.5 minutes oxidized its time, call coal and in 0.5 minutes oxidation starts in 2.5 minutes then whole rubber mass oxidized goes. The whole brown coal and 1 minute less time inside oxidizes. See outgoing of materials public oxidation speed whole mass oxidation since starting calculating In this case, this time in between mass of disappearance to time connection Rubber residues were found. oxidation mass 0.97 kg • m -2 • min $^{-1,}$ brown coal and 0.48 kg • m $^{-2}$ • min $^{-1}$ what organization reached.

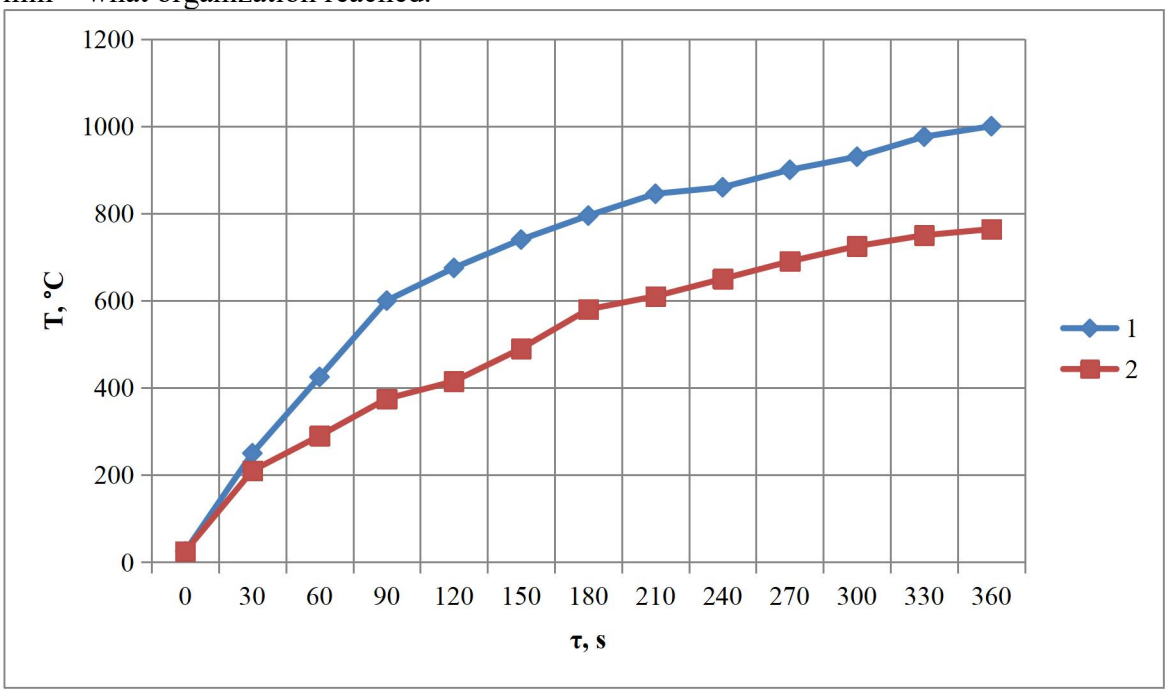

Figure 4. Rubber (1) and fat hungry (2) flare-up temperature flare-up time dependence (τ)

Rubber oxidation during flame temperature brown coal for suitable coming temperature increases by 150-250 ºC (Figure 4). The rubber oxidation mass 0.97 kg • m $^{-2}$ • min $^{-}$

[1] organization to do, his brown coal for suitable coming characteristic two equally many indicates.

Car tires waste using copper slag again work method magnetite restoration way with reduction, oxidized copper compounds sulfidation, liquid the bath a lot of picking (barbotage), reaction in the zone weak restorative the atmosphere harvest to make, optimal mass, composition and features has slags to take such as intermediate processes consists of a sequence (mechanism).

Slag from the converter metallurgical to the bucket from pouring then, to the shovel in advance put placed chopped car tires waste with affected, reaction in the zone rubber article initial harvest doer simple to substances until breaks down and this as a result harvest was restorative substances and slag components between following chemical reactions happened will be (at 1100 - 1200 ° C):

$$Cu_2O_{shl} + C \rightarrow 2Cu_{met} + CO_{gas}\uparrow$$
$$Cu_2O_{shl} + H_2 \rightarrow 2Cu_{met} + H_2O_{gas}\uparrow$$
$$Fe_3O_4 + C \rightarrow 3FeO + CO_{gas}\uparrow$$
$$Fe_3O_4 + H_2 \rightarrow 3FeO + H_2O_{gas}\uparrow$$
$$FeO + C \rightarrow Fe_{met} + CO_{gas}\uparrow$$
$$FeO + H_2 \rightarrow Fe_{met} + H_2O_{gas}\uparrow$$
$$Fe_3O_4 + Fe_{met.\ cord} \rightarrow 4FeO$$
$$3FeO + 4C \rightarrow Fe_3C + 3CO_{gas}\uparrow$$
$$Fe_3O_4 + CO \rightarrow 3FeO + CO_{2\ gas}\uparrow$$
$$C + CO_2 \rightarrow 2\,CO_{gas}\uparrow$$
$$S + N_2O \rightarrow SO_{gas}\uparrow + N_{2\,gas}\uparrow$$

