Briquetting of Metal Chips by Controlled Impact: Experimental Study

Todor Penchev, Dimitar Karastojanov, Ivan Altaparmakov

Abstract—For briquetting of metal chips hydraulic and mechanical presses are used. The density of the briquettes in this case is about 60% - 70 % on the density of solid metal. In this work the results of experimental studies for briquetting of metal chips are presented, by using a new technology for impact briquetting. The used chips are by Armco iron, steel, cast iron, copper, aluminum, and brass. It has been found that: (i) in a controlled impact the density of the briquettes can be increases up to 30%; (ii) at the same specific impact energy Es (J/sm^3) the density of the briquettes increases with increasing of the impact velocity; (iii), realization of the repeated impact leads to decrease of chips density, which can be explained by distribution of elastic waves in the briquette.

Keywords— Briquetting, chips briquetting, impact briquetting.

I. INTRODUCTION

FOR briquetting of metal chips are used mechanical and hydraulic presses with a nominal force of several hundreds to several thousands kN. To obtain briquettes with good density the ratio H/D for different materials vary within wide limits (H / D = 0,8-0,25), where H is the height, and D is the diameter of the briquette. The greater is the density of the briquettes, the smaller are the losses in the transport and melting. Basic parameters used to evaluate the effect of briquetting operation are specific density of the briquette (ρ), g/sm^3, and specific contact pressure for briquetting (p), MPa.

At briquetting with hydraulic presses it is achieved 50% - 65% briquette's density in comparison with solid material density. The specific pressure reaches values p = 200-400 MPa, in briquetting of steel chips [1], [2].

Due to the large size of briquetting presses, large power consumption, and relatively low productivity, methods are searching to improve the efficiency of this process. One such method is high velocity impact briquetting. This method has been successfully used for working-out of parts from powder materials [3], [4].

In [5] are presented the results of use of high velocity explosive presses for briquetting of metal chips – Fig. 1. The obtained briquette's density is (g/sm^3): aluminum alloy - 2.2 to 2.4 (2.7 to 2.75); carbon steel - 5.0 to 5.5 (7.85); alloyed steel - 5.0 to 5.5 (7.48 to 8.0). In parenthesis is given the density of the respective solid metal. As a major drawback of this briquetting method is the impossibility of process control.

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In [6] is described construction of industrial rocket engine propelled die forging hammer. Whit this machine is possible to work with controlled impact and with impact velocities from 4,5 m/s up to 20 m/s.
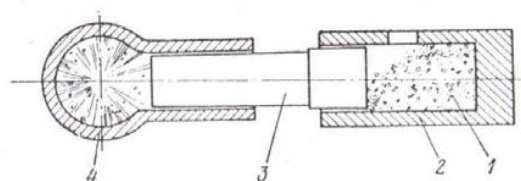

Fig. 1 Scheme of explosion press for metal chips briquetting: 1- filled chips; 2- container; 3- punch; 4- explosion chamber

In [7] are presented the results of experimental study of metal chips briquetting by controlled impact with impact speed of about 7 m/s. In this study are presented the results of laboratory experimental studies for briquetting of metal chips using controlled impact with impact speeds of 4-5 m/s.

II. LABORATORY SETUP FOR CONTROLLED IMPACT BRIQUETTING

The laboratory setup is shown in Fig. 2 (a). Free fall down of falling part 3 is accelerated by cold rocket engine attached to 3. The engine is started up at feeding to it of compressed air with a pressure of 35 bar. The engine force (trust R) at this pressure is 23 kg. From electronic control unit (part No 6 on Fig. 2 (a) can be set four regimes of operation of the engine – Fig. 2 (b).

## III. METHOD OF EXPERIMENT

A. Type and Material of the Chips

In this study, we used chips from the following materials: Armko iron (0,04% C); steel (0.45 % C); gray cast iron (3.25% C); aluminum alloy (0,9% Mn, 1,8% Mg); copper (99.9%); brass (37% Zn). Brocken ships with small thickness produced by turning are used.

B. Sequencing

For obtaining of briquettes are used two containers with hole diameter of 80 mm and 40 mm. The mass of the falling part is m = 35.67 kg.

