International Journal of Current Engineering and Technology
ISSN 2277 - 4106

Available at http://inpressco.com/category/ijcet

Research Article

Improving Time Efficiency using CNC Equipments in Wood Processing Industry

Hektor Thoma[a], Erald Kola[a], Leonidha Peri[b], Entela Lato[a], Muhamet Ymeri[c]

[a] Department of Wood Industry, Faculty of Forestry Sciences, 1029 Tirana, Albania
[b]Department of Forestry, Faculty of Forestry Sciences, 1029 Tirana, Albania
[c]Faculty of Applied Sciences, University of Prishtina, 70000 Ferizaj, Kosova

Accepted 12 June 2013, Available online 17June 2013, **Vol.3, No.2 (June 2013)**

Abstract

The use of CNC machines is changing radically the furniture making industry. Time consuming techniques in the production process, such as cutting curves, became much easier. CNC machines are 'programmed' to perform several steps at a time, cutting down on the time required for human action. With the advent of wood based panel products such as particle board and medium density fiberboard (MDF), CNC equipment has now been widely adopted for the production of components for many types of furniture. This study is focused in showing the advantages of the use of CNC equipments in furniture making industry in Albania. We have considered the processing of wood based panels for producing furniture parts using CNC machines in comparison to the traditional methods used up-to-now in a wood processing company. The efficiency gains in production of "side elements" for wardrobes sized 2400 x 580 x 18 mm are measured in terms of production time, raw material quantity used and quality of the product and compared to the above mentioned elements resulting from the traditional production techniques. Production of "side elements" for wardrobes is done in a drilling CNC machine type "Biesse Rover 20", which is one of the CNC equipment used a wood processing company for production of furniture parts. Saving in production time and raw material used results in decreasing costs per unit of production and the better quality of the parts gives the company a potential higher margin of profit per unit.

Keywords: *CNC equipments, furniture parts, time efficiency, drilling process*

1. Introduction

As in every field of industry, even in the furniture manufacturing industry, efficiency is a key factor which affects the performance of the firm activity. As such, it is aimed to increase the efficiency of using the time of labor and raw materials. By "using of time of work in the manufacturing process" is intended to achieve that stage of the technological process where the coefficient of utilization of machinery to be in such values so the machinery doesn't have idle time during working shifts and by "utilization of working time during the assembling process of finished wooden objects" is intended implementation of all necessary operations in such a way as to eliminate as many "minor works" of assembling from the assembling workforce. By "exploitation of raw materials" is intended reducing as much waste as possible (J.T. Black and S.L. Hunter, 2003).

The traditional production process and assembling of bedrooms include several processes as cutting, edge banding and fixing elements. Final assembling is a very long process in time, because the assembling workforce should carry out a series of measurements in a way such to achieve a accurate and qualitative assembling.

Today, with the introduction and use of numeric-controlled machinery (CNC) many production processes in the wood processing industry including the production of bedroom parts are revolutionized. Computerized numerically controlled (CNC) woodworking machinery can automatically control the movements of a spindle and table. Recently, CNC woodworking machinery has been widely introduced in wood industries for automatically cutting, drilling, and shaping operations (T. Ohuchi and Y. Murase, 2005).

In a similar direction are moving also many wood processing factories in Albania. We have seen in the last years in the wood industry in Albania, investments mainly in 3-axis and less in 5-axis machining technology. 5-axis machining provides flexibility and efficiency that cannot be obtained with 3-axis milling, cause a 5-axis machine can produce parts with more complex geometry using a single setup without the need for complex and expensive fixtures. Such machines can produce special geometry, eliminating the use of specialized cutters often used in 3-axis machining (C.T. Leondes, 2004).

