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TRANSFER OF PROJECT DEVELOPMENT TRAINING TO VOCATIONAL HIGH SCHOOL STUDENTS TO THREE AXIS MINI CNC ROUTER DESIGN: AN APPLIED STUDY*

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Abstract

The aim of this study is to determine the success of the project development and rehabilitation courses given to university students on their students. In this direction, theoretical and practical training was given to the students on the theoretical calculations of machine construction, machine design and manufacturing, assembly stages and system analysis and study. As a result of this training, students were asked to design and manufacture a three-axis mini CNC router. During the design and manufacturing process, the necessary technical support was provided to the students where they had problems. As a result of the study, it has been seen that the students have successfully transferred the theoretical knowledge they have received to CNC router design and manufacturing. After the manufacturing process is completed, a sample is processed and the functionality of the mini CNC router machine is tested and a successful result is obtained. In addition, student achievement was statistically analyzed with a written examination including CNC machine design, construction principles and manufacturing operations. The results and analyzes obtained when the exams are evaluated; shows that the success rate of the exam is 77.75% in the light of the theoretical and practical information that the students have taken during the project period.

Keywords: Project development training, Three-axis mini CNC router design, Manufacturing.

MESLEK YÜKSEKOKULU ÖĞRENCİLERİNE VERİLEN PROJE GELİŞTİRME EĞİTİMİNİN ÜÇ EKSENLİ MİNİ CNC ROUTER TASARIMINA AKTARILMASI: UYGULAMALI BİR ÇALIŞMA

Özet

Bu çalışmanın amacı üniversite öğrencilerine verilen proje geliştirme ve uyulama eğitimi derslerinin öğrenciler üzerindeki başarısını belirlemektir. Bu doğrultuda öğrencilere makine konstrüksiyonunun teorik hesapları, makine tasarım ve imalatı, montaj aşamaları ve sistem analizi ve çalışması konularında teorik ve uygulamalı eğitim verilmiştir. Bu eğitimin sonucunda öğrencilere üç eksenli mini CNC router tasarımı ve imalatı yapılması istenmiştir. Tasarım ve imalat sürecinde öğrencilerin sorun yaşadığı noktalarda gerekli teknik destek sağlanmıştır. Çalışma sonucunda öğrencilerin almış oldukları teorik bilgileri CNC router tasarımı ve imalatına başarılı bir şekilde aktardıkları görülmüştür. İmalat işlemi tamamlandıktan sonra örnek bir numune işlenerek mini CNC router makinesinin işlevselliği test edilmiş olup başarılı bir sonuç elde edilmiştir. Ayrıca CNC makine tasarımı, konstrüksiyon esasları ve imalat işlemleri konularını içeren bir yazılı sınav ile öğrenci başarısı istatistiksel olarak analiz edilmiştir. Gerçekleştirilen sınav değerlendirildiğinde elde edilen sonuçlar ve analizler; öğrencilerin proje süresince almış oldukları teorik ve uygulamalı bilgiler ışığında sınavın başarı oranının % 77,75 olduğunu göstermektedir.

Anahtar Kelimeler: Proje geliştirme eğitimi, Üç eksenli mini CNC router tasarımı, İmalat.

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1. INTRODUCTION

In the 1940s, numeric control (NC) technology was developed by using computer technology to work with numerical programming of classical machining technologies (X. Xu and S. Newman, 2006). In the past, the use of computer numeric control (CNC) became widespread as the structure of the day-to-day NC-controlled looms was integrated into the computer. The fact that classical looms cannot create a competitive power in the industry necessitated the technical elements to get and use CNC looms which entrepreneurs in manufacturing industry could compete with (X. Xu and S. Newman, 2006, Şahin M., et. al., 2007). In today's industry, CNC machines have a very important place. Because of this, CNC education in engineering education curriculum has an important place (Newman ST, et. al. 2008, Şahin M., et. al. 2007). On the other hand, training of CNC machines, which are costly in education institutions, is only provided by showing theoretical and pictorial information about the operation and use of these CNC machines (Altintas, Y., 2012, Çelik, Ş.A., et. al., 2002). In the CNC educational institutions, it causes the loom to be removed from the standpoint of self-education by the student with the concern of deterioration and failure (Uyanık, S., et. al., 2009). Another problem experienced in educational institutions with CNC countertops is that the number of students of the course instructor is so high that it can cause the student to miss important points of the course, lack of attention and motivation, which can adversely affect the quality of education (N. Čuboňová, et. al., 2008).

