

## Review of Doctoral Thesis

<b>1. PhD candidate</b>
Ing. Richard Sovják / Richard.Sovjak@vut.cz
<b>2. Name of PhD programme</b>
Design and Process Engineering (Mechanical Engineering Design)
<b>3. Title of PhD thesis</b>
Volumetric Method for Determining kg CO <sub>2</sub> eq. and Energy Requirements for the Production of Power Tools at an Early Stage of Product Design
<b>4. Principal supervisor</b>
doc. akad. soch. Ladislav Křenek, ArtD. / Ladislav.Krenek@vut.cz
<b>5. Co-supervisor</b>
Ing. Marie Tichá / marie.ticha@iol.cz
<b>6. Reviewer</b>
FH-Prof. Mag. Dr. Günther Grall / guenther.grall@fh-salzburg.ac.at
Salzburg University of Applied Sciences
<b>7. Overview of the scope of PhD thesis<sup>1</sup></b>
<b>Very good</b>
Justification for evaluation: The provided dissertation deals with an important problem. To find out, how to make sure developed products fulfil not only the needs of market-, user- or company-goals, instead integrate a view of future CO <sub>2</sub> -Emissions and energy-costs, is within the strategy of EU New Green Deal and United Nations Sustainable Development Goals highly demanded. The aim of the thesis was to develop a method for Industrial Designers to predict quantifiable environmental impacts in an early design stage without deeper knowledge of complex Life-Cycle-Assessment-Tools. The output of the study is clear on one side, but also unexpected on the other. The thesis proves a strong correlation from volume and CO <sub>2</sub> -Emissions/energy costs, but focussing on CO <sub>2</sub> , there is an exceptional high dependency from the place of production.
<b>8. Significance of the topic and clarity of problem statement</b>
<b>Very good</b>
Justification for evaluation: The significance of the topic and the problem are evident. To increase effectivity it is fruitful to have access to a method which helps to reflect different design-solutions in an

<sup>1</sup> Overview of the scope of PhD thesis is a short description of objectives of PhD thesis's research and summary of main findings and scientific achievements.



early stage of design conception. Since there is a lack of knowledge using methods to judge rough design models a guideline or tool to compare different solutions will help. As soon as designers are then getting feedback regarding their designs, they will learn to increase the number of design variations meeting the environmental needs.

#### **9. Knowledge of existing literature**

##### **Very good**

Justification for evaluation: In chapter 2 of the thesis there are explanations of 22 publications regarding the methods for a volumetric method for determining CO<sub>2</sub> and energy requirements for the production of power tools at an early stage of product design. These publications are chaptered in A Eco-Design Tools in Industrial Design, B Qualitative Approach, C Qualitative Approach and D Comparison of Eco-Design Tools and Methods. They provide results as well as conclusion and display the key-graphics. This overview impressively made and is a perfect basis to start from, though the interpretation and evaluation of the literature is short and limited.

#### **10. Choice of methods and technical soundness**

##### **Good**

Justification for evaluation: The methods chosen are determined by having no fear from very deep analysis. The decision to de-construct more than 130 power tools is maybe the only way to get deeper knowledge. Since 3D-Scanning is nowadays easier and faster to use it was the right physical method to combine with measuring weight and trying to find the exact definition of the material used. Since there are no regulations to producers to add material-information on to each part, this step of the method may be the most time-consuming and that one, where the most errors may have occurred. Due to the lack of alternative ways, it still may have been the right way to go.

#### **11. Quality, originality and significance of the results**

##### **Very good**

Justification for evaluation: Deeper insight into the results of the deconstruction of more than 130 power tools may have been gathered. The work also displays the lack of production- and material-information during deconstruction for recycling. Additionally, it would have been interesting to get deeper knowledge about the development and changings within the period covered by the survey. Since the tool investigated are from a time span of production from 1989 to 2018 (29 years), that information may have been fruitful too. But nevertheless, the thesis proves the most important factors for CO<sub>2</sub> emissions and energy consumption. Even if the outcome looks logical and easy in the end – the important output is the scientific prove of those correlations.

#### **12. Quality of attached papers**

##### **Good**

Justification for evaluation: Author Richard Sovjak attached links to 22 publications from 2015 to present. 16 of them were written as first Author. Four of them were shown to a broader audience at International Conferences in Finland, Bulgaria, and Austria. The latest publication regarding a major topic of this thesis has an impact factor of 3,251. The list of publications also shows the progress of the author, working towards research in the field of power tools already at an early state of his education, since either bachelor and master thesis are part of the attached papers.



