AUTOMATION OF THE MANUFACTURING PROCESS OF THE WOODEN SHIP MODEL IN ALBANIAN WOODEN WORK ENTERPRISES

Summary

The production of ship wooden models like other sectors of industrial production is currently facing the challenges of improving quality, reducing production times and costs. In the present conditions on development and industrialization towards the production systems generally are required a very large flexibility. Under the constant growth of industrialization and the improvement of efficiency in the manufacturing sector of ship wooden model an efficient way to meet the current challenges and overcome the problems is the implementation of a modern production process, supported by work centres with numerical control machines (CNC). In this article will be present a methodology for producing wooden ships models, in the Albanian woodworking enterprises, through the use of CAD/CAM techniques and numerical control machines. The methodology aims the use of computers and technological devices to improve the flexibility and the quality of the production system of ships wooden models. The paper will be concretized to a particular production case of a wooden ship model in a five-axis numerical control machine starting from the design data base until the realize of the final product. The model is manufactured at an Albanian enterprise specialized in various woodworking.

Key Word: CAD, CAM, CNC, Ship Model

AUTOMATIZACIJA PROCESA PROIZVODNJE MODELA DRVENOG BRODA U ALBANSKOJ TVRTCI ZA OBRADU DRVETA

Sažetak

Proizvodnja drvenih modela brodova se poput drugih sektora industrijske proizvodnje trenutno suočava s izazovima poboljšanja kvalitete, smanjenju vremena proizvodnje i troškova. U sadašnjim uvjetima razvoja i industrijalizacije prema proizvodnim sustavima općenito je potrebna vrlo velika fleksibilnost. Stalnim rastom industrijalizacije i poboljšanje učinkovitosti u sektoru proizvodnje drvenih modela brodova učinkovit način za zadovoljenjem sadašnjih izazova i prevladavanje problema je provedba modernog proizvodnog procesa, uz potporu centara s numerički upravljanim strojevima (CNC). U ovom članku predstavit će metodologija za proizvodnju modela drvenih brodova u albanskim tvrtkama za obradu drveta kroz korištenje CAD/CAM tehnika i numerički upravljanim strojevima. Metodologija ima za cilj korištenje računala i tehnoloških uređaja za poboljšanje fleksibilnosti i kvalitete sustava proizvodnje modela drvenih brodova. U radu će biti prikazan konkretni slučaj proizvodnje modela drvenog broda na petosnom numerički upravljanom stroju počevši od baze projektnih podataka do konačnog proizvoda. Model je izrađen u albanskom tvrtci specijaliziranoj za razne obrade drveta.

Ključne riječi: CAD, CAM, CNC, drveni modela broda
1. Introduction

For satisfying the preferences of the clients the manufacturing sector always has had meant the realization of the required quality of the product at the right moment and with the most advantageous price. That means that challenges before every manufacturing enterprise (small, medium, or large) is to increase the quality, reduce costs, and time of delivery of product.

In the current conditions of a very big competition, besides these three elements, manufacturing enterprises should aim in the increase of flexibility of manufacturing, so it can respond rapidly:

− Changes in product:
− Changes in production:
− Changes of the processes:
− Changes of equipments and:
− Change of labours forces.

In Vlora region (south western part of Albania, for a long time, operates a successful enterprise in the realization of different furnishings works, equipped with five axis numeric control machines for the realization of different wooden product.

The enterprise also produces wooden ship models, with length up to 1 m, destined mainly for the internal market in Albania.

In the manufacture of the hull of those models the enterprise had difficulties associated with these elements:

− Extended production time;
− Low precision and symmetry defects;
− Difficulty in finding master carpenter and specialized workers
− High cost of manufacturing, mainly conditioned by the payment of specialized labour force.

For overcoming of the above difficulties the enterprise demanded the cooperation with the Department of Naval and Mechanical Engineering of the University of Vlora, for the implementation of a modern manufacturing process. The enterprise intended of the inclusion in this process of all the capacity, mechanical, electronic and computer. In other words, in the automation of manufacturing of wooden models supported from its centres work, with numerical control machines.

After the production of the hull of the model the manufacturing process can proceed in completing the model, easily, with the other accessories necessary to obtain the final product.