CNC is one in which the functions and motions of a machine tool are controlled by means of a prepared program containing coded alphanumeric data. CNC can control the motions of the workpiece or tool, the input parameters such as feed, depth of cut, speed, and the functions such as turning spindle on/off, turning coolant on/off. There are many types of CNC machine. The common CNC machines are two -axis and three-axis .The two-axis machine can move on vertical and horizontal only which are X and Y axis. Three-axis machine can do movement starting with three primary axis which are X, Y and Z axis. The Z axis is being parallel with spindle (Frank Nanfara et. al., 2001).

The CNC machine operation starts with the collecting data from the programming that extract from computer-aided design (CAD) and computer-aided manufacturing (CAM).The programs produce the computer file and then will extract the command to operate the machine. The program will be transfer via post-processor and then be loaded into the CNC machine to start the machining .This is the flow of the CNC machine operation (Figure 1):

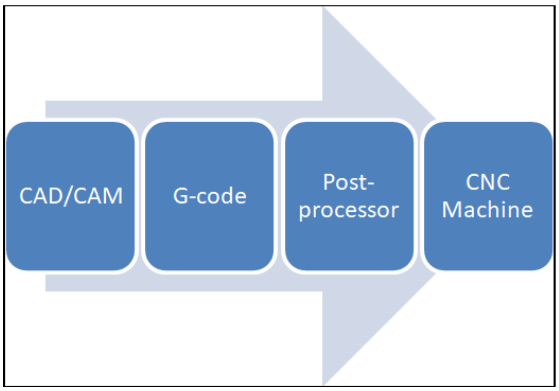

Figure 1. Flow of the CNC Machine Operation

The CNC is a system. To complete the system of CNC machine, there are 4 components which are mechanical design, drives module, system software and Automatically Programming Tool (APT) postprocessor. For the mechanical design system, this part is the hardware part of the machine which is the part body. For the drive system, the command signal was received from microprocessor.

Microprocessor is consisting of motors, amplifier units and a power supply .For the software system, it is generate the program to the CNC machine to start the movements of the tools and workpiece. For the APT post-processor, it was developed to produce the G-code and M-code that can be used by CNC machine.

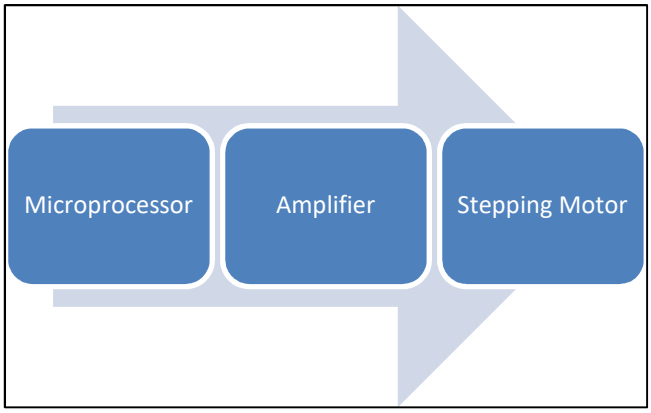

Figure 2. Flow of CNC Machine

To complete the whole CNC machine, all elements must be in the good condition and must put at the right place (Nur Suraini Binti Hashim., 2012).

The applications of CNC include both for machine tool as well as non-machine tool areas. In the machine tool category, CNC is widely used for lathe, drill press, milling machine, grinding unit, laser, sheet-metal press working machine, tube bending machine etc. Highly automated machine tools such as turning center and machining center which change the cutting tools automatically under CNC control have been developed. In the non-machine tool category, CNC applications include welding machines (arc and resistance), coordinate measuring machine, electronic assembly, tape laying and filament winding machines for composites etc. (Asif Hussain Ansar Md., et. al., 2016).

