FROM TRAINING USED VIRTUAL REALITY TO VIRTUAL APLLIED ENGINEERING

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Rezumat. Lucrare argumentează oportunitatea folosirii echipamentelor şi tehnologiilor specifice realității virtuale în activitățile practice de instruire la disciplinele inginereşti, în special, de mecanică aplicată: mecanisme, organe de maşini, sisteme mecanice etc. cât şi la discipline de simulare a proceselor tehnologice de fabricație. Plecând de la folosirea softurilor CAD, pentru modelare geometrică si simularea posibilităților de funcționare a modelelor, sistemelor şi proceselor tehnice, se prezintă în lucrare motivele introducerii realității virtuale cu imersiune în procesul de instruire teoretic şi practic specific disciplinelor de mecanică aplicată. Particularizarea metodicii didactice conduce la extinderea modelului Wegener. Se descrie un post pilot în dezvoltare cu acest scop, popularea scenei virtuale şi interconectarea echipamentelor de realitate virtuală, respectiv a unei mănuşi Cyber Glove cu scena virtuală, operații posibile în scena virtuală, cum ar fi observarea pieselor şi operații de manipulare şi montare. Se descriu echipamentele principale achiziționate pentru echiparea acestui laborator virtual. De asemenea se fac precizări privind structura unei întreprinderi virtuale în care toate activitățile, de la sondarea pieței pentru identificarea tipurilor de produse necesare până la fabricația propriu zisă a acestora, se pot desfăşura cu echipamente şi tehnice specifice realității virtuale. Nu este lipsită de importanță susținerii proceselor de producție robotizate cu ajutorul simulărilor în realitate virtuală.

Cuvinte cheie: metode de învățare, realitate virtuală, inginerie clasică, inginerie virtuală.

Abstract. Virtual reality is considered one of the fundamental directions, with computers and robotics, to reconfigure the global society in this century and even further, as one solution to overcome the current structural crisis, deep crisis with multiple consequences, most negative. This paper describes a possible involvement of virtual reality to shift from traditional engineering to virtual engineering to solve in a significant manner, the current crisis of manufacturing engineering. For the first we discuss main aspects regarding training in mechanical design engineering using virtual reality. We present, in the second part in the paper, in brief the reasons for the introduction of virtual reality with immersion in the processes of theoretical and practical training in mechanical disciplines. We describe a pilot station which is in progress to test the use of virtual reality in the training activities concerned. We present the first achievements in this direction namely: proper populating of the virtual setting, interconnection of Cyber Glove gloves with the virtual setting and manipulating of virtual parts for visual observation and simple assembly operations. We show the main equipments for a virtual reality laboratory for applied mechanics too. Thus, we present the general structure of a virtual engineering entity, the main activities and organizational structures, and we briefly review the main types of virtual reality equipment and technologies useful for our purpose with highlighting a specific direction, namely virtual engineering for services and environment.

Keywords: teaching methods, virtual reality, classical engineering, virtual engineering

1. INTRODUCTION

Labor market dynamics requires adapting the educational offer of schools, both at high school and university level, market that is highly influenced by the current global crisis. Therefore, in terms of qualifications, number of graduates, and especially in terms of their knowledge quality, the interest to approach it seriously, prospecting the future is necessary. Obviously, the problem should be seen particularly in the context of labor market trends in Europe, trying to overcome barriers related to the integration of local graduates.

In the context of the above, the idea of the study ”New Skills for New Jobs” [UE document, 2007] is righteous, where the following priorities were set. The first priority is improving anticipation and timing ability in the case of the labor market, and skills required at European level. Another priority is achieving objectives set within the EU strategy for economic growth and employment, than it is optimizing existing initiatives and instruments. After that, it is collecting comparable results at European level, promoting a truly European labor market, with jobs and training that meet expectations and mobility needs of citizens, and so on [www 1].

Therefore, major challenges in education today are on the one hand reaching in a short time competences corresponding to requirements of various activities on the labor market, which keep diversifying, with increasing complexity, and on the other hand, continuous modernization of methods, techniques, and equipment used in the instructive educational process.

