INTEGRATED APPROACH IN COMPUTER AIDED DESIGN PROCESS

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Abstract: *The concept of design methods integration which can be implemented into design process is presented. The concept is focused on area of industrial computer aided systems within testing procedures for development process in automotive industry.*

1. INTRODUCTION

Today world of markets, industry, customers and competitors is becoming more complex and demanding. The pace of that change is accelerating. The system of innovation development helps manufacturers find competitive differentiation by being more customer focused, competitive, efficient, faster and reliable designs [7].

Design process is getting more complex due to highly demanding customers and aggressive competitors. These two factors forces manufacturers to design and make more robust products what directly influence design process. On the other hand common direction towards cost savings and shortening of design cycle force to make design process highly efficient at high level of performance.

Since many years in top companies the tendency to integrate design process with use of computer systems is arisen. Stand alone applications to control the project management, archive the documentation or perform engineering analyses starts to be implemented within one, integrated computer system what is in fact, long time awaiting, design 'knowledge' systems. In this paper authors try to describe own works in this area.

2. DESIGN PROCESS

There are many listings of the steps or phases covering the engineering design process. In general they can be grouped in three types [3]:

- descriptive models,
- prescriptive models,
- mixed models (including computer models and attributive models [4].

Elementary assumption for prescriptive models is a belive in a common and general procedure for design problem-solving. Meanwhile, it is obvious, that model which is too detailed can not be utilized as universal for wide spectrum of businesses (products) and further, a model too general loses its utility and in case of direct implementation into industry process questions the aim and objectivity of its implementation.

The common features of prescriptive models [4] are as follow:

- design problem identification and definition; scope, boundaries and requirements analyses,
- synthesis of design solutions,
- solution assessment based on technology, financial and other requirements.

Prescriptive model solutions are always located on two levels, both constrained to each-other:

- concept solution,
- design solution.

In practical prescriptive design models implemented within industry, location of split is depended on business specification and company strategy and organization. Prescriptive models characterization is always based on design process phase description.

Pahl and Beitz [1] provide one of well-known design structures. These four activities take place in all industrial design projects, where mostly it starts from design problem definition through concept up to design verification and product implementation (Fig. 1).

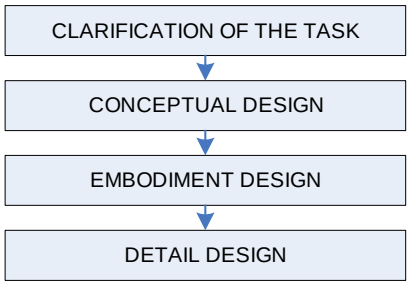

Fig.1. *Prescriptive design model by Pahl i Beitz [1]*

Conceptual design is the generation of a design concept or concepts. The terms used by Pahl and Beitz to describe it is: identify essential problems, establish function structures, search for solution principles, combine and firm up concept variants. Such build-in functions are close to process management specification and moreover can be easily used by designers.

Embodiment design consists of preliminary layouts, design specification and configurations, defining the most desirable preliminary set-ups evaluating the concepts against technical and economic criteria. The detail design specifies full design specification of product, outline and assembly and sub-assembly drawings, component drawings with manufacturing remarks etc. In corporate environment this particular phase requires from designer to issue several documents as material and technology release of product, risk and functionality analyses and many of test reports.

It requires a lot of engineering skills to specify all of items correctly and with high level of project management skill to put the design in a satisfactory manner. Additionally many of alternatives or options can be considered during this phase of the process what frequently leads toward iterative nature of design process.

The exemplary industry implemented design process can be described as follow (Fig. 2).

The six-sigma strategy and methodology is currently one of trend in world industry engineering, services, financial operations and others. Started by Motorola in 1987, developed and implemented by General Electrics in 1995 is well-known business strategy and engineering tools-kit.

The strategy of the change is described in phase model: Define-Measure-Analyze-Improve-Control (DMAIC). Obviously such model can not fully answer to design process needs. First, mainly focusing on the measurement phase, secondly

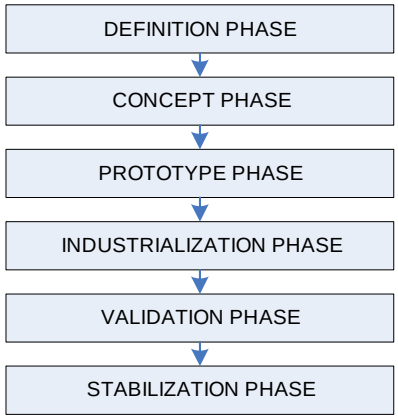

Fig.2. *Example of prescriptive design model in automotive industry*

referring to improvement where the design not always base on the current or available design solution (sometimes trying DO NOT so). For design process the strategy can offer 'Design for SixSigma' methodology well organized and fully detailed model: Define-Measure-Analyze-Design-Verify (DMADV). Such model is focused on CTQ analysis (Critical-To-Quality factors/features) versus customer and technology (business) requirements and expectations and concept variant selection based on quantitative criteria analysis than on 'stomach-knowledge' criteria. The design approach in this environment is presented below (based on [8]):

