Forming of the structure and surface properties of cast Al-Si-Cu alloys

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Abstract

Purpose: *The aim of this work was to present the investigation results concerning obtaining on the surfaces of the aluminum cast alloys AC-AlSi9Cu and AC-AlSi9Cu4 quasi-composite MMCs structure by feeding of ceramic particles WC, SiC, ZrO_2 and Al_2O_3 using the technology of chemical and physical vapor deposition PVD and CVD as well as high-power diode laser HPDL. The particular goal of this work was also to present the investigation of phase transformations and precipitation processes occurring after laser feeding with appropriately selected parameters: laser power, speed, ceramic powder feed rate, as well as after the appliance of the CAEPVD and PACVD deposition methods.*

Design/methodology/approach: *The research issue relates to the design of material of the highest physical and mechanical properties, in particular, there is assumed hardness increase of the surface layer, to improve the abrasion resistance and corrosion resistance respectively to the expected level for the selected aluminum alloys after carried out standard heat treatment. The investigations include analysis of the surface layer formation mechanisms, in particular the base metal melting and crystallization at different HPDL (High Power Diode Laser) laser beam characteristics and technological conditions of surface heat treatment process, melting and feeding of particles in the surface of the cast AlSi9Cu4 and AlSi9Cu alloys. Furthermore, the presented investigations concerns surface treatment of cast aluminum alloys using chemical and physical vapor deposition PAPVD and CAECVD methods. In order to investigate the structure of the obtained surface layers several research techniques were used including light microscopy methods with computer-assisted image analysis, transmission and scanning electron microscopy, X-ray analysis as well as X-ray microanalysis, Raman spectroscopy and appropriate methods for testing of mechanical and functional properties.*

Findings: *There are included among the main achievements of the present work also the basic parameters of the effect of laser treatment process, PVD and CVD on mechanical and functional properties of the investigated materials in tribological wear conditions. Moreover, there was performed the analysis of structural- and chemical composition changes, as well as of the quality of the Al-Si-Cu surface layer. Based on this research the thesis was proved and confirmed, demonstrating the usefulness of the undertaken research work for improving properties of the surface layer using laser and PVD/CVD methods, in comparison to traditional methods, including standard heat treatment.*

Research limitations/implications: *A limitation of the presented issue of laser surface treatment (feeding and remelting) and PVD/CVD are connected to an uniform distribution of the ceramic powder particles fed in the aluminum matrix, as well as to ensure the quality (mainly morphology and adhesion) of the coatings. Because of the above reasons the research activity of this work deals with the need to develop a laser feeding technology of ceramic particles with different chemical composition, as well as the deposition of PVD/CVD coatings on the surface layer of aluminum alloys, and also choosing the appropriate process conditions to optimize the structure and properties of surface layers on the basis of investigation results and detailed metallographic analysis of the phase composition and phase transformations occurring in the alloy surface layers and coatings. En important issue is also to increase the productivity, while reducing energy- and material consumption, which is a very important competition factor in market economy. It should also be noted, that the presented research area applies only to a small group of cast aluminum alloys from the Al-Si-Cu group.*

Practical implications: *The presented in this work novel approach to solving the problems of surface layer shaping with optimum mechanical properties and performance using the techniques PVD/CVD, and laser surface treatment allows further modeling and development of optimal properties using engineering tools also for other groups of materials. Moreover the development of surface treatment and structure modeling technologies for cast Al-Si-Cu alloys by laser feeding and vacuum deposition methods offers the opportunity for comprehensive solution of the existing problem, taking into account economic and ecological issues.*

Originality/value: *The work is an extensive research work of own investigations concerning the development of light metal alloys, as well as surface treatment using laser feeding and/or remelting, crystallization kinetics of aluminum alloys, shaping of functional properties of elements produced from aluminum alloys by applying hybrid PVD/CVD coatings as well as feeding and remelting of ceramic powders. It has been shown that in case of the analysed aluminum alloys, the applied laser surface treatment and PVD/CVD techniques allows to increase functional properties by changing the structure and properties of the surface layer. An important issue is also the carried out and planned continuation of existing researches concerning light alloys aluminium, magnesium and titanium, which are realized since many years in the domestic scientific unit of the author, extending the current knowledge in the field of light alloys constructions.*

Keywords: *Surface engineering; Cast aluminium alloys; Laser surface treatment; HPDL; PVD and CVD surface layers; Structure; Mechanical properties; Functional properties; UMSA; Heat treatment*

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