An effective modern solution, , for the aspects shown, is the use of virtual reality in training. Obviously, most experts know that the future belongs to 3D interfaces, reserves being mainly related to the cost of equipment, which – and this is a good sign - lately are getting lower, and their quality (resolution, response time, and so on).

2. VR SYSTEM TYPE ARCHITECTURE FROM THE PERSPECTIVE OF VIRTUAL REALITY APPLICATION IN TEACHING

Qualifications in the field of applied mechanics, generally involve technical skills and competences with a high degree of complexity. The need for professional training based on key abilities highlighted in Professional Training Standards, requires completion of a curriculum, where specialty culture includes a number of technical subjects with modular structure, whose contents are based on theoretical and practical aspects included in technology laboratory and practical training activities.

Conducting training based on modern strategies, student-centered, requires laboratories with appropriate equipment, difficult condition for many schools nowadays. The solution proposed in this article aims to set up a technological laboratory based on virtual reality techniques, with specific description of the equipment and the technologies required.

VR type systems have three main characteristics that actually differentiate them. They are interaction, immersivity, and movement in virtual environment (navigation) [Starețu & Dudulean, 2007, Ionescu, 2000 , Gutiérrez et al., 2008, WG2., 2006].

Being a computer aided training process, learning applications based on virtual reality techniques, in this respect, must be integrated to the theories and models of computer assisted instruction systems. Specialty literature provides a rich bibliography for this purpose [Roşca et al., 2002]. There are many names and terms, the dominant acronym being CBT (Computer Based Training) of the model proposed by Wegener [Wegener, 1999].

In the case of this model and its components, it should be made clear that virtual reality does not have only a simple quantitative contribution to 3D equipment (gloves, goggles, headphones). As virtual reality is a computer-generated environment where, through immersion, the trainee performs activities in real time without contact with the outside environment, the characteristics of such a system will be different from CAI (Computer Assisted Instruction) systems. Computer assisted training systems in Wegener model are no immersive desktop applications, with high interactivity at the level of mouse, joystick, up to touch screen.

Therefore, reported to the above, the applications of virtual reality techniques fall at least within one extended Wegener model, if not a stand-alone model to reflect the characteristics mentioned

(Fig. 1). Modalities, specific to the computer aided training system through virtual reality have different characteristics. Tutorials, practice, educational game, modelling, simulation, and problem solving should be adapted to reflect the specificity of virtual reality. Learning activities are also different, from one learning style to another, and applications should meet this requirement.

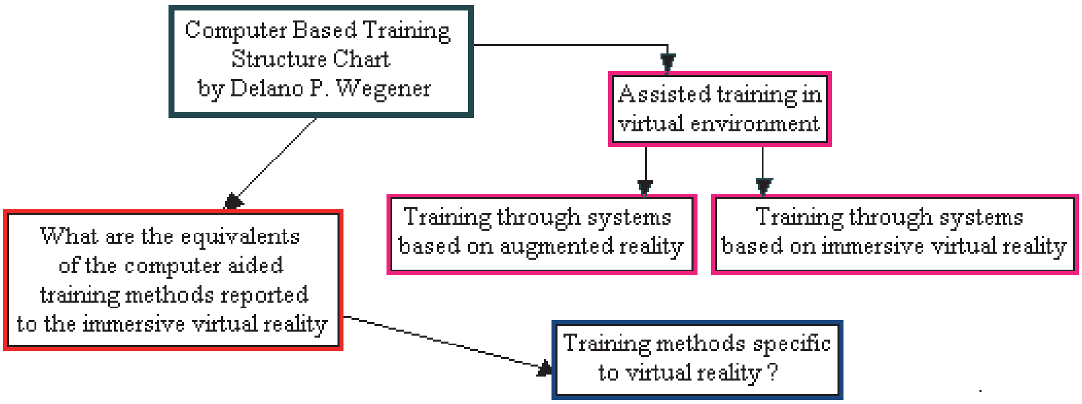
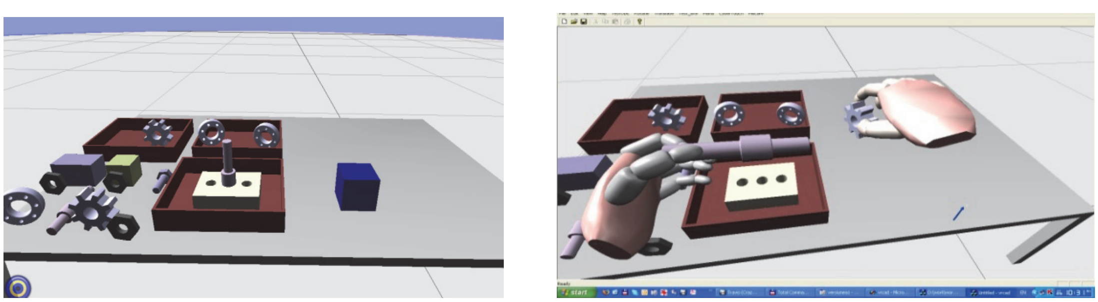


