

## Review of doctoral PhD thesis

Thesis author: Ing. Zoya Ghanem  
Thesis topic: **THE APPLICATION OF PLASMA TREATED  
POLYETHYLENE AND GLASS FIBERS IN COMPOSITES NAD  
SANDWICHES PREPARED VIA ROTATIONAL MOLDING**  
Supervisor: prof. RNDr. Petr Špatenka, CSc.  
Institution: CTU in Prague, Faculty of Mechanical Engineering Department of  
Material Engineering

### Answers to the required contents of report:

- The aims of the thesis were achieved.
- An analysis of the current state of knowledge is sufficient.
- Although the work is more practical, in terms of theoretical contribution, the evaluation and interpretation of the effect of plasma treatment on the adhesion between fibers and the matrix from SEM images can be highlighted.
- The practical contribution of the thesis is extensive, and it can be found mainly in proving the effectiveness of plasma treatment of fibers and matrix and at the same time mastering the production technology of a glass fiber sandwich product.
- The used methods can be considered standard, available, and suitable for solving the problem.
- The methods were applied in accordance with the scope of their applicability.
- The doctoral student acquired sufficient new knowledge, e.g. in the field of production technology and testing of mechanical properties of the composite product. The doctoral student has demonstrated adequate knowledge in the given field.
- Although the results of the work are beneficial, very interesting and absolutely sufficient, the formal side of the thesis is only average. The thesis contains many typographical and grammatical errors.

### Text of Review:

The thesis deals with the application of new technology for the treatment of raw materials for the composite polymer product (sandwich). This quite new technology is low-temperature or cold plasma for the treatment of raw material surfaces. The benefit of the treatment is the improvement of the adhesion properties between connected materials. The thesis is focused on the investigation of the treatment effect on the mechanical properties, structure, and thermal properties of the treated material. The manufacturing process for sandwich composites was rotational molding. The tested materials were polyethylene powder representing the matrix after sintering, polyurethane foam used as the weight-reducing material of the composite, and glass fibers representing the reinforcement. For the sample preparation, the pilot and industrial scale equipment was used. The mechanical properties of the product were assessed by the tensile test, flexural test, impact test, falling hammer test, and debonding test. Thermal properties were investigated by differential scanning calorimetry. Structural changes were observed by optical and scanning electron microscopy.

The thesis consists of 5 chapters. The thesis contains many typewriting errors and also some grammatical errors. All errors are marked in the text of the printed version by the reviewer. The thesis has a logical structure. The range of used literature sources with 106

items is impressive. The author also uses references to her own publications in influential journals to declare the high scientific level of the results.

The thesis goals are clearly stated with the range corresponding to the doctoral thesis. The development of new technology treatment by cold plasma and its current state of the art is described deeply with respect to literature reference, including the effect on the improvement of the adhesion properties of various tested materials. Rotational molding production technology, crucial operational parameters, and its extension for the production of the sandwich product are stated in the text using references to current publications. Investigated materials, methods of measurement, and experiments are chosen correctly, and they are suitable for the achievement of the target thesis aims.

An extensive number of produced samples and experiments have been made by the author of the thesis. The student had to spend a lot of time performing such a number of variants and evaluating the results for statistical and physical interpretations. The polyethylene plates made from plasma-treated powder under the different conditions of production and treatment were investigated. The improvement of mechanical properties or changes in thermal properties of plates made from treated powder is statistically insignificant as the author expected with respect to the already published works. Important and valuable practical results were achieved by investigation of the production of composite sandwich structure products made from treated polyethylene powder and polyurethane foam, no fewer by investigation of glass fiber composite. It's just a pity that such a large number of experimental variations are not more thoroughly and systematically described and revised. Unfortunately, the reader got lost in the multitude of variants of operational parameters of production procedures and physical tests. It cannot be ruled out that the author did not miss some important connections due to this lack of systematicity.

The author of the thesis concludes that the treatment of the PE powder does not affect the thermal and morphological properties of particles, but positively affects the adhesion parameters of particles, finding out the optimal production process parameters for pilot and industrial scale, she improves the adhesion between PU and PE material in the composite sandwich product by specific treatment, also she improves the adhesion between glass fibers and PE material by specific treatment and she proves production ability of such materials in industry application.

Although the work is good written and the results are significant, during reading this work, some questions raised up that I would like to know the answer during thesis defence

- 1) Does exist any technological requirement/purpose to use inert gas or low pressure (vacuum) for the atmosphere in the mold for the rotational molding process?
- 2) MFI value, according to standard ISO 1133-1:2011 has to be referred to measurement conditions. At which temperature and loading were measured MFI of your materials Dowlextm 2629UE and Clearflex 50 U.
- 3) Why fixed values of parameters (10 RPM, angle 45°) for the production of samples by rotational molding were used, without investigation and optimization?
- 4) What was the thickness of the foam of the sandwich sample mentioned in chapter "3.3.2 PE/PU sandwich preparation"?
- 5) How the "proper distribution" of fibers in the matrix was investigated, see the last sentence in chapter 3.3.3? And how is it defined?
- 6) How was the sample surface connected/fixed to the debonding machine?
- 7) I miss the information if the samples in Figure 38 are made from treated or untreated powder.
- 8) Is there any quantifiable criteria to determine the residue of foam on an upper plate for different treatment?

- 9) Where the value 886% (improvement of debonding force) come from, mentioned in the conclusion on page 89? I did not find it in the previous text.
- 10) Is it standard mechanical behavior for a composite of similar materials that the bending stress is higher than tensile stress, see figs 84 and 85? Is there any comparison with the literature?

**Review conclusion**

Considering the importance and value of the results achieved in the thesis, there is no doubt that the thesis deserves to be called a doctoral thesis, that the author of the thesis has fulfilled all the requirements for a dissertation and that it is my pleasure to **recommend** the thesis for defence.

In Prague 25.10. 2022

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