

APPLICATION OF VIRTUAL MANUFACTURING IN AREA OF ROBOTIC WORKPLACES DESIGN AND OPERATION

**Prof. Ing. Jozef Novák-Marcinčin, PhD.
Faculty of Manufacturing Technologies of TU of Košice with a seat in Prešov
Bayerova 1, 080 01 Prešov
Slovak Republic**

ABSTRACT

Virtual Manufacturing system is a computer system which can generate the same information about manufacturing system's structure, states and behaviours as we can observe in real manufacturing systems. Virtual manufacturing includes the fast improvement of manufacturing processes without drawing on the machines' operating time fund. Virtual manufacturing aids real manufacturing processes and systems and it is perfected as the information technologies, the manufacturing systems, automated manufacturing workplaces and the robotic workplaces design and development.

Keywords: virtual reality, virtual manufacturing, robotic workplaces design

1. INTRODUCTION

Maximal benefit for production enterprises is reached only by complete application of the computer aided systems to realisation of the product. This means that besides of the design and dimensioning of parts and products also to design of the production systems, design of the production plans, design of the tools and fixtures, realisation of own manufacturing and assembly and testing the product quality. These trends in engineering are converging to a new engineering concept: Virtual Engineering.

We can also classify virtual engineering in terms of production life cycle as virtual design, digital simulation, virtual prototyping, and virtual factory. Virtual design is done on virtual reality equipment. Digital simulation permits the verification and validation of the product's operation without using physical prototypes. Virtual prototyping builds a simulated prototype that possesses the same geometry and physical behaviour as the real product. Virtual factory is a simulation of factory production line [4].

2. VIRTUAL DESIGN AND VIRTUAL MANUFACTURING

Virtual engineering is currently approached in various ways. Because virtual engineering is an emerging technology, its terminology and definition are not completely established. In manufacturing, the major component of virtual engineering is virtual manufacturing. Virtual manufacturing is defined as an integrated, synthetic manufacturing environment exercised to enhance all levels of decision and control. It can be classified as design-centered, production-centered, and control-centered. Design-centered virtual manufacturing is a simulation environment for designing and evaluating the manufacturability of a product. Production-centered virtual manufacturing is a simulation environment for generating process plans and production plans. Control-centered virtual manufacturing is a simulation environment for shop floor production activities.

The most advanced current form of the Computer Aided Manufacturing is Virtual Manufacturing (VM) based on Virtual Reality (VR). VR representation techniques are widely used which means that they develop rapidly. In product manufacturing techniques and organization, virtual reality has become the basis of virtual manufacturing aimed at meeting the expectations of the users/buyers of products, also as to their low cost and lead time. Virtual manufacturing includes the fast improvement of manufacturing processes without drawing on the machines' operating time fund. It is said that

Virtual Manufacturing is the use of a desktop virtual reality system for the computer-aided design of components and processes for manufacture [5]. Examples of application of virtual reality system in laboratory of Faculty of Manufacturing Technologies in Prešov (Slovakia) are on Fig. 1.



Figure 1. Experimental use of virtual reality in laboratory

It is unquestionable that virtual manufacturing aids real manufacturing processes and systems and it is perfected as the information technologies, the manufacturing systems and the business demands develop. In this context, Virtual Manufacturing should be recognized as an advanced information structure of Real Manufacturing Systems, which integrates the available information tools and the virtual environment immersiveness to achieve business-manufacturing goals [5].

3. VIRTUAL MANUFACTURING BY SYSTEM ROANS

The main attention in the field of VR system applications in the technical practice is given to CAD/CAM/CAE systems of higher level. It is for the cause of realisation of export in format VRML (Virtual Reality Modelling Language). The newest versions of these systems could aid both existing formats VRML 1.0 and VRML 2.0 (97). VRML is description language, which belongs to a field Window on World System. The file, which is in VRML format, can be interpreted by VRML explorer in three-dimensional scene. VRML was created with aim to represent virtual reality on Internet easier. Development of 3D graphic is connected with Silicon Graphic Corporation. This corporation creates expanded Open GL library. Under this library was proposed the format Open Inventor, which is the base for creating VRML 1.0. Official specification of VRML 1.0 was finished in 1995. In autumn 1995 arise independent expert group - VRML Architecture Group (VAG), which aim was co-ordination of other advance, to map user requirements for developing of new VRML format. VRML 1.1 was only as working proposal. The new format VRML 2.0 was approved in 1996 as ISO/IEC standard and became as international standard VRML 97 [5].

VRML 2.0 (VRML 97) is accurately new language than only expansion of VRML 1.0. Against the version VRML 1.0 has lots new abilities and simultaneously takes off or makes some properties from proceeding version, easier. VRML 2.0 is the file format for describing interactive 3D scenes and objects. It can be used in collaboration with www, can be used for 3D complex representations creating of scenes, products or VR applications VRML 2.0 enables represent static and animated objects too. Basic elements of VRML 2.0 correspond with usually used 3D API (Open GL, Direct 3D). The scene in VRML 2.0 is also described by ASCII text file with WRL extension [1, 7].

