

## Thesis Changes Log

**Name of Candidate:** Konstantin Makarenko

**PhD Program:** Mathematics & Mechanics

**Title of Thesis:** Microstructural, Mechanical, and Thermal Properties Evaluation of Functionally Graded Fe-Cu Structures after Direct Energy Deposition

**Supervisor:** Prof. Igor Shishkovsky

*The thesis document includes the following changes in answer to the external review process.*

1. Structure and content of part I, «LITERATURE REVIEW», were revised according to the sum of remarks of Reviewers.
2. The additional discussion of physical properties of the DEDed Fe-Cu FGMs with links to the new references was added to the literature review section (see pages 37 and 38).
3. The advantages of DED over other AM technologies were given (see page 28).
4. The keywords were corrected.
5. The name of §2.6.5 was changed according to the advice of Reviewer.
6. All subchapters from §2.6, «Experimental methods», were checked.
7. Figure 10 with a scheme of the gradient path method was added. The gradient path method was better described in the text of thesis near this figure.
8. New Table 3 with comparison of mechanical and microstructural properties of SS 316L and three kinds of bronze was added to the thesis.
9. The description of the Figure 6 was added below it (page 64).
10. Interim conclusions of each chapter were structured, their language was revised and corrected.
11. Chemical composition of aluminium bronze was given in Table 4, of chromium and tin bronzes – in Table 5.
12. Duplicated descriptions of materials, methods, and equipment were removed in the text of the thesis.
13. The explanation of the choice of group 7 for a separate deep research was given (see page 72).
14. Subsections «Relevant Theory. The Diffusion of Elements and the Parameters of Dendrites» and «Relevant Theory. The Crystallization Rate» were moved to the new §2.3, «Microstructure Evaluation Methods for the DED», of Chapter 2, «State of the Art».

15. The description of Figure 12 (later it was Figure 9) was changed from XRD to EDX in the text.
16. The phenomenon of differences between steel-on-bronze and bronze-on-steel depositions was described (pages 65-66).
17. Abbreviations of the multicomponent alloys (like C18400 + SS 316L (50/50 wt.%)) were corrected and became of a similar type everywhere in the text of the thesis.
18. The explanation that exactly group 9, not group 8, showed poor manufacturability was given in page 71.
19. Sizes of diagrams in Figure 13 (later it was Figure 10) were corrected.
20. The description of phases was revised in §4.3. The possibility of existence of  $\text{Cu}_3\text{Al}$  phase was discussed.
21. The explanation of dark and light areas in SEM micrographs according to the results of EDX was added (page 81).
22. The additional correlation between mechanical properties of alloys and crystal lattice parameters of initial components was highlighted (see page 104).
23. The explanation of a possibility of the analytical estimation of cooling rate and temperature gradient was provided (page 42).
24. The sentence «The specimens of groups 2-4 and 6...» in the page 98 was rewritten.
25. The temperature range and direction of measurement was provided in the caption of Figure 33 (later it was Figure 32). Figure 34 (later – Figure 33) was checked for being correct in the terms of temperature ranges.
26. The beginning of Chapter 8 was added with description of the goal, purposes, and practical significance of this chapter.
27. The name of Chapter 8 was changed to «Future Research Direction».
28. Literature source list was revised; some references were substituted.
29. Overall text of the thesis was checked for misprints.