Appendix 12a

REVIEW

of dissertation for the acquisition of:

educational and scientific degree "**doctor**"	x
scientific degree **"Doctor of Science"**	
	the true is indicated by the sign "X"

Author of the dissertation:

		Nikita	Alexandrovich	Lutchenko	Nazarbayev University Astana Kazakhstan
academic position	scientific degree	name	middle name	last name	workplace

Topic of the dissertation:

Investigation of the possibility of obtaining an ultrafine-grained structure of zirconium alloys by methods of severe plastic deformation

Scientific area:

5	Engineering sciences
code	name

Professional area:

5.6	Materials and Materials Science
code	name

Scientific specialty:

Materials science and technology of engineering materials

The review was written by:

Prof.	PhD	Stoyko	Atanasov	Gyurov	Institute of Metal Science, equipment, and technologies with Center for Hydro- and Aerodynamics “Acad. A. Balevski” at the Bulgarian Academy of Sciences – (IMSETHC-BAS)
academic position	scientific degree	name	middle name	last name	workplace

1. Completion of the provided documents:

A) The dissertation and the competition documents are in full compliance with the Regulations.	4 points	**X**
B) The documents are complete but do not fully comply with the requirements of the Regulations.	2 points	
C) The documents are not completed in accordance with the requirements of the Regulations.	0 points	
		one of the answers given is marked with the sign "X"

Missing documents and violated standards must be described if response C is marked.
Doctoral student Nikita Alexandrovich Lutchenko has submitted the full set of documents necessary to open a procedure for defending a doctoral dissertation, according to the Regulations of the University of Chemical Technology and Metallurgy.

2. Meeting the minimum requirements under the Regulations:

A) The candidate meets the minimum requirements	20 points	X
B) The candidate doesn't meet the minimum requirements	0 points	
		one of the answers given is marked with the sign "X"

It must be filled in if answer B is marked. The publication activity of the candidate is analyzed. The response of the results achieved (quoted) is analyzed.
The dissertation is written on 174 pages, contains 113 figures and 9 tables. 270 sources are cited. The main results are presented in 4 (four) scientific papers published in publications that are referenced and indexed in world-renowned databases of scientific information and in 2 (two) papers in non-referenced publications. All publications are on the topic of the dissertation. The number of points on Indicator G Sum from 5 to 11 is 45.9. The doctoral student fully meets the requirements of the LAW on the development of the academic staff in Republic Bulgaria. 6 (six) citations of publications on the dissertation were also noted.

3. The relevance of the topic of the dissertation:

A) The topic is relevant and new (there are no known results on the topic by other authors)	8 points	
B) The topic is relevant and results from other authors are known	6 points	X
C) The topic is not relevant, but results from other authors are known	2 points	
D) The topic is not relevant and no results from other authors are known	1 point	
E) The topic does not correspond to the level of dissertation	0 points	
		one of the answers given is marked with the sign "X"

The evaluation of the relevance of the dissertation must be substantiated

Zirconium alloys are traditionally used in nuclear reactors, due to their low thermal neutron capture cross section, corrosion resistance and mechanical strength. Over time, they lose their operational qualities due to property degradation, radiation growth, creep, hydrogen embrittlement and cracking. A solution to the problem is sought in the use of ultrafine-grained (UFG) and nanostructured zirconium alloys, which have a high density of grain boundaries. Studying the process of radial-shear rolling of zirconium alloys in order to obtain an ultrafine-grained structure is a current scientific and applied task that meets the high requirements of nuclear power engineering.

4. Knowledge of the problems, subject of research in the dissertation:

A) The doctoral student knows in detail the achievements of other authors on the topic of the dissertation	8 points	X
B) The doctoral student is partially familiar with the achieved results on the topic of the dissertation	4 points	
C) The doctoral student has no prior knowledge of the status of the problems in the dissertation	0 points	
		one of the answers given is marked with the sign "X"

The evaluation must be substantiated if answer C is marked.
The detailed literature review (270 sources were analyzed) and the in-depth analysis of the known information on the topic of the dissertation allow the doctoral student to clearly formulate the goals and objectives. The methods are selected correctly, which is a prerequisite for the reliability of the results obtained. The doctoral student knows in detail the achievements of other authors on the topic of the dissertation.

