

REVIEW

on a dissertation with a topic:

"INFLUENCE OF THE DEEP CRYOGENIC TREATMENT ON THE STRUCTURE AND PROPERTIES OF THERMALLY REINFORCED AND THERMALLY UNREINFORCED ALUMINUM ALLOYS",

for awarding the educational and scientific degree "Doctor" to

Eng. Plamen Ivanov Stoyanov

from TECHNICAL UNIVERSITY - VARNA

in field 5 "Technical Sciences"

Professional direction 5.6. "Materials and Materials Science"

On the doctoral program: "Materials Science and Technology of Mechanical
Engineering Materials"

Scientific supervisors: Assoc. Prof. Dr. Eng. Daniela Todorova Spasova
Assoc. Prof. Dr. Eng. Diyan Minkov Dimitrov

**REVIEWER : Prof. PhD Eng. Angel Velikov,
IMSETCHA - BAS**

1. Relevance of the problem developed in the dissertation work

Aluminum alloys are of great technical importance. The combination of low relative density with relatively high mechanical properties makes them valuable engineering materials. Alloying elements, without increasing the relative density of the material, increase its properties, such as its strength and hardness. It is especially important to choose appropriate processing methods to improve the mechanical and operational characteristics of aluminum alloys. Compared with traditional heat treatment, Deep Cryogenic Treatment (DCT) has some advantages due to improving the characteristics of aluminum alloys. As an environmentally friendly, inexpensive and non-polluting new heat treatment process, DCT can significantly improve the microstructures and characteristics of the metals at that with small deviations in their sizes and shapes. The relevance and dissertationability of the present work lies namely in the use of DCT.

2. Does the doctoral candidate know the state of the problem and does he creatively evaluate the literary material?

The literature review covers 61 pages. The literary sources that the doctoral candidate uses (184 in number) are mainly on the topic of the dissertation.

The literary sources do not include publications on the dissertation.

The literary review ends with a critical analysis and precise formulation of the goal and objectives of the dissertation.

My general impression of the literary review is that the doctoral candidate knows the researched matter well and handles literary facts very competently. The literary review itself is sufficiently complete and provides a good overview of the research.

3. Can the chosen research methodology provide an answer to the set goal and tasks of the dissertation work?

To solve the set tasks, the doctoral student used original stands and equipment for the manufacture of test specimens:

- grinding machine MoPao 260E – Grinder;
- polishing machine MoPao 260E – Polisher;
- X-ray diffractometer TDM-10;
- tensile testing machine type “WPM-5”;
- potentiostat/galvanostat Corrtest CS350;

I believe that the used methodologies, stands and equipment provide a correct answer to the set tasks of the research.

4. Brief analytical description of the nature and assessment of the reliability of the material on which the contributions of the dissertation are based.

The used apparatus and experimental equipment, the conducted research and test regimes, by their nature and method of treatment, include original solutions. The reliability of the obtained results, with which the contributions of the dissertation are related, are based on

numerous studies, as well as on the used theoretical and experimental methods and methodologies.

5. What are the scientific or applied scientific contributions of the dissertation?

I accept thus formulated contributions of the dissertation:

I. Scientific

1. It has been confirmed that the application of the deep cryogenic treatment (DCT) leads to dispersion, more uniform distribution and to an increase of the secondary phases amount, separated from the solid solution, as well as to an increase in the density of dislocations, which is a major factor for improving the strength characteristics of aluminum alloys.

2. It has been proven that the sequence of applying the heat treatment to aluminum alloys (quenching + artificial aging) and DCT has a significant impact on the final result, as the most favorable characteristics being achieved when DCT performs after aging, in contrast to conventional schemes in which DCT is applied after quenching, before the aging process.

3. It has been confirmed that DCT does not deteriorate the corrosion resistance of aluminum alloys, and even leads to a slight improvement, which is important when it is operated in aggressive environments.

II. Scientific and applied

1. A specific reaction of the different groups of thermally reinforced aluminum alloys to DCO has been established, as for casting alloys of the AlSi7Mg type is reported an increase in strength without loss of plasticity, while for deformable alloys of the AlSiMgMn system the effects are mainly aimed at improving of the plasticity at retention of the strength and hardness.

