KOTEL 071: VIRTUAL ENVIRONMENTAL TESTINGFOR ELECTRONIC PRODUCT RELIABILITY (VET)

1. PROJECT DEFINITION

Project background and present state

The use of computational simulation is increasing rapidly in various industrial processes. Particularly, various simulation methods are used at different phases of product design and development work. However, these analyses are still more or less separate studies without natural connection to other phases of product development. Simulation and virtual product models could be used to integrate wider areas of industrial practices. It is seen, that this kind of integration and use of simulation tools is coming into wider practise as natural development and that it is just a question when and how to integrate modelling and numerical methods more into everyday working practices. Still, there are technological challenges to be solved and methods to be adopted.

A potential step into more efficient simulation based product development is to carry out product environmental testing virtually with simulation techniques. With simulation techniques one can use virtual environments and “test” various virtual “prototypes” and get detailed information of the product performance without actually manufacturing prototypes and doing laborious physical prototype instrumentation and measurements. In addition, there is often a need to make early stage decisions concerning mechanical structure of a new product already without any physical product available.

Traditionally different prototypes are manufactured in order to find out the most satisfying product design alternative. However, prototypes are expensive and time consuming to manufacture. In addition, the number of prototypes is limited and they can be studied only in few test environments with typically laborious measurements. Thus, the obtained experimental data is often expensive and incomplete. Furthermore, if the tested prototype is not successful, it has to be modified, and the whole test process has to be repeated with the new prototype. In extreme cases, such as in some space applications, physical testing may be even impossible due to cost and size before you have your product ready and it has to put into actual use without complete system level testing.

With numerical simulation one can do system level tests even to large structures and to study product subcomponents which are normally not possible to test separately. In addition, one can use virtual techniques to produce tailored test specifications and to improve the reliability of accelerated physical testing. Furthermore, with transportation package modelling, it is possible to diminish transportation based failures and have lower warranty costs. With a virtual model it is also possible to simulate manufacturing processes for more optimized final products.

It is recognized, that the technological step into virtual models and simulation based product development may be laborious. This may be even more true for electronic products with various joints, materials and complicated geometrical structures. However, it is seen that this is the way of the future and the key element of successful industrial activities will be the control of high technology knowledge enabling fast product development. With virtual models the product information may be distributed to the most efficient manufacturing sites globally and back to the designer. Furthermore, with the cumulative knowledge, product modifications and new virtual designs become increasingly cost efficient.

The transfer into the use of simulation tools more widely is not only a technological question. Effective work processes are needed. Naturally, the used tools and models have to be validated and the simulation results verified. The reliability of the used tools is essential before one can expect wider use of the developed methods. Also commonly agreed working practices are needed. Standardized tools and methodologies enable business partners and subcontractors to form cost efficient product development and manufacturing networks having similar working practices. General standards do not exist for virtual environmental testing, but the experiences and standards of e.g. aerospace and military applications offer a useful base for the development work.

The purpose of this project is to study and develop the virtual environmental testing work processes, methodologies and tools for practical engineering work. Emphasis is on mechanical shock and vibration. The project will be a part of the new European BESTPRODUCT-TENEEST Eureka project, which provides an international forum for co-operation and research work. The European framework enables wider exchange of information and knowledge and ensures the quality and wide visibility of the results. The results are hoped to form a basis for future standardized methods and processes.

2. PROJECT GOAL

The goal of this work is to develop virtual environmental testing processes and methods for products having electronic components and to define best practices in construction of a simulation model for design.

The emphasis of this work is on the mechanical shocks and vibrations. However, the other environmental factors such as temperature, humidity etc. are taken into account as natural extensions of the developed methods and processes.

Virtual techniques may be used in different phases of product development and in different industrial processes. The main focus is considered to be in design and testing, and more detailed focusing will be done during the project. In addition, the influences of product requirements, manufacturing, packaging and today’s networked working practices are considered to some extent.

3. PROJECT PHASES AND RESULTS

Project is divided into four phases and the results of each phase are reported separately. The handbook development is a parallel task starting from the very beginning of the project.

The project will join from the very beginning into Eureka project "Virtual and Physical Testing" VPET. This European project has already been created under umbrella project "Bestproduct-Teneest". Within this Eureka project research and development work will be shared and more resources and synergy benefits will be available for all participants.

The project phases:

1. **State of Art**
    - The current theoretical and industrial know-how of virtual environmental testing of shocks and vibrations
    - The use of e.g. multi physical models, virtual life testing, accelerated testing, MEOST and HAST are discussed.
    - Standards helpful for virtual environmental testing
    - Eureka project expert network is used to get information
    - The results are used for more detailed project planning.
    - Available commercial virtual environmental testing software are reviewed
    - What can be done and what is difficult/impossible with simulation and with simulation softwares of today.

2. **Theory**
    - Theoretical background for virtual environmental testing for shocks and vibrations.
        a. Mathematical basis
        b. Computational simulation considerations. Particularly joint and material characterization, loading conditions, interaction phenomena, test equipment simulation.
        c. Experimental methods (tests, measurements, environmental loads, model- and simulation verification). Advanced methods combining the benefits of simulation and measurements are discussed.
        d. Signal analysis
        e. Philosophy of the work process
    - Other environmental factors such as temperature, moisture etc. are shortly described, but mainly left for future as a natural expansion of the conducted work.
    - General work process for virtual testing. Product life cycle management with requirements, design and verification give the general framework for the process.