Fig. 1. Wegener extended model.

3. STRUCTURE OF A PILOT TRAINING STATION USING VIRTUAL REALITY - PARTIAL ACHIEVEMENTS

Virtual reality training in applied mechanics in the case of technology high school curriculum, during a first stage aims to implement a pilot station [Starețu, 2008], appropriate teaching materials and steps required for approval and implementation of this procedure.

The pilot station structure consists of an HMD, or for the beginning, a pair of stereoscopic glasses, a pair of gloves, CYBER GLOVE type, corresponding interface between them and the virtual environment (VRML), a computing system and appropriate software. First, an appropriate virtual scene is created. Thus, for applications in the subjects concerned (mechanisms, applied mechanics, machine parts) this virtual scene is designed as a workbench (Figure 2, a) with different parts (screws, nuts, sprockets, bearings, shaft-axis) placed directly on the table or in boxes (containing several pieces of the same type). At this stage, these pieces do not have physical properties. In the virtual scene, two virtual hands are placed (Figure 2, b), and the problem of handling virtual parts by virtual hands is solved, including simulation of a two-piece assembly.



a b

Fig. 2. Configuration of the virtual scene and manipulation of virtual objects.

During the next period, these applications will improve. Assemblies that are more complex are going to be obtained, as well as necessary adaptations for training in the case of disciplines like applied mechanics, and in the case of students, and finally we seek approval of this learning-training procedure. We note that currently we are identifying features of virtual reality based training application for the subject "Motion Transmission Systems" within the technical secondary schools curriculum.

In addition, a corresponding virtual scene for applications of specific subjects is created , presenting the scene as a worktable, where simple various pieces and simple mechanical structures are placed. Modelling is done in Solidworks (Figure 3).

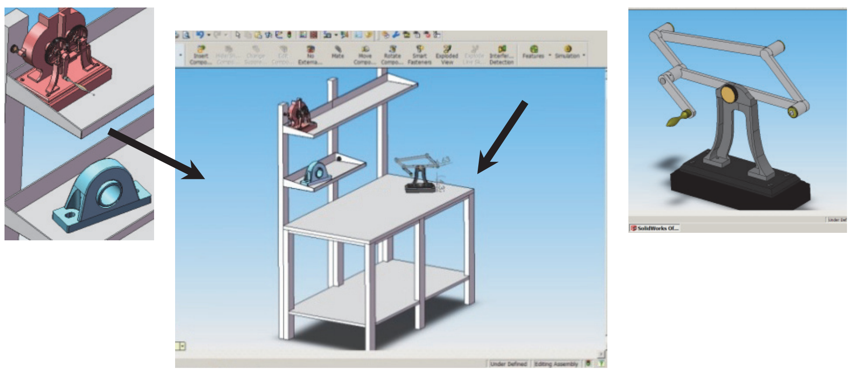


Fig. 3. 3D scene modelling and objects location.

The virtual reality pilot station is located in the real applied mechanics lab so that the teacher can combine elements of the real lab and the virtual lab, activity which will stimulate creativity, imagination, which will develop abstract thinking, decision-making ability, initiative, team spirit i.e. precisely curriculum targeted skills. The virtual lab allows the application of modern training principles such as learning by doing – learning through practice, interaction – interaction with scene and objects, hands on – the possibility to touch objects (haptics). Students can identify various machine parts, they can achieve assemblies of components, and they can identify and fix various errors in mounting, in a great variety of exercises, combined with real laboratory activities.

