DEVELOPMENT OF AN ADVANCED METROLOGY AND INTELLIGENT QUALITY MANAGEMENT AS A STRATEGIC APPROACH IN MANUFACTURING INDUSTRY

Numan M. DURAKBASA[1], Gökcen BAS[2], Jorge M. BAUER[3] and Lukas Kräuter[4]

[1] *Vienna University of Technology /AuM-TuWien, Austria, numan.durakbasa@tuwien.ac.at*
[2] *Vienna University of Technology /AuM-TuWien, Austria, goekcen.bas@tuwien.ac.at*
[3] *UTN-FRBA/ Argentina & AuM-TuWien, Austria, jbauer@doc.frba.utn.edu.ar*
[4] *Vienna University of Technology / AuM-TuWien, Austria, aum@mail.ift.tuwien.ac.at*

Abstract:
Manufacturing industry faces challenges of global competition dealing with increasing cost of energy and raw material as well as meeting higher customer quality and product technology expectations. In the next decade, the progress of technology will require main aspects of strategies for international acceptance and competitiveness. The modern methods of quality management intelligently integrated with environmental management and energy management will be the main strategy developed and refined in manufacturing organizations where advanced metrology enable to perform industrial and technological developments by practicing high precise measurement tasks and essential measurement know-how within the sophisticated production systems.

This paper proposes a strategic approach to develop an advanced metrology and intelligent quality management applicable in manufacturing industry by firstly modelling, generating and experimenting an inter-university network that accesses, cooperates and operates at distance in the laboratory of two distant research laboratories namely the nanotechnology laboratory AuM-TuWien in Austria and the control laboratory UTN-FRBA in Argentina. The key factors to fulfil the main target are defined and discussed in the application model where the indicators are of compliance to the advanced metrology and intelligent quality management system strategy as a conclusion.

Keywords: Nanometrology, Quality management, Intelligent, Manufacturing industry, Telepresence

1. INTRODUCTION

Worldwide research is in a sharp transition to meet the demand of global market trends. Today's manufacturing industry is in demand of collective experience and knowledge to establish profitable and competitive operations while overcoming the challenges of volatile energy prices together with environmental constraints and high quality aspects in their operations.

The European Union has formulated a long-term strategy to dovetail the policies for these targets with the goal of sustainable development, its goal being economically, socially and environmentally improvement of not only current but also future generations. The European Union's long-term strategy to fulfill the sustainable development indicators was integrated into the Treaty of the European Union in the Article 2 by the Amsterdam Treaty in 1997 [1]. The European Union strategy declared again at the Lisbon European Council in 2000 was complemented at the Gothenburg Summit in 2001 [2, 3]. The adopted sustainable development strategy in June, 2006 by the Renewed European Union Sustainable Development Strategy was consequent in December, 2009 by the Review of the EU Sustainable Development Strategy -Presidency Report- assuring that the sustainable development remains as a fundamental objective of the union [4, 5].

There are more than hundred indicators determined to complete the strategy and policy of the union indicated in the strategy papers. There has been research conducted on the management of natural resources, sustainable development and ecological hazards to identify the main indicators [6]. Moreover, the manufacturing process quality as defined one of the most influential competitive parameter for the companies needs to be integrated [7]. This study covers the main indicators of development process in the manufacturing industry to monitor the quality of the process by means of an inter-university network that accesses, cooperates and operates at distance in the laboratory of two distant research laboratories.

2. THE ADVANCED METROLOGY AND INTELLIGENT QUALITY MANAGEMENT APPROACH

2.1 Methodology of an Integrated Management System Implementation

The quality management system that can be integrated with the environmental and energy management systems in compliant with the international standards is the fundamental strategy to obtain the required operation conditions for a competitive manufacturing organization [8, 9, 10].

The operating models to the manufacturing plants are developing to keep up with the robotic and automation applications for advanced industrial processes. The simulation of the control systems for development of computer aided, automated production is demand driven aspects that states the future of the manufacturing industry [11].

The trend of automation, process monitoring and control is modeled under the integrated management approach of international standards as represented in the Fig. 1. The management system is modeled based on the continuous improvement approach. The closed loop model identifies the

Plan-Do-Check-Act processes to be determined, audited, documented and improved as the strategy develops towards advanced manufacturing technology such as intelligent quality system integration.

