N1-O-017703

METALLURGICAL PATTERNS OF THE IMPACT OF HIGH-CURRENT PULSED ELECTRON BEAMS ON METAL TARGETS*

A.B. MARKOV, M.S. SLOBODYAN

Tomsk Scientific Center of the Siberian Branch of the Russian Academy of Sciences, Tomsk, Russia

Electron-beam facilities are widely deployed for welding of various metals, alloys and steel in many industries since the middle of the 20th century. Nowadays, EB-based procedures are also being implemented for both additive manufacturing of metal products and final treatment of their surfaces. For the last-mentioned purpose, in addition to continuous wave EB irradiation, the low-energy high-current pulsed EB (LEHCPEB) processing has been suggested almost three decades ago. Principles of operation of pulsed EB accelerators have been proposed as early as the 1960s and developed in advanced facilities by now, which enable to treat surfaces and alloy them (with several components if necessary) in a single vacuum cycle. Many metals, ceramics, polymers, composites, semiconductors and glasses have been already modified and/or doped by this method. The research results on changes in their various functional properties have been published in several hundred papers (Figure 1), but have not comprehensively summarized yet. It should be noted that this huge amount of data is contradictory in many cases. Some authors have reported the formation of craters, cracks and pores in the modified surface layers in addition to quenching structures and great residual tensile stresses, while others have stated on dramatic improvement in their corrosion resistance. In order to shed light on real achievements, to realize the existing challenges for the wide industrial implementation of this surface treatment method, and to propose unified research methods, the authors have tried to critically summarize the metallurgical patterns of the process. In particular, LEHCPEB processing of aluminum, copper, magnesium, nickel, iron, titanium, zinc and their alloys, as well as steels of various grades have been considered. In addition, both high-entropy and hard alloys, NiTi compounds, as well as superalloys are in the scope of the review. Special attention is paid to alloying of the metal surfaces and the formation of surface alloys due to the preliminary deposition of coatings (including multicomponent ones) before LEHCPEB processing (in a single vacuum cycle). The authors have paid special attention to the need for improving the functional properties of the studied materials and the fundamental possibility of achieving this goal by LEHCPEB processing. For this purpose, typical operating conditions of the materials are shown along with their weldability, as one of the thoroughly studied key parameters that determine the possibility to be processed by such high-energy methods.

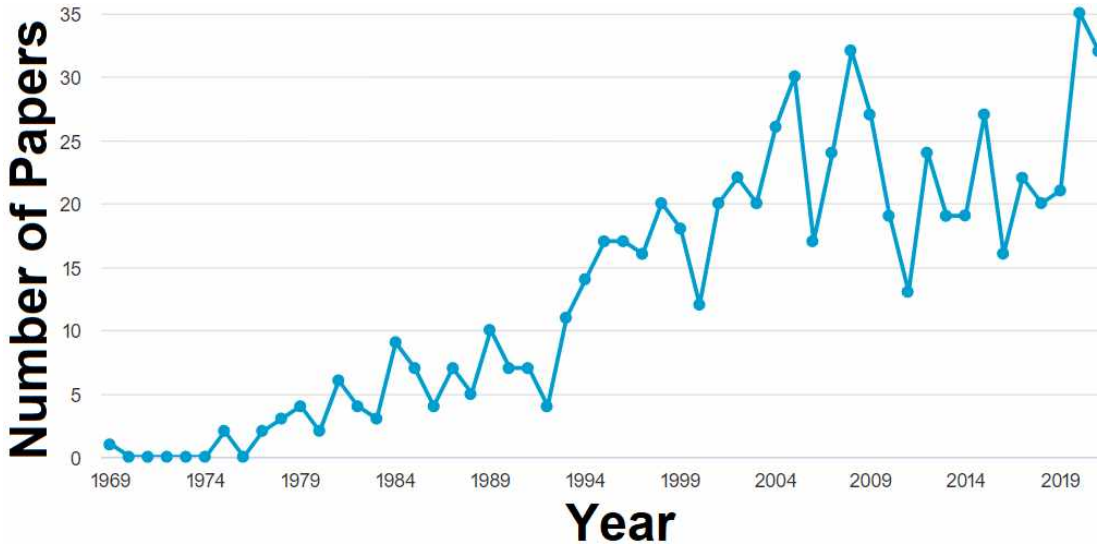

Fig.1. The dynamics of publication of research papers according to the Scopus database, which connected with the ‘pulsed electron beam processing’ keywords

* The work was supported by the Ministry of Science and Higher Education of the Russian Federation (project No FWRF-2021-0001).