All these activities can be implemented in the Romanian education system through an appropriate environment and long-term strategy. Training through these means and methods is useful in activities that may take place in a company whose activity is based on virtual reality techniques and technologies for various purposes specific both to the production of goods, industrial products, and services. In the various structures of such a company, high school and university graduates may find their vocation. In the next section, we will detail the features of such structure that will undoubtedly be one of the next period priorities, as one of appropriate solutions for overcoming the current crisis.

4. THE GENERAL STRUCTURE OF AN ENTITY TO BE USED IN VIRTUAL ENGINEERING

Virtual reality is considered one of the fundamental directions, with computers and robotics, to reconfigure the global society of this century and even further, as a solution to overcome the current structural crisis, deep crisis with multiple consequences, most negative. One of the main aspects of this crisis, less evident, is related to product manufacturing techniques and technologies, e.g. [Cecil, 2010, Jayaram et al., 2007, Narayanasamy et al., 2006 , Huang et al., 2004].

Practical solutions used to manufacture most products have remained significantly behind other sectors development, behind general human activities such as creation, processing and sharing information, general circulation of goods (products and services), interpretation of human society and nature in general, human mentality etc. The main aspect of the manufacturing lag refers to the existence of yet another important role of the human factor. Through its specific behavior, it leads to violation of structural and functional features of the other technical means of processing, technical means of handling and transfer, equipment and processing technologies of technical and technological information pertaining to product design, technology design and technology management, product testing, transport to the beneficiary, maintenance and technical support during product life, etc. In this approach, to actual products, we add as well most services. In the context of the above, virtual reality can be a solution, which, at least in part, can eliminate the sluggishness of manufacturing engineering in general.

This paper describes a possible involvement of virtual reality to shift from traditional engineering to virtual engineering to solve in a significant manner, the current crisis of manufacturing engineering. Thus, we present the general structure of a virtual engineering entity, the main activities and the organizational structures, and we briefly review the main types of virtual reality equipment and technologies useful for our purpose highlighting a specific direction, namely virtual engineering for services and environment.

An entity based on virtual reality equipment and technology has a certain similarity with a current organization, with the important distinction that all activities, from the idea for a product or service to the final documentation required for practical achievement, manufacturing, new product or service. Its implementation is also involved and everything is resolved through appropriate solutions based on virtual reality.

Manufacturing, as phase of physical manifestation of the product, takes place outside the virtual engineering entity in an appropriate location, usually computerized and robotized, with a great capacity for reconfiguration, where the human factor has only a support role both during periods of use and conservation until a new order.

As far as this material is concerned, the simplified structure, by activities, of a virtual engineering entity is given in Figure 4.

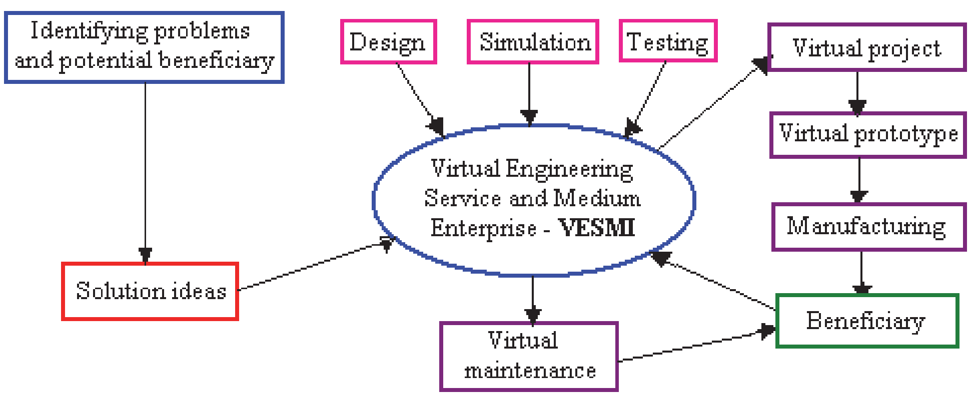


Fig. 4. The structure of the activities of a virtual engineering entity.

