

## Automatic Machines with Multiple Axes Wood Processing in Small and Medium Enterprises

Novak Nedić<sup>+</sup>, Ljubomir Lukić<sup>++</sup>, Dragan Pršić<sup>+</sup>, Ljubiša Dubonjić<sup>+</sup> and Vesna Brašić<sup>+</sup>

<sup>+</sup> Department of Automatic Control, Robotics and Fluid Technique, University of Kragujevac, Faculty of Mechanical and Civil Engineering in Kraljevo, Dositejeva 19, 36000 Kraljevo, Serbia, Phone: +381 36 383 377, E-Mail: [nedic.n@mfkv.kg.ac.rs](mailto:nedic.n@mfkv.kg.ac.rs), [prsic.d@mfkv.kg.ac.rs](mailto:prsic.d@mfkv.kg.ac.rs), [dubonjic.lj@mfkv.kg.ac.rs](mailto:dubonjic.lj@mfkv.kg.ac.rs), [brasic.v@mfkv.kg.ac.rs](mailto:brasic.v@mfkv.kg.ac.rs), <http://www.mfkv.kg.ac.rs>

<sup>++</sup> Department of Production Technologies, University of Kragujevac, Faculty of Mechanical and Civil Engineering in Kraljevo, Dositejeva 19, 36000 Kraljevo, Serbia, Phone: +381 36 383 377, E-Mail: [lukic.lj@mfkv.kg.ac.rs](mailto:lukic.lj@mfkv.kg.ac.rs), <http://www.mfkv.kg.ac.rs>

**Abstract** - *Technological systems for wood in the small and medium enterprises in Serbia belong to the older generation of machines and equipment in terms of the degree of automation and application of computer control systems. Hence the companies are not competitive on the world market and in order to raise their technological level of production, there is an idea in the context of the international project ADRIA -HUB to be introduced into SMEs new technologies based on Automatic machines with multiple axes wood processing. The paper analyzes this possibility and indicates the expected effects.*

**Key words:** *Small and medium enterprises, Woodworking machines, CNC Control, Parallel robot platform*

### I. INTRODUCTION

The study, "Automatic machines with multiple axes wood processing in small and medium enterprises" is realized in the framework of an international research project Adria-Hub, which is coordinated by the University of Bologna, and participate the scientific and educational institutions from several countries, included in the Adriatic region and between them is also the Faculty of Mechanical Engineering and Civil Engineering in Kraljevo. General objectives of the project are to develop and promote international scientific and technical collaboration to solve technical problems in the field of wood processing, in order to form a unique international database that includes data on students / engineers and experts for wood-processing technology, information on the available machines and equipment for wood processing and data about the companies producers of finished wood products. The main objective of the project is, with using a database and the available scientific research and infrastructure potential, jointly implementing scientific research topics that are of special interest to increasing the technological level and improving the technological processes in companies of wood-processing industry in the countries of Adriatic region.

Faculty of Mechanical and Civil Engineering in Kraljevo has a long tradition, significant results and scientific potential in the field of industrial automation based on modern programmable microprocessor technology for the development of modern computer control systems. It has also a great experience in the application of CAD / CAM / CAPP systems in the design of products and technologies

for NC machine tools for metal processing industry, which can be adequately applied to the field of wood processing.

Despite the large number of small and medium-sized enterprises in the region, the Technical wood processing High School works successfully in Kraljevo for several decades, with well-equipped laboratories, which is a basic prerequisite for the education of engineers for wood-processing profession in Serbia. All this makes the assumption that the most important application of the ADRIA-HUB project results in Kraljevo region will give significant impetus to the development of modern wood-processing technologies in the small and medium-sized enterprises.

### II. CONDITION IN SMALL AND MEDIUM ENTERPRICES FOR WOOD PROCESSING IN SERBIA

In the small and medium enterprises, which are engaged in the manufacture of wood products in the region of Kraljevo, as well as in the whole of Serbia, classical and traditional technologies are applied for processing of flat and cylindrical surfaces with the use of universal machines for cutting, drilling, roughing and finishing flat surfaces. They use classical technologies to connect wooden elements by glued, as well as surface paints and varnishes treatment in terms of temperature treatment of the surface layer. The level of these technologies provides production in the class of simple products (joinery and furniture products with simple design and standard geometric shapes).

This type of production that is done in small batches with a very narrow range of production programs, with low-skilled workers, does not ensure high productivity, efficiency and effectiveness of production processes, which would ensure the competitiveness of small and medium enterprises in Serbia on the world market of wood products.

### III. MODERN TECHNOLOGICAL SYSTEM IN SMALL AND MEDIUM ENTERPRISES FOR WOOD PROCESSING

Significant improvement of technical and technological performance of production systems for wood processing in

small and medium-sized enterprises can be achieved through the introduction of automatized CNC machines with multi-axis numerical control, owned integrated warehouse with tools and automatic tool changer, which significantly increases the accuracy in the preparation, since the complete processing is performed in a single clamping. The productivity increases multiply with automatic change of tools and reduces the preparation time for setting and work piece clamping. Modern machining centers creates the possibility of effective flexible highly productive production of a wide range of different work pieces, thus creating the possibility of extending the production program for small and medium enterprises (Fig.1). Multi-axis numerical control on machine centers allows high quality processing of complex spatial objects on the wood surface, creating the possibility of applying modern design in wood products and manufacturing of stylish shaped furniture without limitation of the artistic designer ideas.

