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The study on implementation of agile manufacturing system in Lithuanian industry

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1. Introduction

Global market changes very quickly, and an enterprise which cannot promptly adapt to it can find itself behind competitors. One of the goals of Agile Manufacturing (AM) is to keep enterprises in the forward ranks, which allows them to continue innovations and introduction of new products. In order to achieve agile manufacturing goals organizations have to be well organized and flexible.

Introduction of advanced technologies to the enterprise's system is a huge challenge to its management. Everything has to be balanced, calculated and planned. AM requires rapid adjustment of production capability based on customer demands. To accommodate ever-changing manufacturing requirements, an Agile Manufacturing System has to be equipped with rapid production plan configuration and resource allocation capabilities.

Lithuania's integration into the global economy has affected the country's metal manufacturing industry, and with intensification of the global competition, agility of manufacturing acquires great importance.

2. AM aspects

Introduction of a new technology to the enterprise's operational systems makes changes not only in its organizational structure but also in its processes, facilities and space.

It is evident that many contemporary components of businesses and manufacturing systems comprise suitable combinations of human, computational and electromechanical elements. One way of viewing these components is that they are resource elements capable of acting and interacting in a variety of ways to realize business and manufacturing processes; in so doing collectively, they can operate to accomplish the business goal [1].

AM implementation can reduce material costs, work force, inventory, idle facilities or machine time, and improve material handling. It affects the overall cost, quality, and timing of a product that is very important to the customer. Agile or flexible production systems are focused on customer demands therefore, it is difficult to be in front of competitors. Lithuanian manufacturing companies use to experience the investments deficit, they cannot buy all necessary machines, for this reason, to minimize cost the companies have to search for partners. Co-operation with partners creates favourable conditions for agility, but proper cooperation requires appropriate tools and techniques. AM is a concept of technologies and progressive management techniques. AM makes it possible:

- to managers of the organization to understand better the strengths and weaknesses of technology alternatives;
- better managed technological solutions.

Information exchange is more easily undertaken inside an enterprise not that it possesses better internal knowledge (especially tacit knowledge), concerning technical details of its own products and production processes, but because enterprises are reluctant to exchange their core technologies, or at least part of them, with the external contractors, who might use these technologies in research projects with the other ones [2].

3. Strategy for AM implementation

The design flexibility provides agility against the competitors and satisfies more customer demands. In order to be in front of the competitors the companies have to upgrade their organization units. Fig. 1 intends to identify which organizational characteristics have to be taken into account in purchasing and implementation of AM technology. These elements can guide the process of organizational changes, they can represent the basis for the organizational redesign review. External and internal circumstances and the technology used determine the requirements for the organizational redesign. At first in the purchasing stage, financial possibilities of the organization are to be analyzed, afterwards, the organizational characteristics and manufacturing flexibility, and all this can reveal the weak sides.

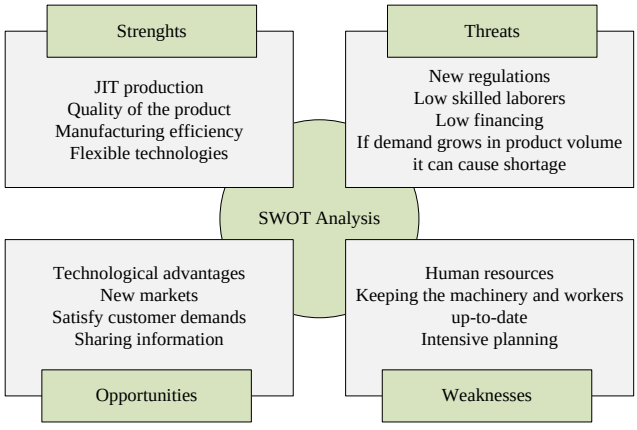

Fig. 1 SWOT analysis for AM implementation

Manufacturing management is an important aspect of AM strategy implementation. Modern manufacturing must take into account some important aspects to be

implemented in the organization, namely:

- labourers' ability to learn;
- specific knowledge of agile technology principles and "know-how" methods;
- ability to solve unexpected incidents;
- ability to investigate each problem solving possibility .