This entity carries out the activities mentioned below in appropriate sections. The first one is identifying problems of behavior in market prospecting. Then there is finding the optimal solution in the section of creativity and invention through design and simulation activities.

It follows the functional-design department through constructive design. Next, there are activities of technological design and virtual prototyping-department of virtual technologies.

We continue with virtual testing and technical evaluation activities of the functional and constructive performances, virtual testing, and certification department. Besides, there are activities of identification of solution and location for manufacturing, manufacturer identification section (usually in close proximity to the beneficiary - as far as possible), activities of commissioning and delivery, delivery and implementation section, maintenance and technical assistance activities along the life of the product, remote compartment of technical support online.

Thus, an entity of virtual engineering practically provides a virtual product, including all technical documentation necessary to its manufacture (once obtained this project similar to the current one, corresponding to the series 0, a manufacturing solution is identified and the location can be virtually at any distance, preferably near the beneficiary). One moves to that stage, where corrections are performed on the computer too. Once done, the physical product is delivered to the beneficiary and receiving and commissioning steps are covered. During the life of the product, technical support, maintenance and, even, any repairs will also be performed online by the entity's virtual maintenance department VESMI. A direct consequence of such an approach is the possibility of decoupling design in the broadest sense of design, from the production stage, which can be performed where a solution is identified, financially and qualitatively affordable, as well as from the distance, from the beneficiary point of view. Obviously, virtually, possibly online too, maintenance activities can take place throughout the product life.

In addition, it is not without interest to separate more specifically the concept above in the form of *virtual engineering for services and environment*.

Thus, you can tackle globally activities that exceed the service area in the current sense, by including in their category beside manufacture and related issues like proper training, and management activities dealing with environmental problems, analysis, protection, configuration, and reconfiguration, especially in residential areas.

Thus, one can study various scenarios likely to develop or restructure the environment piecewise or globally, on short, medium, and long term.

It is not less important the possibility of virtual reconstruction of existing situations in the past and likely in the future, including the possibility of dynamic change simulation by introducing virtual time (such as an urban area, a city, village or other settlement otherwise, but also an existing natural area in the past or future estimated to be). There, the immersion in interior areas and outer ones and interaction with virtual scene components can lead to a unique perception and experience including the cognitive aspect.

5. MAIN TYPES OF EQUIPMENT RECOMMENDED FOR SPECIFIC VIRTUAL ENGINEERING ACTIVITIES

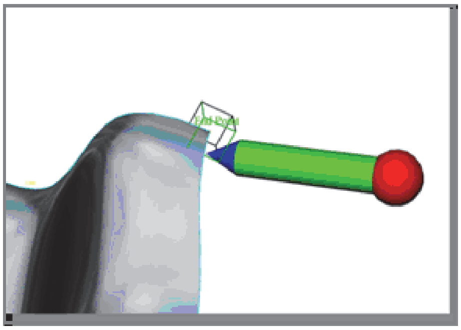
5.1. For Design and Functional Simulation

Design work is typically conception and project activity including functional and constructive design, e.g. [Cecil & Kanchanapiboon, 2007].

For design we already use advanced software like CATIA, Pro-Engineering, AUTOCAD, SOLIDWORKS etc. that for certain issues can turn to specialized software such as the finite element ones: NASTRAN, PATRAN, etc. (see Figure 5, e.g.) [Fiorentino et al., 2008].