2. It was also established that for thermally unreinforced deformable alloys of the Al-Mg system (AlMg6, AlMg4,5), the effect of DCO is more pronounced after reinforcement by plastic deformation than in the annealed state.

3. An innovative, environmentally friendly and economically justified technological process has been developed for strengthening of thermally unreinforced and for enhancing the aging effect at thermally reinforced aluminum alloys by applying DCO.

4. The applicability of DCO, as a final treatment has been proven, considering that it does not cause an increase in the roughness of the surfaces of aluminum alloys, surface-hardened by diamond polishing.

5. Regression models have been created that describe the relationship between the parameters of the DCO and the obtained mechanical and exploitation characteristics of the studied thermally reinforced and thermally unreinforced aluminum alloys. The models allow a prediction of the expected results and support the selection of optimal technological regimes through a quantitative assessment of the influencing factors.

III. Applied contributions

1. Practical guidelines for the selection of a technological regime for strengthening by DCO have been developed, which allow a wide range of changes in the properties of thermally reinforced and thermally unreinforced aluminum alloys, according to the required exploitation characteristics.

2. A technological process for strengthening by DCT, with a duration of 24 hours, has been developed, which leads to an additional increase in the strength-mechanical characteristics

of thermally and mechanically reinforced aluminum alloys, as well as of aluminum alloys in the annealed state, while in the same time, the plasticity is not reducing. The process is suitable for implementation in industrial conditions, where an increase in strength is required without deteriorating the plasticity of the material.

3. A 48-hour process of strengthening by DCO has been developed, which increases the ductility of thermally and mechanically reinforced aluminum alloys, as well as of aluminum alloys in the annealed state, while the strength slightly increasing and mechanical properties. The process is particularly suitable for applications requiring a combination of improved ductility and sufficient strength, such as in the transportation and aviation industries.

6. Can it be assessed to what extent the dissertation work and represented contributions are the personal work of the doctoral candidate?

Of all 4 scientific works of the doctoral candidate, one is independent, and in the remaining three he is in second place, which indicates that the contributions in the dissertation are mainly his merit. No data for citations are provided by the doctoral candidate

7. Evaluation of the publications on the dissertation work.

The main results of the research have been reported and published in the following scientific forums and publications:

- International Journal "NDT Days", Volume VII / Issue 2, p. 67-74
- International Journal "NDT Days", Volume VII / Issue 2, p. 75-82
- Innovative Manufacturing Engineering & Energy Conference, 2024, 23 – 25 October
- International Journal "NDT Days".

8. Have the results of the dissertation work already been used in scientific and social practice? Has a direct economic effect been achieved, etc.? Documents on which the statement is based.

I have not been provided with information about the implementation of the researched technology.

9. Motivated recommendations for use in the future of the scientific and applied scientific contributions: what and where to implement.

I suggest seeking contacts with companies working with aluminum alloys, for example, Elmetal-Sofia, etc.

10. Is the author's abstract prepared according to the requirements, does it correctly reflect the main points and scientific contributions of the dissertation work?

The author's abstract is prepared according to the requirements. I have no comments.

11. Critical comments on the dissertation, including the candidate's literary awareness.

I have no critical comments, that would cast doubt on the reliability of the stated results and contributions from the research conducted. I recommend a final grammatical revision, such as on the title page "scientific supervisors", not in the singular, etc.

12. Other issues on which the reviewer considers that he should take a position.

Very good and interesting work.

13. Conclusion with a clear opinion on whether or not to award a scientific degree.

Based on everything said so far, I believe that the dissertation work submitted to me for review "INFLUENCE OF DEEP CRYOGENIC TREATMENT ON THE STRUCTURE AND PROPERTIES OF THERMALLY REINFORCED AND THERMALLY UNREINFORCED ALUMINUM ALLOYS" for the award of the educational and scientific degree "doctor" in the field 5. Technical sciences, professional field 5.6. "Materials and materials science", fully meets the requirements of the ZRASRB and the regulations for its application and I propose to award Eng. Plamen Ivanov Stoyanov the educational and scientific degree "Doctor".

05.01.2026

Prepared the review:.....

(Prof. Dr. Eng. A. Velikov)