Fig. 1 shows evaluation of the business venture. AM organizations have strengths in technology equipment and manufacturing efficiency – they include innovative and flexible technologies. Moreover, they improve quality of the product and just-in-time production. However, there are some threats of AM implementation. New laws and low-skilled labourers could complicate the innovation implementation. In addition, finance for new technologies could also be a problem. One of the threats could be shortage caused by a sudden increase in demand.

The AM implementation requires keeping the machinery and workers up-to-date, to be competent, to be agile. Intensive planning could be one of the agility weaknesses. It requires additional expenses hence expensive to the enterprise e.g. shifting from production of one brand of a good to another will require adequate research and acquisition of new machinery. Human resources have a great significance in introducing an AM system to Lithuanian organizations. On the other hand, agility improves technological advantages and benefits of information sharing. The AM gives an opportunity to introduce new products to new markets. Agility provides flexibility to manufacturing, which has a possibility to satisfy customers' demands.

Information technology (including the Internet, the Intranet, teleconferences and videoconferences) can play a critical role in collecting and presenting necessary information to managers on a real-time basis [3].

During the evolution of manufacturing enterprises, a number of technologies, computerized systems and methodologies seeking agility of manufacturing has been developed (Table 1).

The AM system implementation involves two main stages (Fig. 2). In the first one the enterprise's financial, organizational and production possibilities are examined, while in the second stage - its innovations to be installed and weaknesses are analyzed, for example, installation of the new software or transmission of information.

Table 1

Technologies, computerized systems and methodologies for manufacturing agility

Technologies [4]	Computerised systems	Strategies and methodologies
• Computer numerical control equipment; • Flexible manufacturing systems (FMS); • Robots.	• Computer aided design (CAD); • Computer aided manufacturing (CAM); • Computer aided process planning (CAPP); • Material resource planning (MRP); • Manufacturing resource planning (MRP II); • Enterprise resource planning (ERP); • Computer aided engineering (CAE); • Finite element analysis (FEA); • Production data management (PDM); • Computer aided analysis (CAA); • Production planning system (PPS); • Computer numerical control systems (CNC); • Bill of material (BOM); • Automated storage and retrieval system (AS/RS).	• Just in time (JIT); • Ability to develop quickly; • Lean manufacturing (LM); • Total productive maintenance (TPM); • Enterprise supplier networks (ESN).

