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To cite this article: E L Strizhakov *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **558** 012051

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The use of impulse electric and magnetic fields in obtaining permanent joints

E L Strizhakov, S V Nescoromniy, S O Ageev and V G Vinogradov

Don State Technical University, Rostov-on-don, 344000 Russia

E-mail: strizhakov@inbox.ru

Abstract. The article discusses the possibility of using electromagnetic influence in the production of permanent compounds such as metal–ceramics, metal–glass, as well as composite compounds from powder materials. It is proposed to use magnetic pulse action to form such joints in the solid phase: in the atmosphere with the position of parts at an angle; in vacuum with preheating and subsequent radial action. When consolidating powder materials (sintering with simultaneous pressing), a scheme of synchronous action of electromagnetic energy is proposed: thermal and mechanical.

In the manufacturing of products in electronics, instrument engineering there is a necessity to connect dissimilar materials such as metal–ceramics, metal–glass, or dissimilar alloys together. Joints of the tips with wires, various composite insulating metal–ceramic components of microwave devices, metal–glass fuses, resistors and other electronic products are obtained by magnetic impulse crimping [1].

The greatest interest is the consolidation of materials in the solid phase by magnetic impulse welding. The scheme of magnetic impulse welding with oblique collision (Magnetic Impulse Welding MIW) is shown in figure 1 [1].

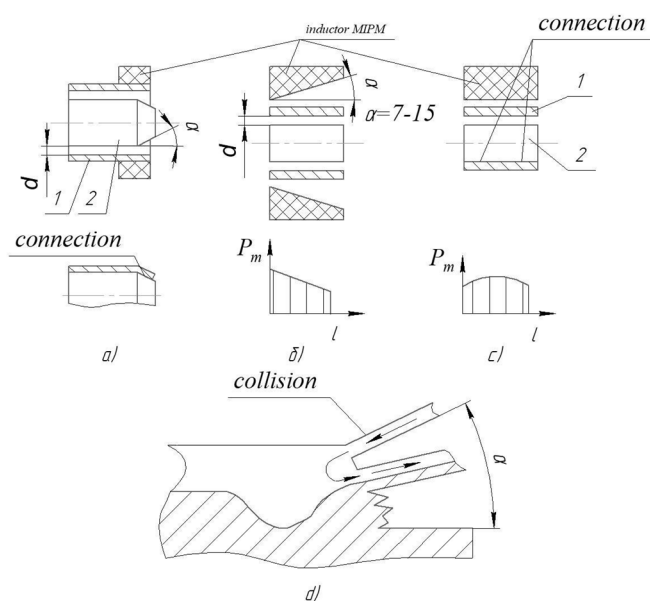


Figure 1. Technological schemes of magnetic impulse welding. (a) the location of parts at an angle; (b, c) with a changing length zones of processing by magnetic pressure; (d) formation of cumulative jet; α , δ —initial angle and gap; P_m is the magnetic pressure.

Parts 1 and 2 are installed at an acute angle α overlap to each other and with a gap δ between them. Opposite the welded surface inductor 3 is set.

Part 1 was fixed to prevent movement during welding rigidly. The workpiece 2 must provide the movement of a welded tip in the direction of the workpiece 1. The inductor 3 is connected by its terminals to the impulse current generator. In the gap between the inductor and the workpiece during the discharge of the capacitor bank, there is a strong magnetic field inducing current in the workpiece. The repulsion forces between the inductor and part 2 arise from the interaction of the inductor current with the induced current in the workpiece, as a result part 2 instantly with high speed moves from the inductor in the direction of fixed part 1; in the contact area at collision, high pressure develops, and the welded joint is formed. In fact, the scheme used in explosion welding is implemented [2, 3]. The replacement of the energy carrier is implemented.

Overlapping joints of single- and multithickness fine-walled tubes of dissimilar materials can be obtained by magnetic impulse welding. For example, copper and aluminum.

Devices of magnetic impulse processing in vacuum can be successfully used for combined process of pressing and welding with the emission of the powder compositions to cathode cores [4, 5]. The scheme of magnetic-impulse pressing in vacuum is shown in figure 2.