Liquid slag to the surface floating came out rubber parts and air with contact what did because of oxygenated in the environment burning starts. Liquid slag on top rubber materials burning process chemical reactions is exothermic, so for this action when done slag temperature does not decrease (1100 - 1200 ° C). 1000 - 1100 ° C at temperature car tires in the waste hydrocarbons carbon and hydrogen harvest to be with It breaks down. Both of these the substance is copper and of iron high oxides restored in the system magnetite amount reduces. Car tires waste thermal from decay harvest was sulfur and metals oxides with influenced them sulfidizes. Reaction in the zone face giving chemical reactions set of the following consists of :

$$2Cu_2O_{shl} + 3S \rightarrow 2Cu_2S + SO_{2\,(gas)}\uparrow$$
$$2Fe_3O_4 + S \rightarrow 6FeO + SO_{2\,(gas)}\uparrow$$
$$2FeO + 3S \rightarrow 2FeS + SO_{2\,(gas)}\uparrow$$
$$Cu_2O_{shl} + FeS \rightarrow Cu_2S + FeO$$
$$2Cu_2O_{shl} + CS_2 \rightarrow 2Cu_2S + CO_{2\,(gas)}\uparrow$$
$$Su_2O + H_2S \rightarrow Cu_2S + H_2O_{steam}\uparrow$$

Magnetite from the decrease then, the slag density and viscosity decreases and this in the system slag phase harvest to do opportunity gives. High density because of harvest was sulfides, iron and of copper metallic amounts bathtub to the bottom drowned stein phase forms. Return and sulfidation in the processes harvest was gases solutions bubbles and mixes, this and small radial, to each other good immiscible, slag in size hanging mold gone liquid sulfide drops faster together stein to the layer sink process to strengthen opportunity gives. Phases divorce schematic As can be seen in Figure 5 illustrated.

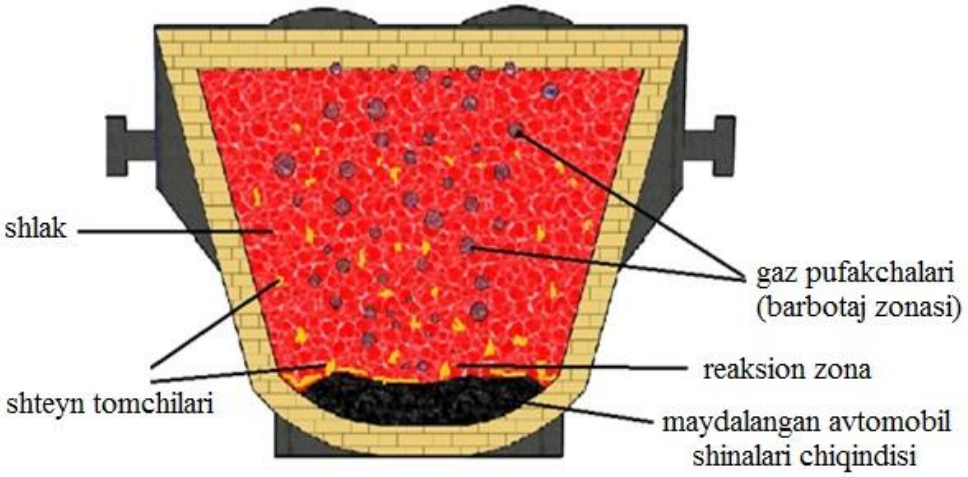

Figure 5. Car tires waste using copper slag again work scheme

Coalescence in the process small stein drops each other with unites and big radial large stein drop harvest will be. Stein drops radius increase their bottom to phase the person who is dead accelerates.

Conclusion. Research results car tires waste copper slag again at work effective be a reducing agent to take showed. Top at temperature rubber thermal decomposition as a result harvest to be carbon, hydrogen and sulfur magnetite and copper oxides return, slag in the content valuable of metals separated to the exit help gives. Experimental research rubber waste public oxidation speed brown to coal relatively two equal high that determined that and their metallurgical in processes high to reactivity has that confirms. Magnetite amount decrease as a result of slag physicochemical properties improves, sulfidation and bubble processes and copper and of iron stein to the phase go away accelerates. As a result, copper losses in slag decreases and man-made waste again work efficiency increases. Therefore, car tires from waste use metallurgy in enterprises resource economic and ecological effective technology as recommendation to be possible.

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