There are many studies in the field literature on efficiency of CNC machinery (Y.L. Liberman, 2010) related to many aspects influencing it directly or indirectly. Ohuchi and Murase (2005) studies the cutting instruments consuming effects on efficiency. The

*Corresponding author: Hektor Thoma

Figure 1. Accessories used in assembling of wardrobes (Hafele, 2012)

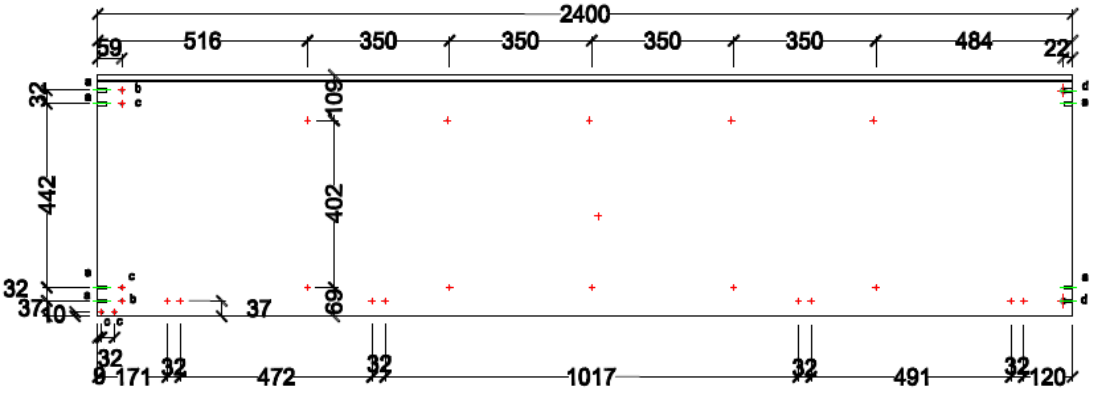


Figure 2. Dimensions of a side element of the wardrobe

Table 1. Holes list and their characteristics

No.	Type	Diameter	Drill depth	No. of holes	Notes
1	a	8	20	8	Horizontal holes
2	b	8	14	2	Holes for metallic sleeves
3	c	8	14	4	Holes for wood dovels
4	d	15	14	2	Holes for metallic connectors
5	e	5	14	18	Holes for Varianta screws and shelf supports

monitoring and evaluation of consuming of cutting instruments or other CNC machine tools have been studied by several authors (W. Weis, 1994; R. L. Lemaster et al., 2000; P. Iskra, and R. E. Hernandez, 2012). Tonshoff et al. (1988) and Byrne et al. (1995) studied the requirements to be meet by sensors for process monitoring of CNC machine tools influencing direct or indirect the process efficiency.

CNC machinery have a positive impact in terms of lowering costs and the realization of large volumes of work in relatively short time and its continuous utilization with minimal operator involvement. In some cases it is possible to exploit the machine during all the shift, except cases of defects and maintenance interventions (FANUC, 2012).

Realization of large volumes of work in pieces is an important factor in lowering the costs of productions, specially the fix costs, when the wood industry has the necessary large market to sell these quantities of products. Local market for wood products in Albania isn't a large one and this is a factor, which is hindering somehow the extensive use of CNC technology in the country (S. H. Suh et al, 2002)

In our study case we will analyze two approaches in the production of side elements of the wardrobe in order to achieve higher production time efficiency through using CNC technology. Here we are dealing with vertical drilling operations, horizontal drilling operations and fiber channel sawing. In such cases, drilling programs are better to be created in the machinery editor as it is more practical and focused on demands.

The general physical layout of manufacturing systems of the factory as a major determinant of a firm's efficiency is not taken into account. With the rapidly-changing environment facing most firms today, as well as the shortened life cycles of many products and process technologies, facility rearrangement and redesign become critical in sustaining productivity and competitiveness (C.T. Leondes, 2004). Anyway the focus of the paper is more related to time efficiency of single operations.