Computer system ROANS is a software package on PC base created for 3D simulation and programming of automated workplaces, robots and other peripheral devices. ROANS offer to user all needed tools for robots creating and simulation. After designing of workplace subsystems and their placing in space, is able to create control program for all workplace is working in multitasking mode. For minimalization of mistakes in program and for simple programming is added program editor [9]. ROANS with help of integrated postprocessor program generates control code for specific robot language. PC hardware enables ROANS to communicate straightly with robot (reading of joint coordinates from encoder of robot, translating of code from postprocessor into robot controller, etc.).

Integrated dynamic and driving modules, which are able to analyse subsystems of robot enables to design by dynamic inversion method. This method is used for creating mechanical and driving subsystems of robots and other peripheral workplaces. The advantage of ROANS is its low requirements on hardware. This is the reason why ROANS is often used in laboratory conditions and in school laboratories. The sample of automated workplace with robots created in software ROANS and displayed in wire and shade regime is on Fig. 2.

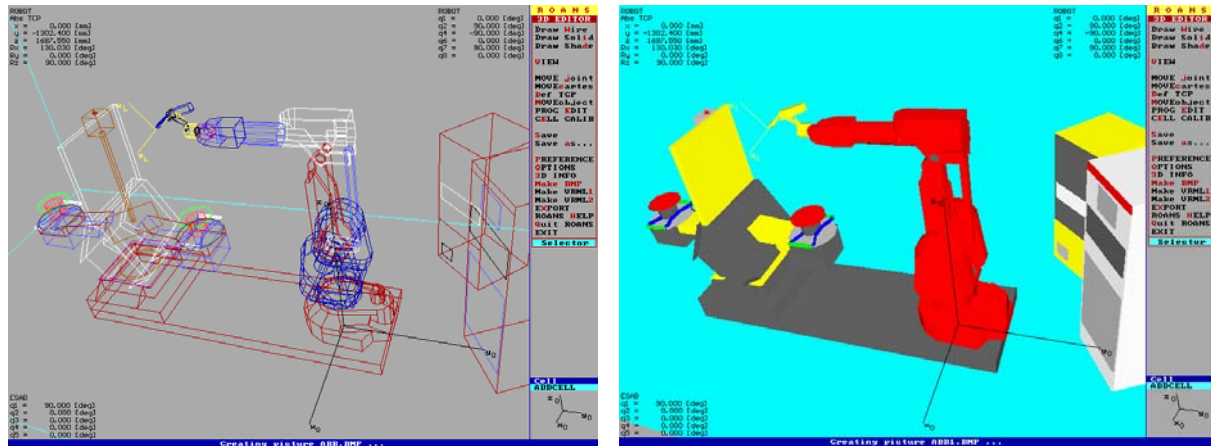


Figure 2. Robot workplace in ROANS

Before initiation of VRML implementation into system ROANS is needed to identify difference between structures in ROANS system and in VRML. This difference mainly comes from used program languages. ROANS were created in program language PASCAL. When the data are writing into the file they are indexed with rising value from number 1.

VRML language was created in C++ language and data writing to file uses abilities of this language. Data are indexed with rising value from number 0.

Differences in describing of points in ROANS system and VRML are in points indexing and in dimension units. Millimetres and indexing by rising value from 1, 2, 3, ... are used by ROANS. Meters and indexing by rising value from 0, 1, 2, ... are used by VRML. Differences in line defining in system ROANS and VRML are in colour indexing and indexing of points which are needed to line defining. Line colours has their own identification number in ROANS system. Identification number of a colour depends on order of colour defining in knots, which give a colour.

Differences in surface defining in system ROANS and VRML are in points indexing and in order of points, which describes creating of surface. Every surface has 2 sides. Feature in which surface is drawn in one or other side of object depends on order of point defining. ROANS system uses opposite principle for point defining like VRML. That is why the program for VRML creating needs to write this indexing in opposite order like in ROANS.

The program for export ROANS data to VRML language is solved as part of ROANS system. In this case there are some changes in ROANS menu. The changes are 3D Editor for Object structure, 3D Editor for Cell Structures and Anim for Cell Structures.

Created program works with data, which are saved in memory of computer. This is the reason why displaying of workplace is not needed for exporting into VRML. If somebody makes export of ROANS file without creating of any points, lines or surfaces, there will be only base structure in VRML. By activating of item MAKE VRML1 (stand with cursor on this item and than press ENTER, or right click of mouse, or pressing of hot key "1") is initialised activity of program. After this step you need to set the name of file in which will be result of export saved. It is needed to enter the name without extension, which will be automatically added. After file creating, starts export of data. First are exported header and preparatory knots (Info, BackgroundColor, ShapeHints, Material Binding, and Material). After this are exported data of points (Coordinate3) and depending on displaying regime are exported data of lines (IndexedLineSet) and surfaces (IndexedFaceSet). After ending of export is exported file closed and it is possible to work in ROANS system like before.