**13. Overall assessment, strengths and weaknesses (based upon the above evaluation categories 8–12)**

**Very good**

Justification for evaluation: Overall the thesis "Volumetric method for determining kg CO<sub>2</sub> eq. and energy requirements for the production of power tools at an early stage of product design" is a step forward into preparing our society for the needs of environmentally friendly production of needed power tools. Especially providing methods and tools making right decisions in an early phase of product design development are efficient and needed. The strength is very clear: Making clear that volume and place of production are the most significant factors is understandable and may be integrated by designers coming up with variants of future products. On the other hand, the topic is still not fully investigated, concentrating on production is maybe just a small part of total power needs and CO<sub>2</sub>-Emissions. But nevertheless, there is an important step done, but since the product variety is immense and production is only overlooked in a rough way, there is a large field for future theses. Personally, I am very happy, that Technical University Brno is doing a great job in this research field. The tools, methods, and human power to develop these important topics are available at the University and used to bring Design, Production and therefore Society forward. Looking forward seeing more work like this.

**14. Questions and comments**

There are of course some questions left. The progress will go on and with every answer, new questions arise. The reason why the thesis focusses on production only may be described in detail. The list of deconstructed power tools could have been more detailed and the improvement and changes over that long production-period of investigated power tools would have been interesting. Since the use phase is calculated with one factor of 1000 hours for every product, it may be interesting to do some equations with other forms of usage, for example tools for private users with much less time of usage during life span.

**15. Conclusion**

PhD thesis is an independent scientific work that presents a novel solution to a significant problem in the research area and demonstrates the candidate's ability to conduct independent research.

YES

**16. Date and signature**

28/09/2022

Please note

- A. Evaluate categories 7 to 13 using the following scale: unacceptable, acceptable, satisfactory, good, very good, excellent. The qualification of 'excellent' should only be given for research in the top 3% of the research in your field of expertise.
- B. E-mail the completed form to: [Klara.Javorceko](mailto:Klara.Javorceko)

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<b>6. Reviewer</b>
doc. Ing. Lydia Sobotová, PhD. / lydia.sobotova@tuke.sk
Technická Univerzita v Košiciach
<b>7. Overview of the scope of PhD thesis<sup>1</sup></b>
<b>Very good</b>
Presented dissertation (PhD) thesis with the topic "Volumetric method for determining KG CO <sub>2</sub> EQ. and energy requirements for the production of power tools at an early stage of product design" is very relevant nowadays, when there is a requirement to reduce waste. The aim of the dissertation thesis was to develop and create new methods for determining of the impact on the environment in the early stage of product design in industrial design. In the presented thesis, the doctoral student prepared a dissertation thesis on 174 pages and together with a large number of appendices. The doctoral student introduces used 82 literary sources from quarantined magazines, book publications of important domestic and foreign authors and research literature. It is based on scientific and research works of foreign authors as well as from its own workplace and also uses professional experience from practice. The dissertation thesis is balanced in terms of content; it consists of 14 chapters that logically follow each other. The results of the PhD student's research are documented in the extensive appendix section of the appendices - "Appendices A to E" with a large number of pages and information from the experiments. An interesting part of the practice is the developed VEME program application, which uses computer applications of Monte Carlo programs, OPM program methods and other statistical methods to process results using LCA methods and other results. The final phase of the dissertation thesis analyses the impact of

<sup>1</sup> Overview of the scope of PhD thesis is a short description of objectives of PhD thesis's research and summary of main findings and scientific achievements.



recycling, landfilling and incineration, CO2 emissions and the impact of energy consumption together with economical calculations and results.

#### 8. Significance of the topic and clarity of problem statement

**Excellent**

The topic of the PhD thesis is highly relevant and related to the topic of eco-design in the design of products and production, transport, recycling, incineration and landfilling of materials from chosen 10 categories of electric tools after their end – of – life. In connection with the fact that it is necessary to develop specific recommendations for the designers of new products to minimize the carbon footprint, to improve recyclability, to reduce waste and to improve the usability of materials after their end- of- life. At the same time, it enables to reduce energy consumption in production and reduce CO2 emissions in all stages of the product's life cycle (including repairs and innovations) and the subsequent recycling of materials. In the PhD thesis, software products such as OPM, Monte Carlo model, LCA, their simulations and VEME methods and calculations for reverse technologies for the electric products after their end – of – life were effectively used. There were compared and calculated the costs of electric tools during the transport to recycling, incineration and landfilling places. At the same time, the dissertation thesis points out the advantages of eco-design for the environment and the importance of studying in this area and familiarizing designers with this issue.

#### 9. Knowledge of existing literature

**Good**

In the presented dissertation thesis, the doctoral student relies on scientific knowledge and information from the literature he cites in the work. These are 72 sources of different character, such as scientific journals of renowned publishing houses - for example, Elsevier, proceedings of international conferences, standards and decrees related to the addressed issue, as well as various Internet sources. It also uses the results of research works by foreign and domestic authors as well as its own published works. Literary sources are listed in the work according to the standard and are correctly cited. It is obvious that the problem being addressed is relatively new and the amount of available literature as well as other sources is limited. Nevertheless, it would be advisable to enrich this work with other sources of information and knowledge and not to use the so-called popular-scientific information of a basic information type such as e.g. literature 67.