5. Type of research:

A) Theoretical	4 points	
B) Applied	4 points	X
C) Theoretical with application elements	4 points	
D) It does not correspond to the level of dissertation	0 points	
		one of the answers given is marked with the sign "X"

The level of research must be substantiated if answer D is marked.
As a result of the conducted research, an applied scientific task has been solved for the formation of an ultrafine-grained (UFG) structure in zirconium alloys by the method of intense plastic deformation with subsequent analysis of the structural and operational characteristics of the material. The dissertation work covers theoretical modeling of the processes; development of technological regimes for full-scale experiments; study of microstructural and mechanical characteristics; as well as assessment of the radiation resistance of the resulting material.

6. Objectives of the research:

A) Realistic and of scientific and / or applied interest	8 points	X
B) Realistic, but not of scientific and / or applied interest	3 points	
C) Unattainable (unrealistic)	0 points	

		one of the answers given is marked with the sign "X"

Objectives must be specified. The type of the set objectives must be justified.
The main goal of the dissertation is to investigate the application of radial shear rolling to zirconium alloys to form an ultrafine-grained structure, which will improve the mechanical properties, texture and radiation resistance of the alloys. To achieve this goal, the doctoral student has planned to solve the following tasks: 1. To establish the key mechanisms of degradation under radiation conditions and the feasibility of using ultrafine-grained (UFG) structures based on zirconium alloys; 2. To summarize and classify the existing methods for obtaining an UFG structure and to assess their applicability to zirconium alloys; 3. To develop and optimize a technological scheme for radial shear rolling of a zirconium alloy; 4. To study the evolution of the microstructure along the cross-section of the obtained test bodies, using the methods of transmission and scanning electron microscopy, including EBSD-mapping, as well as analysis of the texture characteristics (incl. calculation of the Kearns parameters); 5. To study the fine structure by high-resolution electron microscopy of the test bodies obtained by radial-shear rolling; 6. To obtain experimental data on the mechanical properties of the obtained test bodies; 7. To irradiate test bodies of the studied zirconium alloy with heavy ions in order to simulate the conditions of damage by fission fragments in the reactor cores. The tasks are in a logical sequence, and their solution provides a guarantee for achieving the set goal.

7. Methods of research:

A) Adequate to research and set objectives	8 points	X
B) Partially appropriate, enabling part of the scientific objectives and / or applications to be achieved	4 points	
C) Inappropriate methods	0 points	
		one of the answers given is marked with the sign "X"

Methods must be specified. The type of methods used is justified.
The dissertation uses theoretical and experimental methods for scientific research. The theoretical methods are: • Experimental planning and statistical processing of experimental data; • Computer modeling using the finite element method (FEM); • The finite element method was also used to predict the stress-strain behavior of the studied zirconia during rolling in a radial-shear rolling mill in order to achieve fine-grained microstructure refinement and improve the mechanical properties of the resulting rolled rod. Mathematical modeling and simulation of the processes was carried out in the DEFORM software environment. The experimental methods are: • Radial-shear rolling; • Standard tensile tests and microhardness measurement on the Vickers scale (HV); • Obtaining rheological data with a plastometer; • X-ray diffraction (XRD); • High-resolution scanning electron microscopy and transmission electron microscopy; • Heavy ion radiation irradiation. The selected methods ensure the realization of the set goal and are relevant to the tasks formulated in the dissertation.

8. Contributions of the dissertation:

A) With lasting scientific and / or applied response, they form the basis for new research and applications	20 points	
B) They are of significant scientific and / or applied interest, complete and / or summarize previous research	16 points	
C) They are of scientific and / or applied interest	12 points	X
D) Lack of significant contributions	8 points	
E) Lack of contributions	0 points	
		one of the answers given is marked with the sign "X"