2. Materials and methods

As already mentioned above in the introduction part the paper is focused in analyzing two approaches in the production of side elements of a wardrobe in order to

Table 2. Drilling unit initial configuration

Nr	Diameter	Length	Depth of drilling	Type
1	10	30	15	Counter
2	5	50	40	Normal
3	8	50	40	Normal
4	15	50	40	Normal
5	14	50	40	Normal
6	8	30	20	Counter
7	35	50	40	Large
8	8	50	40	Lance
9	5	50	40	Lance
10	8	50	40	Counter
11	8	50	40	Counter
12	8	50	40	Counter
13	8	50	40	Counter
14	8	50	40	Counter
15	8	30	40	Counter
16	8	30	40	Counter

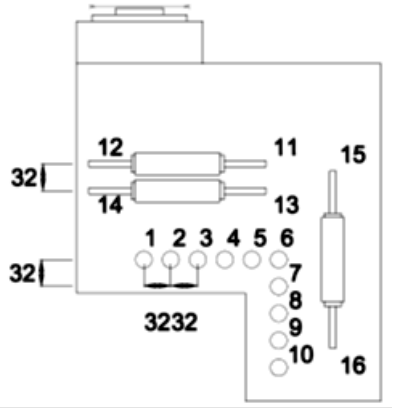
achieve higher time efficiency through using CNC technology.

After the side elements are worked in the edge banding they are ready to be drilled in the CNC machine, which realizes drilling, milling and fiber channel sawing operations. In this way the assembling of bedrooms can be performed in very short time, not necessarily by two or three people as traditionally done, with qualitative RTA (Ready To assemble) accessories who are quality certified and aesthetic appearance.

During the study will be taken in consideration time needed for the realization of the drilling process of side elements of a wardrobe. A single side element is sized 2400 x 580 x 18 mm and should be drilled for accessories such as Minifix, Rafix, Varianta screws, shelf supports, plastic feets, etc. Some of these accessories are presented in Fig. 1 above. The dimensions of the side element of the wardrobe and drilling positions are presented in fig. 2.In the tab.1 is presented the list of holes to e drilled and their characteristics, mainly according to their function related to the accessories to be used.

The drilling process is realized with a CNC machinery type Biesse Rover 20, produced in year 2002 and according to Machine User's Manual of NC processing centre Rover 20, with characteristics as below:

- Space working of pods and rail table of aluminum elements “easy to position” size 3200x900x100 mm
- Electro spindle power 7 KW
- Equipped with saw aggregate, disc diameter 120 mm, which moves along X axis
- Equipped with drilling group with 10 vertical drilling instruments and 6 horizontal drilling instruments
- Equipped with tool changer with three positions
- Machine control NC 500, with three axis
- Drilling group, the saw aggregate and electro spindle are showed in the fig. 3 below.



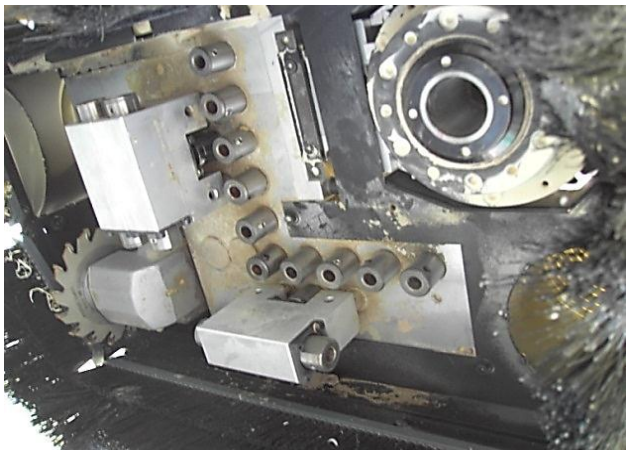


Figure 3. Graphical representation of drilling group and a picture of the saw aggregate and electro spindle of the Biesse Rover 20

For purposes of the study we configured the drilling group according to the characteristics presented in the Table 2.

Table 2. Recommended drilling unit configuration

Nr	Diameter	Length	Drilling thickness	Type
1	8	30	20	Counter
2	8	30	20	Counter
3	5	50	40	Lance
4	35	50	40	Large
5	8	50	40	Lance
6	20	50	40	Normal
7	14	50	40	Normal
8	15	50	40	Normal
9	8	30	20	Counter
10	8	30	20	Counter
11	8	50	40	Counter
12	8	50	40	Counter
13	10	50	40	Counter
14	10	50	40	Counter
15	8	50	40	Counter
16	8	50	40	Counter