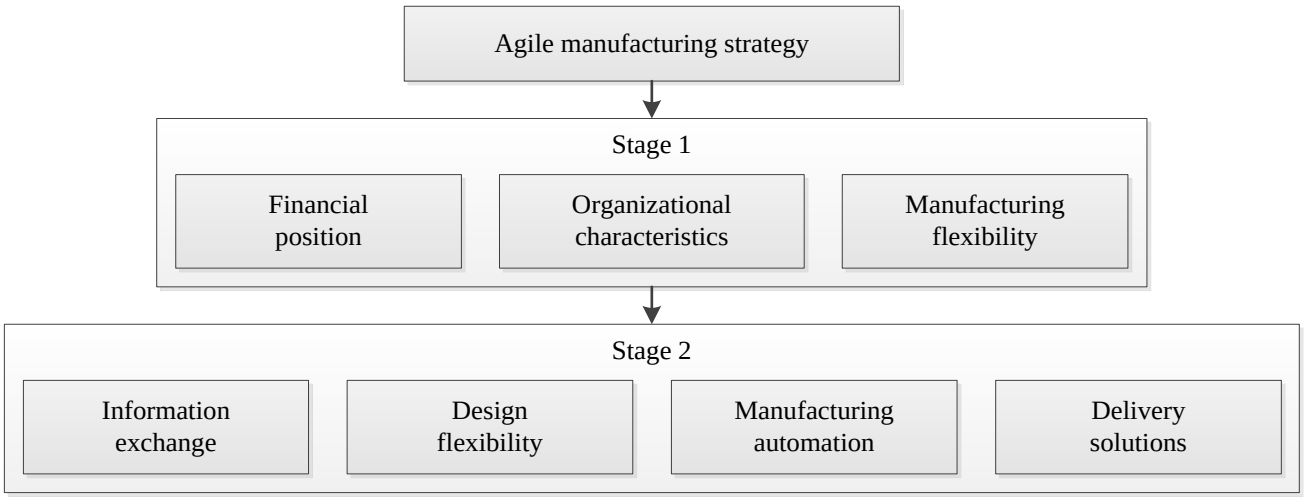

Fig. 2 Stages of AM implementation

Table 2

Computerized systems for AM improvement

Application area	Software
Computerization of product design	**CAD:** NX Cad; Tebis; Eagle; Just CAD; 3D Max; AC3D; Aladin 4D.
	CAM: Solid CAM; DelCAM; TopSolid.
	CAD/CAM: Cimosa; Dura; Emerson Industrial Automation; Siemens automation; Scada.
Software for product statistical analysis	**CAA:** Salome; CatiaV5; Fluent; Abaqus; Mathlab; Simulink; Get CAA; Mode X3D.
Software for Inventory control	**MRP:** Provisions; Smarter Manager; Delmia; Kenandy; Meta systems; ProModel; Consona; Mie Track Pro; Sage; Microsoft Dynamics.
Software for product material bills	**BOM:** Master Control; Microsoft; MPD Manager; Parts and Vendors; Scada; BOM Builder; Enovia.
Production planning computerization	**PPS:** Exact; ECI; Intuitive; Preactor; Orchestrate.
Product analysis of whether a product will break, wear out, or work	**FEA:** Algor; Ansa; AutoForm; Lisa; ADINA; Impact; FEBio; J L Analyzer; CADRE; FEMM; UNA; FrameWork; Structural Mechanics.
Software for computer numerical control	**CNC**: Siemens(sinumerik); Fanuc; SimulatorPro; Mitsubishi sim; Fagor sim.; HAAS sim.; KND sim.; DASEN sim.; WA sim.; Burny AMC; Vectric; SANYING RENHE; Sky; MED model.
Software for data of the product	**PDM:** MAXQDA; SolidWorks; Siemens; MSDS; Soft Expert; PDM; Works; Autodesk; Tool Data Management; PTC; Cameleon; Draft Sight.
Storage automation software	**AS/RS:** Genesis; HP X1000; SIM X; Henning Visual Esti Track.

In line with the corporate goals of small manufacturing companies, the computer system should be able to support decision making of the product life cycle management. Effectiveness of the computerization process should be determined by whether the computerized system design is technically feasible to the company workers' qualification. The technical system design process involves computer hardware and software selection and deployment [5].

After a comprehensive analysis of computerized systems usage in manufacturing enterprises, investigation of various software and their application areas, taking into account the suggestions and opinions of users, the list of possible software for AM improvement is composed (Table 2).

4. Aspects and opportunities of AM implementation in Lithuanian companies

4.1. Capital investments

Participation in a global market requires the cooperation among enterprises. Nowadays, short product manufacturing development time and production lead times are also required. The enterprise has to be agile, if it wants to determine customers' requirements quickly and continuously. In fact, AM should be seen as a natural extension and evolution of the lean manufacturing. Leanness makes it possible [6]:

- a waste free efficient system that is in the bottom line and, in turn, provides a competitive pricing advantage;
- most of the customers today come to local manufacturing facilities for their quick response to changes;
- better technical support, shorter time to the market and, most importantly, short production runs.

Fig. 3 shows capital investments for the new equipment in Lithuanian enterprises during the period of 1997-2011 (according to the Statistics of Lithuania [7]). Indicators show that diffusion of technological innovation in Lithuanian industry is constantly growing. To ensure the country's industrial competitive ability, organizations have to create favourable conditions for the industry as a whole, and especially for development of priority industries.

