

# Methods of Hot Compaction and Infiltration of Powder Materials Based on Recycled Non-Ferrous Alloy Chips

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## Abstract

Promising methods have been developed for cold and hot compaction of powder materials, as well as for the infiltration of porous preforms combined with sintering, using chip and dust-like waste from non-ferrous Al and Cu alloys as a raw material, as well as utilizable Cu-based powder moldings.

**Keywords:** Compacting; Powder material; Infiltration; Sintering; Chips of Al And Cu alloys; Dusty waste; Recycling

## Introduction

SRSPU (NPI) has developed methods for producing compacted and infiltrated powder materials based on non-ferrous metal shavings (Al, Cu), as well as sintered materials for the disposal of powder moldings and dusty waste of Cu-based powder blends.

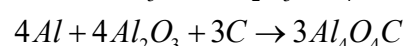
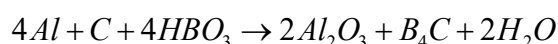
## Discussion

### Hot-compacted materials based on mechanically activated Al alloy chips

Mechanical activation is accompanied by a continuously sequential process of dispersion-agglomeration-dispersion, affecting the average size of the powder particles. In this case, three options for particle aggregation are possible: the formation of agglomerates that are destroyed during subsequent manual processing; formation of an active charge, agglomerated during processing in a mortar; the formation of intractable agglomerates. Agglomeration of powder particles of the mixture is carried out by: flow of topochemical reactions along the front of particle interaction; setting on the contact surfaces of the particles; sharpening the material of soft particles with solid particles and cladding solid particles with a layer of material of soft particles [1,2]. At the first stage of activation in a saturated aqueous solution of  $H_3BO_3$ , Al-based charges proceed with the evolution of  $H_2O$



An increase in the duration of mechanical activation leads to the enveloping of  $B_2O_3$  chip particles, forming a coating  $mAl_2O_3 \cdot nB_2O_3$ , which prevents the interaction of Al with oxygen, prevents the melting of Al during short-term heating and promotes compaction during hot compaction. With the introduction of graphite into the mixture, exothermic reactions may occur.



The mechanical activation of the mixture in a liquid medium contributes to a shift in the dynamic equilibrium of competing dispersion-agglomeration processes towards the destruction of the initial particles of Al alloy chips and alloying elements, as well as agglomerates based on them due to the Rebinder effect - absorption strength reduction. The hereditary effect of dispersion-agglomeration processes on the laws of compaction and formation of the structure and properties of powder materials was established [3,4]. Upon receipt of hot-compacted materials with increased bending strength (620MPa) based on

crushed chips of Al alloy, mechanochemical activation is carried out in a saturated aqueous  $H_3BO_3$  solution followed by cold and hot compacting [5]. Processing a mixture of activated chips (50 wt.%) And Al powder in a planetary ball mill in a saturated aqueous  $H_3BO_3$  solution provides a hot compacted material with a density of  $2.91g/cm^3$ , shear strength 369MPa and bending 325MPa, hardness HRB 96 with specific wear of  $0.2\mu m/km$  and a friction coefficient of 0.09 in the conditions of boundary friction (pressure in the contact zone of 8.7MPa) [6]. In order to reduce the cost of starting materials in the manufacture of parts for structural purposes, a method for mechanical alloying carbon alloy Al. The technology includes mechanochemical activation (3.6ks) of Al alloy shavings in a saturated aqueous  $H_3BO_3$  solution (20% of the mass of the charge), mechanical alloying with carbon during joint processing (5.04ks) of activated shavings with graphite (2 wt.%) In ball planetary mill, subsequent cold compaction with a pressure of 120MPa, heating (973K; 0.12ks) in an air atmosphere and hot compaction with a reduced compaction work of  $55MJ/m^3$ . The hot compacted material had a density of  $2.84g/cm^3$ , a shear strength of 250MPa and a hardness of HRB 65 [7]. The introduction of Ni or FeTi powders into a mixture based on Al alloy chips intensifies its grinding processes, providing the formation of hot-compacted materials with enhanced mechanical properties. The technology for producing the material includes mechanochemical activation of Al alloy chips together with Ni or FeTi powder in a saturated aqueous  $H_3BO_3$  solution, separation of a fraction of less than  $315\mu m$ , its subsequent mixing with Al powder, and hot compaction [8,9].

### Compacted materials based on mechanically activated Cu alloy chips

In order to obtain antifriction material based on Cu powder during utilization of the chips of the Cu alloy, a method is proposed that includes mechanical activation of the chips, preparation of the mixture, compaction of powders (400MPa), sintering (1253K; 8.1ks) of the workpiece in a protective medium, followed by its cold compaction (600MPa). The mechanical activation (10.8ks) of the chips is carried out in the attritor with the mass ratio of balls and chips of 27:1, followed by the isolation of a fraction of less than 315 microns. The mixture is prepared on the basis of a mixture of powders of Al(9 wt.%), Fe(4 wt.%), Cu(ost.) And powdered mechanically activated shavings of Cu alloy (8 wt.%). The technology provides a cold compacted powder material with a flexural strength of 560MPa and a bend angle of  $25^\circ$  [10].

### Infiltrated composite powder materials

In order to reduce the cost of obtaining low-porous powder materials during utilization of chips of Cu alloys, a method for melt infiltration of a low-melting porous refractory skeleton material with a melt has been developed. The technology includes two-stage cold compaction of a bimetallic billet (low-melting infiltrate 34 wt.% - refractory frame based on Fe) by pressing (610MPa) chip briquette of the infiltrate, followed by pressing (410MPa) of Fe powder. The resulting laminated preform is sintered (1423K; 9.0ks) in a glass melt with simultaneous melt impregnation of the chips. Composite infiltrated material has a tensile strength of 370MPa

[11]. Upon receipt of low-porosity (5.2%) materials with increased bending strength (760MPa), preliminary pressing (200MPa) of iron powder is carried out, followed by pressing (600MPa) of brass briquette (25 wt.%) And sintering combined with infiltration [12].

### Sintered powder materials

In order to increase the efficiency of the technology for producing powder materials by using dusty wastes of Cu-based charges, a method is proposed that includes preparing the charge, cold compaction of the preform and its sintering. At the first stage, grinding (6.3ks) in the attritor of FeMn powder is carried out, screening is not associated with FeMn balls, mechanically activating the dusty waste of the powder mixture based on Cu by treating (6.3ks) with balls coated with FeMn during its grinding in the attritor. At the second stage, a mixture is prepared consisting of a mixture of Sn(9 wt.%), Graphite(5 wt.%) And Cu(ost.) Powders, as well as an activated additive of 16 wt.%. Then carry out cold compaction (280MPa) and sintering (1123K; 7.2ks) of the workpiece in a protective environment. The developed technology ensures the utilization of pulverized wastes of Cu-based powder blends and an increase in the strength (180MPa) of sintered material during radial compression tests [13]. When disposing of waste based on Cu-based powder moldings, pre-ground ( $\sim 5mm$ ) and kerosene-impregnated waste powder moldings are activated in a high-energy mill using grinding balls coated with FeMn. The technology intensifies the grinding of powder molding wastes [14].

### Conclusion

The paper gives a brief overview of promising methods for hot compaction of Al-based powder materials with the addition of "chip" powder obtained by mechanochemical activation of chips of an Al alloy. For the disposal of chips from Cu alloys, technologies have been developed for cold compaction and dosed infiltration from a pressed chip briquette. The possibility of using pulverized waste as a raw material obtained by mixing a mixture based on Cu powders, as well as the disposal of defective Cu-based powder moldings, is shown.

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