Table 3. Comparison of time before and after improvement of drilling unit configuration

Time measurement	Needed time (in sec.)		
	Total	Drilling	Sawing
Initial configuration of drilling unit	200	128 (64%)	72 (36%)
Recommended configuration of drilling unit	160	124 (77%)	36 (23%)

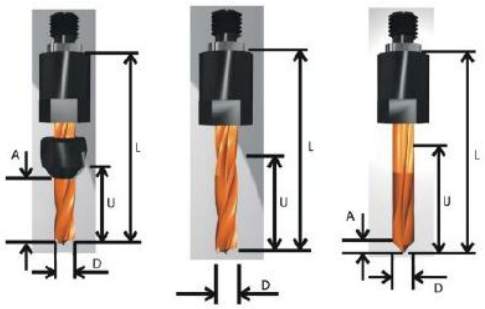


Figure 4. Different types of drilling tools, counter, lance and normal

All CNC machine tools require some form of work setting, tool setting, and offsets (compensation) to place the cutter and work in the proper relationship. Compensation allows the programmer to make adjustments for unexpected tooling and setup conditions (Krar and Gill, 1999).

3. Results and discussion

Initially we measured the time required for the execution of the program of drilling and fiber channel sawing operation for the side element of the wardrobe, which include measurements related to the time required for the execution of:

- 8 horizontal holes, depth of 20-21 mm and feed rate of 2m/min (changes in depth are made to eliminate simultaneously drilling two a single decrease on Z axis of the drilling group)
- 22 vertical holes, depth of 14-15 mm and feed rate of 3m/min
- fiber channel sawing, feed rate of 4 m/min, in a length of 2.4 m, depth of 9 mm which will be achieved with two steps, because of the consumption of the circular saw

Given the product we want to process with the CNC machinery, we start to write drilling program for the side element of the wardrobe. Thus, as can be seen from the tab.2 we have to execute vertical and horizontal drilling and fiber channel sawing operations. Horizontal holes are drilled with an advancing speed constant of 2 m/min, vertical holes are drilled with an advancing speed constant by 4 m/min, while the operation of fiber channel sawing is programmed with advancing speed of 4m/min and the number of steps.

Accessories placement is generally standardized and we have to adapt to their requirements. Instruments in the machinery are placed once in machine, are calibrated carefully and with accuracy and their physical

configuration must necessarily be reflected in machine control program.

Instruments changes are made in case of damage and instruments repositioning and configuration are advised to be determined according to the drilling unit configuration.

According to the scheme of assembling required, drilling program and drilling group initial configuration, measurement of time shows that the execution of the program requires about 200 seconds. The time measurement is done once, because the execution time of the program is unchanged. Within this period of 200 seconds about 36% of the time the time spent for disk fiber channel opening.

After executing the necessary operations according the initial configuration of the drilling unit, the drilling scheme is changed and the drilling unit is reconfigured according to the parameters shown in the tab.3.

By measuring the execution time of the program for the changed drilling scheme and a new configuration of drilling unit it turns out that the program execution time takes about 160 seconds. Within this period of 160 seconds, 23% of the time is spent for the fiber channel sawing, because a sharpened cutter blade with diamond-tipped teeth is used.

The result of the study is obvious and can be summed up in the fact that an optimal drilling scheme and a good configuration of machine drilling group influences the use of working time significantly, reducing the time required for the execution of a drilling-sawing program by 25%. A comparison of the time required for the realization of the side component of the wardrobe before and after the improvement of drilling group configuration is shown in the tab.4

We can say that drilling group configuration and calibration of the instruments is a process that requires a lot of time and tests at the beginning of the work, but we achieve a higher precision in work and higher efficiency. A great influence in the time efficiency of the drilling-sawing operation has also the quality of circular saw.
On the other hand the time efficiency increases by the use of CNC machines lies also in the fact that assembly times of the elements are significantly reduced and volumes taken in packing and transportation, affecting at the same time the transport costs.