The statistical data of Lithuanian Statistics Department in 2010 introducing the expenditure of technological enterprises on innovation activities present 1810.6 million LT [8].

It should be noted that Lithuania's economy is based on small and medium enterprises, which do not have such favourable possibilities as large international companies do to make use of knowledge. Changes in the business environment affect small enterprises in particular. The government should create better opportunities for the interaction among academic institutions, businesses and innovation centers.

During the period of 2008-2010, less than a half of Lithuanian companies were upgraded (Fig. 4). Fig. 5 shows an increasing demand for the metal products export during 2007-2011. These data indicate that metal products have a great potential to attract investments to Lithuania [8].

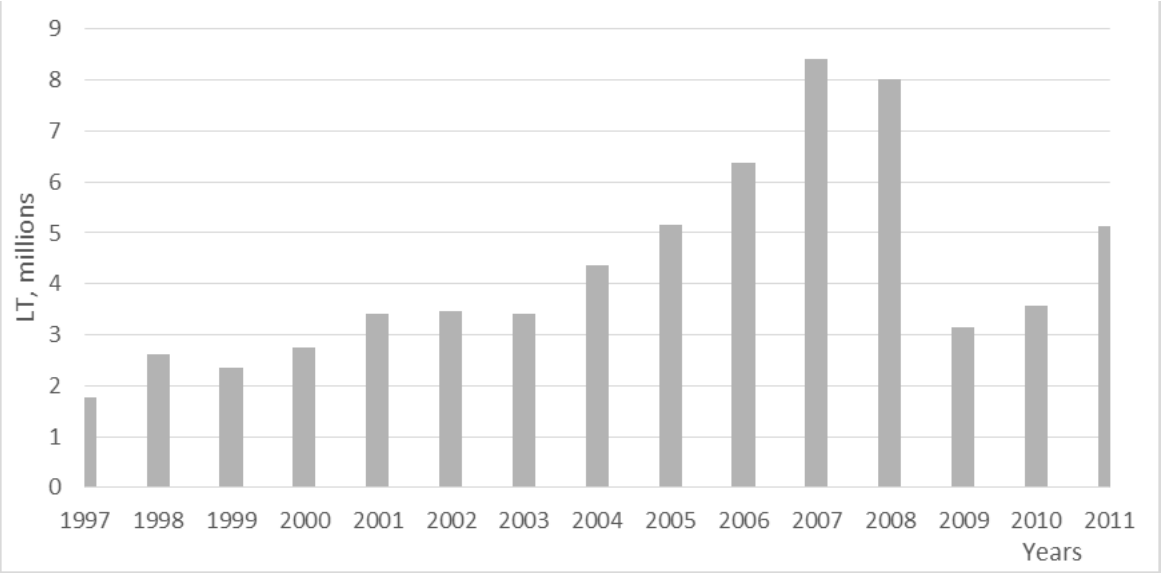

Fig. 3 Capital investments for manufacturing equipment in Lithuanian enterprises during 1997-2011 [6]

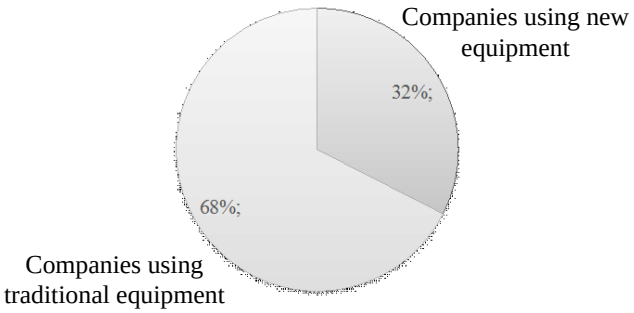

Fig. 4 Technology upgraded in Lithuania during 2008-2010

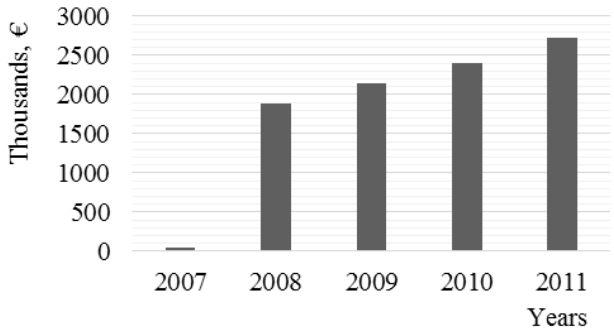

Fig. 5 Export of metal parts in Lithuania during 2007-2011 [8]