The benefits of CNC are (1) high accuracy in manufacturing, (2) short production time, (3) greater manufacturing flexibility, (4) contour machining (2 to 5-axis machining), (5) reduced human error. The drawbacks include high cost, maintenance, and the requirement of skilled part programmer (Mike Lynch, 1996). This study covers the design, manufacture and application of three-axis mini CNC machine tools to minimize the above-mentioned problems.

This study is expected to make a significant contribution to the development of students' ability to design, think, imagine, plan and construct based on a project-based learning approach, as well as reducing problems in the manufacture of the mini-CNC machine with three axes. In this study, the success of the project development and application training on the students was evaluated with statistical data.

2. MATERIALS AND METHODS

2.1. Machine Design and Properties

The main frame of the CNC loom is made of MDF material with the X-axis module being fixed, the mainframe with 30x30x2 mm iron profile, but the movable frame is made of 30x30x2 mm iron profile, the main frame of Z-axis module is also 30x30x2 mm iron profile but the moving table is designed and manufactured as MDF. Solid modeling in the CNC machine design CAD program has been carried out (Figure 3). The actual size of the lathe is 40x60cm and the machining area is max. It is 25x25cm. It is a LOTUS brand grinding motor which can work at 230V-50Hz and 8000-30000 cycles.

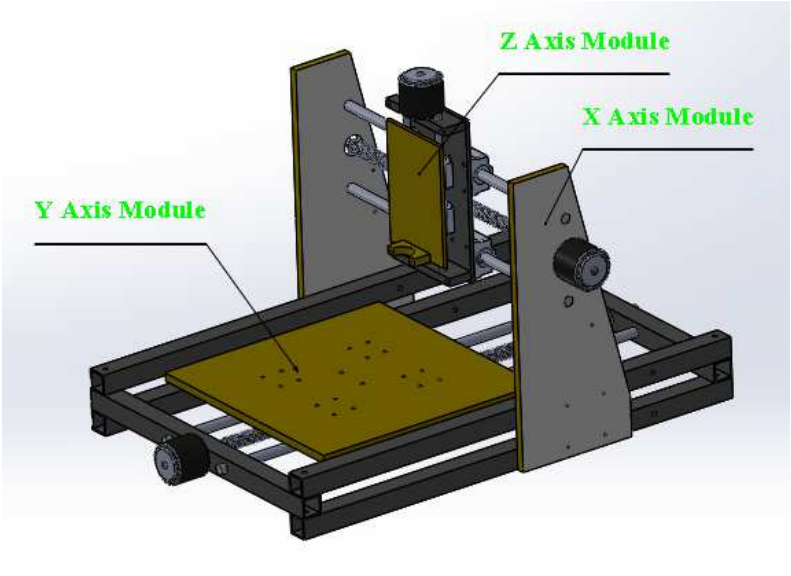

Figure 3. Solid Model of a three-axis Mini CNC Machine

The assembly of all material and machine elements prepared in the appropriate measurements of the model designed in the CAD program has been completed (Figure 4).

Figure 4. Fully Assembled View of a Three-Axis Mini CNC Machine

The technical drawing dimensions (mm) of the three-axis mini CNC machine are shown in Fig 5.

