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Review

of the doctoral dissertation by Ms. Selma Gütmen, M.Sc., titled: *"A Novel Decision-Making Framework for Robust-Reliable Aggregate Production Planning Problem"*, written under the supervision of Dr. habil. Gerhard-Wilhelm Weber, Prof. PUT, and co-supervised by Assist. Prof. Erfan Babaee Tirkolaee.

1. Basis for Preparing the Review

The formal basis for preparing this review is the letter from the Dean of the Faculty of Engineering Management at Poznan University of Technology, Dr. hab. Marcin Butlewski, Prof. PUT, dated April 30, 2025, in which I was appointed as a reviewer of the doctoral dissertation of Ms. Selma Gütmen, M.Sc.

The academic basis for this evaluation is the doctoral dissertation titled *"A Novel Decision-Making Framework for Robust-Reliable Aggregate Production Planning Problem"*, written under the supervision of Dr. habil. Gerhard-Wilhelm Weber, Prof. PUT, and co-supervised by Assist. Prof. Erfan Babaee Tirkolaee.

In this review, I evaluated the key aspects of the dissertation, including the choice and justification of the research topic, research goals, hypotheses, research questions, the scope of the thesis, sources of information, and research methods. I also assessed the structure and content of the dissertation, as well as the presented results. In the final part, I provided a concluding evaluation of the entire dissertation.

2. Research Problem and Justification for the Dissertation Topic

Modern enterprises, in order to meet the emerging market challenges and respond to the production-related risks, must implement methods that support rational and well-balanced decision-making. This requires a comprehensive and systematic approach that considers both the dynamic nature of the market and the multi-criteria nature of the decision-making process.

In this context, the issue of Aggregate Production Planning (APP) is of particular importance, as it is a key element of operational management in the manufacturing companies.

This dissertation by Ms. Selma Gütmen fits well within this research area. Its main goal is to develop a new approach to Aggregate Production Planning (APP) that takes into account human factors (HF), which are often overlooked in traditional production models. The core research idea is to integrate human aspects into decision-making processes in order to reduce costs and increase the reliability of the production system under conditions of fluctuating demand. This approach

responds to modern challenges related to the need to combine advanced technologies with human aspects in the production management.

The research problem arises from a gap in the literature identified by the Author, concerning the need to include human factors in APP. Traditional models focus mainly on technical aspects and automation, often ignoring the human role, which remains essential in a rapidly changing production environment. The Author recognized both a theoretical gap, referring to the lack of integration between human aspects and production processes and a practical gap, which involves the absence of tools effectively implementing such solutions in real production settings. This motivated her to develop a new decision-making model that includes human factors and addresses the challenges of modern production systems.

It should be noted that the research by MSc Selma Gütmen is a response to the growing need for innovative ways to manage production, where human aspects are treated as equally important as technology. Including human factors in decision-making helps improve the reliability of the system and reduce costs, which is very important for today's economic demands and sustainable development. The use of a multi-criteria approach gives the research both theoretical and practical value, making it a valuable contribution to the development of modern production strategies.

In my opinion, both the main and the applied objectives are very ambitious and well justified, as they address a little-known problem of integrating human factors into Aggregate Production Planning (APP) under conditions of changing demand. It is especially important to highlight their innovative and timely nature. The proposed HF-APP model is a new decision-making tool that allows human aspects to be included in the aggregate production planning process, while also adjusting production capacity to the dynamic market conditions.

The developed decision-making model for APP is highly relevant in the context of today's production challenges. It supports more accurate production planning and helps manage risks related to the uncertainty of human factors. By using this tool, companies can not only improve the efficiency and effectiveness of their production processes but also optimize the use of human resources, which directly contributes to the better operational performance.

Next, the PhD candidate defines the research problem:

"The problem is considering a robust-reliable multi-period and multi-objective APP problem to produce, e.g., more than one product in four weeks of a year with market uncertainty, especially, under uncertain demand and uncertainties of human factors. Moreover, the stability of the system (which can be improved through providing the options of overtime and outsourcing) is defined as the ability to meet the customers demand, especially based on the JIT production policy." (p. 17)

In my opinion, the presented problem is well thought-out and helps organize the structure of the research process, as it is focused on solving an important scientific issue. However, a small weakness lies in the way the research problem is written. The sentences are too complex and include unnecessary parts, which reduces their clarity and precision. In particular, there is no clear cause-and-effect link between the described problem (market uncertainty and human factors) and the research objective (developing a model). This makes the interpretation of the problem more difficult.

