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INTEGRATED SIMULATION METHODS FOR VIRTUAL ENGINEERING

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Abstract: The paper presents some integrated simulation methods for virtual engineering and point the virtual reality, which became a powerful tool for manufacturing system analysis and design.
In order to consider the feasibility of an integrated simulation method, it is necessary to combine virtual reality and simulation techniques, to support the virtual factory engineering, at different lifecycle phases.

1. INTRODUCTION

Recently, the world of Manufacturing Systems experienced the introduction of many new concepts and tools: advancements in Robotics and NC Machining to develop lean and flexible systems, the evolution from 2D drafting tools to 3D modelling tools, the development and deployment of sophisticated simulation tools, the introduction of graphical diagnostic and monitoring tools, high speed Local Area Networks and distributed controls, the reality of low cost Internet connectivity.

By adopting leading edge tools and technologies, now is the moment to transform the world of Manufacturing Systems from being focused on "HARDWARE" and "TOOLS" to an ever-increasing focus on "KNOWLEDGE" and "INFORMATION".

The deployment of modelling and simulation tools allows researchers to share a "Virtual Vision" of a Manufacturing System well before its first components are built or assembled.

It is necessary to survive in severe market competition and operation of factory from design to maintenance must be agile.

2. VIRTUAL REALITY, VIRTUAL FACTORY ENGINEERING, VIRTUAL FACTORY TEACHING SYSTEM

More and more used modern concepts are introduced in our technical language: **Virtual Engineering, Virtual Reality, Virtual Factory Engineering, And Virtual Factory Teaching System.**

Future becomes present, fuelled by price and performance improvements in the hardware and software technologies, **virtual reality** (VR) is quickly becoming a powerful tool for manufacturing system analysis and design.

It's natural to consider the feasibility of an integrated simulation method, combining virtual reality and simulation techniques together, to support the **virtual factory engineering** at different lifecycle phases.

About virtual factory engineering, there are two different understandings: the point of view of "strategy management" and the "techniques of implementation" point of view.

For the former, the term virtual factory refers to manufacturing activities carried out not in one central plant, but rather, in multiple locations by suppliers and partner firms as part of a strategic alliance [1].

For the latter, sophisticated computer simulations what might be called virtual factory-call for a distributed, integrated, computer-based composite model of a total manufacturing environment, incorporating all the tasks and resources necessary to accomplish the operation of designing, producing and delivering a product [2].

In fact, there is a close relationship between them: the former is based on the latter.

There are studies which described virtual factories in the future whose the key techniques included: simulation, controlling, self diagnosis [1].

For monitory and control of complex manufacturing system, four dimensions can be conceived to express complexity: space, time, process and network. Learning from past effort, the requirements of efficient factory model were discussed.

Others studies classified the current simulation software tools into two kinds of way: discrete event simulation and geometric simulation [3]. Major applications of discrete event simulation are as follows: material flow simulation, manufacturing system analysis, and information flow simulation. These applications can be decomposed into smaller, more precise tasks to examine, e.g., inventory, work in process, queues or transporting time.

Contrary to discrete event simulation, geometric simulation proceeds time-linearly, and therefore also is referred to as continuous simulation. Geometric simulation systems simulate the geometry of a part of, or the whole manufacturing system, usually in three dimensions. The necessity of integration in simulation was also discussed.

Different references represent the virtual factory in an analytic form so that many existing mathematical analyses can be applied. New pseudo resources can be added to form a new virtual environment, and control policy designed by engineers will be evaluated before being issued [4].

There are described the contents and development methodology of a **Virtual Factory Teaching System** (VFTS), whose aim is to provide a workspace that illustrates the concepts of factory management and design for complex manufacturing systems. The VFTS is unique in its integration of four domains: web-based simulations, engineering education, the Internet, and virtual factories.

3. THE CONCEPT OF VIRTUAL MANUFACTURING

The study of Integrated Simulation Method for Virtual Engineering leads to the concept of **Virtual Manufacturing**; this concept is simplified as an application of virtual reality in manufacturing, but it is only a tool for visualization.

There are Virtual Engineering Centres which brings together expertise on Virtual Reality, Engineering Computation, Physical Modelling and CAD technologies (Fig. 1).

Fig. 1. *Example of Virtual Engineering Centre - in the Northern Ireland Technology Centre, [2]*

Virtual Manufacturing is a manufacturing of imaginary objects in an imaginary environment to attain concrete objectives [6].