4.2. Analysis of the possibilities of AM strategy implementation in Lithuanian industry

The virtual enterprise environment facilitates reconfiguration of the organization's quick response to the changing market requirements. An individual organization is often not able to respond effectively within a short period of time due to the lack of internal capabilities (finance, weak management, low-skilled workers, etc.)

Internal technological development and activities of an enterprise ensure greater control over the enterprise distribution and serve to maintain its viable technical capability. Based on the above argument, it is expected that there will be a positive relationship between internal technology development and that of a new product [9].

Lithuanian companies have an order handled manufacturing system, and they should change the strategy, which earlier comprised customers-manufacturers in the manufacturing process. It has been done to avoid misunderstandings (Fig. 6).

In manufacturing enterprises the most common production process consists of technological and economic aspects. The technical processes are product design, production organization, execution of economic, market research, and financial analysis of the production process. All of these components are to be interdependent.

To become an agile Lithuanian manufacturing organization, an innovative technology that allows marketers, designers and production personnel to share a common database of parts and products, to share the data on production capacities and problems has to be supported.

Traditional methods may be insufficient to deal with the level of complexity associated with manufacturing processes and products. To remain competitive in the rapidly changing environment, flexibility, responsiveness, agility, and better quality are urgent. This obviously points out the importance of automated knowledge exchange between manufacturing units. In other words, to create a good knowledge exchange system, enterprises have to share their knowledge and available information in real time.

One of the aims of a manufacturing organization should be the relation between the internal organization departments and the information exchange with customer-manufacturer who have to participate in all production stages. Agile manufacturing is closely related to CAD, CAM, CAPP and others computerized systems in the CIM environment [10].

Usefulness of CAD/CAM systems integration is ability to visualize a product design, to support a design analysis and to link to the generation of part programmers for manufacturing. However, CAD/CAM systems have to be standardized to acquire an ability to communicate with each other. Different CAD or geometric modelling packages store the information related to the design in their own databases, and the structures of these databases differ from each other [11].

