

## Review Report on PhD Thesis

Faculty: **Faculty of Mechanical Engineering** Academic year: **2021/2022**  
**Czech Technical University in Prague**

Student: **Ing. Hadi Husain**

Doctoral study program: **Mechanical Engineering**

Field of study: **Manufacturing Technology**

Supervisor: **prof. Ing. Jan Suchánek, CSc.**

Supervisor-specialist: **Ing. Jan Kudláček, Ph.D.**

Reviewer: **doc. Ing. Ladislav Čelko, Ph.D.**

PhD thesis title: **Risk factors of tribological processes and their environmental impact**

### **Achieving the objectives set in the doctoral thesis:**

The main objectives of the dissertation thesis were interdisciplinary and belong to research areas of advanced coatings manufacturing, surface material wear, materials characterization, and wear debris health and environmental risk issues. Specifically, (i) plasma transfer arc deposition parameters of composite Inconel® 625 and B<sub>4</sub>C coatings were successfully developed, (ii) the results of tribology tests of coatings surface and characterization of wear debris were studied in detail, and (iii) risk factors of micro- and nanoparticles on health and environment were in general discussed, that is, the objectives of doctoral thesis were met.

### **Topicality and the level of analysis of the state of the art:**

Undoubtedly, the development of advanced coatings resulting in a reduction of material surface wear during tribological processes and leading to reduced production of inevitable debris that affects reliability of the components, health of the end users, and impacts the environment is a highly topical issue. The level of

analysis of current knowledge in the field of tribology principles and risks, available materials and deposition, and environmental impacts is average. I especially miss the effort for at least a brief description of several published EU strategies on the negative influence of nanoparticles on human health and environment.

### **Contribution of the doctoral thesis theory to fundamental knowledge:**

The first part of the thesis, i.e. the theoretical part, is written in a very concise but relatively clear form with a focus on the thesis topic. The short introduction is followed by chapters describing the theory of tribology principles and risks, materials studied in the thesis, plasma transfer arc technology used for composite coatings manufacturing, and impact of tribology on the environment and risks in general. Unconventionally, the “State-of-the-art” chapter follows the theoretical background part of the thesis, and it ends with the introduction to the “Thesis objectives”. As is evident mainly from the results of experimental work, some contribution of the thesis to fundamental knowledge in manufacturing technology science can be found in the utilization of non-conventional characterization techniques that were used to obtain additional information on the chemical and phase composition of the debris produced by the tribological wear.

### **Contribution of the doctoral thesis to applied practice:**

The experimental part of the thesis is less systematically divided into sub-chapters mixing together experimental methodology with measured results, but at least sorted in a logical order of separate experiment sequences done, i.e. substrates preparation and composite coatings deposition, heat treatment and modification of coated surface for tribology testing, tribology tests, and material characterization of wear debris. Here, especially the information provided on the heating/cooling rate during composite coatings deposition, changes in weight and surface topography after the tribology test, and the size of the debris particles and their chemical composition were found valuable. The obtained results were very briefly discussed in the following separate chapter.

### **Selection and suitability of methods and techniques used:**

The selection of methods and techniques for the study is often limited by the ownership of the institute. Taking into account this fact, it can be stated that the methods and techniques were suitably designed and definitively enabled the manufacture of advanced composite coatings, the provision of tribology testing, and the detailed description of the size, morphology, and chemical composition of wear debris.

### **Utilization of methods and techniques for the study:**

Methods designed to produce composite coatings, for tribological tests, and characterization of wear debris were utilized suitably. The data obtained from the measurements were presented but only partially discussed.

### **Knowledge and orientation of the student in the doctoral thesis discipline:**

The thesis itself is based on very low number, i.e. 41, references (references No. 24 and No. 30 were found the same) related to the topic but, unfortunately, only 9 of these were published less than 5 years back from now. Ing. Hadi Husain is the main author of 1 publication from the METAL conference that is listed in the WoS/Scopus databases. He is also the author of other 6 contributions at the national conferences. It should be noted that at least one thesis-topic-relevant IF journal publication or other significant engineering work are the current standard at most public universities in the Czech Republic, and, therefore, at least higher publication activity of the doctoral student as a main author was in my general expectation.

### **Formal level of the thesis:**

The thesis was submitted by the author in English language; the text is readable but full of errors, both in typography and grammar. Especially, very low quality of some tables inserted as print screens and missing or inappropriately rounded measured values can be highlighted. Nevertheless, it can be stated that the thesis met the minimal criteria for the formal level of the doctoral thesis.

### **Questions and comments:**

- (1) The term “Nano/Micro particles” is used very often in the thesis, and as introduced in Chapter 2.6: “Nanoparticles are characterized by the dimensions between 1-100 nm, and microparticles by the dimensions between 1-1000  $\mu\text{m}$ ”. I would like to ask the author to complete this scale bar based on terminology used (if any) at least for the particles: (i) below 1 nm, (ii) in the range of 100 nm and 1  $\mu\text{m}$ , and (iii) above 1000  $\mu\text{m}$ .
- (2) Some general parts of the thesis deal with the risk of wear debris on human health and environment. Nevertheless, it is not clear to me, based on the debris size distribution, which specific element and/or phase of studied materials may be declared restricted according to EU strategies. Therefore, I want to ask the author to provide and discuss this information, that is, to introduce the part/parts of EU strategy/strategies relevant to studied wear debris of Inconel<sup>®</sup> 625 and B<sub>4</sub>C coatings.
- (3) The description of Figure 5.60 mentions the Electroscop, but it is not clear what it is.

- (4) From page 66, the author uses in relation to Scanning Electron Microscope (SEM) the term “Chemical Mapping by Backscattered Electrons”. The related questions are the following: (i) What are the capabilities of SEM to provide information on chemical or phase composition of studied material, and (ii) Is there any difference in Chemical Mapping provided by imaging in Backscattered and Secondary electron regimes?

**Conclusion:**

In my opinion, the reviewed **doctoral thesis met the requirements** on the thesis aimed **at obtaining a doctoral degree**, and this work is ready to be defended orally in front of the respective committee. Therefore, if its author, Ing. Hadi Husain, successfully defends his thesis, I **recommend awarding him the Ph.D. title.**

*doc. Ing. Ladislav Čelko, Ph.D.*