#### 10. Choice of methods and technical soundness

**Excellent**

In the PhD thesis, the doctoral student uses a systemic approach to solving the given research issue. The overall procedure is logical, using several specialized methods (computer applications, scans of individual parts of materials and the tools themselves, reverse technologies. A number of time-consuming experiments, which the doctoral student worked on, are very valuable. 138 products were analyzed, classified into different categories according to certain common characterizing elements. The doctoral student used the reverse engineering method, by scanning each electrical tool used in the experiment, the 3D model was optimized and the relevant material composition was determined. The doctoral student chose the parameters and values of recycling processes, incineration and landfilling operations as well as the transport of related materials, they were statistically processed by using of LCA methods. Using Monte Carlo computer programs, the doctoral student determined energies for categories of power tools, for energy evaluation of the



product for future designs of materials for designers, determined emissions of kg CO2 equivalents for selected countries.

#### 11. Quality, originality and significance of the results

**Excellent**

The presented dissertation thesis is of a high level, it has original results. Thesis is a very good example for eco-designers, because it shows the way from the beginning of the design of individual parts to the end of their end-of-life. We can influence CO2 emissions as well as energy costs associated with transport, landfilling, recycling and incineration. The greatest contribution of the presented PhD work can be considered the fact that it deals with relatively complex widely used products, which it analyses in all phases of their life cycle. In his thesis, the doctoral student interested in and deals not only with the process of production design and with the associated energy demand, but also with the process of transportation, stacking, recycling and incineration. It compares selected components of the life cycle - landfilling, recycling, incineration in terms of their efficiency, energy consumption and their impact on the carbon footprint. The doctoral student used the VEME method, with which it is possible to calculate energy savings from the point of view of production, but also take into account the location of production and transport.

#### 12. Quality of attached papers

**Very good**

In the chapter "Current stage of the knowledge", the doctoral student gradually analyses more than 20 current scientific works, mostly from foreign journals. Each literary source is processed in a logical sequence, a short summary is created and the basic conclusions resulting from each relevant scientific publication are presented. The listed literary sources are grouped into three thematic areas - subsections, and at the end a conclusion is drawn up, i.e. generalization of acquired knowledge and basic problem areas are also identified. The doctoral student took these conclusions into account when determining his own procedure for the preparation of his dissertation work. The cited literary sources are of course also listed in the overall list of literature at the end of the thesis. Working with these literary sources is quite demanding in terms of the ability to analyze information and the ability to capture the essence in abbreviated structured form.

#### 13. Overall assessment, strengths and weaknesses (based upon the above evaluation categories 8-12)

**Very good**

The submitted doctoral thesis has several strengths, among which it is possible to include: 1. The very selection of a highly current topic with an effort to obtain scientifically confirmed results that can be applied in the eco-design process. 2. Selection of a category of products that are widely used in technical practice and basically known to the general technical public. 3. A very suitable combination of tools and computer applications for problem solving - LCA method, OPM, Monte Carlo method. 4. It is possible to highly appreciate the experimental part of the work, namely 134 test samples, i.e. products and their classification into the relevant categories. It is also possible to make a state that part of the work, for example scanning individual parts of products and creating their 3D models to determine the volume, is very laborious. 5. For the main contribution can be considered the confirmation of the hypothesis that it is possible to determine the energy requirements for the production of selected types of products based on the volume characteristics of the given category of products. The weakness of the presented work is the use of some literary



sources mentioned in the previous parts. It is also possible to consider the quality of some images taken from used literary sources as a formal deficiency , for example Fig. 2-9.

#### 14. Questions and comments

I have a few questions for the doctoral student: 1. How complicated do you think it is to correctly determine the material of individual components and parts of products if you do not have all the information about them available, and you do not have this information. In your opinion, what other types of software could be used? 2. What do you think is the biggest problem with eco-design of products? 3. It is possible to use your methodology for other types of products, e.g. white goods, computers, or other groups of products? I have a note about the comment: The work is prepared according to the requirements placed on this type of work, both in terms of content and form. It is at the required language and professional level.

#### 15. Conclusion

PhD thesis is an independent scientific work that presents a novel solution to a significant problem in the research area and demonstrates the candidate's ability to conduct independent research.