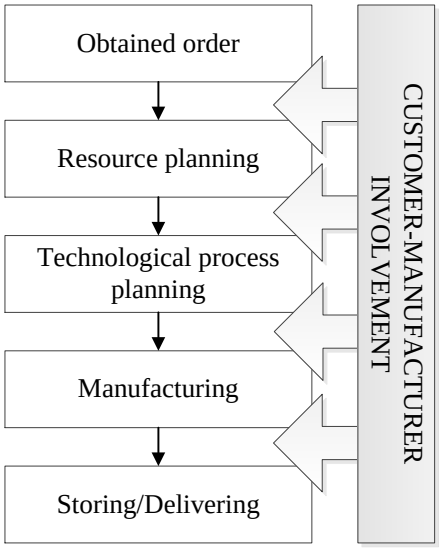

Fig. 6 Customer-manufacturer involvement in production cycle

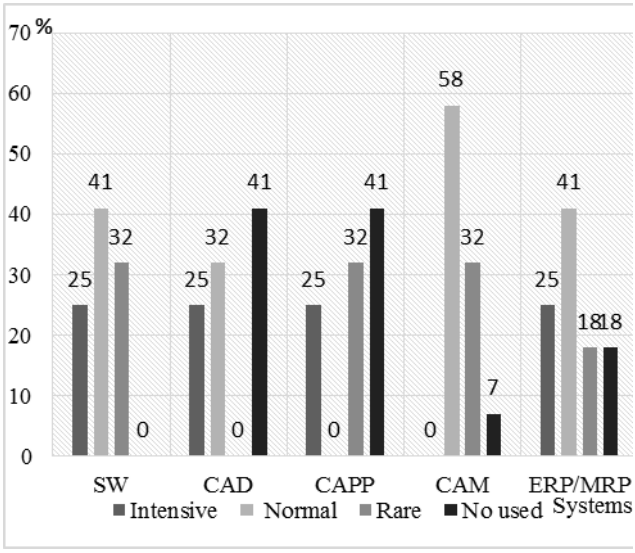

Fig. 7 Computerization level of Lithuanian manufacturing enterprises [13]

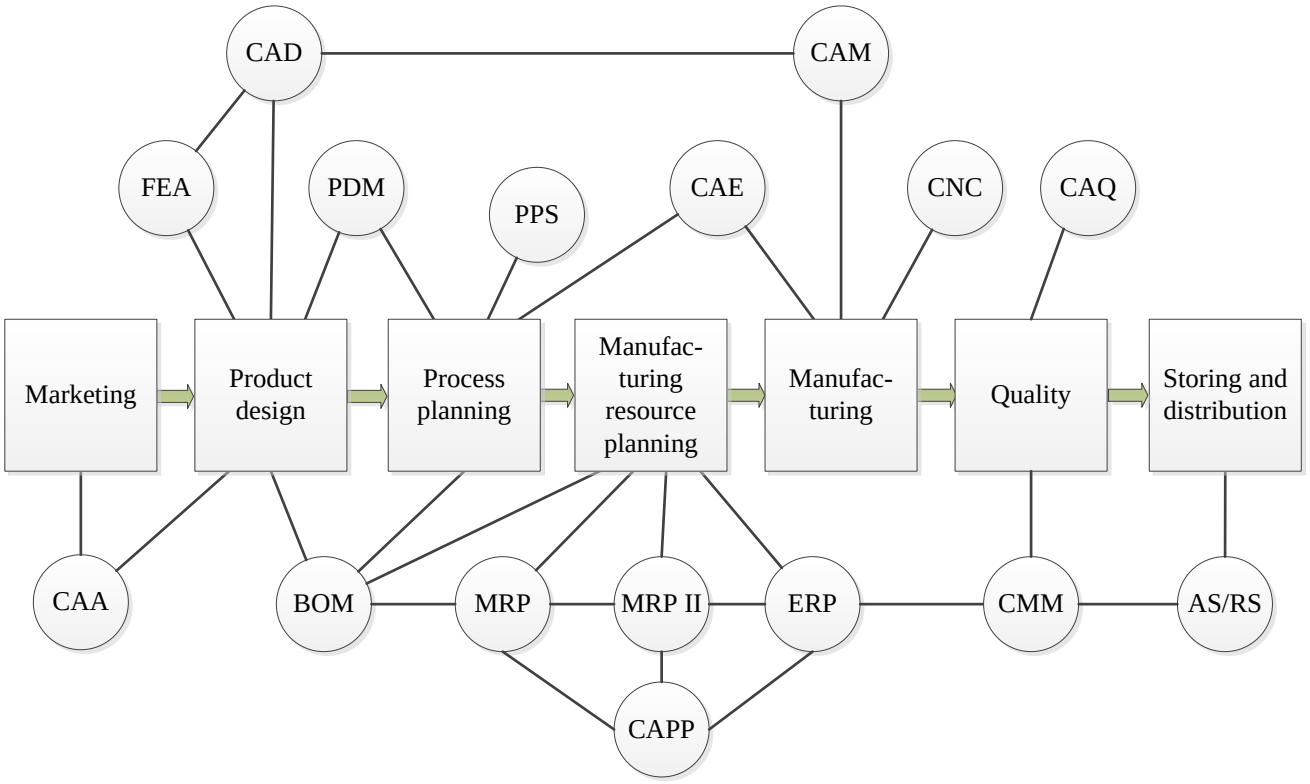

Fig. 8 Integrated approach for software application

Fig. 7 shows the software usage level in Lithuanian enterprises [11-13]. Despite of 100% usage of modern software (SW) technologies, the other results are not very optimistic: even 42% of enterprises are not optimizing the product design according to price and manufacturing cost. Only in 25% of enterprises usage of Computer Aided Processes Planning (CAPP) systems is intensive, but in 33% – rare and even 42% are not using CAPP system at all. Maybe, Lithuanian enterprises do not believe in their activity effectiveness when applying CAPP systems [12].

