General Principles of Engineering Designing in Frame of IMS

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Abstract: Mechanical, electrical and software engineers have different knowledge, language, training and tools. On the other hand they compose complex product together. The understanding and assessment of interrelationships among the various factors involved in the design process (i.e., actors, working means, methods, information, management design object, activities environment and organisation) is a central focus of Engineering design research therefore. The objective of recent research projects is statement of logical framework for engineering design processes, understanding multidisciplinary (mechatronic) design approach and reasoning of design methodology and consequences for CAD systems.

Keywords: Mechanical Engineering, Intelligent Manufacturing Systems, Design Methodology, Multidisciplinary Design, CAD

1 Introduction

In nineties last century academic circles with advanced producers of automation equipment and their customers from advanced industrialised economies took the initiative in new projects dedicated to total industrial automation known like IMS – Intelligent Manufacturing Systems [Kusiak, 1992]. Project goal was research and development so technology that will be able to flexible adaptation to market changes and economic development with valid costs. With regard to IMS number problems was submitted, solving of them are open to present time: (1) Clean Manufacturing – creating of conditions for clean manufacturing development production without pollution, In frame of CAD system were developed so called CAD systems ”Design for”, so special solutions like DFA (Design for Assembly) and DFE (Design for Environment), with help of them future costs for disassembly, liquidation and recycling of product is possible to state. (2) Concurrent Engineering – parallel product and manufacturing development with high quality, low prices and reduced time of product development, manufacturing process and delivery. Concurrent Engineering concept is built on international

development teamwork co-operation from various countries in all stages of product development using information and communication technology. (3) Rapid Product Development - methods software and hardware for rapid product development in stage of prototype or for small series production. (4) Flexible Manufacturing and Operations Management – development of advanced methods and practise that will make able flexible and intelligent management of production process. With order to IMS designing like very complex engineering systems engineering practise needs knowledge about design methodology, general design theory and their abstract. Present design theory does not offer good overview of the whole situation during multidisciplinary designing because it is often based only one discipline, does not use the same terminology and concentrates on one aspect of designing.

2 Development of Design Theory

Literature on modern design methods began to appear in the industrialised countries in the nineteen fifties and sixties, and has grown a lot since then. Together with working principles, diagrams, guidelines, etc. design methods compose the set of tools that design actors (i.e. designers, design teams and managers) have at their disposal for establishing and executing the various task involved in designing.

If we are talking about design generally, this is making of visions, ideas or models in the objective future objective world. Process of composing so model can be quite different: realisation of architectural projects, where design phase is segregated from phase of implementation; realisation of mechanical component in virtual prototyping, where between design phase and phase of implementation are common points.

Manufacturing system designing is regard to intellectual and targeted process that is a part of production management. In literature we are able to find more definitions of designing: [Mesarovic & Takahara 1975] define designing like changing of analytical phase, phase of synthesis and decision-making. [Vlcek 1984] count designing as a part of process control. [Tondl 1988] considers designing as plan for decision making in problem situation, e.i. set of activities for decrement or elimination primary vague or cut down of entropy level. [Buda & Kovac 1985] characterise designing like specific creative process of system creation (robot system, production line, etc...). In project documentation function and composition of system in space and time are express and material and finance needs for realisation and effective operation of system.

Research of new methods of designing would be based on knowledge general theoretical principles of technical objects design. From point of view of this idea

[Hubka 1973] define so called theory of design. Designing is considered as complex process realized by human intelligence. This process has all characters of intelligent activity: acquisition of knowledge, process of reason and opinion, solving presentation, learning, computer representation and so on. Creative designing is supported by advanced computer aided design systems now [Petr 1989].

Later authors found possibility of description designing models by means of cybernetic approach. In above-mentioned approach [Yoshikawa 1981] defines general theory of design based on topological model of human intelligence. Topological models use for modelling objects description definition, axiom a theorem. This approach is based on idea that design is set of entities and consequent definitions. From these definitions is possible to state axioms. Axioms are possible to make by reasoning (deduction, induction, intuition). From axioms is possible to deduce theorems by that process of designing is characterised. In present time above mentioned approach is developing like Abstract Design Theory. Abstract Design Theory is mathematical theory of design which aims to abstract the common features from such problem-solving phenomena based on Channel Theory, theory of information flow by Badwise and Seligman first developed by [Kakuda, 1999]. Design is an activity for realising desire or intention in the objective world. In engineering, the objects which realise our desire are usually physical entities in real world, like machines in mechanical engineering, buildings in architecture and so on, and the desire is usually specified as the functions of such objects. We utilise the physical lows which govern the real world in designing physical entities. The functions of entity are described by its behaviour, and the behaviour of physical entity is determined by attributes of entity, as well as the physical laws they are governed by. Hence, design is possible as long we have sufficient knowledge about the relation between the functions and attributes of these physical entities. This is the basic philosophy of Yoshikawa's General Design Theory. His approach was to mathematically express this basic idea by comparison of coarsenses of two topologies of functional and attribute spaces. He gave the definition of functional space in an axiomatic way, but how ca we get the functional space?

Function is the concept by which we explain the behaviour of entities. This concept inhabits the world of knowledge, while the attribute concept is contained in the real physical world Design is the activity which connects these two worlds. When we do design, information flows between the world of knowledge and real world, and we can obtain a functional space from this flow. This is a general scheme, which can be found in many examples of human activity of problem solving. Design Theory is mathematical theory of design which aims to abstract the common features from such problem-solving phenomena based on Channel Theory, theory of information flow by Badwise and Seligman.

In last time new approach is used inspired by biology and called like emergent synthesis [Ueda, 2000]. The definition of "emergence" varies in such fields as

biology, physics, philosophy, etc. From the system-theoretical view point, however, authors use here the "emergence" in the following sense: "a global order which expresses new function, structure, and action is formed through bi-directional dynamic processes where a local interaction of elements reveals a global behaviour and the global behaviour feedback to the local elements as certain constraints". Moreover, this definition implies the property that implicit globality emerges from explicit locality. As for the characteristics of an emergent system, such key words as evolution, adaptation, learning, co-ordination and interactivity are mentioned. The ways to utilise these concepts as basic mechanisms for solving synthesis problems of manufacturing systems are searching.

Conclusion

With regard to IMS design like complex (mechatronic) engineering systems the necessity of knowledge about designing theory is more and more important fro more point of view:

- quick changes on the market and therefore of production conditions resulting in systematic product and production systems innovation. So innovation requires adequate concepts and new engineering concepts supported by corresponding abstract basis,
- new engineering complexes are build like integrated from various components: mechanical, electrical and electronic, optical, maybe bionic sometime in future), what brink new quality but new problems in designing of integrated systems also,
- computer aided design of new products with simple connection to computer aided manufacturing and computer aided process planning are standard in modern production. Implementation of information systems supported production in frame of all product life cycle needs adequate abstract basis of designing.

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