Universitatea Transilvania din Brașov

HABILITATION THESIS

SUMMARY

LEAN MANUFACTURING – MATERIAL AND INFORMATION FLOWS ANALYSIS AND OPTIMIZATION

Field: Industrial Engineering

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BRAŞOV, 2019

The habilitation thesis *Lean manufacturing-Material and Informational flows modelling and simulation* represents the synthesis of the author's scientific and academic activity, within the field of Industrial Engineering, subsequent to the defense of her doctoral thesis entitled *Data Management in Concurrent Engineering*. The above mentioned Doctoral thesis, carried out under the coordination of prof.dr.eng. Nouraș Barbu Lupulescu was defended in 2008, at Transilvania University of Brașov.

The first section of the present paper, *Scientific and professional achievements*, includes the main results of the scientific research activity carried out by the author.

Each chapter begins with a presentation of the current state of the research in the field, by using mainly information from works published in important journals in 2019. The results of the author's research, published in journals, presented at specialized conferences or proposed to organizations in the economic environment, are then presented. This approach continues with the presentation of future possible research directions.

The research context is represented by the fact that the current competitive environment requires the companies to be more and more efficient. In order to increase manufacturing efficiency, two apparently independent approaches have been developed: on one hand the Lean strategies, through focusing on identifying and minimizing activities with no added value, as well as by identifying system losses and eliminating them and on the other hand the IT tools for planning and controlling activities. The Lean 4.0 paradigm requires capitalizing on the benefits of both approaches.

Chapter 1, entitled *Lean manufacturing*, contains, in a classical approach, a description of the concept, of the principles and of the specific tools. The first subchapter begins with the definition of the concept of Lean manufacturing and its individualization in relation to Lean management and Lean production.

Industry 4.0 defines the digital revolution of the industrial production, through extensive networks and the computerization of all production areas. The equipment, the materials, the machines and the products can detect the state of the processes and the environmental parameters by using sensors, through interconnectivity and, implicitly, this will improve the production processes. In this context, the next subchapter contains the description of Lean 4.0. By analyzing the lean development in the context of Industry 4.0, we can draw the following conclusions:

- Industry 4.0 technologies can support and further develop good manufacturing practices. One of these is lean manufacturing;
- lean manufacturing systems facilitate the implementation of Industry 4.0;
- the changes imposed on the production system by integrating Industry 4.0 and lean production have an influence on the performance of the organization.

Lean manufacturing is based on five principles. The first principle is the *definition of value* from the customer's perspective. Once the value has been defined, the *mapping of the processes* by identifying the value flows will follow. After the losses have been identified and eliminated from the process, the next step involves *ensuring a smooth flow of the process*, without dripping, fluid, without interruptions, to the client. *Continuous improvement* is the fifth Lean principle.

By following the steps described above, if implemented correctly, through lean, remarcable results can be achieved in terms of efficiency, cycle time reduction, productivity, material costs, waste reduction, resulting in lower overall costs and higher competitiveness.

Chapter 2 is entitled *Modeling and simulation of information and material flows*. The methodologies described in this chapter are Value Stream Mapping (VSM) and Material Flow Cost Accounting (MFCA).

The first sub-chapter presents the description, modeling, simulation and evaluation of the processes mapped by using Value Stream Mapping. VSM is a tool for improving the performances of an organization and consists in mapping the entire manufacturing process, through the representation of the flows of information and materials.

VSM defines the value flow as the collection of all the activities, both those with added value and those without added value, which are necessary to create a product or a family of products using the same resources, starting from the raw materials and ending to the final consumer.

After presenting the concept and the stages of the classical mapping of the process, the author introduces a six-step model. This model allows the quantification of the process reaction in dynamics. The Agent-based model (ABM) is chosen for the representation of the entities in the process. The software solutions described are Tecnomatix Plant Simulation and Anylogic. The application of the D-VSM instrument is presented through two case studies, one in the field of automotive engineering, the other in the field of the electronic component manufacturing industry. The first application describes the situation for which it is necessary to increase the production capacity in order to respond to the increase in the demand of the customer, in order to increase the productivity of a production line. The system is characterized by the number of operators, the cycle time and the productivity. Simulating the agent-based production process will generate an action plan that will be proposed by the system managers.

By analyzing the presented applications, it can be stated that the integration of the simulation in the design and the analysis of the value flow on the production chain allows the use of the information provided by VSM regarding:

- the possibility of choosing the most favorable option from several possible scenarios, without additional consumption of resources;

- visualizing the reaction of the system over time (it is possible to expand or temporarily compress it so that the observer can capture the details of the reaction of the system);
- the simulated model can be an instrument in itself, which can be used without the consumption of other resources, but only by connecting it to a different data set;
- the detailed analysis of the reaction of the system, which leads to a complete understanding of it;
- identification of system constraints, of the weak links in the value chain.

The optimization result is measured by using specific KPIs.

The second subchapter is entitled *Material Flow Cost Accounting (MFCA)*. This instrument is regulated by ISO 14051, which defines the three objectives of the MFCA (p.4):

- increasing the transparency of the flow of materials and of the energy used, of the associated costs and of the environmental aspects;
- decision support for the organization for areas such as process engineering, production planning, quality control and supply chain management;
- enhancing the coordination and the communication regarding the flows of material and energy within the organization.

The first subchapter describes the concept of the MFCA. As methods of cost determination, Activity Based Costing (ABC), the cost related to the product functions and the cost-material-energy-environment model are described.

The ABC methodology is presented descriptively and developed mathematically. The presentation is followed by a simulation in the same framework as VSM, respectively Agent-Based model and Anylogic. The Anylogic software provides Excel tables with both the input and the output parameters. Also, the Anylogic module that is created allows graphical representations of the process parameters.

The application of the cost model by functions is analyzed in the industrial context.

The third cost approach from the MFCA perspective is the cost calculation starting from the analysis of the sustainability attribute of the manufacturing process. In this framework, the author proposes the multi-objective optimization, respectively the definition of the objective functions for minimizing the consumption of materials, minimizing the energy consumed and for minimizing the carbon dioxide emissions.

Given the areas of interest of the author, the aspects presented in the habilitation thesis generate new research directions.

Thus, in the lean context, from the Lean 4.0 perspective, there can be defined themes such as:

- modeling and comparative simulation of VSM entities, using DE, SD, ABM;

- integration of VSM and MFCA in the Lean context;
- evaluation of Lean instruments.

The second section of the habilitation thesis, entitled *Career Evolution and Development plans*, contains a brief presentation of the professional evolution of the author, from graduation to present. Then follow the expected directions for the evolution of the professional activities by continuing the scientific research and by improving the academic activity, as well as disseminating the results of the research carried out by the author, both nationally and internationally.

The habilitation thesis ends with the list of bibliographic references consulted for its realization.