

## Review Report on PhD Thesis

Faculty: **Faculty of Mechanical Engineering** Academic year: **2020/2021**  
**Czech Technical University in Prague**

Student: **Mgr. Barbara Nevrlá**

Doctoral study program: **Mechanical Engineering**

Field of study: **Materials Engineering**

Supervisor: **prof. RNDr. Petr Špatenka, CSc.**

Supervisor-specialist: **doc. Ing. Pavel Ctibor, Ph.D.**

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

PhD thesis title: **Geomaterials in plasma spraying**

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

The dissertation thesis main objectives were set interdisciplinary and belong to the research areas of mineralogy, materials and coatings processing technology, and physico-chemical and materials characterization. Specifically, (i) several groups of natural mineral materials (Zircon, Mullite, Diopside, Tourmaline, and Clay shales) representatives were properly selected, (ii) their plasma spray deposition parameters were successfully developed, and (iii) the produced coatings were studied in detail. The doctoral thesis objectives were completely fulfilled.

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

Undoubtedly, the issue of utilization of natural mineral materials suitable for plasma spraying, as an alternative to relatively expensive commercially produced plasma spray powders, is topical as it enables to produce industrially competitive coatings with the reliable and robust properties. The level of the analysis of the current knowledge in the field of advance materials science, specifically surface science and engineering, is very good.

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

The first part of the thesis, i.e. the theoretical part, is written in a concise and clear form. The short introduction is followed by chapters describing the theory of plasma spray technique and coating forming process, conventional feedstock materials available on market, and alternative natural mineral materials investigated in the subsequent experimental part of the thesis. The chapter on plasma spraying is predominantly focused on the introduction of water stabilized plasma and hybrid water stabilized plasma (the plasma gun recently developed at the Institute of Plasma Physics) spray processes used further for the experimental work of the thesis, rather than the introduction to the theory of relatively well-known thermal spray technologies, which can be potentially harder to understand for readers from different research areas. On the other hand, the chapter on alternative natural mineral materials is well written and clearly understandable even for readers who are not experienced in the areas of mineralogy, civil engineering, or silicate chemistry.

As it is also apparent from the results of experimental work, Kaolinite and Tourmaline material systems have been plasma sprayed and introduced in this thesis for the first time, and together with other studied natural mineral coatings contribute positively to the current state of the art of fundamental knowledge in materials science.

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

The second part of the thesis, i.e. the experimental part, is systematically divided into subchapters based on the studied types of natural mineral materials and follows the logical order of powder pre-processing, plasma spray parameters development, single splats characterization, coating deposition and its physico-chemical and materials characterization. Here especially the information on temperature-dependent phase transformations, which restricts the coating reliability in service, were clearly indicated and are valuable. The obtained results on each studied material system were briefly discussed and thoroughly summarized. In the case of Kaolinite coating trial against environmental silicate attack, I do not believe that the test found in the literature was clearly understood and disagree with the statement that the coating can survive environmental attack thermal exposition. On the other hand, I highly appreciate the detailed work on Kaolinite/ Meta-kaolinite and Clay shale powders and the role of powder pre-processing in plasma spraying.

Of studied materials, the mullite coatings are already used for certain applications in the industry, and I sincerely believe that the other geomaterials from the thesis can find proper applications as an alternative to commercially available feedstock powders.

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

The selection of methods and techniques for the study is often limited by the involved institutes ownership. Considering this fact, it can be stated that the methods and techniques were suitably designed and definitively enabled to describe the splat size and morphology, coating thermal properties, and its chemical and phase composition. Mechanical properties of the coatings were represented by the microhardness and slurry abrasion response. Nevertheless, it will be useful to complete the list of methods by near final application tests, such as, for example, pressure test, fatigue, corrosion test, etc. However, involving these tests would result in an inappropriate enlargement of the thesis, and these can be subject of further studies, if the Institute or the author plan to continue with the topic.

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

The methods designed to produce feedstock powders and plasma sprayed coatings, and to characterize their physico-chemical and material properties were suitably utilized. The data obtained from the measurements were properly presented and discussed.

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

The thesis itself is based on 140 references related to the topic but, unfortunately, most of these were published more than 5 years from now. Mgr. Barbara Nevrlá is the main author of 1 publication and the co-author of 5 publications related to the thesis topic and listed in WoS/Scopus databases. She is also the co-author of 1 contribution at the national conference. It should be noted that a higher publication activity of the doctoral student as a main author is generally expected. Nevertheless, based on the high quality of the thesis, it is concluded that the author proved the knowledge and good orientation in the thesis discipline.

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

The thesis was submitted by the author in English language; the text is easy to read and contain only a few grammar errors, which I highly appreciated. The thesis also fulfilled the criteria on formal adjustment of the doctoral thesis.

### **Questions and comments:**

- (1) It is assumed that during plasma spraying of silica-based minerals, the silica decomposes in the interaction with the plasma environment and forms amorphous silica and silicon monoxide solid phase and/or vapours. I would like to ask the author to present at least one example of mineral studied in the work to describe and discuss the reaction occurring and the mechanism of silica-based coating formation.

- (2) Most of the coatings produced from natural mineral materials studied in the thesis were found to be predominantly or partially amorphous in the as-deposited state. The question is if there exist the industrial applications where plasma sprayed amorphous coatings have advantages over the crystalline ones, or if it is always necessary to apply a proper subsequent heat treatment to ensure the coating crystalline state.
- (3) Discuss, please, at least one example of conventional coatings with comparable properties (with respect to the target application) and the potential economic benefit of the experimental coatings, that is, compare the coating (i) produced from plasma sprayed natural mineral material with heat treatment, i.e. in its fully crystalline form, and (ii) produced from commercial available feedstock powder. Can be true that with the heat treatment process of as-sprayed natural mineral coatings, the costs can be almost equal?

#### **Conclusion:**

In my opinion, the reviewed **doctoral thesis fulfilled** all 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, Mgr. Barbara Nevrlá, successfully defends her thesis, I do highly **recommend awarding her** the deserved **Ph.D. title**.

*doc. Ing. Ladislav Čelko, Ph.D.*