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Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Konstantin Makarenko

PhD Program: Mathematics and Mechanics

Title of Thesis: Microstructural, mechanical, and thermal properties evaluation of functionally graded Fe-Cu structures after direct energy deposition

Supervisor: Associate Professor Igor Shishkovsky

Name of the Reviewer: Fei Chen

I confirm the absence of any conflict of interest	**Date: 10-Sep-2023**

The purpose of this report is to obtain an independent review from the members of PhD defense Jury before the thesis defense. The members of PhD defense Jury are asked to submit signed copy of the report at least 30 days prior the thesis defense. The Reviewers are asked to bring a copy of the completed report to the thesis defense and to discuss the contents of each report with each other before the thesis defense.

If the reviewers have any queries about the thesis which they wish to raise in advance, please contact the Chair of the Jury.

Reviewer's Report

The present study focuses on the fabrication of SS 316L – bronze functionally graded materials (FGMs) using direct energy deposition (DED) and the subsequent investigation of their microstructural, mechanical, and thermal properties. The outcomes of this research are applicable to the production of functionally graded components.

Innovation:

1. The thesis successfully demonstrated the possibility of joining dissimilar immiscible materials of the Fe-Cu system via direct energy deposition, which supplemented the material system and fabrication methods of FGM. The results of the research can be used for producing functionally graded parts from SS 316L with Al, Sn, and Cr bronzes for aerospace, automotive, nuclear, electronics/optoelectronics, tooling, medicine, defense, and milling areas of industry.

2. The preparation of bimetal structure with different strategies is of significance. The study innovatively compares 3 deposition strategies of SS 316L – bronze bimetallic material by DED. Both the alternating

layers' technique and gradient path method provided significantly better quality of bonding without observable defects than direct joining.

3. The microstructural, mechanical, and thermal properties of the laser-deposited Fe-Cu FGMs and quasi-homogeneous materials were successfully investigated for the first time. This is a carefully done work and the results are profound.

A few minor revisions are listed below:

4. In the Literature review part, more data indexes should be added to support the study, such as mechanical properties data, porosity, etc. from others' research results, so as to compare with the test results of this study and to guide the next steps of the study. Besides, the advantages of DED technology to other AM technologies should be clarified.

5. As to Figure 4, the configuration could be further refined. It is suggested to combine the printing principle to form a thorough scheme.

6. In the 3.3 Alternating SS 316L and bronze layers part, the author is advised to account for the phenomenon that interpenetration of steel and bronze between nearby layers is observed in the case of steel-on-bronze deposition, but the bronze-on-steel sequence presents a sharp and clear interface, as well as the effects of this phenomenon on defects.

7. In the 3.4 Fabrication of SS 316L - bronze FGMs using the gradient path method part, the gradient path method is too concisely written. The author should further state the deposition sequence and the compositional change details of the gradient layers. A scheme of the deposition as Figure 6a will be favored.

8. As to Figure 10, each diagram should be the same size to form a normative group of diagrams.

9. It is mentioned before that the alloy of alternating layers of tin bronze and SS 316L was excluded from consideration because it showed poor laser manufacturability and did not obtain an appropriate shape during the fabrication because of low heat consumption and poor adhesion of Sn bronze and steel. So the Coefficient of linear thermal expansion data of Group 8 in Figure 32 is unnecessary. Relevant data of Group 8 in Chapter 6. Thermal properties of SS 316L – bronze FGMs could be removed.

10. The interim conclusion of every chapter should be broken down and the language should be sufficiently refined to present the conclusion clearly.

Provisional Recommendation

☑ *I recommend that the candidate should defend the thesis by means of a formal thesis defense*

☐ *I recommend that the candidate should defend the thesis by means of a formal thesis defense only after appropriate changes would be introduced in candidate's thesis according to the recommendations of the present report*

☐ *The thesis is not acceptable and I recommend that the candidate be exempt from the formal thesis defense*