Activity of making VRML 2.0 is similar like in VRML 1.0. It is initialised from menu by activating MAKE VRML2 item (stand with cursor on this item and than press ENTER, or right click of mouse,

or pressing hot key “2”). After this procedure follows set of file name without extension WRL, which will be added automatically. After file creating, starts export of data. First are exported header and preparatory knots (WorldInfo and Background). After this, all data are exporting in dependence of displaying regime. Export of lines (Shape - for lines) and surfaces (Shape - for surfaces). In no visible shapes regime is process of points writing arranged. This is made in the case that some points are written twice and than they are marked with name “pts”. When a points and surfaces are defined they are extended by name (“pts”), which were defined in lines. After ending of export is exported file closed and it is possible to work in ROANS system like before [5, 6].

On the Fig. 3 we can see displaying of automated workplace in VRML environment.

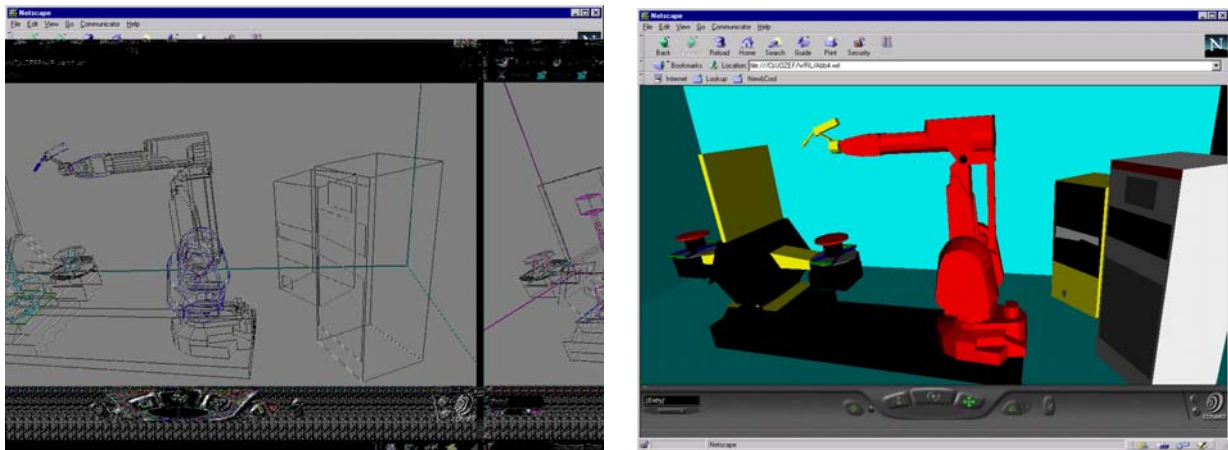


Figure 3. Robot Workplace in Netscape Navigator Environment

4. CONCLUSION

After implementation of VRML maker into the ROANS system it is possible to represent all 3D automated workplaces with robot created in ROANS system by VRML browser, and it is not needed to have a license for ROANS. This enables companies, which use ROANS system, to communicate better without personal contact even they are thousand kilometres apart. This could save financial resources and expressively decreases time of workplace designing expressively. VRML maker is integrated part of ROANS and do not increase hardware even software requirements on system [2, 3]. Slovak Ministry of Education supported this work, contract application research No. aAV/1107/2004 and contract agency KEGA No. 3/2236/04.

5. REFERENCES

- [1] Austakalnis, S. - Blatner, D.: Real about Virtual Reality. Jota, Brno, 1994 (in Czech).
- [2] Banerjee, P. - Zetu, D.: Virtual Manufacturing. John Wiley and Sons, New York, 320 pp., ISBN 0-471-35443-0.
- [3] Chang, T. Ch. - Wysk, R. A. - Wang, H. P.: Computer-Aided Manufacturing. Prentice-Hall, New Jersey, 1998, 748 p., ISBN 0-13-754524-X.
- [4] Lederer, G.: Virtual Manufacturing - Manufacturers Challenge of the 1990s. CIME - Computer Integrated Manufacture and Engineering. Vol. 1, No. 2, 1996, pp. 44-46.
- [5] Marcinčin, J. N.: Application of the Virtual Reality Technologies in Design of automated Workplaces. Transactions of the Universities of Košice, Vol. 10, No. 1, Košice, 2001, pp. 47-51, ISSN 1335-2334.
- [6] Marcinčin, J. N. - Brázda, P.: Virtual Reality and Augmented Reality in Technologies. Automation and CA Systems in Technology Planning and in Manufacturing (Editor: S. Legutko). Vol. 5, No. 1, Poznan - Giewartow, 2004, pp. 198-201, ISSN 1335-3799.
- [7] Neaga, I. - Kuric, I.: Virtual Environments for Product Design and Manufacturing. In: Proceedings „CA Systems and Technologies“. Zilina, 1999, pp. 60-65.
- [8] Ong, S. K. - Nee, A. Y. C.: Virtual and Augmented Reality Applications in Manufacturing. Springer-Verlag London, 387 pp., ISBN 1-85233-796-6.
- [9] ROANS v. 2.0. Reference manual. JHF Ltd. Presov, 1993.
- [10] Vasilko, K. - Marcinčin, J. N. - Havrila, M.: Manufacturing Engineering. Faculty of Manufacturing Technologies of TU v Košice, Prešov, 2003, 424 pp., ISBN 80-7099-995-0.