Intelligent Manufacturing Systems

NOVEL TRENDS IN DESIGN CONCEPT OF INTELLIGENT MANUFACTURING SYSTEMS

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Abstract: *The current trend of increasing quality and demands of the final product is affected by time analysis of the entire manufacturing process. The primary requirement of manufacturing is to produce as many products as soon as possible, at the lowest possible cost, but of course with the highest quality. Such requirements may be satisfied only if all the elements entering and affecting the production cycle are in a fully functional condition. These elements consist of sensory equipment and intelligent control elements that are essential for building intelligent manufacturing systems. Intelligent manufacturing system itself should be a system that can flexibly respond to changes in entering and exiting the process in interaction with the surroundings. In this paper a concept of designing and building intelligent decision support systems in production management is introduced. The new approach to the design of intelligent management systems is proposed based on integration of artificial intelligence technologies (fuzzy logic, artificial neural networks ,expert systems and genetic algorithms) with exact methods and models of decisions search and simulation techniques. The proposed approach allows for creating intelligent decision support systems of complex, unstructured management problems in fuzzy conditions. The systems learn based on accumulated data and adapt to changes in operation conditions.*

Key words: *sensory equipment, intelligent manufacturing systems, manufacturing process, control system artificial neural networks, fuzzy inference systems decision support system*

1. INTRODUCTION

The industrial intelligence is still forwarding. Today we are not talking only about using of IT, classical automated instruments. But when we are talking about flexible intelligent manufacturing systems it is effective to talk also about possible using of new generation intelligent manufacturing systems. This new generation of manufacturing systems are also called intelligent manufacturing systems. All IMS subsystems are including parts of so called machine intelligence (sensor equipment). Using of given systems with combination of machine intelligence will lead to the complete labor remove from the manufacturing system. The concept of intelligent manufacturing combines the ability of decision-making support systems in generative systems to obtain knowledge, to learn and to adapt to a changing environment and to the actual arrangement of system components. The nature of intelligent manufacturing is system's possibility to learn and its self development as well as the possibility to generate information necessary to control the integrated production

system. The aim of the work is to present a conception of designing and creating one of the components of Intelligent Management Systems as Intelligent Decision Support Systems alongside with the basic methods and tools of artificial intelligence which are necessary to support decision making in these systems.

2. USE OF CA SYSTEMS IN FLEXIBLE MANUFACTURING

CA systems are computer systems that are intended to support of activities at all stages of manufacturing – from development and design of component, production planning to production and assembly, storage and expedition.

Use of CA systems in manufacturing and execution time of the components is shown in Fig. 1 [1]

In the design and planning stage is made after modeling, simulation and analysis activities the complete design and technological documentation, respectively, are generated by CAD and CAPP data - *Computer Aided Engineering works CAE*.

Second stage is characterized by different automated systems with computer support (manufacturing, assembly, storage) - *Computer Aided Production Engineering*

CAPE

Computer-Aided Design (CAD)/ Computer Aided Manufacturing (CAM) systems integrate different tools (e.g., e-mail, multimedia, 3-dimensional CAD geometry viewer) in a distributed multimedia-designing environment through the Internet (e.g.). In CAD, the computers are used in the design and analysis of products and processes. In CAM, the computers are used

directly to control and monitor the machines/ processes in real-time or offline to support manufacturing operations (e.g., process planning). [3]

Computer integrated manufacturing (CIM) systems have been used to integrate different areas within manufacturing enterprises. They use a graphical user interface within aprogramming environment and incorporate multimedia packages to facilitate the dissemination of product information.