- Creating and handling of structural responses in design. The effects of manufacturing and other relevant individual company processes are evaluated. A potential special question is the use of shock and vibration isolators.

3. **Case studies (to be determined during the project)**
   - Industrial cases (given by the Finnish industrial partners)
     a. Three (3) models from the industry
     b. Real life products or substructures of participating companies.
     c. Work includes measurable information of material properties, structural response and determination of load conditions (real measuring data versus simulated values). Challenges of real products such as joints, materials and complicated geometries are studied.
     d. Note: parallel product development project for each industrial case is encouraged. This separate funding insures the control of the confidential information and resource volumes for each case. The exchange of experiences and information between such parallel industrial product development projects would take place with this proposed research project.
   - Generic case
     a. A generic structure for research and verification of numerical and experimental methods is developed.
     b. This general case represent wider spectrum of products and can be studied without the confidentiality considerations needed for true industrial cases.
     c. A simplified structure in order to enable more focused study of complex phenomena of electronic product joints and materials.
     d. Is used for system and substructure (part, module, component) level studies.
     e. A platform of project co-operation.
     f. To be introduced as research platform for Eureka project partners. Joint effort for practical international co-operation

4. **Training**
   - The developed handbook is used as the basis for the training.
   - Theory and exercises.
   - Material for company internal training.
   - Guidance: “How to carry out a successful virtual environmental testing”.

The handbook is an introduction of the theory and work processes for virtual environmental shock and vibration testing of products with electronics. In addition, methods and tools for virtual testing are given .Industrial and generic cases are used to demonstrate the work and results. The handbook provides guide and best practices: “How to carry out a successful virtual environmental testing”.

4. UTILIZATION OF THE RESULTS

Virtual techniques are already used successfully in various applications and in different phases of product development. Thus, e.g. product requirement definition, design, testing, manufacturing and packaging may benefit from the new techniques. Furthermore, today’s networked working practices are often considered as challenges but also offer new possibilities with virtual techniques. It is seen, that virtual techniques will be essential part of future industrial practices. Particularly, virtual environmental testing is not only an approach to be more efficient but a technology to have better control of product quality and reliability.

The development and adaptation of virtual environmental testing will enable higher quality products with more efficient and faster product development processes well suited for today’s global networked industrial practices (design, manufacturing, subcontractors). The developed methods are particularly useful in the critical early stage product development work. However, with numerical methods it is also possible to reduce investments in physical testing facilities and the costs of complicated product testing. Moreover, it is easier to take into practice new methods and to gain results that would have been difficult earlier: such examples are new methods of force controlled testing, requirement management and testing of substructures, advanced tailored and accelerated testing. A new interesting and increasingly important possibility is to integrate the artistic visual design and usability studies of the product closely to the traditional engineering design work. With the virtual model also manufacturing simulation may be a natural part of product development.

The benefits and possible utilization of the virtual techniques are numerous, which make the evaluation of the virtual environmental testing somewhat confusing. Thus, it is important to focus the project into the most relevant research areas. Some of the ways to utilize the project results are listed here:

- state of art knowledge
    - decision making
    - work process development
    - product development
- more efficient product development
    - increased company internal co-operation
        - design, testing, manufacturing and requirement management.
    - virtual prototyping and testing
    - early stage design
    - acceptance testing
- increased product reliability control
    - requirement management
    - tailored and accelerated testing
- more efficient testing
    - new advanced test methods
        - force controlled testing
        - tailored and accelerated testing
- more efficient networked product development and manufacturing
    - subcontractors and industrial partners
    - requirement management

Utilization from the point of view of work phases:

- *State-of-art review* of virtual environmental testing provides a basis of decision making for experts and management.
- *Theory* of computational simulation methods and the supporting experimental methods needed for virtual environmental testing form the basis of the developed methods, practical design rules and future development.
- *Industrial cases* provide real life examples of virtual environmental testing with experimental verification.
- *Generic case* study provides a generic case of the virtual environmental testing and is used to enhance the international co-operation within the Eureka project. The generic case is expected to gain wide international visibility.
- *Work process* proposed for virtual environmental testing is the basis for the implementation of the methods into real life work and networked co-operation. Various levels of modelling and simulation may be used on the basis of the real needs and requirements.
- *Handbook* can be used for training and practical design work. In addition, the handbook is helpful for communication for national and international co-operation needed in this new field of technology.
- *Training* phase enable the adoption of the developed methods. However, the project partners get the best introduction to the field and the most efficient training thorough the project by participating to the case studies and more general development work.

Utilization from the point of view of short and long term planning:

- *In the short term* participants achieve immediate increase in their knowledge, improved work practices and co-operation and basis for product development improvement. In addition, the gained national and international visibility may be used for marketing and networked co-operation.
- *In the long term* the participants gain competitive edge with the use of state-of-art high technology methods. Efficient design process integrated into the other company practices is critical in the increasingly competitive global markets.
- *Future national and international research, development and standardization work* are natural follow up of the project. In addition to the studied shock and vibration loads there are more environmental factors to be studied. Furthermore, virtual environmental testing is a new field of technology and the conducted work can be seen as an important initialization of systematic continuous development of processes and methods needed for wider practical use.

5. RESOURCES AND ORGANISATION

A management group and a responsible leader are set for the project. KOTEL will select a suitable party to perform this research according to recommendations of the management group.

KOTEL workgroups will participate in the project.