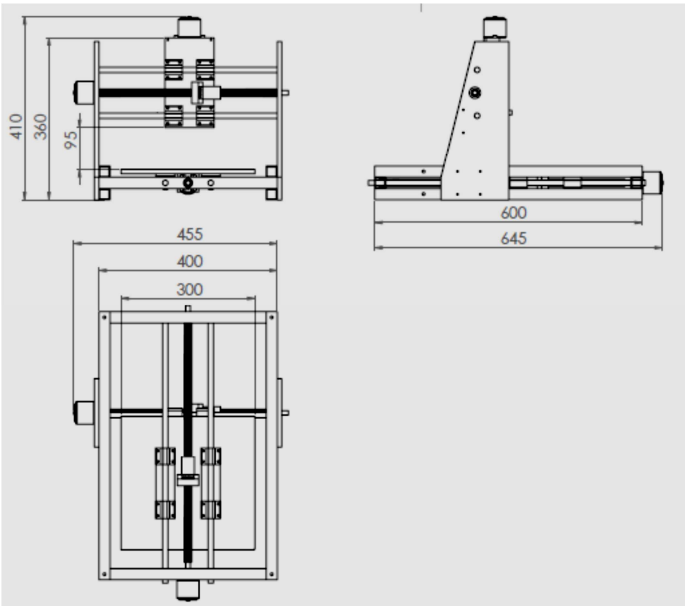

Figure 5. Technical Drawing Measurements of a Three-Axis Mini CNC Machine

2.2. Retention System

One of the most important issues to be considered during the design and manufacture of CNC looms is the very good maintenance and operation of the tilting systems. Otherwise, the bearings, miller and stepper motors that provide movement in the axis system will be forced to make it harder for the system to operate at full efficiency. The bearings of the axis system, the bearing of the miller and the stepper motor are shown in Figure 6.

Figure 6. Axis Tilting and Miller Image

2.3. Drive and Motion Transmission System

In the design of three axes mini CNC looms, three stepper motors, which are X, Y and Z axes, are used. These are the Astrosyn Minebea Stepper Motor Model Type 23KM-C051-07V. Figure 7 shows the stepper motors used.

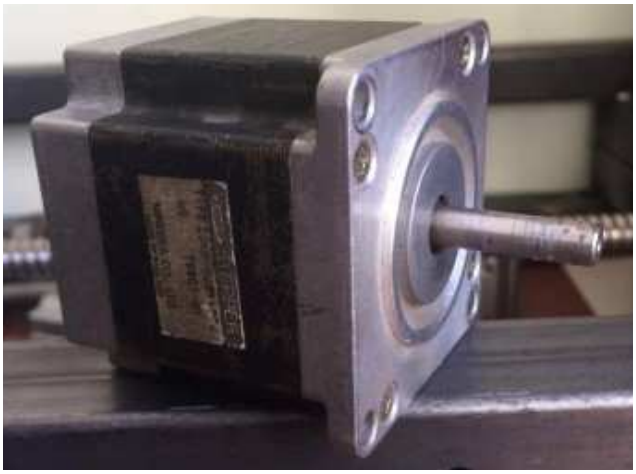

Figure 7. Stepper Motors Used in Machine Tools

Axis systems driven by stepper motors transfer the rotational motion to screw shaft systems with the help of double-cardanic (DK) type couplings. This rotational motion the ball screw nut, which is part of the ball screw system, transmits the rotational motion taken by the motor to the axis systems in linear motion, by fixing the ball screw nuts to the moving system. Figure 8 shows the ball screw and nuts with a diameter of 16 mm used for the X, Y and Z axis tool in this work. Since the ball screw systems have a very precise structure, there are a few features to be considered during assembly. There is a special pipe in the nut so that the balls coming out of the ball screw nuts come out of their slots. This pipe is fixed on both sides and prevented from coming out of the installation. This assembly must be carefully replaced with a ball screw shaft during assembly. Otherwise, it is inevitable that the balls will disperse. (Kutlu, M., 2006).

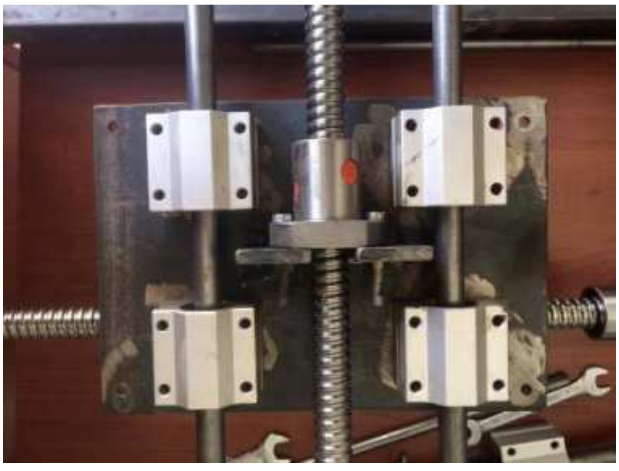

Figure 8. Ball Screw Nut

2.4. Electronic Control System

In the control unit of the three-axis mini CNC machine, the integrated driver card shown in Figure 9 and one power supply are used to bring the voltage obtained from the city network to the driver card.