The following paragraphs will be dealt with the procedure applicable, in this enterprise, for the manufacture of wooden models of ships (as a single body) with length up to 1 m.

2. Material and methods

FAPIEL Group is a wholly-owned enterprise founded in Albania in 2003. Since 2004, the company is expanded and technologically increased, reaching the current situation. To realize with quality its products FAPIEL has installed a CNC working centre, through which the various furnishings works are realised.

Work centre, CNC Conquest 4200 (Figure 1), which is installed near FAPIEL is a 5 axes milling machine (pantograph type).
Numerical control of the machine is realized through language OSAI 10 with Windows interface.

In this section of the paper will briefly treat the procedures to be followed for the manufacture of the ship wooden model.

Since the surface of the ship is complex, with variable curvature in all directions, to ensure the quality of the operation of such surfaces it is necessary that the code for the numerical control machine be developed by the help of computer. [1]

For determining the flow of information we have been considered to ensure the flow of information from the database, in CAD software, in CAM software, in CNC and getting into the final product. [1]

The main works necessary for the manufacturing of the model are: the machining in the numerical control machine of the external surface of the model and the machining of deck surface. The surface of the ship deck is a 3D curved surface. To ensure the fixing and non movement of the piece in the desk of the numerical control machine is necessary to produce the deck shape (template) of the model. Above the shape of the model must be placed the piece of work and fulfils the machining of the external surface of the model.

The main processes for the production of the model of the vessel, and their order are:
1. The preparation of work piece.
2. Machining in the numerical control machine of the surface of the deck template.
3. Machining in the numerical control machine of the deck surface.
4. Machining in numerical control machine of the external surface of the model.

During the work on surfaces care must show that the work piece does not move during the work of the machine. These four processes are not necessary in all manufacturing cases of wooden ship model. This depends from the specific requirement for the model. So, for example, if the deck surface of the model is required flat, then processes 2 and 3 are not necessary. Also, where the product is realized in series, only for the first model the four processes are realized. Whereas, for the other models is not necessary the realization of the second process.

The procedure of flow information up to the production of the model is as follows:
- Projecting the surface of the body of the vessel in CAD software. [2], [3]
- Convert the data information of the projected surface in a neutral file, which can be a file DXF, IGES or STEP
– Import the neutral file in CAM software.
– Planning of manufacture processes in CAM software
– Simulate and verify the manufacture processes and make necessary corrections, in the CAM software
– Compile the codes for machine the numerical control (CNC), for each process
– Execute the codes on the numerical control machine

In Figure 2, is presented, the complete block scheme of the flow of information, CAD/CAM / CNC, for the production of wooden ship hull models.

Figure 2. Block scheme.
3. Results and discussions

The above mentioned block schemes have been applied for the production of a model with maximum length equal to 1 m, maximum breadth 0.353 m, moulded depth 0.161 m.

Therefore, geometric modelling of the external surface of the model is realized in the CAD software MAXSURF PRO. While the planning of the manufacture processes and the developments of the codes for the numerical control machine are realized in the software AlphaCam 2007.

After the development of the NC codes we have realised the machining of the model surfaces, which are worked on the CNC Conquest 4200.

In figure 3, is presented the designed surface, in the software Maxsurf Pro, of the model to be produced.

![Figure 3. Surface designed in the software Maxsurf Pro](image)

Surface, designed in Software Maxsurf Pro, is converted to DXF format and then imported in ALPHACAM2007 for further procedures of planning of the manufacture processes in this program. The model is manufactured with “MDF”. Unable to have a massive working body we have joined in one body few pieces of MDF. Pieces are cut with dimensions of 1030 * 370 * 25 mm. Body work is prepared with dimensions 1030 * 370 * 200 mm. All surfaces have been subjected to two works, gross work and finish work.