The presented research problem served as the basis for formulating the main research hypothesis:

"The inclusion of Human Factors (or Human Resource Management operations) into APP leads to significant advancements of a company by optimised production planning, thus, for a modern economy, in terms of the 2 goals of cost minimisation, reliability maximisation." (p. 18)

This hypothesis was broken down into eight research questions:
RQ1 – What (which variables) are "Human Factors" with a possible impact on Aggregate Production Planning?
RQ2 – What input and output variables are crucial for cost-efficient and reliable decision-making?
RQ3 – What are the intercultural and multidisciplinary constraints for data collection?
RQ4 – How to process data obtained from the MQ?
RQ5 – What is the relation between HFs and the reliability and cost criteria?
RQ6 – How to include and cope with uncertainty in APP?
RQ7 – What is the impact of HFs on the quality/efficiency of APP and its results?
RQ8 – What are the managerial implications of APP?
In my opinion, the presented hypothesis is well formulated, as it clearly shows the scientific goal — to study the impact of integrating human factors into Aggregate Production Planning (APP) on cost minimization and reliability maximization. This is highly relevant to modern production management challenges. The research questions are thoughtful and comprehensive, covering both the identification of key variables and practical aspects such as data processing and the analysis of how human factors affect the efficiency and reliability of production systems.
In conclusion, I believe the PhD candidate has skilfully planned the research process, creating a well-thought-out and well-justified structure that allowed her to achieve the intended results.

4. Scope of the Dissertation, Information Sources, and Research Methods
The scope of the dissertation includes an analysis of the problem of multi-period, multi-criteria Aggregate Production Planning (APP) under market uncertainty, especially in the context of fluctuating demand and uncertainty related to human factors. The main research assumptions focus on minimizing total costs and maximizing the reliability of the production system, which aligns with the principles of sustainable economic and social development.
Ms. Selma Gütmen has successfully attempted to create a solid and reliable decision-making framework that takes human factors into account within dynamic market conditions. In her research, the PhD candidate applied a range of advanced research methods, combining both simulation-based and analytical approaches. In particular, she made use of Simulation and Data Mining, Goal and Fuzzy Programming, Optimization and Multi-Criteria Modelling, and Sensitivity Analysis.
I believe that the methods used in the study demonstrate a high level of complexity and precision in addressing decision-making challenges in the industrial sector, taking into account both technological and human aspects. Unlike previous studies, which focused mainly on the industrial dimension (e.g., issues related to machines, technology, or production capacity), Ms. Selma Gütmen has taken an innovative approach by including human-related factors and the sustainability of the production system in the decision-making process.
I highly value this research approach, as the inclusion of human factors and sustainability aspects in decision processes is an important step toward modern production management, especially in the context of rapidly changing industrial conditions.
It can therefore be emphasized that the research methods proposed by the PhD candidate represent an innovative and comprehensive approach to decision-making in the industrial sector. The inclusion of human aspects and sustainable development in the decision-making process is a step toward more holistic production management, which deserves recognition.

It should also be noted that the theoretical and exploratory part of the dissertation is based on a rich and diverse body of literature. The PhD candidate used over 200 sources, including both scientific journal articles and monographs. The selection and scope of the literature are appropriate and well thought-out. The critical analysis of the materials enabled the author to formulate her own conclusions and critical reflections.

The literature reviewed covers a wide range of topics related to the production planning, human resource management, and modern optimization methods. The literature review was conducted thoroughly and highlights existing research gaps in the integration of human factors into APP, which justifies the choice of this research topic. The author relies on recognized academic sources as well as the most recent studies, which demonstrates the relevance and timeliness of her research approach.

5. Structure and Content of the Dissertation

Moving on to the content evaluation of the reviewed dissertation, I would like to highlight that the chosen topic is very important and interesting from the perspective of modern business. The dissertation focuses on the role of human factors in Aggregate Production Planning (APP) and their impact on the reliability and efficiency of production systems. I believe that the work has significant cognitive value, as it helps to better understand this issue and also offers a practical and methodological approach that can be useful in today's economic environment.