Figure 9. Driver Card and Power Supply Panel

Mach3 control software program was used in this study. After the drawn part in CAD program is saved in different format, CNC codes can be extracted automatically in Mach3 control software interface. The Mach3 program is a handy CNC control program that allows you to control up to 6 axes of CNC output in parallel port and recognize all CNC codes with data exchange format (.dxf) and image import. The interface of the Mach3 program is shown in Figure 10 (Art Soft Using Mach II Mill).

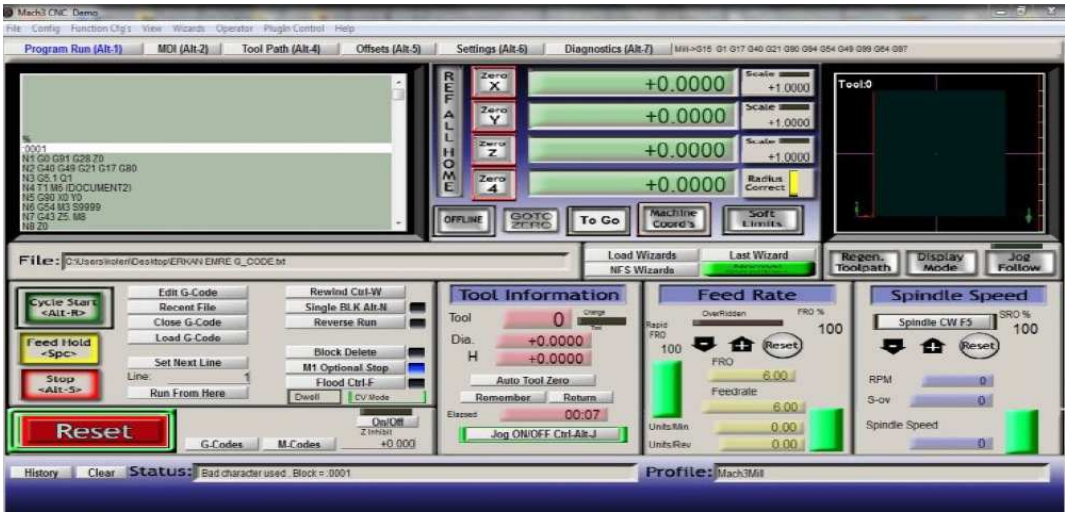

Figure 10. The Interface of the Mach3 Program

3. CONCLUSION AND DISCUSSION

As shown in Figure 11, the three-axis mini CNC workbench was connected to a personal desktop computer after all manufacturing assembly was accomplished.

Figure 11: Connection of the Machine with the Computer

In order to see and control the function of the workbench, 3 mm thick wood material, called plywood in the market shown in Figure 12, was processed as a sample. The drawing of the sample specimen was performed in CAD environment and the codes were extracted in Mach3 program and sent to the workbench. It is seen that there is a similarity and similarity between the measurements of the sample drawn in the CAD environment and the measurements of the processed sample on the loom.

In this study, the working dimension of the Y-axis module of the loom is not within the expected range of 40 to 45 cm. For this reason it is determined that the X-axis module is fixed and the Y-axis module is moving.

Figure 12: Sample Specimen Processed on the Countertop

As a result of this study, transfer of the information given in the course of project development and application course to vocational high school students has been successfully carried out. Throughout this work, students have seen how the transfer of the theoretical knowledge, the problems encountered, what the difficulties are, and how these problems are resolved, from the beginning of the design to the

time of manufacture. As a result of this study, it was seen that the most important problem of vocational college students was the problem of self-confidence, which was solved in one stroke. In the future studies, it is planned to process and analyze the metallic materials by adding liquid cooling system in addition to the workshop in this study.

In this article, the student effect of theoretical and practical courses given to the students is examined. Student performance was analyzed statistically with a written exam. When this examination is evaluated, it is estimated that the results and analyzes obtained by the students are 77,75% of the theoretical and practical courses they have taken during the project. The results of the students' exams (Table 1), achievement scores (Table 1), achievement grade points (Table 2), and grade success charts (Figure 13) were given.