A manufacturing process could be represented by the Norbert Wiener's black box model (Fig. 2):

Fig. 2. *Norbert Wiener's black box model, [6]*

It is important to understand the relationships between the process factors and parameters. Once a set of factors is identified, it is possible to establish a relationship that connects the factors to the phenomenon under observation, (process attributes, production cost, production rate, dimensional precision, surface finish).

Establishing a parallel between real and virtual engineering, in the real manufacturing process, the engineer studies the real process attributes *a posteriori.* The conclusions related to the process attributes are based on observations and measurements of the real process. Optimization of the process with respect to one or more of the process attributes is done iteratively, through the method of trials and errors.

In virtual manufacturing, the engineer studies the real process *a priori,* which means that the process is conceived beforehand. No empirical study is necessary anymore. Thus, virtual manufacturing allows for inexpensive, fast evaluation of many processing alternatives before committing the process to the shop floor. The manufacturing process is optimized, potentially down to the physics level. Furthermore, it is possible to include within the scope of virtual manufacturing and the design process. Many "soft" design prototypes can be virtually manufactured to optimize the design of the product for a specific manufacturing goal.

In real manufacturing, the black box represents the interacting, interrelated, and interdependent objects, processes and activities, which form the entirety of a manufacturing system.

In virtual manufacturing, the black box contains an abstract model, which must adequately represent the real object. The procedure of model exploitation is known as a simulation. Applying simulation techniques to the model, we can measure the process attributes. Modelling and simulation procedures are in the heart of virtual manufacturing.

The adequacy of a virtual manufacturing system is defined as the agreed degree of accuracy and precision between the responds of the Virtual Manufacturing System (VMS) and the real system under the same conditions in all points of the modelling space, (Fig. 3), [6].

Accuracy determines the deviation of the results produced by VMS from the results, produced by the real system.

Precision defines the *spread* of modelling results. The problem is how to increase the spread of simulation results rather than to reduce it. VMS often exhibits a "perfectly precise" behaviour, yielding repetitive constant responses at a point of the modelling space, something which is quite far from the real situation.

The process of proving the adequacy of a VMS is called *validation.* If the VMS does not represent adequately the real system, it should be improved iteratively until the desired degree of accuracy and precision is achieved. This process is referred to as a *calibration.*

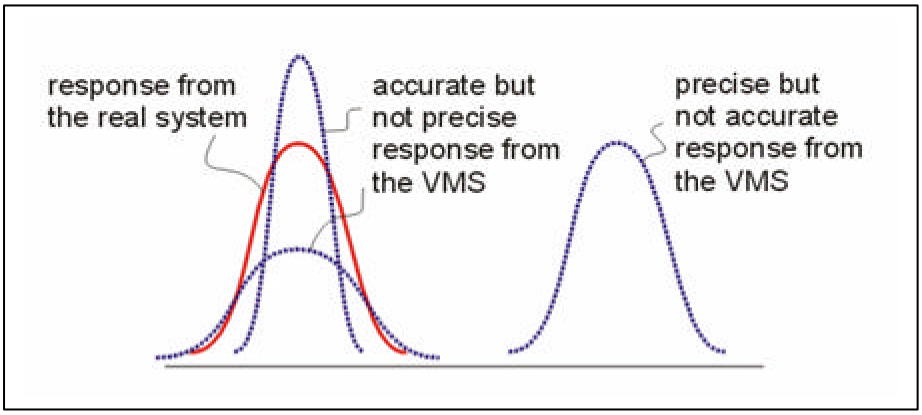

Fig. 3. *The adequacy of a virtual manufacturing system, [6]*

Modern concepts take place and improve the manufacturing and factory organization. In this area, concurrent engineering takes an important role in reduction the time of factory design and implementation and improvement of the efficiency of factory operation.

Considering virtual factory design, it is necessary to evaluate the factory organization and to do ergonomics analyses of manufacturing system.

At the virtual factory implementation level, it is necessary to train operators and at the level of virtual factory operation and maintenance, feasibility of operation plan have to be evaluated before being issued and performance of manufacturing system also needs to be evaluated. The all requirements above constitute demand layer of virtual factory.

CAD (computer aided design), VR (virtual reality) and simulation tools are integrated, which provide information to requirements of application layer. Plant practice uses three databases integrated in data layer: databases, model database and knowledge database. The data and information abstracted from real factory can be saved in database related at data layer. The system layer provides a support of software operation system and hardware for layers above. Finally, under the support of Integrated Simulation Method (ISM), real factory can be projected into virtual one, (Fig. 4, 5).