The objective of this paper is not to asses the value of six-sigma methodology. The fact is that both DMAIC and DfSS methodology are currently in use in many industry branches and due to detailed phase input/output description and kind of 'receipt' approach can be easily implemented into design process.

Design model gives to a designer general view on the design process. This objective can be realized by prescriptive design models, for instance the SixSigma model DMADV mentioned above. The model can support with functional information and working methodology for general approach to a design task. Additionally such general model creates company 'strategy' how design issues are investigated and finally solved.

Unfortunately the prescriptive model, due to its general nature, can not support a designer with all necessary functions required in a project. It seems that descriptive model must be implemented on operation level of design process in industry engineering. Such behavior can be proved by many industry examples.

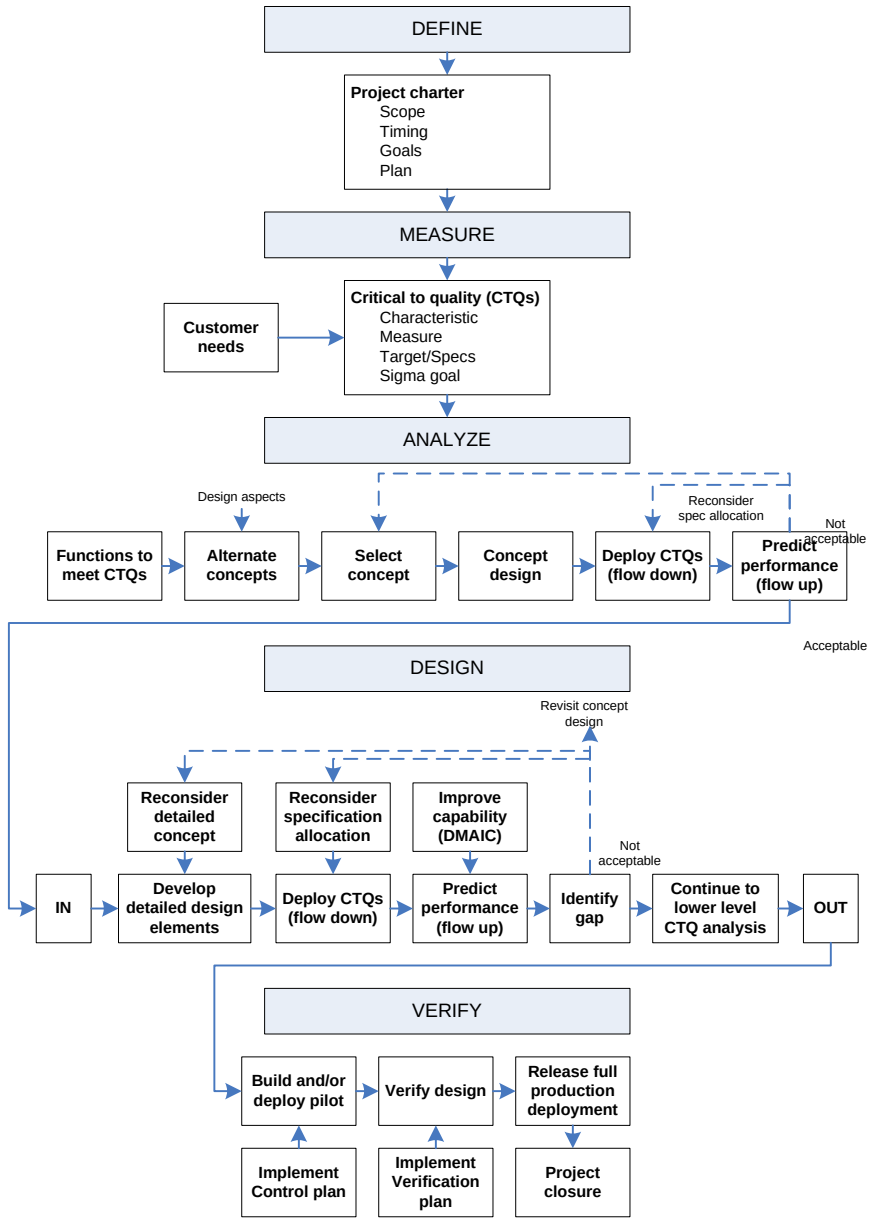

Fig.3. *Prescriptive design model by Design for SixSigma (DfSS) with actions and functions details [DuPont and GE sixsigma information*

3. DESIGN ENGINEERING

For particular range of design tasks and scope a designer may, or even must due to a quality system policy, follow steps of roadmap based on general design model.