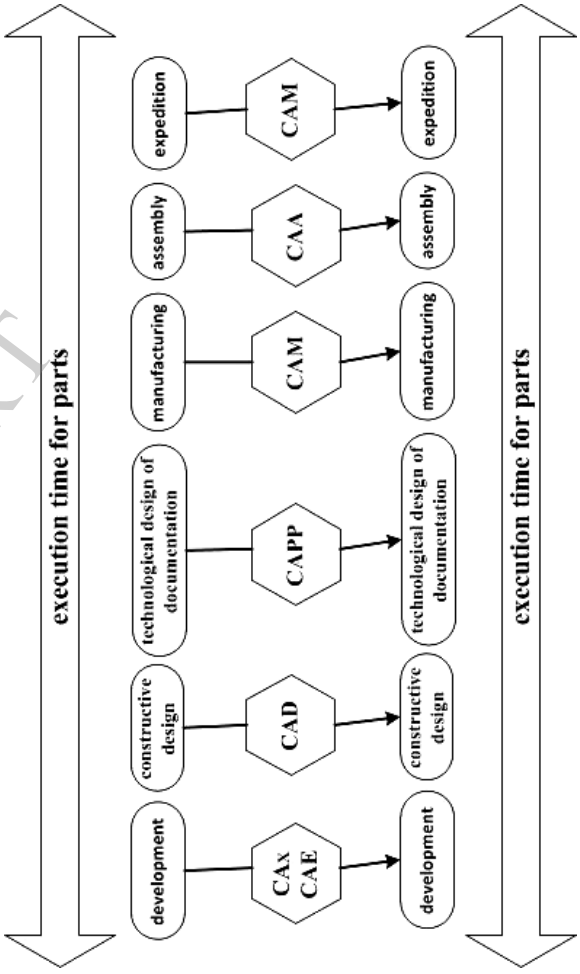

Fig. 1. CA systems and execution time of components [1]

The analysis of the existing methods and approaches to the creation of enterprise management support systems indicate that data warehouses currently constitute the basis for modern information systems and guarantee

effective use of the information included. Thus, implemented ERP systems and systems with Business Intelligence technologies can be utilized as sources of knowledge while creating intelligent management system of an enterprise.

3. AUTOMATIC MANUFACTURING SYSTEM

For better understanding of "intelligent manufacturing systems" term, is the most suitable to compare its behavior with behavior of flexible manufacturing system.

Automation manufacturing system is today known as manufacturing device with various levels of automation of operating and non-operating activities and with various levels of subsystems integration (technological, supervisory, transportation, manipulating, controlling):

• technological (set of technological workstations)
  - transportation and manipulating (is realized by industrial robots, manipulators and transporters)
  - supervisory (is included to system if machines in system do not have own supervisory devices)
  - controlling (there are dominating own controlling systems of all devices) [2]

Using of intelligent production systems is conditioned by efficiency of all subsystems, which are contain in given system. Subsystems are developed with automatic manufacturing systems, in order to save the system parameters.

Automatic manufacturing systems in repetitive production, where is demanded big rate of flexibility, are called flexible manufacturing systems. [2]

To category of automated manufacturing systems (flexible manufacturing systems) are included one or more technological workstations, at which are all inputs, material and immaterial, automated. Basic classification of automated manufacturing systems takes into the account also the number of the machines in the system as well as flexibility of the production.

According to this classification we distinguish three basic types of automated manufacturing systems:

• Flexible manufacturing cell – up to maximum three of the machine tools; it's characterized by highest level of flexibility.
  - Flexible manufacturing line – is characterized by the lowest level of flexibility; range of goods is narrow and being produced in large batches.
  - Flexible manufacturing system – minimum three machines and more; is characterized by lower level of flexibility.

4. INTELLIGENT MANUFACTURING SYSTEM

Intelligent manufacturing system presents system with self-contained capability of adaptation to unexpected changes, i.e. assortment changes, market requirements,

Technology changes,social needs etc. However, intelligence of these systems is frequently understood as control of the software product, and not as implementation of modern technologies of machine artificial intelligence.

