REVIEW REPORT
on the doctoral thesis of Claudia Kawalla,
entitled:
Development of a supply chain quality management
model for innovative construction materials

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Review report prepared on the base of the letter from Prof. Izabela Jonek-Kowalska, Vice Dean for Science, Faculty of Organization and Management, Silesian University of Technology, October 1st, 2018.

1. Preliminary remarks

In the doctoral thesis presented for review, the Author attempts to develop an integrated quality management model of the supply chain for the manufacturing of innovative components used in various industry sectors. The dissertation shows the results of research carried out on the example of the automotive industry. The subject of this paper is also focuses also on modern technology of continuous casting and rolling of magnesium alloys – twin roll casting (TRC).

Modern enterprises have to meet many requirements, both set by customers and resulting from the provisions and regulations of external stakeholders. In order to face today’s challenges, companies need to change their way of acquiring, manufacturing and distributing their goods. The goal is to create more value with less effort, reduce costs and minimize the negative impact on the environment. Achieving these goals requires integrating the economic, ecological and social aspects of business, and such integration usually goes beyond an organization’s framework. Integration must also cover the concepts of enterprise management, which include quality management (QM) and supply chain management (SCM). This postulate is extremely important for manufacturing companies cooperating in global supply chains and offering innovative products. More and more activities, processes and services are being outsourced to external suppliers, which results in the supply chain’s increased complexity and the need to ensure the quality of processed goods at every stage of their flow. It can be said that the current managerial approach is headed towards supply chain quality management (SCQM), which is
a concept based on a system paradigm used to improve performance, integrating partners within a supply chain and focusing on creating value and satisfying intermediate and final customers. Despite the widespread awareness of the need for such management, there is still a shortage of both scientific studies and practical examples of a holistic approach to integrating the principles of quality management and supply chain management, as well as the results of detailed research.

Therefore, the subject of the dissertation should be regarded as original and relevant for both cognitive and practical reasons, especially considering that:

- an analysis of the state of the issue indicates that there are no models in literature that would holistically cover the principles of quality management and supply chain management, as well as no examples of their implementations,
- there is a research gap in the area of studies on quality parameters and their relationships between relevant process and technological parameters of innovative components made of magnesium alloys.

2. Evaluation of formal aspects of the thesis

The content of the thesis was presented on 122 numbered pages of A4 printout, and its composition includes: lists of acronyms and the most important symbols, six chapters, a list of literature, lists of figures and tables. I think that the general layout of the paper is appropriate, the content of the chapters is consistent with the titles given, and subsequent chapters are a logical development of the dissertation’s main topic.

It is also worth emphasizing the great transparency and conciseness of the doctoral dissertation in question. The basic results of the dissertation are the result of research and experiments supported by careful literature study. The selection of literature sources raises no objections – it contains 261 items, including the latest publications on the subject matter of the dissertation. The list of literature shows correctness and completeness of bibliographic descriptions.

3. Dissertation content and substantive evaluation of the work

The first chapter of the dissertation begins with the general characteristic of the issue – the Author shows that there is a strong need in the automotive industry to use lightweight structures, which make it possible to reduce energy consumption and emission of harmful substances. This leads to seeking new materials that will meet these requirements, and also have the required physico-chemical and mechanical properties. Such materials include magnesium alloys, which are used for making various components, including by automotive manufacturers. The technology and manufacturing process of components delivered to recipients is a major element of the PhD student’s research who believes that meeting high quality requirements for semi-finished products is becoming a challenge. In this part of the dissertation, the Author defined the research issue and the research goals of the study:

- filling the existing research gap in the field of a holistic approach to supply chain management and product quality management,
- developing a conceptual SCQM model based on modified procedures from the ISO 9001-2015 standard, particularly regarding the manufacturing of automotive components made of semi-finished products,
• identifying relationships between relevant process and technological parameters of the tested magnesium alloy products.

**In the second chapter** of the dissertation, the Author reviews the current state of research regarding supply chain quality management and the issues related to the technology and the process of manufacturing innovative semi-products from magnesium alloys. Obtaining a high-quality product at the lowest possible price is an extremely important aspect. This is possible with the twin roll casting technology (TRC), i.e. the process of simultaneous casting combined with partial plastic forming of the hot material. The Author points out that, despite there being many papers available on this technology, most of them concern such materials as steel, aluminum and its alloys. Papers on magnesium alloys, which are important from the point of view of the automotive market, have not been thoroughly researched so far, which shows a research gap. To sum up the literature review presented, I express the opinion that it has been developed in a professional, concise and critical manner. The dissertation’s Author confirms that she is very well-prepared to implement the thesis topic proposed.