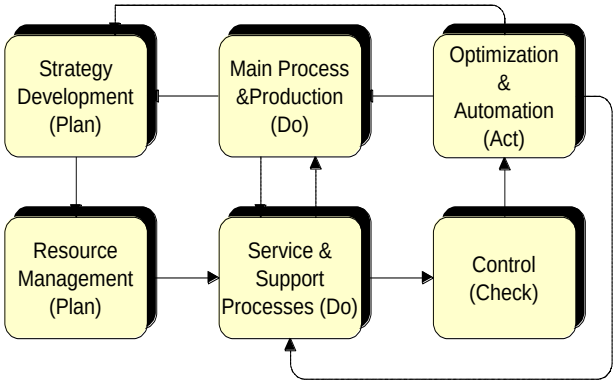

Fig. 1: The process flow of the management system proposed for the advanced manufacturing plants

The system to approach contributes to understand and manage interrelated processes as a whole and moreover enhance the organization's effectiveness and efficiency in fulfilling its targets. The system approach principle is presented in the ISO 9001, ISO 14001 and ISO 50001 through the requirements that address [8, 9, 10]:

- Defining the system objectives
- Establishing, implementing and maintaining the management system as a set of processes
- Describing the system
- Continual improvement
- Interconnection, interrelation and sequence of processes
- Maintaining the integrity of the system
- Establishing measurement processes

The challenges to overcome within the integrated management approach exist for organizations that proceed towards the modern manufacturing environment such as the estimation of the hidden costs and potential savings. Therefore, the documentation requirement covers the financial reports to be implemented in the management strategy.

The approach of overcoming the challenges that can occur is proposed in this work by means of process management toolbox analysis. The management system to be implemented in a manufacturing plant is modeled and represented in the Fig. 2.

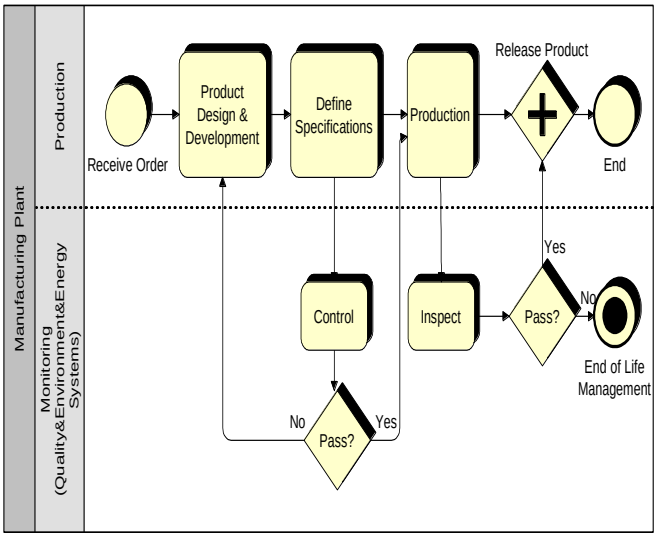

Fig. 2: The process flow of integrated management approach in a manufacturing plant

The process flow of integrated management approach in a manufacturing plant offers the case studies and future estimations to be processed before. The process management simulation toolbox [12] provides the reporting system that is used for calculation of development aspects in the plants. As an example, s system performing 4 cycles of production lines with one worker of predefined time intervals on each activity performs the results of simulation with 20,4 minutes of average working time. The similar attributions are possible in terms of cost and labor use and resource management to be applicable to any kind and size of organizations. The approach of modeling enhances the efficiency of modern technology integration plans in the industrial plants.

- ***2.2 Intelligent Metrology Cycle in Modern Manufacturing Industry***

The modern manufacturing industry integrating the intelligent automation solutions require quality control for their operation. Metrology as the measurement science provides the functional methodology for quality control under the defined specifications and standards.

The quality assurance process starts with the data collection and evaluation using the measurement science methodology. When considering the automation quality assurance, it is required to deal with complex, variable and dynamic control problems of the production process. Hence, the design system and other manufacturing processes must be considered as a whole while implementing the self-optimizing process. This approach can be summarized for an intelligent measurement process with the following tasks:

- Automatic intelligent measurement by using CNC metrology
- Off-line CNC programming of measuring instruments
- Automatic changing of workpieces
- Automatic changing of probes and sensors
- Automated evaluation of measuring results

The intelligent coordinate metrology is of essence when considering flexible and high accuracy demands of the industry. This way, the metrology offers the solution to the complex dimensional and geometrical problems demanding high quality results.

The proposed solution methodology can be considered as a further step with a target of intelligent and economical manufacturing environment using the quality assurance cycle as represented in the Fig. 3.

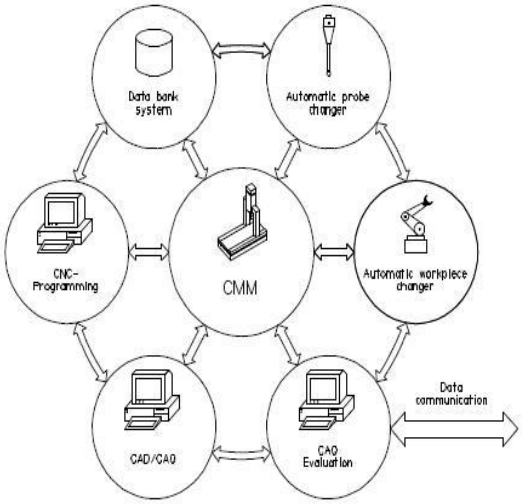

Fig. 3: The intelligent quality assurance cycle in the manufacturing industry

3. THE PRACTICAL EXPERIENCE OF AN INTER-UNIVERSITY NETWORK

Implementation of the intelligent metrology cycle as the target, research and development process is established at the universities and institutes. The experience obtained by integration of the process concept will create a roadmap for future developments.

