Editorial

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Biographical notes: Faysal Khalaf has been contributing to Ford Motor Company since 1995. He received a PhD in Industrial Engineering, a Master's degree in Manufacturing and a Bachelor's degree in Mechanical Engineering. Currently, he is leading global deployment and integration of DFSS at Ford Motor Company. He led and coached numerous DFSS/DMAIC projects. He also led development and training of the DFSS training modules and deployed the DFSS integration in the product development at Ford Motor Company. He holds the position of Global/Corporate Design for Six Sigma Manager and is a recognised DFSS expert at Ford Motor Company.

1 Introduction

Product development, an essential factor of humanity, is based on creative applications of art and science. The nature of developing product is very dynamic and continuously competitive, especially in a global commercialisation like the one we live in nowadays. This challenge has been growing by an increasing rate year over year, requiring from us further discipline and rigour to deliver product with speed, quality and affordable cost structure. This discipline covers the whole curriculum starting with anticipating market need for future product architectures. The next phase surrounds art and science of defining product requirement, designing and characterising feasible design solutions and delivering these requirements reliably and robustly, as delivery time is very important. These new and improved products have to be launched just in time when markets are ready for purchasing and paying premium for these products.

This special issue focuses on integrating Design for Six Sigma discipline and approach to creating and improving the product and process design in technical and transactional environments. Each paper identifies either an opportunity for developing advanced methods and/or applying and executing these principles and methods to a variety of waste elimination, lean execution and quality improvement opportunities. All the papers of this journal focus on the development of new and improved methods and followed by the application and case studies. The following are the highlights for each paper coverage and extract from their abstract.

In the first paper, the authors propose a new search method for the Most Probable Point (MPP), which is a good metric for measuring the product robustness. The new method is based on a simulation within a limited radial sampling region determined by an initial uniform DOE that guarantees a good coverage of design space. The numerical non-linear examples are used to compare and verify the validity of the new method.

The second paper describes a simulation-based approach for applying a lean Design for Six Sigma (DFSS) methodology on a service system. To this end, an enhanced Identify, Design, Optimise and Verify (IDOV) process is proposed. Discrete Event Simulation (DES) is utilised to model the stochastic and dynamic characteristics of the service process. Design of Experiments (DOE) is applied to set the levels of process parameters so that a close-to Six Sigma performance is achieved and lean techniques are applied to enhance the structure of the service process so that a high process effectiveness is achieved. The DES model provides as a flexible and inexpensive process prototype for conducting the experimental design and implementing the lean techniques. A case study of a dental clinic is used to clarify the application of the proposed approach.

The third paper examines various aspects of complexity in product design and development and proposes a Total Cost of Complexity (TCC) equation to quantify the impact of non-value-added complexity. This paper tries to conceptually link the complexity concepts to the DFSS approach and looks at the DFSS project types, project structure to match it with complexity reduction efforts. A model for the DFSS evolution in an organisation is proposed covering various stages an organisation goes through during the DFSS implementation. An automobile fluid connection case study clearly illustrates the DFSS approach to reduce the component complexity and quantifies the benefits using the TCC equation.

The fourth paper identifies an evolution to applying DFSS in designing for manufacturing. DFSS is generally used in the context of either product design or business process design. In product design optimisation using the DFSS approach, the interaction with the manufacturing process is modelled as noise. This paper highlights areas of manufacturing process DFSS by developing some concepts and showcasing some recent successes at Ford Motor Company.

The fifth paper presents a product model, which enables the communication of the design between the participants in the process of product development. This product model includes the assembly states to support various activities involved in the assembly process. Because of its more comprehensive approach, this model both bridges the gap that exists in current CAD and CAM systems and proves valuable in the design of all inclusive systems combining various stages in the development of a product.

The sixth paper addresses further refinement to FMEA. Robust Design FMEA, the subject of this paper, is an enhancement to the currently in use design FMEA by anticipating safety and reliability failure modes through the use of a Parameter Diagram (P-Diagram).

Emphasis on testing strategy is a main topic in this issue and covered in papers seven and eight. An important phase of any product development process is the design optimisation and validation. This phase ensures through a predetermined testing strategy that the product failure modes are studied and addressed. Analytical and hardware type of testing present the engineering community with a selection. However, inherent deficiencies exist in each one. The paper seven illustrates the need for testing strategy through an example and provides the mechanics on how to deliver a balanced strategy to improve both analytical and hardware testing for better and more correlated tests.

Degree of complexity involved in preparing a testing strategy reflects degree of complexity embedded in product design architecture. Capitalising on recent development in design development such as axiomatic design principle, design innovation such as theory of inventive problem solving and task management such as design structure matrix, paper eight offers a step-by-step approach to prepare testing sequence for various possible cases of the uncoupled and decoupled designs.

The ninth paper presents an application of DFSS to automatic transmission shift quality. Shift quality is a high-leverage attribute for the customer satisfaction. Full-vehicle CAE models have been developed to enable the prediction of shift quality before the availability of physical prototypes. The four phases of the DFSS process – Define, Characterise, Optimise and Verify – are used in conjunction with ADAMS full-vehicle models. Two candidates meta-models are developed, each of which represents a transfer function between an automatic transmission torque output and a customer-correlated engineering metric (Vibration Dose Value).

The tenth paper presents another application of DFSS on Exhaust Manifold Design. This study uses a parametric model for the computational fluid dynamics and experimental design techniques especially suitable for the computer model responses. The meta-modelling in this case is the measure against the resource-intensive CAE applications. Analysing the range of all packageable alternatives, rather than just the nominal parameters, allows for the assessment of robustness under the presence of noise factors, such as dimensional part-to-part variation. That leads to a new approach in manifold design.

On the basis of evolutionary trend of the product development, I envision an increasing competitive challenge in developing the new technology and improving the existing ones. The winner in the marketplace will be reserved to the companies and societies, which admit and accept this challenge and continuously execute flawlessly by preventing the mistakes and learning a more effective and leaner approaches to address the knowledge discovery.

My sincere regards go to Dr. Dorgham for inviting me to lead this special issue and my management and colleagues at Ford Motor Company for supporting me during its development, especially Debbe Yeager, Colleen Moynihan and Ev Schweizerhof. I would like to extend my sincere thanks to those individuals who acted as reviewers for the papers submitted to the issue. I also appreciate Dr. Yang for helping me co-editing this special issue.