**In the third section** of the dissertation the specifics of the research methodology are presented. Based on the literature review conducted in the previous chapter, the PhD Student formulated her research hypotheses. In this part of the paper, the PhD Student also specified the following research goals:

• developing a quality management model in the supply chain for the manufacture of components in the automotive industry,

• developing and analysing the relevant quality indicators of manufactured semi-finished products, based on a causal analysis of the relationship between said indicators and the parameters of the technological process.

Implementation of such formulated objectives was subject to the verification of the following two research hypotheses:

**Hypothesis RH 1:** *The introduction of innovative materials requires an SCQM from the raw material supplier via the producer, supplier to the customer.*

**Hypothesis RH 2:** *The implementation of the SCQM model requires quality assurance for innovative materials, which considers the requirements of the parties involved in the supply chain.*

The author also formulated auxiliary hypotheses for the RH 2 hypothesis:

**Sub RH 2.1:** *The thickness profile is influenced by the conditions in the roll gap.*

**Sub RH 2.2:** *The thickness profile is a quality indicator for the development of segregations.*

**Sub RH 2.3:** *The mechanical properties in transverse direction are influenced by the formation of the thickness profile. They are connected with the development of segregations.*

I believe that the goals of the work have been formulated clearly; they are strict and specific. I also express the view that the research hypotheses in the above-mentioned wording were defined correctly.

In subsection 3.2, the Author discussed the details of the research workshop used in the study. During research, qualitative and quantitative methods were both used. This is justified due to the complexity of the issues raised. The qualitative research, used particularly to develop
a conceptual model for supply chain quality management (SCQM), included literature review, in-depth individual investigations focused on the issue, and case studies. This way, the author of the dissertation could acquire the data necessary for constructing models. Research conducted for over 1.5 years in the industry’s leading companies and cooperation with research centers allowed the PhD student to identify the quality requirements for semi-finished products used for the manufacturing of automotive components, taking into account the internal and external conditions determined by individual supply chain participants.

Quantitative research, on the other hand, concerned the manufacturing process of innovative magnesium strips made in TRC technology. The Author of the dissertation together with her co-workers thoroughly researched the manufacturing process and the technological process, from obtaining raw materials through the individual stages of the process, to the stage of delivering the components to recipients. An interdisciplinary approach was applied, where the technical, organizational and economic factors of the phenomena in question were taken into account. Particularly noteworthy is the use of modern and sophisticated techniques of statistical multidimensional analysis, particularly SEM (structural equation modeling) and its class – PLS-SEM methods (partial least-squares structural equation modeling). Modeling structural equations is a next-generation statistical method that allows reflecting the studied phenomena in a multidimensional way. In the case of the subject of research, we are dealing with a very complex system (complicated technological process, complex structure of relationships and quality requirements formulated by stakeholders), and the relationships between process parameters (mechanical and physico-chemical properties of the intermediate) and qualitative factors (relevant for recipients of intermediates) are implicit, non-linear and often unobvious.

I consider the approach used in the paper to be correct, particularly emphasizing the advantages of the applied analysis in relation to traditional methods of multidimensional statistical analysis (e.g. multidimensional regression) – SEM models allow visualizing cause-and-effect relationships, including many dependent variables, independent variables and latent (hidden) variables. The Author thus refers to the latest research trends using structural modeling and path models in mapping the relationships between the studied factors and verifying research hypotheses.

Section four is the key element of the dissertation. It consists of a series of eight scientific publications, whose main co-author is the Candidate. The assumed cycle of publications consists of the following items:


The reviewed collection of papers is an essential achievement of the PhD Student and includes studies prepared and published in 2017-2018 in renowned international scientific journals and monographs. The issues discussed in the works [1–8] are closely related to the title of the dissertation submitted for assessment. The PhD student is a co-author of the work, with her high own contribution documented. This shows the Candidate’s self-reliance in her scientific work on the one hand (high participation in the preparation of papers), and her ability to work in research teams on the other. In this part of my opinion I shall refer to the characteristics of the papers presented, without their detailed review. Papers [2–8] have been published and have successfully passed the peer review process, paper [1] currently under review.

The paper [1] presents an SCQM model concept for components in the automotive industry based on the modified ISO 9001:2015 standard. Based on the results of literature research, the common features characteristic of quality management and supply chain management have been identified. To this end, approaches based on the quality standards set out in the ISO 9001:2015 and the guidelines for supply chain management included in the SCOR reference model were compared. My critical remark concerns the relatively brief commentary in the text of the paper for the SCQM conceptual model developed and presented in Figure 11. I’d like to ask you to clarify the presented concept during the public defense of the dissertation.

Papers [2–7] relate to quality aspects in the manufacture of innovative components delivered to recipients in the automotive industry. Paper [2] presents a proposal for a system of quality assurance for components made of innovative hot-rolled strips made in the TRC technology. This technology was developed at the Metal Forming Institute of Technische Universität Bergakademie Freiberg and has a high potential at implementation.