**YES**

#### 16. Date and signature

**28/09/2022**

Please note

- A. Evaluate categories 7 to 13 using the following scale: unacceptable, acceptable, satisfactory, good, very good, excellent. The qualification of 'excellent' should only be given for a PhD Thesis in the top 3% of the research in your field of expertise.
- B. E-mail the completed form to: [Klara.Javorcekova@vut.cz](mailto:Klara.Javorcekova@vut.cz)

## Principal supervisor's final report on the PhD study

<b>1. PhD candidate</b>
Ing. et Ing. Richard Sovják / richard.sovjak@vut.cz
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<b>5. Co-supervisor</b>
Ing. Marie Tichá / marie.ticha@lca-cz.cz
<b>6. Stays at other institutions (min. 7 days)</b>
Institution / Country / From / To
<b>7. Teaching activities</b>
Course name / Total number of hours Design of Instruments and Devices (YDI) Advanced Materials in Design (YAM) Design Project Concept (YE1) Design Project Development (YE2) Workshop - Industrial Design II (YA6) Workshop - Industrial Design I (YA5) Modelling - Relief Design (YML) Modelling - Spatial Design (YM1) Diploma Project I (ZDP) Diploma Project II (ZD5) Workshop - Bachelor Project (6AP) Workshop - Experimental Design (YED-A) Workshop - Pre-diploma Project (YAD) Workshop - Industrial Design V (YPP) Workshop - Graphic Design (YG1) Mentor of 15 bachelors thesis

## **8. List of main publications**

### **Papers in journals with IF:**

SOVJÁK, Richard, Marie TICHÁ and Eva FRIDRICHOVÁ. The Volumetric Method Describing the Life Cycle of Power Tools during Their Production with Different Ends of Life. *Sustainability*. 2022, 14(3). ISSN 2071-1050. Available on: doi:10.3390/su14031498 (**Impact Factor = 3.251, Q2**)

### **Papers in journals without IF:**

SOVJÁK, Richard. Studying Knowledge about Eco-design Tools at Department of Industrial Design, Brno University of Technology. *GRANT Journal*. 2017, 5(1), 72-75. ISSN 1805-0638.

### **Papers at conferences:**

SOVJÁK, Richard. Volumetric Methodology for the Determination of CO<sub>2</sub> Emissions and Energy Requirements for the Production of Products at the Early Stage of Product Design. In: *NORDSCI Social, Sciences Conference July 17 – 19 2018*. Helsinki, 2018.

SOVJÁK, Richard. Summary of Eco-Design Tools for Industrial Designers. In: *Book of Proceedings of 57th International Conference of Machine Design Departments*. Pilsen, 2016, p. 399-404. ISBN 978-80-261-0609-8.

SOVJÁK, Richard, Martin ONDRA and Markéta ZDVIHALOVÁ. Method of Mock-up Scanning for Acceleration of Design Process. In: *Book of Proceedings of 56th International Conference of Machine Design Departments*. Nitra, 2015, p. 229-232. ISBN 978-80-552-1377-4.

## **9. Assessment of the supervision process**

### **Excellent**

Dissertation is thematically anchored in the overlap of industrial design in the field of ecodesign methodology and environmental impact factors of industrial product production. Within this framework, the author created a new unique method VEME, whose methodology for determining the environmental impact in the early stages of product design is based on the volume characteristics and structural, material composition of the product. The method, which is intended for the product category of hand tools, was verified by extensive measurements, which analyzed the volume and material data of 134 pieces of tools.

## **10. Assessment of the candidate's ability to work independently**

### **Excellent**

The candidate worked on his dissertation more or less completely independently. As an industrial designer, I do not feel competent enough to assess specific mathematical, chemical or physical aspects of the proposed methodology. For this reason, I trust the professional guidance of the doctoral student by a supervisor specialist from the Faculty of Environment UJEP Ústí nad Labem, Ing. Marie Tichá, who focuses closely on the LCA method.



**11. Assessment of the contribution that the research makes to knowledge in the field**

**Very good**

One of a number of monitored factors in solutions in the field of industrial design are the environmental impacts of products or services. The proposed methodology should enable the designer who creates the external lines of the product to verify in a simple way the potential environmental impacts of his design and possibly correct it. This can be the first step in the process of determining and optimizing the degree of environmental impact in the production of the final product and also an important marketing tool, is a kind of tongue on the scales in consumer decision, if, for example, the manufacturer can state a favorable value on the sales packaging. The method will have meaning and a positive impact especially in the case of large companies and large-scale production, where even a small reduction in energy for production and emissions in the production of one piece of tools can bring significant improvements to the global manufacturer.

**12. Other comments**

none

**13. Conclusion**

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**YES**

**14. Date and signature**

28/02/2022

Please note

- A. Evaluate categories 9 to 11 using the following scale: unacceptable, acceptable, satisfactory, good, very good, excellent.
- B. In each category 9 to 11 explain reasons for evaluation using between 100–200 words.
- C. E-mail the completed form to: [Klara.Javorcekkova@vut.cz](mailto:Klara.Javorcekkova@vut.cz)