A greater impact would have the use of a post processor to achieve the transfer of data directly from .dxf CAD formats in the machine language (P. Ashley, 2003). It would reduce even more the time needed to realize milling operations. Anyway it can be times, as in product replication within a large sheet of material cases, when it can be advantageous to make use of both CAM and manual programming techniques (A. Overby, 2010).

Conclusions

The use of CNC machines is changing radically the furniture making industry. Time consuming techniques in the production process, such as cutting curves, became much easier. With the advent of wood based panel products such as particle board and medium density fiberboard (MDF), CNC equipment has now been widely adopted for the production of components for many types of furniture.

This study is focused in showing the advantages in time efficiency of the use of CNC equipments in furniture making industry in Albania, specially in the production of furniture parts. We have considered only the drilling-sawing operations on a side element of a wardrobe and measured the program execution times for two drilling schemes and corresponding drilling unit configurations. The optimization of the drilling scheme and especially the drilling unit configuration can increase the time efficiency of the drilling-sawing operation by 25%.

In this paper the efficiency gains in production of "side elements" for wardrobes sized 2400 x 580 x 18 mm are measured only in terms of production time of a single operations, but we have to consider also other several factors influencing the time efficiency as use of appropriate cutting/drilling instruments in order to set high and correct interpolation speeds, use of appropriate post processors, to avoid writing by hand drilling and milling programs, manufacturing large capacities, product standardization, etc.

On the other hand, increasing the time efficiency of production operations through using CNC technology can influence the time efficiency of other operations as assembling, through decreasing it.

References

P. Ashley (2003). Improved high value-added furniture manufacturing in Australia using Computer Numerically Controlled (CNC) equipment". *Gottstein Trust fellowship study report*. Available at the Gottstein Trust website, www.gottsteintrust.org

J.T. Black and S.L. Hunter (2003). Lean Manufacturing Systems and Cell Design. SME 2003.

G. Byrne, D. Dornfeld, I. Inasaki, G. Ketteler, W. Konig and R. Teti (1995). Tool condition monitoring (TCM)—the status of research and industrial application. *Ann CIRP 44(2):541–567*

FANUC America (2012). Total Cost of Ownership - the total cost of a CNC over the life of a machine tool, *White Paper. Document No. MWA-015-EN_03_1211*. Available at www.fanucfa.com

Hafele. (2012). Furniture/Cabinet Hardware Catalog. Germany.

P. Iskra, and R. E. Hernandez (2012). Toward a process monitoring of CNC wood router. Sensor selection and surface roughness prediction. *Wood Sci Technol (2012) 46:115–128*

S. Krar and A. Gill (1999). CNC Programming Basics: A Primer for Skills VICA Championships, Industrial Press, Inc.

R. L. Lemaster, L. Lu and S. Jackson (2000). The use of process monitoring techniques on a CNC wood router. Part 1. Sensor selection. *Forest Prod J 50(7/8):31–3*.

C.T. Leondes (2004). Computer Aided and Integrated Manufacturing Systems. A 5-Volume set. *In Vol. 1 Systems Techniques and Computional Methods*. World Scientific Press.

Y.L. Liberman (2010). Efficiency of numerically controlled metal cutting machines. *Russian Engineering Research, 2010, Vol. 30, No. 1, pp. 81–83*. Allerton Press, Inc.

T.Ohuchi and Y. Murase (2005). Milling of wood and wood-based materials with a computerized numerically controlled router IV: development of automatic measurement system for cutting

edge profile of throw-away type straight bit. *Journal of Wood Science 51:278-281*. The Japan Wood Research Society.

A. Overby (2010). CNC Machining Handbook: Building, Programming, and Implementation. McGraw-Hill/ TAB Electronics. 1st Edition.

S. H. Suh, S. K. Kang, D. H. Chung and I. I. Stroud (2008). Theory and Design of CNC Systems. Springer

H. K. Tonshoff, J. P. Wulfsberg, H. J. Kals and W. Konig (1988). Developments and trends in monitoring and control of machining processes. *Ann CIRP 37(2):611–622*

W. Weis (1994). Survey: industrial applications of TCM systems. WBK, University of Karlsruhe, Germany (cited by Byrne et al. 1995, Lemaster et al. 2000)