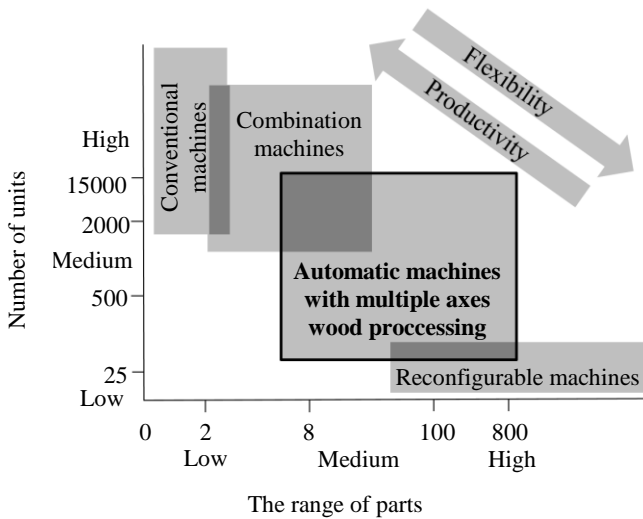


Fig. 1 The place of Automatic machines with multiple axes wood processing in product system for wood processing

Application of new technology gives wide possibilities in the production of special work platforms, the revolving tables and other elements of the technological equipment which enhance production processes.

Figure 2 shows an example of the working platform that is used in machines for wood processing [1]. The parallel robot platform is obtained through a generalization of the mechanism proposed by Stewart as a flight simulator [2]. This spatial platform mechanism consists of a fixed base platform and an upper moving platform. The six extendable legs connect these platforms. Their lengths determine the position and orientation of the platform.

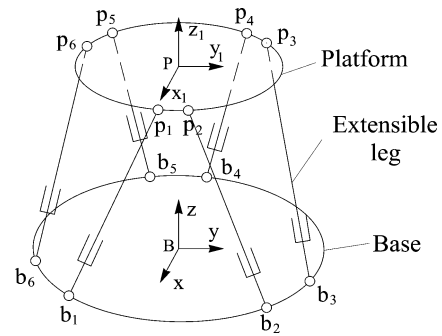


Fig. 2 Schematic diagram of a 6-DOF parallel robot manipulator

Devices placed on the top plate can be moved in the six degrees of freedom in which it is possible for a freely-suspended body to move. Besides greater stiffness and accuracy, these robot platforms have high payload-weight ratio due to parallel linkage, in comparison with typical serial mechanisms. Parallel linkage enables the payload distribution and averaging of the positioning error. The payload and positioning errors would be accumulated without parallel linkage. Accordingly, these types of parallel robot platforms are attractive for certain applications, such as machine tools. Using pneumatic linear drives in the realization of such a parallel mechanism leads to lightweight, compact, and low-cost construction.

A parallel robot platform represents an extremely difficult problem to control [3-5]. Strong nonlinearity, time variance, and coupling of a parallel robot platform lead to great difficulty for control. Furthermore, in order to provide optimal control, it is necessary to adjust 24 parameters at the same time (four parameters for each of six cylinders). Therefore, it is necessary to solve the optimization problem in a 24-dimensional space.

#### IV. CONCLUSION

The introduction of automatic machines in the small and medium-sized enterprises contributes to increasing the qualification structure of engineers, working on product design and technology. The application of CAD / CAM systems significantly accelerates the process of making the product, simulation and visualization eliminates possible designer errors and provides the high quality production without prototypes. In this case there is no direct effect of experience and knowledge of workers on the quality of production and the management of the technological system which ensures continuity in the quality of the product. All this mentioned significant raises technical and technological level and competitiveness of small and medium enterprises.

#### ACKNOWLEDGMENT

This research has been supported by the European Commission through IPA Adriatic CBC Program 2007 - 2013 through ADRIA-HUB project.

## REFERENCES

- [1] Guo HB, Liu YG, Liu GR and Li HR, "Cascade control of a hydraulically driven 6-DOF parallel robot manipulator based on a sliding mode", *Control Engineering Practice* 16(9), 2008, pp.1055–1068
- [2] D. Stewart, "A platform with six degrees of freedom", *Proceedings of the Institution of Mechanical Engineers, Journal of Power and Energy* 180(15), 1965, pp. 371–386
- [3] N. Nedić, D. Pršić, Lj. Dubonjić, V. Stojanović and V. Djordjević, "Optimal cascade hydraulic control for a parallel robot platform by PSO", *International Journal of Advanced Manufacturing Technology* vol. 72, No. 5-8, 2014, pp. 1085-1098.
- [4] N. Nedić, D. Pršić, Lj. Dubonjić, V. Stojanović and V. Djordjević, "Optimal tuning of PID Controllers for a Hydraulically Driven Parallel Robot Platform Based on Firefly algorithm", *CAII International Conference AUTOMATICS AND INFORMATICS '2013*, October 2013, Sofia, Bulgaria, pp. I 277-280.
- [5] N. Nedić, D. Pršić and V. Stojanović, "A cascade load force control of a hydraulically driven 6-DOF parallel robot manipulator based on input-output linearization", *X Triennial International SAUM Conference on Systems, Automatic Control and Measurements*, November 2010, Nis, Serbia, pp. 89-92