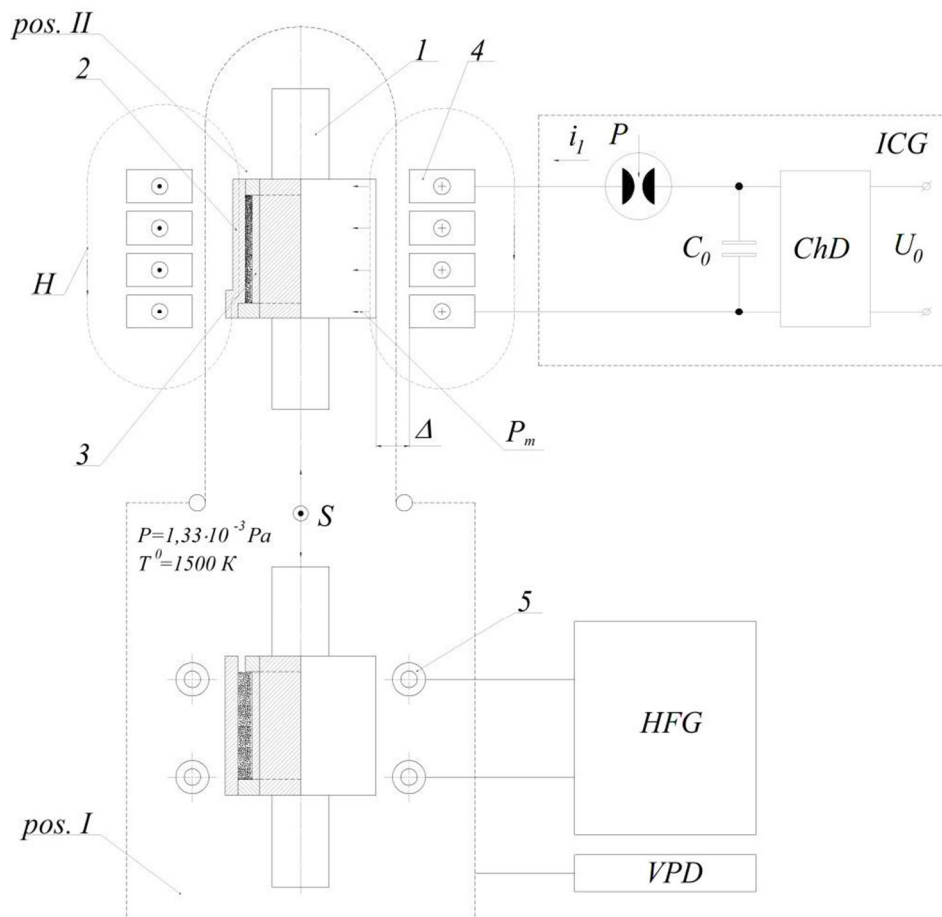


Figure 2. Scheme of magnetic impulse pressing in vacuum: 1 base; 2 cover; 3 powder coating; 4 MIPM (magnetic impulse processing of materials) inductor; 5 high frequency inductor; U_0 is the line voltage; ChD – charger device; C_0 is the capacity drive MII (magnetic-impulse installation); P is the commutating device; i_l is the discharge current; P_m is the magnetic pressure; H is the magnetic flux; IGG – impulse current generator; VPD – vacuum pumping device; Δ is the gap between the inductor and the cover; pos. I is the preliminary heating in vacuum; pos. II is the magnetic impulse welding (pressing) in vacuum; S is the movement of the workpiece.

The process is carried out as follows. Base with coating and the satellite is attached to the stem of electromechanical drive of the vacuum chamber and is inserted into the area of the high-frequency inductor heating. Using vacuum system, the rarefaction is created in the working volume. After that, the HF generator is switched on. Reaching the required temperature node is transferred by electromechanical drive to the MIP (magnetic-impulse processing) zone. Radial crimping is carried out.

Magnetic Impulse Pressing Technology (MIPT) allows to combine outgassing operations, compaction of powder materials, sintering of powder particles and welding with cathode core in one technological operation proceeding in a vacuum chamber without intermediate technological transitions, and exclude the operation of subsequent sintering. It significantly (2–3 times) reduces the complexity of manufacturing cathode nodes ultra-high frequency EVD (electric vacuum device) [1].