Design task taxonomy (based on [1]) can be defined in groups as follow:

- routine design task
- minor redesign task
- major redesign task
- non-routine design task

For each of the group the detailed design model must be created. Based on experience, such models are descriptive models which support a designer with specific information about inputs and outputs for each of sub-steps and define functions within the process. The examples of descriptive design models are well-known for industry design engineering roadmaps, which support designer work with direct information and follow a project with required documentation and minimum of required tools.

Unfortunately for complex design the problem arises which tools should be in place. Which of wide variety of tools skip to meet with project time deadlines but keep the design quality on respectively good and reasonable level. The number of tools engaged in design process is very high. Many of them are hidden behind 'Design to X' approach. Below there is a short listing of tools available for vehicle industry for routine design tasks [9]:

- structure geometry CAD: model check, mold advisor, sheetmetal, plastic advisor,
- structure analysis: FEM (pro/M, Nastran/Patran), mechanism design,
- structure optimization analysis: DFA (design for assembly) and DFM (design for manufacturing),
- reliability prediction and analysis: FMEA, FTA, CC,
- rapid prototyping,
- prototype and product test kinds: OFAT (one factor at time), ALT (accelerated life time), HALT (highly accelerated life time) and others for different tests of: life test, corrosion test, vibration tests,
- Value analysis, Risk analysis,
- Tolerance analysis,
- QFD (quality function deployment) and Kano analysis for concept evaluation,
- Product history: SPC, internal claims, external claims: 0-km/field data,
- Best Practice library,
- and other.

4. DESIGN

The major issue to a designer seems to be a choice of best and most efficient set of tools to reach the project goal with best performance. Validated design must be mature for production process to decrease to absolute minimum cost of design iterations after project closure (so called Job1 when main efforts to finalize the design have been done) and redesigns due to customer claims or production problems.

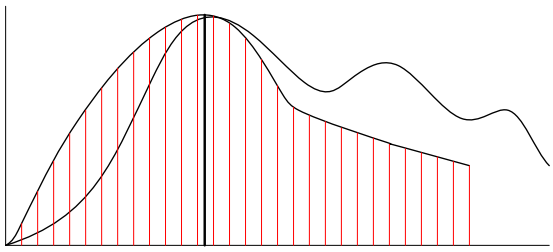

Fig.4. *Design project cost in time scale*

To reach the project cost scheme it is necessary to integrate the tools available in product development process and directly implement into the process and life cycle of products.

One of the solutions for such integration can be a PLM system (Product Lifecycle Management) being a platform for tools integration. The new system is a huge step forward from existing PDM (Product Data Management) systems, mainly focused on cad files as models and drawings, in direction of 'knowledge' databases for product development process or in different words ICAD systems.

Fig.5. *WTPart technology by PTC (Parametric Technology Corp.) a container for all documents concerning product numbers through its life cycle [PLM system by PTC, product information]*

The PLM system seems to be a well organized platform for integration of tools within product development process. The open issue is organization of data and process with sub-processes build-in to the system. Unfortunately the capacity of this paper does not accept run-flow presentation of such process management issue.

The last but not least problem is to fully implement the system through a corporation. All new tools and computer systems raise technology problems for both: users and hardware. At such stage of process development significant issue must be solved, whether to customize a system to a user or customize users to a system. On one hand, there is a strong need for deep customization of a system including different masks regarding different needs of segmented end users. This solution is called as a user-friendly interface. In deed, customization is best method for quick and successful system implementation. But the hidden problem of system administration, key-users, and not suitable upgrades remains for further work. On the other hand, it is possible to implement complex and full-feature system directly to end-users and furthermore enable training sessions, helpdesk support and some additional help. Users can utilize all necessary features required by the process build-in the system. Problem is if they are able due to high software complexity what is popular for sophisticated systems.

5. CONCLUSIONS

The design tool integration approach to design process based on PLM technology can significantly increase the number of information available in process and support design efforts. This solution is close to soft model definition owing to its flexibility and project utilization by combining the descriptive model on operation level with prescriptive strategy model [5]. The system answers for many of business requirements on knowledge databases.

The concept of product development test database as a part of PLM system with build-in testing

process in automotive industry is a subject of author's PhD course, which is currently in run at Wroclaw University of Technology and will be partly presented during the conference presentation.

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