Briquetting of Metal Chips by Controlled Impact: Experimental Study

Todor Penchev, Ivan Altaparmakov, Dimitar Karastojanov

Abstract—For briquetting of metal chips are used hydraulic and mechanical presses. The density of the briquettes in this case is about 60% - 70% on the density of solid metal. In this work are presented the results of experimental studies for briquetting of metal chips, 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 $E_s$ (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 ($\rho$, 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.

In [6] is described construction of industrial rocket engine propelled die forging hammer. Whith 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.2a. 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 Figure 2a) can be set four regimes of operation of the engine – Fig. 2b.

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). Broken 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. 2b), at a speed of falling parts 4.1 - 5.3 m/s. Only those experiments are taken into account in which the difference in the impact speed \( \Delta V_i \) for the same amount of material for briquetting by both Regimes is \( \Delta V_i \leq \pm 2\% \).

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

\[
E_s = E_i / \Xi, J / sm^3
\]

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 - \( \rho = 1.6 \) 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/sm³ and briquette loosening was observed - Fig. 3.

**B. Briquettes with 40 mm diameter**

The obtained results by 40mm briquettes are presented in fig.4a. 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.4a 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.4b) 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.
- The density of the metal chips briquettes obtained by impact depends from the impact specific energy $E_s$, J/sm$^3$.
- 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 $\rho_c$ obtained by $E_s = 70$ J/sm$^3$ (fig.4e) is: $\rho_c = 5$ g/sm$^3$, $V_i = 4.5$ m/s; $\rho_c = 6.4$ g/sm$^3$, $V_i = 7$ 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.4.2c.
- 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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REFERENCES


Todor N. Penchev is a member of the Bulgarian Scientists Association. He was born in Sofia, Bulgaria in 1941. He has a master degree in Mechanical engineering. He graduated Technical University Sofia in 1967. The author received a doctoral degree in 1979, Industrial Technology from the Technical University Sofia. Dr. Penchev is an assoc. professor in Institute of Information and Communication Technologies (BAS). His professional interests refer to forging systems, industrial engineering and technology.

Ivan L. Altaparmakov is born in Kroumov Grad, Bulgaria in 1972. He has a master degree Mechanical engineering. He graduated Technical University Sofia in 1995 and he has a master degree in Applied Mathematics and Informatics. He graduated Technical University Sofia in 1997. The author received a doctoral degree in 2003, Industrial Technology from the Technical University Sofia. Dr. Altaparmakov is assistant professor in Faculty of Applied Mathematics and Informatics at Technical University Sofia and assistant professor in Institute of Information and Communication Technologies (BAS). His professional interests refer to forging systems, industrial engineering and technology.

Dimitar N. Karastoyanov is a member of the Bulgarian Scientists Association. He was born in Stara Zagora, Bulgaria in 1952. He has a master degree in Electrical engineering. He graduated Technical University Sofia in 1977. The author received a doctoral degree in 1982, Robotics from the Institute of engineering cybernetics and robotics (BAS). Dr. Karastoyanov is a professor in Institute of Information and Communication Technologies (BAS). Prof. Dr. Karastoyanov is a key professor under AcomIn project at the IICT – BAS. He is conducting research on design, dynamics and intelligent control of robots and mechatronic systems. His professional interests refer to real time systems, adaptive control, industrial engineering and robotics.