Talk on Advanced Computational Engineering is the way forward for reducing cost and time to market: A Myth or Reality.
by Ir Assoc Prof Dr Faris Tarlochan
A report by Ir Thavanendran Mahalingam

Ir Assoc Prof Dr Faris delivered a talk on the 20 Sept 2010 attended by a total of 41 participants. The talk in the area of design optimization through Advanced Computational Engineering (ACE) was organized by the Engineering Education Technical Division. Since the advent of the industrial revolution and the boom of the manufacturing sector, the quest for perfection has been more demanding due to the high standards set. An introduction to the concept of finite element analysis was presented in a very simplistic yet articulate approach. Many problems in engineering and applied science are governed by differential or integral equations. However, complexities in the geometry, properties and in the boundary conditions that are seen in most real-world problems usually means that an exact solution cannot be obtained in a reasonable amount of time to cope with great market demands. The Finite Element Method (FEM) is a numerical procedure using ACE for obtaining approximate solutions in a short time to many of the problems encountered in engineering analysis. The FEM is one of the most important developments in computational methods to occur in the 20th century. In just a few decades, the method has evolved from one with applications in structural engineering to a widely utilized and richly varied computational approach for many scientific and technological areas.

In the FEM, a complex region defining a continuum is discretized into simple geometric shapes called elements. An assembly process is used to link the individual elements to the given system. When the effects of loads and boundary conditions are considered, a set of linear or nonlinear algebraic equations is usually obtained. Solution of these equations gives the approximate behavior of the continuum or system. The number of equations is usually rather large for most real-world applications of the FEM, and requires the computational power of the digital computer.

The speaker explained the advantages of FEM in a sense that it can readily handle complex geometry, complex analysis types such as vibration, transients, nonlinear (crash analysis or impact/blast), heat transfer, fluids, complex loading, complex restraints where indeterminate structures can be analyzed. It also handles bodies comprised of non-homogeneous and non-isotropic materials and the ability to handle special effects to material i.e. plasticity and creep as well as to geometry i.e. large displacements/rotation.

He further moved into the disadvantages of FEM as discussed here. As applied to an approximation of the mathematical model of a system, the FEM inherits errors. Experience and judgment are needed in order to construct a good finite element model. A powerful computer and reliable FEM software are essential. Input and output data may be large and tedious to prepare and interpret.

A typical example of how FEM is applied to solid mechanics was demonstrated where a beam is subject to loading and stresses/strains are calculated from the deflections obtained by solving the assembled set of linear equations.

The Three measures of the effectiveness of design process was given as

1. Product Cost

- Design costs are a small fraction of total cost
- Decisions made during the design phase have large impact on product cost giving possible cost savings of over 50% and

2. Quality of the design

- Quality of the design improves with more time spent on concept design and minimal redesign efforts minimizing material wastage.

3. Time to market

- Global competition has affected this greatly. The faster to market, greater will be the returns.

Dr Faris presented a case study how an American copier company lost out to Japanese copier companies who dropped the cost significantly with an efficient design process called the Virtual Product Development (VPD) that allocates **more time in the design phase** and resulted in the reduction of cost and time to market. Hence, the decisions made during the design process have a great effect on the cost of a product, but cost very little. Another case study presented how Japanese automotive companies made early design changes which required more engineering effort but less on the assembly line changes resulting in **cheaper, better quality and faster** to market compared to American car makers still making changes after release for production.

The VPD process is compared against the traditional design process in **Fig.1**. Throughout the solution process, knowledge gained about the problem is represented by the learning curve, the steeper the curve the better. Unfortunately in the traditional design process, design freedom is lost as time progresses because capital has been committed. Once in production, any changes require great expense. Hence freedom to make changes is limited. In contrast the goal during the VPD is to learn as much as possible by simulation, testing and improvement as early as possible in the concept stage because it is least expensive and this avoids abortive production. As a result time and money is saved in the VPD process.

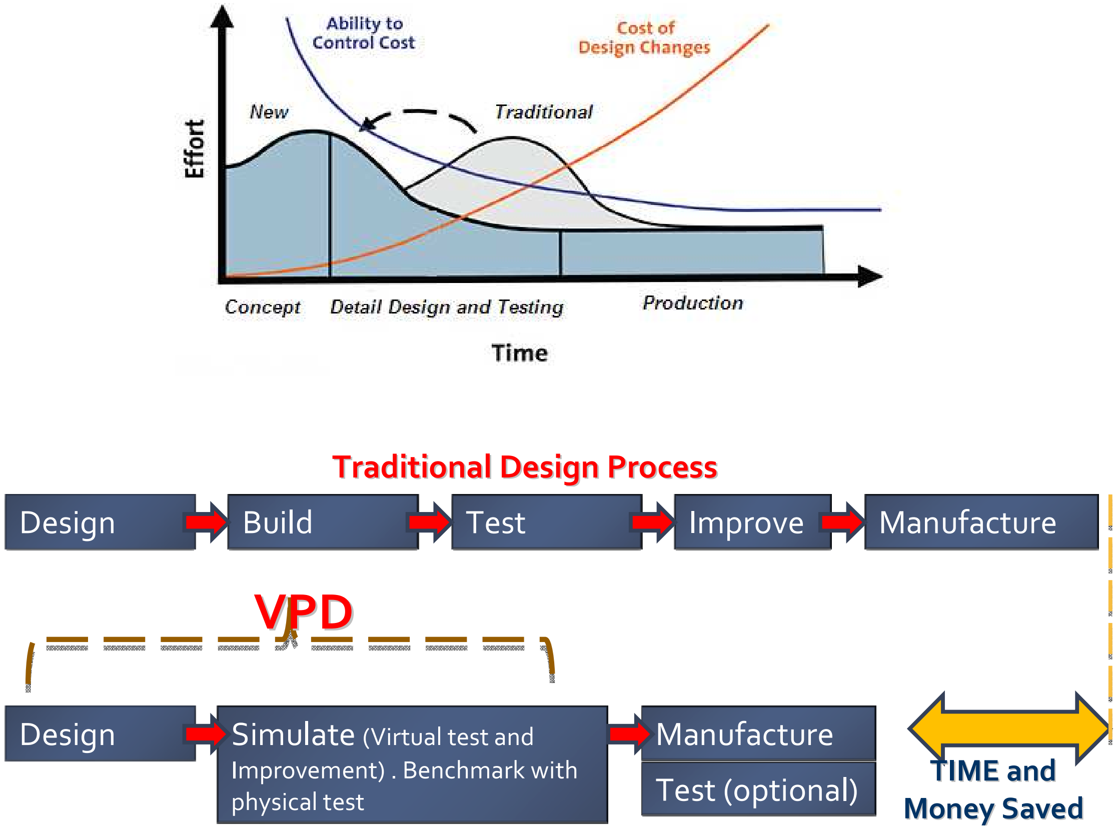

Figure 1

The speaker went on citing 8 case studies involving VPD in various industries explaining how optimization of the design is achieved in the end product final design.