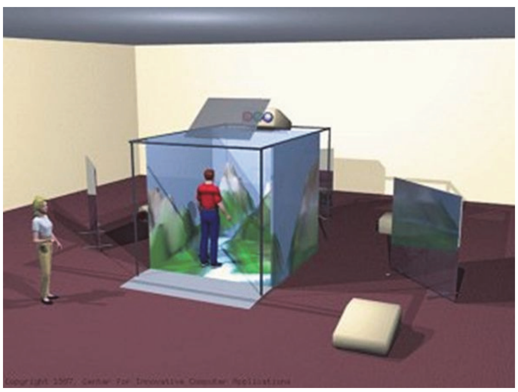
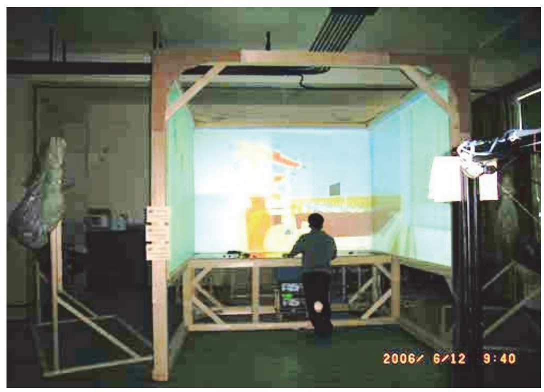
For functional simulation, virtual reality role is much more important, and equipment in this category is more varied and of unquestionable utility. 3D functional simulation can be generally through CAVE type equipment or similar (which covers only some of the amenities of a CAVE equipment, sufficient for the problems considered to be solved) (see Figure 6*a*). Following this simulation, improvements are possible so that approaching the optimal solution of the product or service is maximal.

Functional simulation is even more significant as it can return with force and can use real virtual reality versions, as increased virtual reality or improved virtual reality (see Figure 6*b*).




a b

Fig. 5. Virtual design: special device (*a*) and an example to use its (*b*), e.g. [6].

a b

Fig. 6. CAVE equipment: general structure (*a*), e.g. [Talaba et al., 2008] and used at robot simulation (*b*), e.g. [Gîrbacia, 2007].

Following these simulations, we can make suitable improvement so that approximation of the optimal solution of the product or service should be maximum.

5.2. For Virtual Manufacture - Virtual Prototyping and Testing

Production simulation can be fully realized in virtual environment, e.g. [Probst et al., 2009], [Cecil & Gobinath, 2009, Cassier et al., 2002, Chung & Peng, 2008 , Yang et al., 2007, Wei et al., 2007, Whisker et al., 2002, Ferreira & Hamdi, 2004 , Hamdi et al., 2008, Lim et al., 2006, Xu et al., 2008, Whisker et al., 2002]. The whole succession of technological stages, hence of the operation of handling and transfer and processing can be simulated in virtual environment, even if currently there are not performed simulations for all the physical-chemical processes specific to manufacture and transfer (see Figure 7).

They are already solved and operational (virtual simulation can already be highlighted in the case of the physical and chemical process of a welding operation, namely electric arc cutting and processes specific to alloy casting). An important direction is virtual simulation of the cutting processes (processing) of different metallic materials (turning, milling, drilling, threading, grinding, etc.), non-metals (wood, plastic) or composite materials, simulation of forging and hot or cold cupping etc.

Virtual simulation of most technological processes should be a priority for research in the next step.

Virtual testing is also very important view the high costs of testing of real prototypes, e.g. [Farahmand, 2009], [Sivertsen, 2011]. In this direction, achievements are important as one can discuss complete virtual solutions for virtual prototyping testing like virtual cars (see Figure 8) from which solutions can be extrapolated successfully to other types of products and even services.

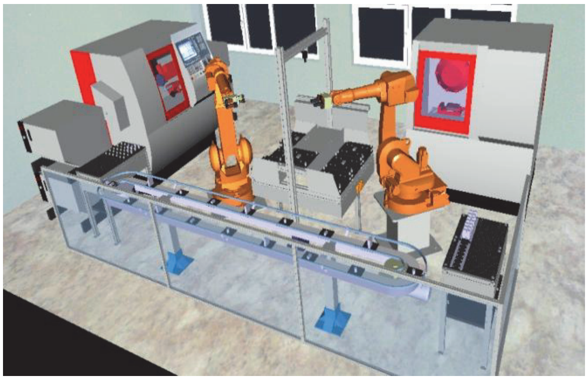


Fig. 7. Virtual robotic cell for manufacturing and transfer, e.g. [Aron & Mogan].