The feature of the gross work is that the instrument moves in horizontal planes parallel to each other, having a border profile under which the gross work is realized. [4] [5]

In all cases the gross work of surfaces (template, deck and hull) was conducted using the following key features: [4] [5] [6]

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cutter diameter</td>
<td>18 mm</td>
</tr>
<tr>
<td>The number of rotations of the Spindle</td>
<td>12,000 rpm/min</td>
</tr>
<tr>
<td>Progress in work</td>
<td>4000 mm/min</td>
</tr>
<tr>
<td>Advancing according Z</td>
<td>1000 mm/min</td>
</tr>
<tr>
<td>The distance between work plans</td>
<td>9 mm</td>
</tr>
<tr>
<td>Cutter type</td>
<td>Cylindrical (Figure 4a)</td>
</tr>
<tr>
<td>Tolerance of cord</td>
<td>0.1 mm</td>
</tr>
</tbody>
</table>

Feature of finish work is that instrument passages become parallel to each other according to a pre-determined direction [4], [5]. In this case the instrument passages are performed in the longitudinal direction where the distance from each other passage in all cases was equal to 1 mm.
The tolerance of the cutting cord is located 0.1 mm. A so small value has made the code compiled to be longer, but this has guaranteed that the trajectory of instrument follows increasingly the projected surface. [6]

Others key features of the finish work of all surfaces are presented below: [4] [5] [6]

- Cutter diameter: 12 mm
- The number of rotations of the Spindle: 13000 rpm/min
- Progress in Work: 4000 mm/min
- Advancing according Z: 1000 mm/min
- Cutter type: Spherical (Figure 4b)
- Tolerance of cord: 0.1 mm

Before drafting the codes for CNC, are made simulations of processes to verify the planning processes.

With the conclusion of all simulations of the processes have been drafted the codes for CNC. One code is developed for each process. Overall have been developed six codes. Developed codes occupy in total 5037 pages of A4, or approximately 1.5 kilometres of paper.

In figures 5, 6, 7 are presented view of machining processes in the numerical control machine. In Figure 8 is presented the wooden model of the ship after completion of all manufacturing processes in the numerical control machine.

To verify the accuracy of the work we have performed several measurements of the main dimensions of the model produced. Their comparisons with the planned dimensions to be manufactured are presented in Table 1.
Figure 6. Machining of deck surface: a) Gross work in CNC; b) Finish work in CNC;

Figure 7. Machining of hull surface: a) Gross work in CNC; b) Finish work in CNC;

Figure 8. Completed model

Table 1 - Comparison of elements planned and realized in CNC

<table>
<thead>
<tr>
<th>Items</th>
<th>Planed</th>
<th>Realised</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum length</td>
<td>1000 mm</td>
<td>999 mm</td>
</tr>
<tr>
<td>Maximum breadth at amidships</td>
<td>353 mm</td>
<td>353 mm</td>
</tr>
<tr>
<td>Moulded depth at amidships</td>
<td>161 mm</td>
<td>161 mm</td>
</tr>
<tr>
<td>Moulded depth at Bow</td>
<td>180 mm</td>
<td>179 mm</td>
</tr>
<tr>
<td>Moulded depth at Stern</td>
<td>174 mm</td>
<td>173 mm</td>
</tr>
</tbody>
</table>

As can be easily ascertained from the data of the table the error in no way exceed 1 mm. After the completion of the production process of the body of the model in the numerical control machine, can easily proceed with setting others accessories. In this case the model is complete with masts for setting the sail and subjected to the process of painting. In Figure 9, appears the wooden model at the end of these processes.
4. Conclusions

In this paper we have treated the implementation of a methodology for producing of the hull of ship model at furnishings enterprise “FAPIEL-Group”. Compared with the traditional production process of wooden models of ships in this enterprise the use of the CNC in the production of such models provides a better quality product, faster production and lower cost.

Some of the conclusions are summarized below:

Visual verifications conclude that the physical and CAD model matching completely.

From the measurements we conclude that the deviations of dimensions from the planned are of order of mm, this is difficult to reach through the traditional process.

For its production are needs 16 hours of work, including the time of production of the deck template.

The production of another model with the same dimensions would require 10-11 hours.

The methodology provides a production in series.

At the end of all machining processes the wooden ship model has a very good surface roughness.

The production of wooden model in CNC can also be done by workers not very much specialized, since CNC codes are prepared in advance.

Although we have not done a detailed assessment of costs, according to estimates made by the company can say that it is in satisfactory value versus the traditional process. The entire product cost at the end of manufacturing of the hull is approximately equal to the value of payments that the company was making to specialized employees.

5. References