On a laboratory scale is measured with an accuracy of 0.01 g the chips mass G, g, and the container is filled. The punch with guide is placed so that the top of the punch touches the chips. Regime 3 and Regime 4 are used (Fig. 2 (b)), at a speed of falling parts 4,1 - 5,3 m/s. Only those experiments are take

into account in which the difference in the impact speed ΔV_i for the same amount of material for briquetting by both Regimes is $\Delta V_i \leq \pm 2\%$.
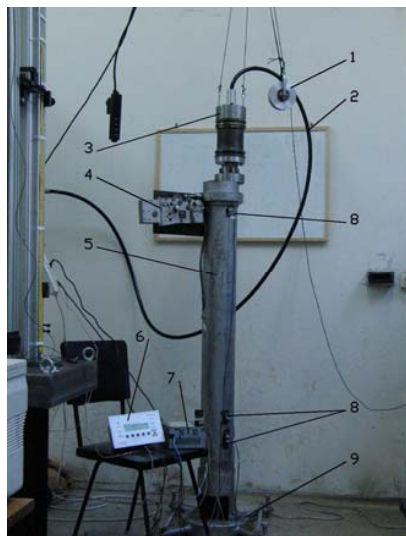
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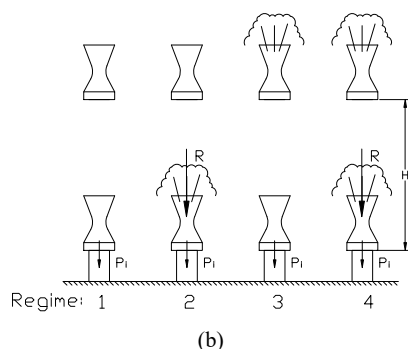
(b)

Fig. 2 (a) Laboratory setup: 1 – hose support roller; 2 – hose for pressure air feed; 3 – falling part; 4 – system for hold up of the falling part in upper position; 5 – tube body; 6 – electronic control unit; 7 – power supply of system 4; 8 – inductive sensors; 9 – base; (b) Regimes of the experimental setup: 1 – simple impact; 2 – simple impact + controlled impact; 3 – accelerated by rocket engine simple impact; 4 – accelerated impact + controlled impact; Pi – impact force; R – rocket engine trust

After the impact the briquette is removed and the briquette height Hbr is measured. Determine the impact velocity V_i, m/s, according to data from the lower inductive sensors 8, located on the tube (Fig. 2(a)). Are calculated: the volume of the briquette Ξ,sm^3; density $\rho = G/\Xi$,g/sm^3; impact energy $E_i = mV_i^2/2$,J; specific impact energy for briquetting E_s:

$$E_s = E_i / \Xi, J / sm^3 \qquad (1)$$

Specific energy E_s instead specific pressure p is used, because the main parameter for hammers is the impact energy.

III. EXPERIMENTS RESULTS

A. Briquettes with 80 mm Diameter

The first material with which the experiments start was Armko iron. It was found that briquettes are with very low density - ρ=1.6 g/sm^3. The reason for this is the small impact energy, and small specific impact energy E_s=0.60, J/sm^3. To increase the impact energy the briquette was put back into container and second impact was realized. Instead of increasing a reduction of the briquette density to 0.9 g/sm^3 and briquette loosening was observed (Fig. 3).

Fig. 3 Briquettes from Armco iron chips with 80 mm diameter: left – after one impact; right – after two impacts

B. Briquettes with 40 mm Diameter

The obtained results by 40mm briquettes are presented in Fig. 4 (a). For comparison in Fig. 4 (b) are presented the results from [7], where the impact velocity V_i and specific impact energy E_s are higher.