Intelligent production systems consist of subsystems like automatic production systems (technological, supervisory, transportation, manipulating). Subsystems have to be equipped with aids, which give to subsystems specific level of intelligence. It is possible to consider it as higher phase of flexible production systems. [2]

Components of an intelligent manufacturing systems consist of (Fig.3):

- intelligent design,
- intelligent operation,
- intelligent control,
- intelligent planning
- intelligentmaintenance

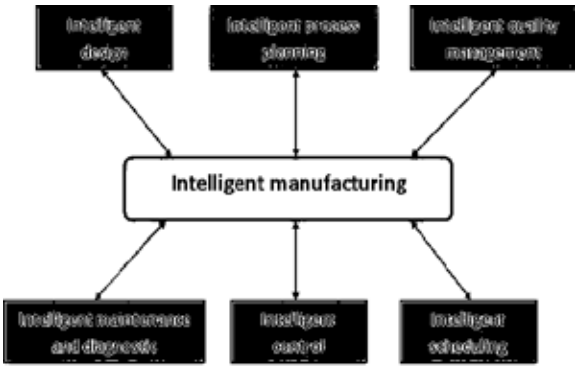

Fig.2 Components of an intelligent manufacturing systems

Manufacturing engineering systems evolved in order to meet several objectives, such as:

- reduction of cost;
- reduction of lead times;
- easy integration of new processes, sub-systems,technology and/ or upgrades; interoperability;
- reduction of production waste, production process and product environmental impact to 'near zero';
- fast reconfiguration; fast adaptation to expected and unexpected events

5 .MECHANICAL PERIPHERY INTELIGENCE ENHANCEMENT POTENTIAL AND LIMITATIONS IN PRODUCTION

In term of automation assembly is the most complicated operation. Sequences like correct grip, orientation and positioning of the component entering the assembly system in disordered condition (e.g. loose in a container) are very easy to realize by a human. In term of automation however these seemingly simple acts represent one of the most complicated problems. Usually we try to keep aloof from such acts in the automated assembly process so that individual components enter the assembly system already oriented and in a defined place by means of various feeders, tanks or pallets.

In case the automated assembly system is entered by individual components which are unpositioned and non-oriented an intense cooperation between the sensor subsystem and various intelligent mechanical peripheries is necessary. Various types of sensors (contact, contactless, pressure, sensors of strength and moments, CCD cameras and others) are used dependent on specific demands of the specific application. Simultaneous combined use of various sensor types affords solution opportunities also of very complicated monitoring tasks. Individual sensor types can differ also in their output signals. Some sensors have only simple binary output signals, others can have a more complicated output signal consisting of several simple binary signals (e.g. sensor differentiating colours) and others can provide an analogue signal (e.g. rheostatic thermometer). All these signals must be processed and correctly evaluated by the control system because only on the basis of this information it can correctly respond to the actual state of the production system en bloc, of its individual subsystems as well as the actual state of the technological process.

Selected sensor or sensorial systems (monitoring systems) must meet technical, economic and operative indices. Factors, which affect their selection are multiple and multilevel. Center of the sensors application is mostly in robotized assembly, where the sensorial systems enable to assembly (so-called intelligent robots) and others technical elements to identify and monitor workspace and system environment with building elements.In robotized assembly the ideal event occurs when PR can recognize, place and grab random oriented object.

Sensorial equipment applied in assembly systems use three basic groups:

- tactile sensors
- proximity sensors
- visual sensors

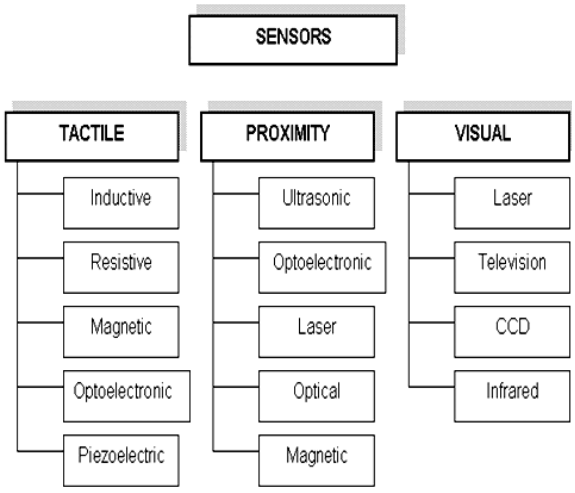

Fig.3 Classification of the most frequently used kinds of sensors

6. Conceptual Model of Intelligent Management System

In the presented approach to IMS design it is recommended that IMS's should be created as open architecture and modular structure systems, enabling the application of several methods of knowledge presentation and the integration of different knowledge processing schemes in the inference process, as well as the application of several learning methods. In intelligent manufacturing systems, the following selected contemporary methods and techniques of knowledge and decision process modeling should be integrated:

- Artificial neural networks – the most fascinating tool of artificial intelligence, capable of modeling extremely complex functions and, to some extent, copying the learning activity in the human brain.
- Fuzzy logic – technologies and methods of natural language formalization, linguistic and quality knowledge processing and fuzzification.
- Genetic algorithms and methods of evolutionary modeling – learning algorithms based on theoretical achievements of the theory of evolution, enriching the artificial intelligence techniques above.