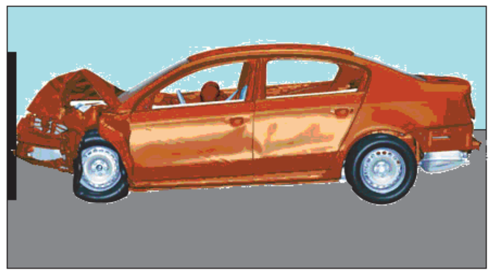


Fig. 8. Virtual testing of the car.

5.3. For Maintenance

Having the virtual model of the product, all maintenance activities, including the replacement of defective parts can be simulated in the virtual environment. Even if current attempts have met some difficulties and led to some skepticism, solutions during the next period will successfully solve all the current problems.

Thus, maintenance can be achieved on the virtual product online with the actual product (see Figure 9: an instructor can track all trainees in the field using a free view camera available as a window on the instructor station, e.g. [Rovaglio, 2011]). It is similar to virtual remote surgery. This example is not exaggerated, view the maintenance, including in the case of equipment operating outside the Earth, such as satellites and circum-terrestrial stations, but they can operate as well in hostile environments, such as seas and oceans at great depths (e.g. interventions in the underwater infrastructure of a sea platform, aboard a submarine, etc.).

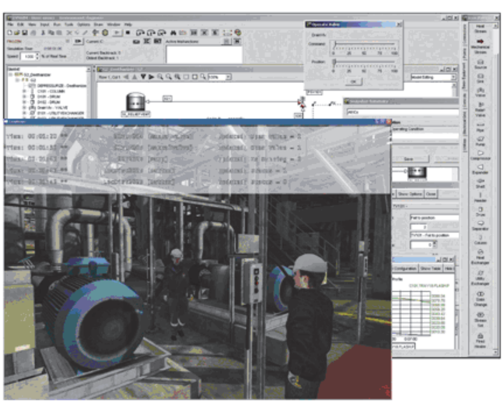


Fig. 9. An example of virtual maintenance, e.g. [Rovaglio, 2011].

5.4. To promote Products and Services

Virtual promotion opens special perspectives because the product can be fully presented in the work environment, but also in hypothetical environments and situations, and possible alternatives may be presented, identifying specific advantages. It can be made available to interested parties by means of remote information sharing.

A very important application is related to virtual exhibitions, e.g. [www 2]; see Figure 10. The main advantage of virtual exhibitions is the modern promotional online method, for the first time in the car parts area, with the chance to promote each exhibitor's products. The method is seeking to relate companies and buyers, in an easy-to-use and direct environment, like the internet, sharing everything about car parts, the latest services in the automotive sector, in the same area etc., e.g. [www 2]. The main objectives of the application are to stimulate the interest of the public, with its originality and innovation, to become an annual online meeting point and to provide agreement conclusions between exhibitors and visitors etc., e.g.[www 2].

For example, the first **virtual exhibition AutoP-Expo 2011** hosted up to 500 exhibitors with products and services, such as car parts and systems, repair and maintenance equipment, lab equipment, medical equipment and car painting, car washing, sound accessories, IT parts and electronic management, environmental protection, energy-saving, new products, quality certification, banks, financial organizations, insurance companies, media associations etc.[www 2].

Fig. 10. Virtual exhibition, e.g. [www 2].

Obviously, a virtual product in the future will be tested and used online for a limited period, similar to the current situation of trial use, after which the product may be returned. Thus, a virtual product can be changed on demand and adapted as a customized product, with much lower costs than today's similar activities.

Therefore, training activities, functionality development increasing, and products and services utility of have become more effectively continuous than today.

6. CONCLUSIONS

Based on the data presented in this paper, we can draw two important conclusions:

– recent progress in information sharing requires new methods of learning and training, consistent with the Internet and mobile phones possibilities, but with powerful learning features, corresponding to virtual reality techniques and technologies, already on the market;

– traditional engineering, particularly manufacturing, is in crisis despite the powerful promotion of simultaneous engineering and re-engineering;

– virtual engineering in a global approach can be a viable solution to overcome the current critical situation, particularly of manufacturing engineering and new release of engineering. It is possible primarily by covering steps to virtual prototyping from the actual production, and by the transition to a stage when interaction between customer and virtual product can acquire new meanings, with optimized effects on functionality and efficiency of use, in the case of very important financial resources, at occupational level,.

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