From Fig. 4 (a) it is seen that in all materials the density of briquettes obtained by controlled impact is higher then the density of the briquettes obtained by simple impact – 7% higher at Armco iron briquettes; 4% at steel briquettes; 8.9% at cast iron briquettes; 5.8% at aluminum alloy briquettes; 6% at cooper briquettes; 6.9% at brass briquettes. Comparison with results by briquetting with high speed at the same specific energy shows (Fig. 4 (b)) that in all materials, with exception of cast iron, the briquettes density obtained by high impact velocity is much larger.
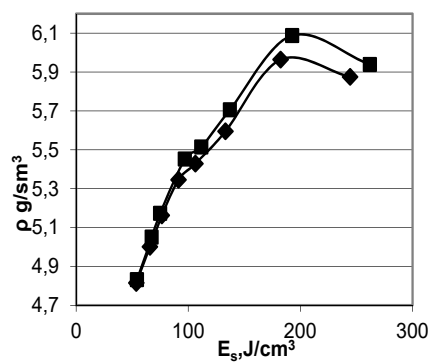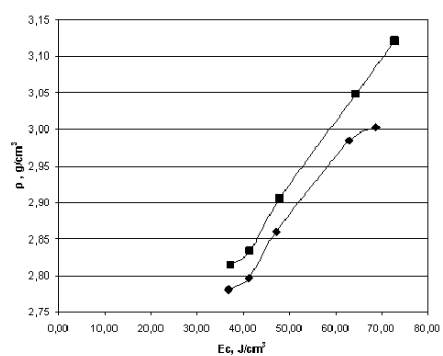
IV. CONCLUSION

The following characteristics which distinguish controlled impact briquetting than other types briquetting are established.
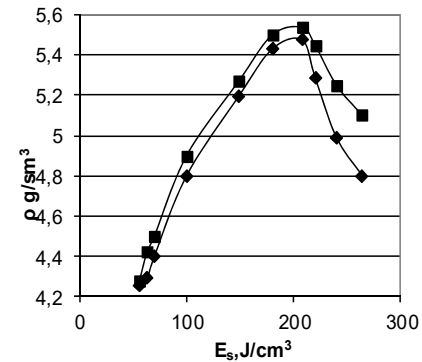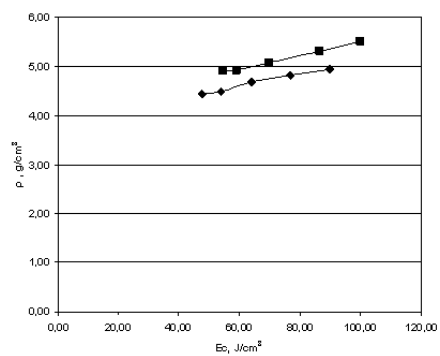- Obtained in this work and in [7] results shows that briquetting of the metal chips with a controlled impact increases the density of the briquettes with up to 30% in comparison with a hydraulic press briquetting.
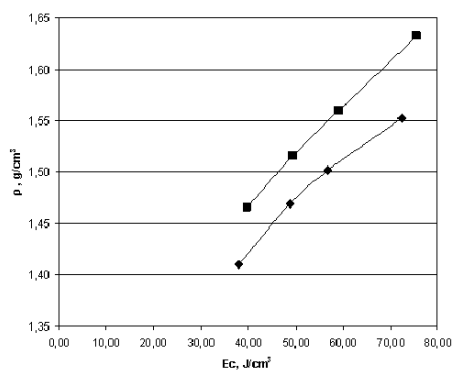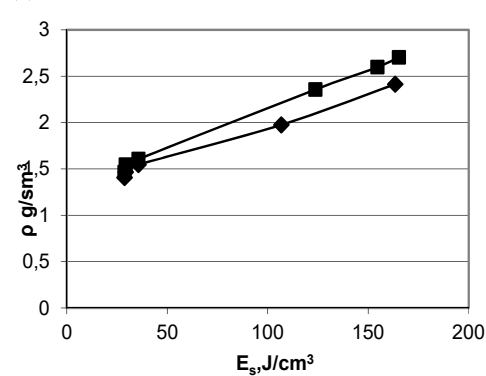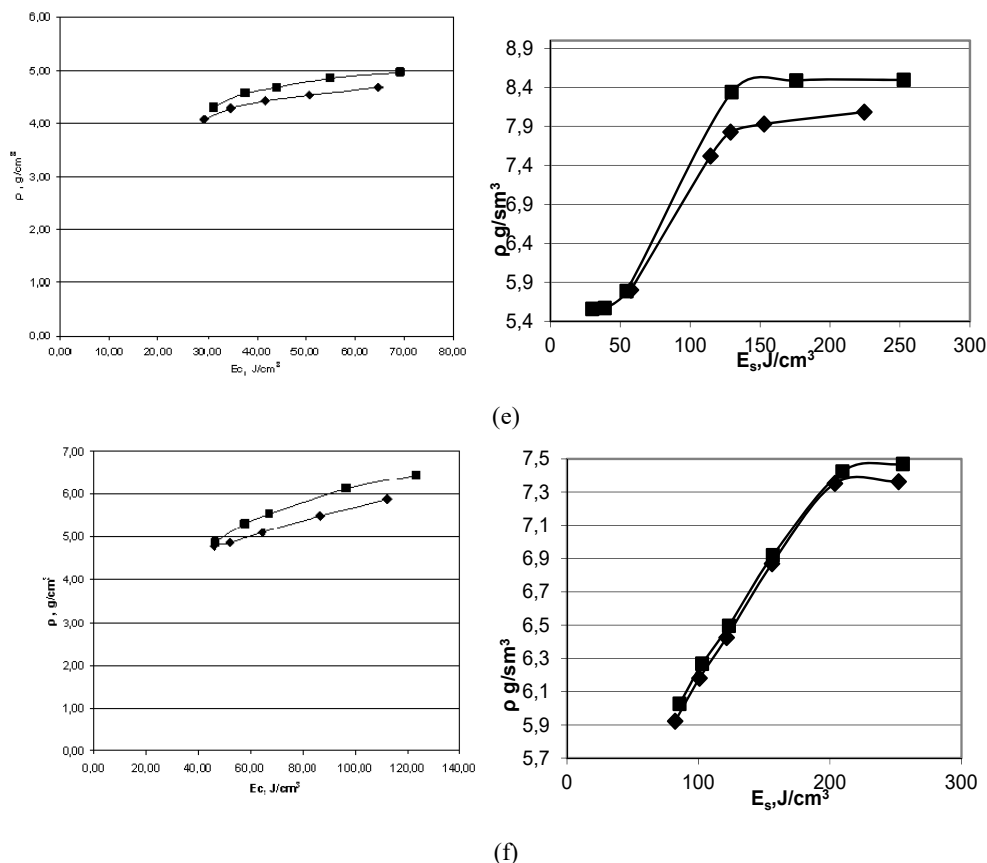
(a)