The PhD dissertation by Ms. Selma Gütmen consists of four chapters, seven appendices, and a bibliography. However, it is missing the typical accepted layout of a doctoral thesis like separate introduction not being the chapter 1 and a final overall conclusion. This makes the structure of the work different from the usual editorial standards for this type of academic writing.

Attention should be drawn to Appendices C–G, which include, among others, source codes (GAMS), MARS models, detailed mathematical formulas, calculation results, and questionnaire data. These materials complement the main content, but their presentation makes interpretation difficult. The tables in these sections are often hard to read, sometimes missing clear titles, references to the main text, and explanatory comments that would clarify the context and meaning of the data. There is a lack of consistency in labelling and information structure, which negatively affects the transparency of the analytical process and the verifiability of the results.

The entire dissertation consists of 173 pages, of which 87 pages make up the main part of the thesis. The text includes 32 tables and 8 figures, which to some extent enhance the cognitive value of the work.

Considering the scientific and practical goals, the hypothesis, and the research questions, the structure of the dissertation can be considered appropriate. All parts form a coherent, complementary, and logical whole, clearly focused on achieving the main objectives of the research.

Chapter I, titled "Introduction", introduces the reader to the subject of the dissertation by presenting the research background, motivation, objectives, and main research assumptions. It focuses on the issue of Aggregate Production Planning (APP) in the context of human factors and their impact on the reliability and efficiency of production systems. The author highlights the importance of including human aspects in planning processes and presents the concept of innovative decision-making frameworks aimed at improving production reliability and flexibility.

This chapter also includes the research assumptions and questions which form the foundation for further analysis. In my opinion, the chapter introduces the topic in a clear and structured way,

starting from a general overview and then moving onto more specific research aspects. The author clearly emphasizes the importance of human factors in APP, which is an innovative and well-justified approach in light of today's production challenges. Furthermore, this section includes clearly defined research objectives and hypotheses, which help the reader to understand the main purpose of the study.

Despite the high overall assessment of the chapter, I would like to point out a few shortcomings to the PhD candidate.

First of all, there is no clear and complete definition of Aggregate Production Planning (APP). The author defines APP as *"an instrument or method to find and establish an equilibrium or approximate equilibrium between capacity and demand in PP"* (p. 11), which is imprecise and does not fully explain the role of APP in the production planning process. Such a general description may be difficult to understand for readers who are less familiar with the topic.

Another weakness is the overly general approach to the issue of human factors. The author writes: *"Human factors remain essential for effective and sustainable production, but it is not easy to effectively impose the influence of human-related factors"* (p. 12). However, this part lacks practical examples or explanations of how human factors actually affect production in the real industrial conditions. Adding a brief description could significantly improve the cognitive value of this section.

In addition, the description of the research methods, such as MARS and WGP (p. 18), is incomplete. There is no short explanation of these techniques or justification for their use in the context of APP. The sentence: *"The inclusion of new parameters (mnj, TRCkn, and Rtjnk) into APP through cost and reliability objective functions will be applied"* (p. 19), sounds too technical and should be clearly explained in simpler terms.

Despite some shortcomings, I highly evaluate the substantive value of Chapter I. It provides a solid and well-thought-out introduction to the research topic, logically presents the objectives and hypotheses, and clearly justifies the need to integrate human factors into production processes. A strong point is the structured presentation of the research motivation and the effort to link theoretical concepts with practical challenges in modern production.

In Chapter II, Ms. Selma Gütmen presents a literature review on Aggregate Production Planning (APP) and optimization methods. The chapter outlines the historical development of APP theory, discussing both classical approaches (deterministic and stochastic) and modern concepts such as fuzzy modeling and robust optimization. The author also draws attention to the importance of human factors in APP and the evolving role of industry in the context of Industry 4.0 and 5.0.

At the end of the literature review, the author identifies research gaps, pointing to the need for further studies on including human aspects in the production processes.

In my opinion, Chapter II is characterized by a high degree of structure and logical content organization. The author effectively presents the evolution of approaches to Aggregate Production Planning (APP), comparing classical methods with modern optimization techniques. A particularly noteworthy section is the one dedicated to Industry 4.0 and 5.0 (pp. 31–32), where the author highlights the necessity of integrating human factors in the context of automation and digitalization of production processes. Another strong point of this chapter is the discussion of the importance of human factors in APP, which gives the research both a contemporary and practical dimension.

