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ROZPRAWA DOKTORSKA

"Fizykochemiczne właściwości materiału stopowego na bazie molibdenu z dodatkiem renu wytwarzanego technikami metalurgii proszków"

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Abstract

The presented doctoral thesis deals with producing an alloy material based on molybdenum with the addition of rhenium in the form of a powder with a morphology enabling the production of protective coatings using the APS plasma spraying method. The bibliographic analysis of molybdenum-rhenium alloys produced by powder metallurgy shows that there needs to be more work on producing these materials in powder form, particularly powders with a morphology enabling their use as a coating material. In this aspect, the research problem posed in this work is new. There are also few literature reports on preparing these alloys, or rather alloy powders, by reducing rhenium salts in the presence of molybdenum granules proposed in this work. The use of the Mo-Re alloy as a raw material for producing protective layers using thermal spray techniques has not been tested so far. Therefore, the thermal spraying of Mo-Re powders and the characterization of the structure and properties of the coatings thus obtained are a new research element.

Achieving the goal set in the work required solving several indirect research problems enabling the selection and verification of technology allowing the production of powder materials with the assumed composition and morphology.

One of the basic research problems was the selection of the method for producing the powder mixture. Two different technological methods of combining molybdenum with rhenium were tested. One was based on the process of mechanical grinding of pure metallic components: molybdenum and rhenium. In the second method, molybdenum was combined with rhenium physicochemically, using ammonium rhenate NH4ReO4 as a source. The influence of such process parameters on the properties of the obtained mixtures was examined:

- in the case of the mechanical grinding method - process duration;
- in the physicochemical method - process duration and the influence of temperature.

The research focused mainly on determining the impact of changing process parameters on:

- phase composition (qualitative and quantitative),
- chemical composition in micro-areas,
- grain morphology,
- density
- specific surface area.

Moreover, for materials produced using the physicochemical method, the influence of temperature and process time on the parameters of the unit cell of the solid molybdenum solution was investigated. Additionally, for powder mixtures produced in both processes, the influence of heat treatment on the phase composition and morphology of the final powders was examined.

The study examined two materials with significantly different rhenium content:

• Mo-85% + Re-15% and

• Mo-56% + Re-44%.

As part of the work, layers obtained in the APS process were produced from the developed powder materials and characterized in phase and microstructure.

The scope of research also concerned the characteristics of silicified Mo-Re coatings. Diffusion silicification was used to improve the oxidation resistance of new Mo-Re coatings produced by plasma spraying. The following research stage assessed the silicified coatings' resistance to oxidation.

The conducted research has shown that it is possible to obtain a material based on molybdenum modified with rhenium in the form of powder without the need to use high-temperature melting and sintering processes and to use it as an effective coating material for the production of plasma-sprayed Mo-Re protective coatings.

The most effective method of producing such powders is the physicochemical process. Mechanical milling did not give satisfactory results due to the morphology of the powders, the introduction of iron contamination and the formation of unfavourable σ phases. The production of Mo-Re-Si coatings on a Mo-ZrO2 cermet substrate allowed obtaining a material with high practical utility in the glass industry, ensuring the preservation of the quality of the glass mass (no contamination) and the material's service life throughout the glass cycle.