Contributions must be specified. The type of results achieved must be justified.
Scientific contributions: 1. An original scientific systematic approach to the study of radial shear rolling technology as a method for intensive plastic deformation of zirconium alloys has been created and implemented, including: modeling; experimental rolling; microstructural analysis; analysis of mechanical properties and radiation resistance testing. 2. Original data on the formation and evolution of an ultrafine grain (UFG) structure in zirconium alloys during radial shear rolling (RSR) have been obtained. The obtained data expand the fundamental concepts of the mechanisms of grain structure and texture formation in zirconium alloys during RSR. 3. The physical mechanisms for increasing strength properties and radiation resistance when reducing grain size to the UFG level have been confirmed. 4. It has been confirmed that the high density of grain boundaries contributes to the formation of a stable structure and improvement of the complex of material properties. Scientific and applied contributions 1. A model of the PCB process was created using the finite element method in the DEFORM-3D program. 2. Data were obtained on the stress-strain state of test specimens from the studied zirconium alloy E110 (Zr-1%Nb) under conditions of high deformation intensity. 3. The optimal rolling parameters were determined and verified: billet temperature; roll rotation speed; degree of unit relative deformations and friction coefficient. 4. Original data were obtained on the evolution of the microstructure at all stages of radial shear rolling. 5. Highly detailed maps of the microstructure and texture were obtained, the grain orientation was determined and values for the Kearns parameters were obtained. 6. The mechanical properties of the zirconium alloy test specimens obtained by PCB were established and evaluated. 7. Radiation damage to the alloy by irradiation with heavy ions at the DC-60 accelerator was modeled and it was found that the resulting zirconium alloy with a UFZ structure retains a stable morphology, demonstrates moderate radiation strengthening, which is not accompanied by embrittlement, and resistance to Young's modulus. 8. Data were obtained on the influence of temperature on the stability of the resulting UFZ structure and the mechanical properties of the material. Applied contributions: 1. A technology has been developed for the production of long parts (rods) of different diameters from a zirconium alloy with a gradient structure and a high degree of grain fragmentation. 2. The proposed technology is applicable for industrial production of structural materials with improved performance properties.

9. Evaluation of the compliance of the dissertation summary with the dissertation:

A) Full compliance	4 points	
B) Compliance of the main parts	2 points	X

C) Lack of compliance of the main parts	0 points	
		one of the answers given is marked with the sign "X"

The evaluation must be substantiated if answer C is marked.
The dissertation summary is 48 pages long, following in the main parts the structure and content of the dissertation. However, there is no Table of Contents and the pages are not numbered, which makes it difficult to compare with the dissertation. The text is written concisely, clearly, with precise and accurate presentation. The figures, diagrams and tables are well selected, of excellent quality and objectively reflect the experimental results obtained. The abstract in the main parts covers the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria.

10. Participation of the doctoral student in the achievement of the results of the dissertation:

A) The doctoral student has at least an equal participation	8 points	X
B) The doctoral student has secondary participation	5 points	
C) The participation of the doctoral student is unnoticeable	0 points	
		one of the answers given is marked with the sign "X"

Critical notes must be provided if one of the items B or C is marked.
The doctoral student has submitted a list of 6 (six) papers. In two he is in first place, and in two he is in second place. All publications are in collaboration with the doctoral student's scientific supervisors. He has also submitted a declaration of authorship. I have no doubt that he is the author of the dissertation and has at least equal participation in the submitted publications.

11. Critical notes:

A) Lack of critical notes	8 points	
B) Critical notes of a technical nature	7 points	X
C) Critical notes that would partially improve the results achieved	4 points	
D) Significant critical notes	0 points	
		one of the answers given is marked with the sign "X"

Critical notes must be provided if one of the answers C or D is marked.
I have no critical comments regarding the contributions received in the dissertation. I have comments on the dissertation summary, which is without page numbering and without a Table of Contents.

12. Conclusion

A) The evaluation of the dissertation is **POSITIVE**	This evaluation is assigned to a total number of at least 65 points	(87) X

B) The evaluation of the dissertation is **NEGATIVE**	This evaluation is assigned to a total number below 65 points	
		one of the answers given is marked with the sign "X"

To be filled in at the request of the reviewer
The dissertation work meets the requirements of the LAW on the Development of the Academic Staff in Republic Bulgaria and the Regulations of the University of Chemical Technology and Metallurgy and fully covers the scientometric indicators for the acquisition of the educational and scientific degree "doctor" (PhD. I would like to propose to the esteemed Scientific Jury to vote positively and award to Master of Engineering Nikita Aleksandrovich Lutchenko educational and scientific degree "doctor" (PhD) in Scientific Area 5 Technical Sciences; Professional Direction 5.6 Materials and Materials Science in the Scientific Specialty "Materials science and technology of engineering materials“.

	The review was written by:	
date	**Prof. Eng. Stoyko Atanasov Gyurov, PhD**	signature