However, I have identified a few aspects that may require further attention. For example, there is a lack of explanation regarding the practical differences between deterministic and stochastic approaches in APP. The author writes: *"Deterministic APP models assume that all parameters*

are known and fixed at the start, while stochastic models incorporate randomness and uncertainty" (p. 25). However, this lacks an elaboration on the real-world implications of both approaches. It would be valuable to explain in which situations each approach is more effective and to provide examples of their use in industrial settings. Such clarification would help the reader to better understand the rationale behind the methodological choices made later in the dissertation.

A similar issue applies to the part discussing Industry 5.0. The candidate states: *"Industry 5.0 emphasizes the human-centric approach in production environments, focusing on collaboration between humans and intelligent systems"* (p. 32). I believe this section lacks an analysis of the practical challenges associated with implementing this concept in enterprises. It would be useful to provide examples of its adoption in various economic sectors and to discuss the difficulties the companies may face when integrating human workers with intelligent systems.

A minor shortcoming is also the lack of a critical perspective on the reviewed literature. While the selection of sources is appropriate, the chapter would benefit from a more analytical discussion of differing viewpoints or gaps in the existing research.

In summary, I would still like to emphasize that Chapter II offers a well-structured literature review, presenting both classical and modern approaches to Aggregate Production Planning. The discussion of human factors in the context of Industry 4.0 and 5.0 is a clear strength of this part of the dissertation.

In Chapter III of the doctoral dissertation, Ms. Selma Gütmen presents the research methodology, which includes the construction of a decision-making model for Aggregate Production Planning (APP) that incorporates human factors. The author provides a detailed description of the analytical tools used, such as fuzzy programming, Weighted Goal Programming (WGP), and Multivariate Adaptive Regression Splines (MARS), which are applied to identify key variables influencing the efficiency and reliability of the production system.

The empirical data was obtained through original questionnaires (MQ1 and MQ2), and then transformed into the model parameters. The chapter is logically structured and generally clear; however, at times it includes an excessive amount of technical detail, which could have been more appropriately placed in the appendices. An additional shortcoming is the absence of graphical diagrams that could help the reader better understand the structure of the model, as well as the use of relatively technical and specialized language in certain sections.

Moreover, the chapter does not indicate whether the MQ1 and MQ2 questionnaires were validated (e.g., through reliability analysis, validity testing, or scaling procedures). This omission may weaken the credibility of the conclusions drawn from the MARS analysis, particularly if the input data was not properly prepared. There is also no information on the number of respondents, the method of their selection, the industry sector, or the country of origin. This limits the possibility of assessing the representativeness and generalizability of the results.

Furthermore, the author does not clearly explain how the outcomes of the MARS analysis were translated into specific parameter values for the model. This may raise concerns about the transparency of the mathematical modelling process. The chapter also lacks key statistical indicators such as goodness-of-fit measures, prediction errors, or R^2 values. It is not stated whether the data were normalized prior to analysis.

In the WGP model, there is no information about the source of the weights assigned to the objective functions. The author does not specify whether these weights were based on expert opinion or derived from empirical data.

Despite these issues, the methodology is well justified and demonstrates a conscious, interdisciplinary approach to the research problem.

In Chapter IV, Ms. Selma Gütmen addresses in detail all the issues outlined in the introduction, consistently pursuing the research objectives and verifying the stated hypothesis. This part is dedicated to the integration of human factors into Aggregate Production Planning (APP). The author discusses the results of the sensitivity analysis, practical implications, research limitations, and provides answers to the research questions. Special emphasis is placed on the impact of human factors on the reliability, cost, and efficiency of production systems, as well as on the development of decision-making frameworks to support managers under conditions of uncertainty.

It is important to note that the answers to each research question are comprehensive, supported by empirical analysis and practical conclusions.

In my opinion, the considerations presented in this chapter demonstrate a very high substantive quality. The author bases her findings on solid theoretical and empirical foundations. It is worth highlighting that the study employs advanced analytical methods, such as MARS, sensitivity analysis, fuzzy logic, and bi-criteria modelling. Moreover, a strong aspect of this part of the dissertation is the presentation of specific results and their interpretations, which indicate a deep understanding of the topic. The content is enriched with numerous clear tables and charts, which enhance the cognitive and scientific value of the work.