Consolidation of dissimilar materials by using powders can be reached by using electroimpulse pressing sintering (EIPS). Schematic diagram process EIPS is presented in figure 3.

The device is assembled so that the thermal (electric current) and mechanical (dynamic loading) impact occurred simultaneously [6, 7].

When discharging capacitor batteries, high frequency current consistently passes through the electrode carried thermal effects on the powder, which leads to intense local heating in the contact area and through the spirals of the inductor, which form a force magnetic field. Magnetic pressure is converted into mechanical force and gives extra compaction and is also a way of activation of interparticle contacts. In this way copper wire is connected to steel basis.

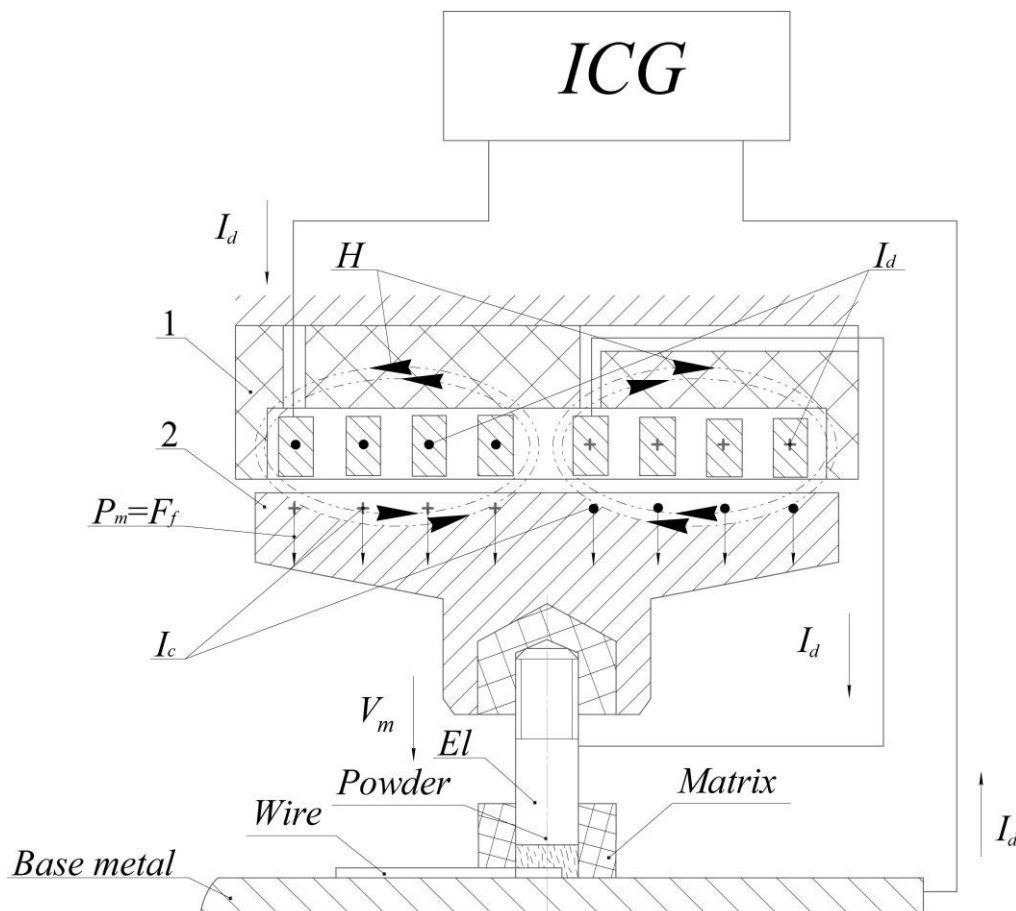


Figure 3. Schematic diagram of the EIPS process: 1 inductor; 2 pusher; I_d is the discharge current; I_c is the induced current; V_m is the speed of movement of the pusher; H is the magnetic flow; P_m is the magnetic pressure; F_f is the forging force; ICG – impulse current generator; El – electrode.

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