(b)

(c)

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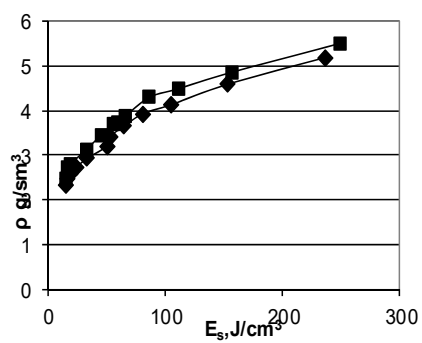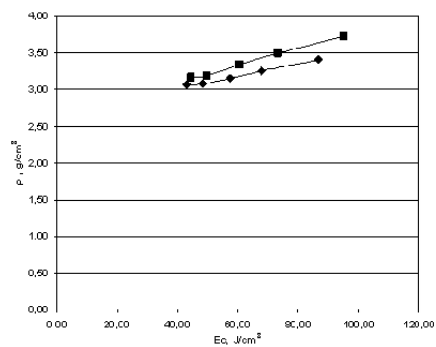
Fig. 4 Results of impact briquetting with different impact velocities V_i: left- V_i = 4.10-5.32 m/s; right V_i = 6.9-7.16 m/s [7] a) Armco iron; b) steel; c) gray cast iron; d) aluminum alloy; e) pure cooper; f) brass

- The density of the metal chips briquettes obtained by impact depends from the impact specific energy Es, J/sm³.
- At the same specific energy E_s, the greater is the impact velocity, the greater the density of the briquettes. This applies to all tested materials, except for gray cast iron. For example the density of cooper briquettes ρc obtained by E_s = 70 J/sm³ (Fig. 4 (e)) is: ρ_c=5 g/sm³, V_i = 4.5 m/s; ρ_c = 6.4 g/sm³, V_i = 7 m/s.
- When briquetting of grey cast iron chips it can achieve higher density of the briquettes at low impact speed, with the same specific energy E_s – Fig. 4 (c).
- Realization of the repeated impact leads to decrease of chips density, which can be explained by distribution of elastic waves in the briquette.

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