The chapter is characterized by a high scientific and empirical standard, with clearly defined and achieved research objectives. The author applied a broad interdisciplinary and cross-cultural approach and innovatively incorporated human factors into Aggregate Production Planning (APP). Minor shortcomings include the high complexity of the applied models, which may pose challenges for implementation in smaller enterprises, and the reliance on a single case study, which limits the generalizability of the results.

However, it should be emphasized that the chapter makes a very valuable contribution to the field of production management, especially in terms of integrating human aspects with the technical and economic requirements of the modern production systems.

In conclusion, the doctoral dissertation by Ms. Selma Gütmen demonstrates the author's strong research competence. She successfully combines theory with practice in a thoughtful and interdisciplinary way, creating innovative decision-making frameworks for production planning that incorporate human factors. This work makes a significant contribution to the development of management sciences, offering a practical approach to integrating operational efficiency, reliability, and human-centred management within the context of contemporary industry.

In the context of the presented results, I would kindly ask the PhD candidate to address the following questions:

1. Could you explain how the sensitivity analysis was conducted for the variables related to human factors, and what practical conclusions can be drawn from this analysis for management staff?
2. Why is the inclusion of human factors in production planning important in the context of Industry 5.0, and what benefits does it bring to organizations?
3. In your dissertation, you mention the international nature of the research team, which included collaborators from several countries, such as Poland, Turkey, Germany, Iran, and Singapore. Could you clarify the exact nature of this collaboration and how it influenced the research project? What was the project about?

6. Research Results of the Dissertation

After analyzing the content of the dissertation, it can be stated that the work has a strong interdisciplinary character. It fits primarily within the field of management and quality sciences, with particular emphasis on management engineering. The author focuses on the problem of Aggregate Production Planning (APP), while considering not only technical and economic aspects, but also human factors such as employee satisfaction, skills, fatigue, work flexibility, and learning dynamics. This approach is an innovative attempt to integrate engineering tools (such as fuzzy programming, optimization models, and data analysis) with a social and organizational perspective.

It is worth noting that the dissertation goes beyond a single academic discipline. The work includes elements of data analysis, simulation, and programming, which indicate connections with technical informatics. Additionally, the practical context of the study, being based in a real production environment and involving operational process analysis,places the dissertation within the scope of mechanical and production engineering. The inclusion of workers' psychophysical and cognitive factors links the research to work psychology, and the discussion of system reliability and the impact of human error is also relevant to the field of safety science.

All of this makes the dissertation a strong example of interdisciplinary research that combines system-based, technical, and human-centered approaches in the practice of management.

I would like also to emphasize that, in my opinion, the dissertation by Ms. Selma Gütmen is an ambitious and demanding academic work, marked by a high level of complexity, significant effort, and an interdisciplinary character. Its scientific and practical value is unquestionable, and the topic addressed is both timely and innovative, highly relevant to modern production management systems.

The key strengths of the dissertation include:

- **The relevance and importance of the topic**, focused on integrating human factors into Aggregate Production Planning (APP), which responds to the challenges of Industry 5.0.
- **Clear identification of a research gap**, showing that most existing studies on APP focus mainly on technical aspects (e.g., machines, logistics), while human factors—essential for system reliability and sustainable development—are often overlooked.
- **A clearly defined research motivation**, highlighting the importance of human factors in the context of market dynamics, demand uncertainty, and the growing role of intelligent but still non-human production management systems.
- **A well-selected and well-analyzed literature review**, covering both Polish and international sources, with a retrospective overview and thoughtful interpretation.
- **A strong link between theory and practice**, demonstrated through the application of the proposed decision model in a real industrial environment and the translation of analysis results into specific recommendations for managers.
- **A well-structured research design**, with a clearly formulated main objective, hypothesis, and relevant, meaningful research questions.
- **Skillful design of a mixed-methods study**, combining qualitative and quantitative approaches, with a clear emphasis on quantitative data analysis and mathematical modeling.
- **The use of advanced and appropriately chosen research methods**, such as fuzzy programming, MARS, and WGP, well-suited for studying complex relationships and uncertainty.

- **Correct application of research methods**, along with the author's awareness of their strengths and limitations (see p. 80).
- **Original research tools (MQ1 and MQ2)**, which allowed the operationalization of "soft" human-related variables into a quantitative model.
- **Consistent execution of research assumptions and logical empirical analysis** throughout the dissertation.
- **Practical recommendations for managers**, based on sensitivity analysis results, which strengthens the practical value of the study.
- **Clear and well-designed tables and figures**, which support the analytical discussion and illustrate key findings effectively.