FEA in AM manufacturing shows whether a product will break, work, or wear out, the way it was designed. In the product development process, it is used to predict what is going to happen when the product is exploited. CNC programs produce a computer file, that is interpreted to extract the commands for operating a particular machine. Product data management (PDM) tools are for tracking and controlling the data related to a particular product.

A detailed analysis of computer aided systems presented in Table 2 has revealed that there is different software (Scada, Mathlab, Simulink, Sinumerik, Fanuc, Solidworks, ect.) that can be successfully used by Lithuanian manufacturers, particularly, for agility improvement.

Fig. 8 presents an approach of software systems integrated application in an AM enterprise. An integrated approach of this article's preposition is part of an AM production integration to help Lithuania businesses compete in

the international market.

One of the strategic steps to become agile is to implement lean manufacturing features [14]. This type of manufacturing system is based on the integration of production flow, process control, organization, metrics, and logistics. In Lithuania there are 68% of mechanical machining enterprises, which use obsolete equipment (Fig. 4). It is important to remember that leanness makes it possible to have a waste free efficient system that adds to the bottom line and in turn gives a competitive pricing advantage what Lithuanian industry needs today.

5. Conclusions

The production capability to satisfy customers' demand requires industrialists to install adaptive technologies in manufacturing enterprises. The customer-manufacturer should be included in all product manufacturing processes, like material planning, technology process planning, manufacturing and product delivering. To be ahead of competitors Lithuanian manufacturing enterprises should invest in the flexible equipment implementation.

1. Firstly, one of the important aspects of AM implementation is identification of weak sides of the enterprise.
2. Essential directions of the AM strategy are: ability to learn; "know-how" methods; fast problem solving.
3. Major problems in Lithuania for implementation of the AM system are: investments; poor cooperation between academic institutions and business; stereotypical attitude of the enterprise management.
4. The most common missing links in Lithuanian enterprises are: information exchange; computerization of enterprise activities and technology flexibility
5. Computerization is one of the most important parts of the AM system that connects work of all organizations. The integrated approach for software application can increase enterprise productivity, product quality, and make the enterprise attractive to new customers.

