

REVIEW

of the doctoral dissertation entitled:

Method of selecting an optimal bucket filling process for automation of the loading process in wheel loaders

by Mr. Jörg André Lommatsch, M. Eng.

1. Legal basis - Letter of July 21, 2023, W10/D/69/2023 and Contract for specific work No. 31/07/PRR/2023, concluded between Prof. Dr. Eng. Andrzej Ożyhar, Vice-Rector for Science of Wrocław University of Science and Technology and the undersigned.
2. Short characteristics of the dissertation

2.1 Basic information

The doctoral dissertation submitted for evaluation was written by Mr. Jörg André Lommatsch, M. Eng., dissertation supervisor is Prof. Dr.-Eng. Piotr Dudziński, Wrocław University of Science and Technology, the second supervisor is Prof. Dr.-Eng. Alfred Ulrich, Cologne University of Applied Sciences, Germany, assistant supervisor is Dr. Aleksander Skurjat, Wrocław University of Science and Technology. The dissertation has been divided into 7 numbered elements, including chapters. It also contains abstract, list of abbreviations, indexes, list of tables, list of figures, formula directory as well as the bibliography and additionally contains attachments.

2.2 Subject matter and scope of the dissertation

The dissertation deals with the topic related to the process of filling the bucket of a wheel loader, which is one of the main issues in the operation of working machines such as a loader or excavator. Research aimed at reducing energy consumption and improving the efficiency of the process of filling a bucket of a loader is carried out in only a few centers in the world and concerns both the filling process itself and other areas, e.g. optimal technique of work (handling) of the loader or assistance systems and automation of the loader's work. One of the important aspects of the issues addressed by the Author of the dissertation is obtaining energy-efficient filling processes for different bulk materials.

The currently used methods are still not perfect, which is why new, more favorable solutions in this area are sought. In addition, it is important to conduct research towards obtaining a model description of the filling process, which can be the basis for control algorithms for the assistance system or for an autonomous loader. This is confirmed by the numerous literature on the subject, discussed and quoted by the author of the dissertation. In the light of the above, the reviewer considers that the subject of the dissertation is current and important from the point of view of the development of the scientific discipline.

2.1.2 The aim of the doctoral dissertation

The aim of the dissertation was to answer the following questions:

- how can bucket filling processes be designed for energy-saving operation of a loader;
- how can resource-saving filling of a loading bucket be implemented?
- is it possible to integrate the assistance system into a machine control system.

2.1.3 The scope of the doctoral dissertation

The dissertation includes: analysis of the state of the art, analysis of wheel loader operation in practice, experimental research, analysis of research results, development of the concept of an intelligent system for optimal bucket filling, summary and conclusions.

2.3 Methods

The Author's research was carried out on the following measurement and research stands:

- stand-demonstrator based on Avant 218 loader;
- laboratory test bench.

The research was carried out using three different bulk materials: sand, sand-gravel mixture as well as basalt. The research was carried out for 2 different loading strategies: "slice" and "stairs". The following parameters of the filling process were measured: fill level, required energy for loading.

2.3.1 Comments

2.3.1.1 On page 63 the Author mentioned „more than 350 tests“. It would be of help for a reader to include a table summarizing the test campaign (variants, repetitions, etc.) How about repetitions of test variants, how many of them has the Authors performed?

2.3.1.2 There is no deeper, scientific justification for the choice of research materials.

2.3.1.3 What is Author's contribution to the experimental setup used in this work? Has the Author designed and/or built, eventually modified the test rig and the measurement equipment for His specific purposes?

2.4 Results

The research results are included in Chapter 5. They are presented both in tabular (numerical) form and graphically, on charts.

2.4.1 Comments

2.4.1.1 Page 79, „The geometric shape ...“, this is an unproven hypothesis rather than a conclusion from research. The influence of grain geometry has not been studied. Yes, it is a valuable observation and may be an inspiration for future research.

3 A general assessment of the doctoral dissertation

- 3.1 The dissertation is an original solution to the undertaken scientific problem carried out on the basis of Author's research as well as analysis of the results of this research. Mr. Lommatsch has demonstrated extensive theoretical knowledge in the scientific discipline of mechanical engineering and has also proven the ability to independently conduct scientific research. As mentioned earlier, the selected topic of the dissertation is still valid and important, and the results and conclusions presented in the dissertation are an original and significant impact on the development of the discipline of mechanical engineering.
- 3.2 The approach to the problem presented in the doctoral dissertation is interesting and original. The approach to the problem of the analysis of the bucket filling process in order to obtain the optimal strategy or method of filling is noteworthy due to the scarcity of research results in this area, as well as the importance of this issue in practice (work of the loader operator). The test stand with instrumentation used in the doctoral thesis deserves special attention.
- 3.3 The promoting institution played also an important role. At the Faculty of Mechanical Engineering of the Wrocław University of Technology, research has been carried out in the field of construction and operation of working machines, in particular wheel loaders, for years. The eminent achievements and many years of experience of the supervisor, Prof. Piotr Dudziński in the field of research on loaders contributed to the high level of the dissertation. In addition, an important element in favor of a high assessment of the quality of work is the fact that it was created in international and inter-university cooperation.

3.4 The results presented in the doctoral dissertation of Mr. Jörg André Lommatsch have application significance due to the approach to solving the aimed problem. In the opinion of the reviewer, it is advisable to conduct further research in the considered area.