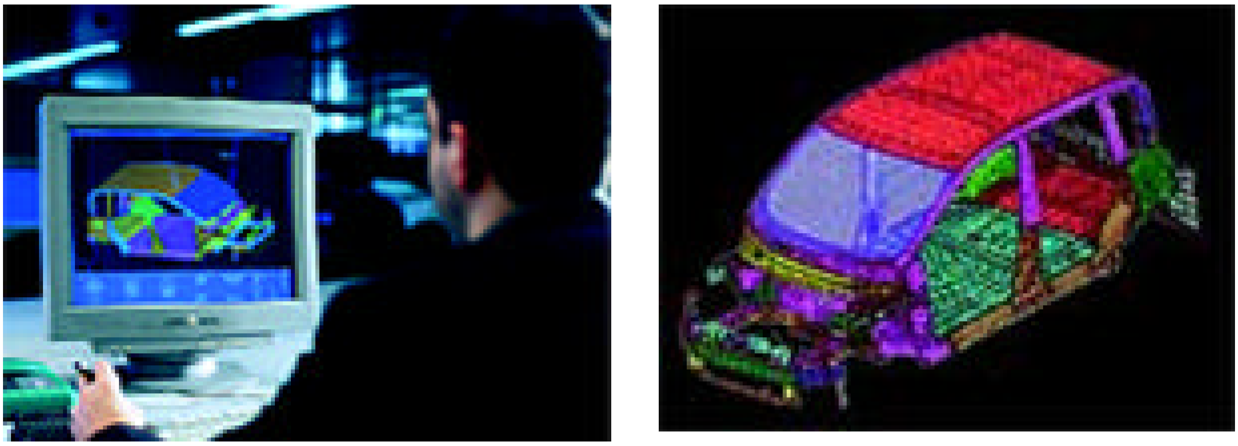

Fig. 4. *The stage of virtual factory design*

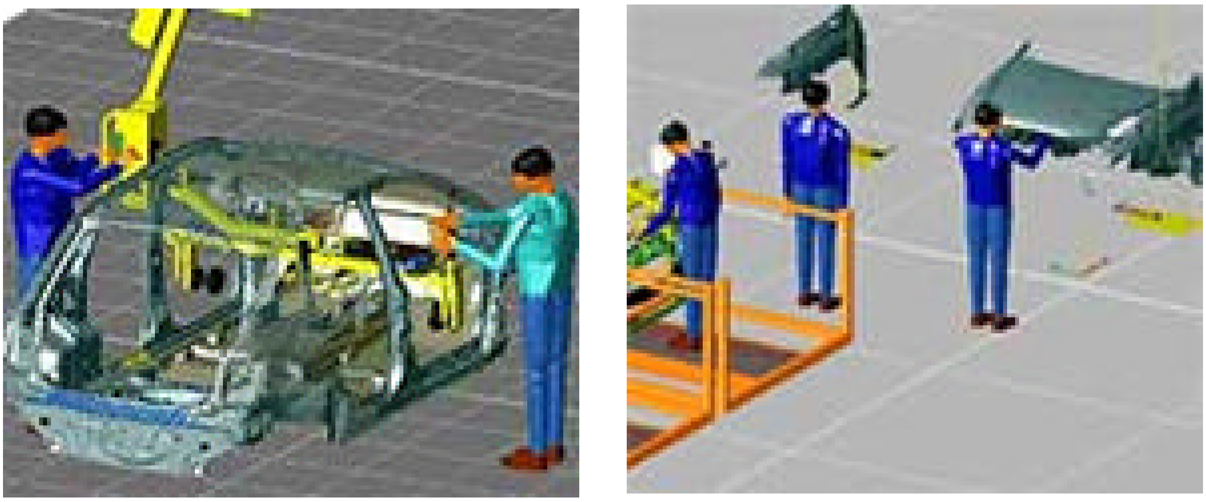

Fig. 5. *The stage of virtual factory operation and maintenance*

4. CONCLUSIONS

Virtual reality is a collection of technologies, which offer the opportunity to integrate the human into a computing system. Virtual reality may support the development of enhanced graphic user interfaces for virtual manufacturing.

The concept of virtual manufacturing can be expanded to encompass activities, processes and objects both along the production stage and across the enterprise hierarchy.

It is important to point the idea as Virtual manufacturing is a *concept* and should not be mixed with Virtual Manufacturing System, which is only one of the possible *implementations* of this concept.

Due to Integrated Simulation Methods for Virtual Engineering - tolerances, efficiencies, cycle times, and ergonomics can all be simulated and checked in advance and all necessary adjustments can be implemented, enhancing value for the Customer and improving time to market.

The same "Virtual Vision" is applied through the Manufacturing System's total life cycle, reducing risks, costs and times related to improvements, refurbishments and retooling.

5. REFERENCES

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