

Summary

Additive Manufacturing Technologies (AM) are defined as the process of combining materials to produce parts from 3D model data, usually layer by layer, as opposed to subtractive and formative manufacturing methodologies [ISO/ASTM 52900:2021]. AM technologies are increasingly used in production processes, prototyping and in the regeneration of machines and equipment. Unfortunately, the machines and devices required to perform AM processes require significant investment. Manufacturing companies interested in AM technologies recognize potential benefits such as reduced production costs, reduced human resource involvement in the production process, optimization of the process stages and material utilization. However, the decision to implement AM should be preceded by an analysis of the demand and effectiveness of implementing additive technology. Considering the need of manufacturing enterprises in the area of decision support for the application of AM technology, research work has been undertaken on building decision support models and assessment of the demand and effectiveness of AM technology application using Bayes and Petri nets. The work consists of eight chapters. Chapter one presents the research problem, defines the main objective and specific goals of the study and presents the scope of the work. Chapter two presents the research model and method. Chapter three provides a characterization and division of AM technologies used in manufacturing industries. Chapter four presents the results of surveys conducted in the metal and automotive industries in Poland regarding the implementation and interest in AM technologies. Chapter five characterizes Bayesian networks and Petri nets and emphasizes the possibilities of using these tools to formulate decision-supporting models in manufacturing companies. Chapter six presents original Bayesian network and Petri net models, which enables the evaluation of the effectiveness of implementing additive technologies in a given class of manufacturing companies. Chapter seven verifies the constructed models in economic practice and confirms the importance and usefulness of research results. The final chapter presents an IT tool to support decision-making and evaluate the effectiveness of implementing AM technology in specific manufacturing companies. Literature studies were conducted in the areas of additive manufacturing technologies used in production, knowledge and production process modeling methods and methods used to analyze and evaluate the effectiveness of implementing additive manufacturing technologies in production. Based on this, a division and characterization of AM technologies used in production was made, the application of AM technologies in metal and automotive manufacturing enterprises was presented and modeling methods of production processes were presented with the use of Petri nets and Bayesian networks and the characterization of production processes supported by AM technology, including DMLS (direct metal laser sintering), was made. The results of survey research conducted in 250 metal and automotive manufacturing enterprises in Western Poland were presented. As the research shows, a significant portion of the surveyed companies use AM technologies and a considerable number of enterprises declare that they are considering implementing AM technologies. An attempt was made to implement the knowledge obtained from literature and industry into a Bayesian network to predict the demand for AM technologies. In the proposed solution, experiments were conducted involving a production enterprise. Based on the results of literature analysis, knowledge levels related to the type of material used, the type of laser used in the AM process, tested properties of a given product, and the impact factor (IF) index, defined for research purposes as an indicator of the level of knowledge availability, were modeled. The results of the experiments showed a relationship between the needs of the enterprise and the knowledge contained in the literature. The second stage of the research was the design of a model using Petri nets, which allows for a parametric analysis of the production process used by the surveyed enterprise, as well as the parameters of the process carried out using AM technology. The use of the developed model makes it possible to create recommendations in the area of AM implementation. As part of the scenario recommending additional analysis, a second Petri net model was designed to analyze disturbances occurring in the production process. The model enables analysis in the area of material supply, employee rotation, and energy consumption costs. In addition, a web application was designed and developed as an implementation of the built models to support decision making and evaluate the efficiency of AM technology use. Verification of the IT solution was carried out at three medium-sized manufacturing companies in the metal and automotive industries in Western Poland.