4 Detailed comments and discussion

- 4.1 The thesis of the work is trivial. More specific scientific aspects needed to be highlighted
- 4.2 Page 59, 60, the definition of the angle of repose is unclear, neither is the test for this parameter described clearly
- 4.3 Where is the ML (Machine Learning) applied in the dissertation? It is important since the Author has indicated ML as one of the keywords.
- 4.4 A summary of the state of the art, described in Chapters 2 and 4, should be included in the Chapter 3. Objective
- 4.5 Page 18, „This dissertation will build on and intelligently extend the assisting systems... „. In fact, this dissertation may help to.

5 Evaluation of the editorial elaboration and presentation of the dissertation

5.1 The doctoral dissertation by Mr. Jörg André Lommatsch, M. Eng has been written in a language that contains specialized vocabulary, the style of the text is correct, although there are passages with minor typographical errors (see 4. Detailed comments and discussion in this document).

5.2 The dissertation contains a total of 7 numbered elements, including 4 chapters. In addition, the dissertation contains the required formal elements and attachments, a list of illustrations, tables and formulas as well as a list of references. According to the reviewer, it is not advisable to include tables containing technical data of the devices used in the research in the doctoral dissertation.

5.3 Generally, the language requires some minor corrections for its style and grammar. It is suggested to do the text edit if the Author decides to publish His dissertation in a form of a monograph.

5.4 Detailed comments

5.4.1 Has the Author asked for permissions to include illustrations taken from published papers/books? For instance, Fig. 1.3 comes from a SAE Paper. The SAE strongly requires copyright permissions prior to use of their content in any form.

5.4.2 The chapter 2.1 should be divided into several subchapters

5.4.3 Decimals should be separated by a comma, not a period: e.g. page 9, "1.0" should be "1,0".

5.4.4 Chapter 2.3 Efficient loading strategies is divided into elements, which are not numbered.

5.4.5 The author uses the present tense, e.g. "An ultrasonic sensor (...) is used". According to the reviewer, the perfect tense ("has been used") should have been used.

5.4.6 The Chapter 4.3.1.1 is divided into several subchapters, but not numbered. Moreover, the Author uses bold and underline characters, which are somehow confusing for the reader. For example, a sentence on page 39, „On the other side...wall are important‘. This is not a title of a part/subchapter of the body text, but is undelined.

5.4.7 The comments on the editorial work of the dissertation quoted here do not diminish the scientific value of the reviewed work. The reviewer's suggestion is to take these comments into account if you intend to publish fragments of the dissertation in the form of, for example, a monograph.

6 Minor comments

6.1 Page VII, subscripts are a calque from German, e.g. m_{Gesamt} , should be in English, m_{Total}

6.2 Page 1, Energy expedition J – is it a symbol or an unit [Joule]

6.3 Page 2, „the upper edge...of the motor“, should be „of the engine“

6.4 Page 3, „...naturally limited load capacity of humans“, does the Author mean *human factor*?

6.5 Page 4, „Research results show...“, missing reference

6.6 Page 4, „...significant cost factor from up to 40%“, 40% of what?

6.7 Page 5, missing references

6.8 Page 6, „The Smart Loader research project... and cloud“, what does the Author mean writing „cloud“? Data cloud?

6.9 Page 6, „never the less“ should be nevertheless

6.10 Page 9, „He“ should be „Hemami“, full name instead of a pronoun *he*

6.11 Figure 2-4, labels hardly readable

6.12 Figure 2-8, left graph – hardly readable

6.13 Page 16, „wear cost“, better should be „the cost of worn parts“

6.14 Page 17, missing references

6.15 Page 18, missing references

6.16 Figure 4-12, hardly readable

6.17 Figure 4-14 not informative, a schematic would be better

6.18 Figure 4-16, 4-17 and 4-18 symbols hardly readable, indexes not readable

6.19 Page 40, units: „N/mm²“ should be „N/m²“ (of course, recalculated)

6.20 Pages 47 – 48, bullet list from 1 to 5, each should start with a capital letter

6.21 Page 60, „Trajektorie“ should be „Trajectories“

6.22 Page 62, „...too great“ should be „too high“

6.23 Page 63, „As a result of the test...“, which test does the Author mean?

- 6.24 Page 70, „The two loading strategies (...) are also...“, instead of „are“ should be „have been“
- 6.25 Page 71, a portion of text in German, should be translated into English
- 6.26 Page 76, „are“ should be „have been“
- 6.27 Page 79, what does the Author mean „stacatto“? (the reviewer used to play the piano in his youth...)
- 6.28 Page 79, „...to lift the kinematics“- unclear
- 6.29 Page 81, „Summary“ of what, of results?
- 6.30 Page 90, caption to Figure 6-6, „Flowchart of bucket filling“, missing „of“
- 6.31 Page 97, Laboratory test rig – labels in this figure are hardly readable

7 Final conclusion

It is stated that the doctoral dissertation „Method of selecting an optimal bucket filling process for automation of the loading process in wheel loaders“ by Mr. Jörg André Lommatsch, M. Eng., meets the requirements for doctoral dissertations, specified in article 13 section 1 of the Act of March 4, 2003 on academic degrees and academic titles, and on degrees and titles in the field of art (Dz. Ustaw nr 65 poz. 595, as amended).

The undersigned requests that the Author of the doctoral dissertation, Mr. Jörg André Lommatsch, M. Eng., be admitted to the next stages of the doctoral procedure.

Jarosław Pytka