As a part this strategy, the High Precision Micro and Nano Metrology Laboratory at the AuM-TuWien (The Department of Interchangeable Manufacturing and Industrial Metrology, Vienna University of Technology) is chosen as a node to create an inter-university network. The developed platform serve not only as a practical experience of an intelligent metrology process model but also as an educational concept for the current students taking part in high precision measurement activities.

The cooperation between the local laboratories in Argentina enables the practical applications to develop and create a resource for future connection nodes that is already in the near future plans.

The time, cost and expertise for establishing metrology and mechanical laboratories is very high for many small and medium size enterprises. The facility infrastructure and the personnel expertise will be available in the global market as one of the targets in this development project.

The current status of the project focuses on automatic control of the high precision measurement instruments through the network established using a server. The operation requirements of remote control results an increase of the workload of the channel in the network. Hence, the bandwidth limitations generate a reduction speed of the process. To resolve this difficulty; a client server computing technology is used for the control of all the equipments in the laboratory. Establishing a paradigm in the Linux server enabled us to connect to the equipments which is required for further applications.

The existing status of the inter-university network exhibits good results using also mobile phone technology. The mobile phone technology enables currently to connect to the other nodes (e.g. Buenos Aires) using the Wi-Fi network established in the laboratory environment. The mobile phone and the measurement application is represented in the Fig. 4.

Fig. 4: Measurement represented using the Coordinate Measurement Machine

The system established is based on the assumption that it works under the condition that each single operation is controlled and reported. The model working environment is a sample for any manufacturing plant that is prepared to integrate intelligent manufacturing machines in its environment. Cooperative activities in the laboratories create systematic knowledge transfer and data acquisition. Each process is carried out step by step in harmony with the required standards.

The practical approach of this inter-university network project offers a collaboration to any industrial or university organization without boundaries. Learning and continuous improvement are the basics of each module of the system. Once the targets are achieved, it is possible to implement the modules in another node using the systematic knowledge obtained throughout the project.

4. CONCLUSION AND FUTURE WORK

The manufacturing industry in demand of advanced technologies needs a methodology to stay competitive and profitable in the global market. The international standards provide the framework and guidelines to overcome the challenges of modern competitive market. Hence, the proposed model of quality, environment and energy standards implementation in a manufacturing plant offers a roadmap for current state and future estimation analysis.

The intelligent metrology applications will be the future solution for advanced manufacturing industry. The collaborative project with the target of practical approach to the measurement applications offers the main aspects of the technology progress. By putting the project modules into practice, a systematic development is realized to implement high precise measurement tasks and establish essential measurement know-how within the sophisticated production systems.

REFERENCES

[1] European Commission, " Treaty of Amsterdam amending the Treaty on European Union, the Treaties establishing the European Communities and related acts", *Official Journal C 340*, 10 November 1997.

[2] European Council, "Lisbon European Council", *Presidency Conclusion*, 23-24.March.2000.

[3] European Council, "Gothenburg European Council", *Presidency Conclusion*, 15-16.June.2001.

[4] Council of the European Union, "Renewed Eu Sustainable Development Strategy", *10917/06*, Brussels, 26.June.2006.

[5] Council of the European Union, "Review of the EU Sustainable Development Strategy- Presidency Report", *16818/09*, Brussels, 1.December.2009.

[6] P.H. Osanna, M.N. Durakbasa, J.M. Bauer, H. Tahirova, L. Krauter, "Management of Natural Resources, Sustainable Development and Ecological hazards", *Wessex Institute of technology Press*, Southampton, UK, ISBN: 978-1-84564-048-4, 2006.

[7] A. Weckenmann, G. Akkasoglu, T. Werner, „Paradigm Shifts in Quality Management“, *Proceedings of the 2nd International Conference on Quality and Innovation in Engineering and Management – QIEM*, Cluj-Napoca, Romania, November, 2012, pp. 11-16.

[8] ISO 9001:2008: Quality management systems - Requirements.

[9] ISO 14001:2004 + Cor. 1:2009: Environmental management systems - Requirements with guidance for use.

[10] ISO 50001:2011: Energy management systems - Requirements with guidance for use.

[11] P. Kopacek, "Intelligent Manufacturing: Present State and Future Trends", *Journal of Intelligent and Robotic Systems*, Volume 26, 1999, pp.217-229.

[12] iGrafx Inc., "iGrafx Process Modeling and Analysis 2013", 2013.