The combination of these tools, in which knowledge is represented symbolically, with the traditional expert system will make it possible to create complex programmatic tools for solving difficult decision-making problems at each stage of enterprise functioning.

IMS Design Approach

The suggested frame of IMS design uses the basic rule of object methods in which modeling of information and processes is concurrent. It is also assumed that the design process is based on a single conceptual category of 'an object'. The frame works on some assumptions made in the methodology of design and implementation of open systems for computer integrated enterprises CIMOSA (Open Systems Architecture for CIM). CIMOSA was developed by AMICE (European Computer Integrated Manufacturing Architecture) Syndicate within European Union ESPRIT research projects in the years 1986-1996 [CIMOSA Association, 1996], [Ladet, Vernadat , 1995]. CIMOSA introduced an integrated enterprise modeling methodology based on processes.

The Intelligent Management system can be described as a distributed system in the following way:

IMS =<M,R(M), F(M),F(IMS)>,

where

M={Mi} – set of formal or logic-linguistic models performing specific intelligent functions;
R(M) – choice function of required models (set of models) in a given current situation;
F(M)={F(Mi)} – set of model modification functions;
F(IMS) – modification function of IMS and its basic structural elements M, R(M), F(M).

The conceptual structure of Intelligent Management System is illustrated in fig.4.

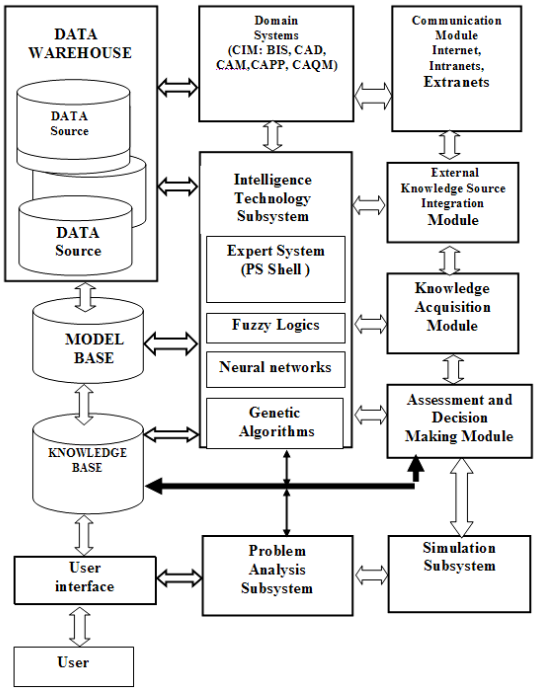

Figure.4 A conceptual structure of Intelligent Management System

technologies with exact methods, well-known in the decision making theory, as well as with simulation modeling methods. The approach proposed will open up a possibility to build an IMS of open structure, combining existing information systems with the information sub-systems in production engineering using artificial intelligence technologies in order to create an integrated environment for comprehensive solving of decisionmaking problems in the system of intelligent manufacturing.

8. REFERENCES

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7. CONCLUSION

Despite the developments in the area of engineering systems and advancements of information and communication technologies, current (manufacturing) engineering systems fail to address all the needs of today's manufacturing enterprises.
Current trends of manufacturing engineering system are towards enhancing machines with bioinspired and human abilities (e.g., intelligence, wisdom, cognitive functions), and in hiring (fewer) highly skilled employees. However, this trend has to be closely accompanied with (positive and negative) human, social and environmental consequences.
In the work, a certain conception of designing intelligent systems for enterprise management was presented.
Based on the conception, a methodology of creating the IMS is being developed based on the integration of artificial intelligence

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