References

1. **Richard H. Weston; Ian A. Coutts; Paul E. Clements** 2006. Integration Infrastructures for Agile Manufacturing Systems, Springer Berlin Heidelberg, 789-823.
2. **Kai Xu; Kuo-Feng Huang; Shanxing Gao** 2012. Technology sourcing, appropriability regimes, and new product development, Journal of Engineering and Technology Management 29(2): 265-280. http://dx.doi.org/10.1016/j.jengtecman.2012.03.003.
3. **Andersen, T.J.** 2001. Information technology, strategic decision making approaches and organisational performance in different industrial settings, Journal of Strategic Information Systems 10(2): 101-119. http://dx.doi.org/10.1016/S0963-8687(01)00043-9.
4. **Anuziene, L.; Bargelis, A.** 2007. Decision support system framework for agile manufacturing of mechanical products, Mechanika3(65): 51-56.
5. **Walter W.C. Chung; Stanley K.O. Chik** 2001. Computerization strategy for small manufacturing enterprises in Hong Kong, Int. J. Computer Integrated Manufacturing 14(2): 141. http://dx.doi.org/10.1080/09511920150216260.
6. **United states Environmental protection Agency**. 2003. Lean Manufacturing and the Environment: Research on Advanced Manufacturing Systems and the Environment and Recommendations for Leveraging Better Environmental Performance. Online http://www.epa.gov/lean/environment/pdf/leanreport.pdf, 14-18p. [visited 07 December 2012].
7. **Statistics Lithuania**. – http://www.stat.gov.lt/lt/ [visited 25 September 2012].
8. **Statistics Lithuania: Database of Indicators**. – http://db1.stat.gov.lt/statbank/default.asp?w=1440 [visited 27 September 2012].
9. **Ayyappan, S.; Jayadev, P.K.** 2010. Enabling technologies and implementation framework for agile manufacturing, The IUP Journal of Operations Management, 9(1-2): 55-70.
10. **Prakash, A.; Chan, F.T.S.; Deshmukh, S.G.** 2012. Application of knowledge-based artificial immune system (KBAIS) for computer aided process planning in CIM context, International Journal of Production Research, 50(18): 4937-4954. http://dx.doi.org/10.1080/00207543.2011.616234.
11. **Abouel, E.** 2007. Computer-Based Design and Manufacturing, Springers Science + Business Media, LLC USA, 370 p.
12. Forum of project IRMA. – http://www.irmaproject.eu [visited 29 November 2012].
13. **Bargelis, A.; Mankutė, R.** 2010. Impact of manufacturing engineering efficiency to the industry advancement, Mechanika 4(84): 38-44.
14. **Mankutė, R.; Bargelis, A**. 2010. Inter-Countries Research For Manufacturing Advancement in Lithuania, Mechanika-2010: Proceedings of 15th International Conference, Kaunas University of Technology, Lithuania, 287-292.
15. **Salah A.M. Elmoselhy** 2012. Implementation of the hybrid Lean – Agile manufacturing system strategic facet in automotive sector, International Journal of Advances in Engineering & Technology 5(1): 241-258.

N. Toliušienė, R. Mankutė

JUDRIOS GAMYBOS ĮGYVENDINIMO GALIMYBIŲ TYRIMAS LIETUVOS GAMYBOS PRAMONĖJE

R e z i u m ė

Straipsnyje nagrinėjamos judrios gamybos diegimo strategijos principai bei jos ypatumai Lietuvos pramonėje. Apžvelgiamos svarbiausios įmonės sritys ir galimybės, norint išlikti tarptautinėje rinkoje. Pateiktos Lietuvos įmonių investicijų tendencijos atnaujinant įrangą. Nagrinėjami judriosios gamybos sistemos diegimo privalumai siekiant pagreitinti gaminio kūrimo procesą, greičiau dalintis informacija įmonės viduje, padaryti gamybos procesą efektyvesniu bei lankstesniu. Vienas iš judrios gamybos reikalavimų yra kompiuterizuota įmonės veikla. Padaryta analizė rodo jog maža dalis Lietuvos įmonių naudoja kompiuterinę įrangą ir naujus įrenginius, kurie leidžia padidinti konkurencingumą tarptautinėje rinkoje. Straipsnyje pateikta kompiuterinių programų analizė parodo jog yra didelė įvairovė programų, kurias gali naudoti Lietuvos įmonės, norėdamos įgyvendinti judrią gamybos sistemą.

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INVESTIGATION OF AGILE MANUFACTURING IMPLEMENTATION FEATURES IN LITHUANIAN INDUSTRY

S u m m a r y

This paper deals with a agile manufacturing setup principles of the strategy and its peculiarities in Lithuanian industry. There are an overview of the most important features for the companies in order to have ability to survive in the international market. Lithuanian business investment trends in upgrading equipment there is presented also. The consideration of agile manufacturing system implementation advantages to speed up the product development process, to share information within the company and to make the production process more efficient and flexible are discussed. One of the requirements for agile manufacturing features of the company is computerized activity. The analysis shows that a small part of Lithuanian companies are using computer equipment and new equipment, which allows to increase competitiveness in the international market. The analysis presents a great variety of software applications that can be used by the Lithuanian company, in order to implement agile manufacturing system.

Keywords: Agile manufacturing, lean manufacturing, computerization, strategy, integration computer integrated manufacturing.

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