Despite the high academic value of the reviewed dissertation, the PhD candidate did not avoid certain shortcomings and inconsistencies, both in terms of form and content. However, I would like to stress that many of these issues are open to discussion and interpretation. In my opinion, the following aspects may be considered debatable:

- The limited length of the main part of the dissertation, which spans only several dozen pages – significantly shorter than the standard for works in the field of management and quality sciences.
- The relatively brief theoretical section. The literature review in Chapter 2 is condensed and, in some parts, only mentions important concepts without providing full definitions or in-depth analysis. This weakens the theoretical foundation of the research problem and may make it harder for readers to understand the methodological basis of the chosen approach.
- The absence of a classical introduction and conclusion. There is no separate, synthetic introduction outlining the structure of the entire dissertation, nor a closing section that would summarize and reflect on the study as a whole.
- The lack of a list of figures and tables, despite the presence of over 30 tables and several charts, which makes it more difficult to navigate the empirical material.
- No clear separation between the theoretical and empirical parts, which in several places leads to the mixing of general concepts with the presentation of research results.
- A limited presentation of research findings and insufficient empirical discussion. The results presented in Chapter 4 are not thoroughly interpreted or discussed in a broader empirical context.
- Missing description of the research sample and lack of basic analysis of respondent data, which restricts the ability to assess the representativeness of the findings and place them in a wider research perspective.
- Excessive transfer of key content to the appendices. Placing crucial elements of the model, results, and analyses outside the main body of the text weakens its coherence and gives an impression of incompleteness.
- Low readability of many tables in the appendices. This creates difficulties for the reader, especially since some tables contain too much information without proper structure or explanation, making interpretation and connection to the main text more difficult.
- The use of highly technical and specialized language, which may be too narrow for a dissertation in the field of management and quality sciences. For example, symbols such as mnj, TRCkn, and Rtjnk are not clearly explained and may be difficult to understand for readers outside a specific expert group.

- The lack of a graphical presentation of the decision-making model, which would make it easier to intuitively understand its structure and the relationships between variables.
- The methodological part contains an excess of coding details and technical parameters, many of which could have been placed in the appendices to improve the flow of the main text.
- The study is limited to a single case without broader validation, which reduces the potential to generalize the results.
- There is insufficient reference to existing implementations of similar models in industrial practice. Including such examples would enhance the practical relevance of the study.
- The dissertation does not clearly distinguish between general, empirical, and application-oriented objectives. Although these aims can be identified through content analysis, they are not clearly listed.
- There is no information about the formal nature of the research project referenced by the author. The name of the project, the funding institution, and organizational details are missing. This makes it difficult to assess the institutional and formal framework of the international cooperation mentioned several times, including the participation of researchers from different countries.

The identified shortcomings are, however, of a secondary nature and do not significantly affect the overall assessment of the dissertation. The work of Ms. Selma Gütmen represents a valuable contribution to the development of knowledge in the field of production management, particularly in the area of integrating human factors into decision-making models. The author has demonstrated not only a solid understanding of modern management and optimization concepts but also the ability to apply them creatively to real industrial problems. This reflects a high level of research competence and scientific maturity.

7. Qualification Conclusion

The doctoral dissertation by Ms. Selma Gütmen, titled *"A Novel Decision-Making Framework for Robust-Reliable Aggregate Production Planning Problem,"* prepared under the supervision of Dr. habil. Gerhard-Wilhelm Weber, Professor at Poznan University of Technology, and co-supervised by Assist. Prof. Erfan Babaee Tirkolaee, constitutes an original and valuable contribution to the development of management sciences. The work stands out for its innovative approach to the integration of human factors into production planning, its high level of interdisciplinarity, and its methodological rigor.

In conclusion, I state that the dissertation by Ms. Selma Gütmen, titled *"A Novel Decision-Making Framework for Robust-Reliable Aggregate Production Planning Problem,"* written under the supervision of Dr. habil. Gerhard-Wilhelm Weber, Professor at Poznan University of Technology, and co-supervisor Assist. Prof. Erfan Babaee Tirkolaee, meets the requirements for doctoral dissertations as defined by the Act of 20 July 2018 – Law on Higher Education and Science (Journal of Laws of 2023, item 742, as amended), and I recommend that it be accepted and approved for public defense.

Dariusz Nowak