Papers [3–5] present the concepts and results of the evaluation on the impact of casting parameters, thickness profile and the formation of segregation on the mechanical properties of magnesium strips made in the TRC technology. These properties are decisive in the qualitative assessment. The studies applied advanced analyzes using structural equations based on the PLS-SEM (partial least-squares structural equation modeling) model. The results of the analysis allowed the researchers to identify the major factors affecting the studied process.

Article [6] describes the potential areas of application for innovative wire made of magnesium alloys and provides an overview of the required quality features based on similar
products made of aluminum. Two technologies used in the manufacture of components were also compared: the conventional and modern technology of continuous casting and rolling – twin roll casting (TRC).

The results of the paper [7] were presented by the PhD student and the team of authors at the international conference THERMEC'2018 – International Conference on Processing & Manufacturing of Advanced Materials Processing, Fabrication, Properties, Applications in Paris. The article covers the concepts, assumptions, examples and recommendations for supply chain quality management for components made of magnesium alloys, and refers to the issues in articles [2–6] and constitutes the basis for developing the conceptual model discussed in paper [1].

Paper [8] discusses issues related to the economic efficiency of the manufacturing process of magnesium strips made in the TRC technology (twin-roll casting). In order to clarify the defined issues, models have been built for the manufacturing process, using material flow cost accounting (MFCA). The MFCA analysis is currently the primary management instrument and concerns the measurement of individual flows and stocks of materials and/or energy. Such an analysis evaluates raw materials, semi-finished products and key components involved in the manufacture of finished products. Models using the MFCA methodology provide potential to identify losses in manufacturing processes, detect the elements of processes generating the highest costs, and create opportunities for process optimization. The article is noteworthy for its correctly formulated models using the Petri apparatus and presentation of results in the form of the Sankey diagram. The results of experiments deserve high praise, where the influence of various manufacturing parameters (e.g. batch size) on the process costs and the conclusions formulated in the paper was investigated.

In the fifth chapter, the Author summarizes the issues and presents a synthesis of the most relevant achievements of research discussed in the previous chapter. The last chapter is a recapitulation of the dissertation and covers conclusions resulting from the conducted considerations. The directions for further research and the expected results are also presented.

While positively assessing the approach and the results of the Author’s own research, it should be emphasized that the dissertation is a successful, mature and fully useful (both scientifically and practically) attempt to construct integrated models of supply chain quality management.

I consider the following to be the Author’s original and significant scientific and pragmatic contribution to solving the research issue raised:

- systematization of knowledge as well as extensive and critical literature review, referring to the accomplishments in the field of models and concepts of supply chain quality management,
- developing an original concept of a quality management model for innovative semi-finished products delivered to customers in the automotive industry using PLS-SEM structural equation models,
- development of the concept of quality assurance for magnesium strips manufactured in the twin-roll casting technology (TRC),
- verification of the proposed research methods for the manufacturing process of magnesium strips using a simulation experiment and tests in laboratory conditions.
Having read the paper, some questions arise and I would like them to be answered during the public defense:

- How do you perceive the relationship between the proposed SCQM concept in the context of other issues, such as the resilience of the supply chains or their vulnerability?
- Was the comparison of relationships between the parameters of the manufacturing process and the qualitative indicators in PLS-SEM models with other statistical models or machine learning methods taken into account?
- Is there any research planned using other methods and simulation models, e.g. discrete event simulation models for analyzing material flows and including random factors and emergency situations?

4. Final conclusions

After an in-depth reading of the dissertation, I can state that as a result of literature studies and reliable own empirical research, the Author has verified the formulated hypotheses and achieved the adopted goals of the dissertation, thus leading to an effective solution to a scientific issue. I believe that the research issue raised by the Author is of a dissertative nature and fully refers to the modern achievements and needs of science and business practice in the area of supply chain management and quality management for products and processes carried out in these chains.

The presented research issue is interdisciplinary and requires multi-faceted analysis and the use of various research methods and tools, and covers both technical and economic aspects. The PhD student navigates the subject with ease, showing her ability to independently define a scientific issue and conduct research, interpretation and justification of results and to verify hypotheses based on the adopted assumptions. The considerations presented in the dissertation confirmed the high scientific maturity of the PhD student.

In my opinion, the reviewed paper entitled Development of a supply chain for quality construction materials meets all the requirements set before doctoral dissertations and can be qualified as a double doctorate in technical sciences (in the discipline of production engineering, in the field of quality engineering) and in economic sciences (in the discipline of management sciences). Therefore, I am asking for the Author to be allowed for public defense before a competent committee.

Marek Karkula, PhD, D.Sc., Assoc. Prof.