Table 1. Student Exam Grade System and Achievement Grades

Coefficient (System of 4)	**Raw Achievement Grade**	**Letters-Based Success Note**	**Student Number**
4	90 – 100	AA	13
3,5	85 – 89	BA	9
3	80 – 84	BB	6
2,5	70 – 79	CB	5
2	60 – 69	CC	3
1,5	55 – 59	DC	2
1	50 – 54	DD	1
0,5	40–49	FD	1
0	39 and below	FF	0
		Total	40

Table 2. Student Achievement Grade Average Data

Total number of students on the exam list	40
Number of students entering the examination	40
Number of students who did not take the examination	0
The grade average of the students entering the exam. (system of 100) (%)	77,75

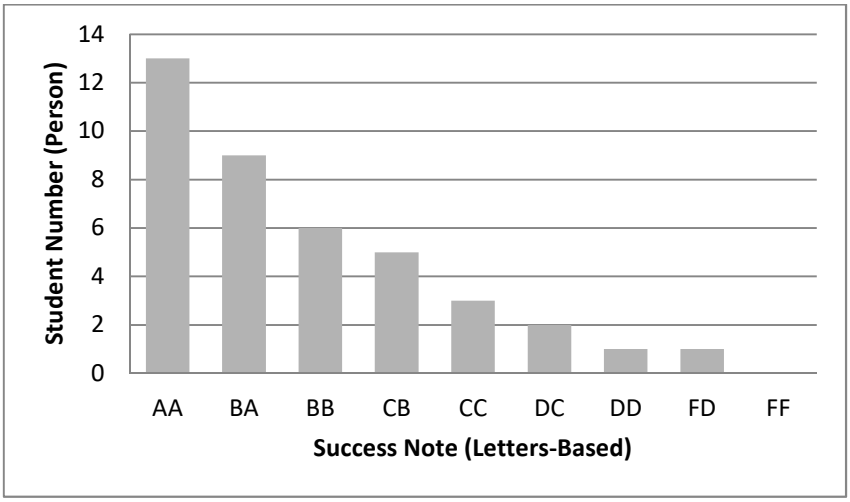

Figure 13. Student grade success statistic

4. REFERENCES

X. Xu, S. Newman (2006). Making CNC machine tools more open, interoperable and intelligent - a review of the Technologies. Computers in Industry, 57:141-152.

Newman ST, Nassehi A, Xu XW, Rosso Jr. RSU, Wang L, Yusof Y, Ali L, Liu R, Zheng LY, Kumar S, Vichare P, Dhokia V. (2008). Strategic advantages of interoperability for global manufacturing using CNC technology. Robotics and Computer-Integrated Manufacturing; 24: 699-708.

Şahin M., Bilalis N., Yaldız S., Antoniadis A., Ünsaçar F., Maravelakis E. (2007, 2-3 May).Revisiting CNC training–a virtual training center for CNC. EPVET 2007. International Conference on E-Portfolio Process in Vocational Education, Present and Future, Bucharest, Romania.

Altintas, Y. (2012). Manufacturing Automation: Metal cutting mechanics, machine tool vibrations, andCNC design. Cambridge University Press, United States of America.

Çelik,Ş.A., Kayacan,M.C.,Aydoğan,T.,Çakır,A. (2002). Bilgisayar kontrollü kumaş kesme makinası tasarımı ve imalatı. Politeknik Dergisi, 5 (2), 173-177.

Uyanık,S., Şimşek,İ., Aytan,N., Onat,M., Erdal,H. (2009). 3 eksenli yüzey işleme tezgâhının bilgisayar ile kontörlü. 5. Uluslararası İleri Teknolojiler Sempozyumu (IATS'09), Karabük/Türkiye.

N. Čuboňová, J. Kardoš. (2011, 01-04 June). E-learning – new approach in quality education of CNC machine programming.In Proceedings 7th Research/Expert Conference with International Participations, QUALITY 2011, Neum, Bosnia and Herzegovina, 885-890.

Ye X.Z., Liu H.Z. & Chen L. (2008). Reverse ınnovative design — an ıntegrated product design methodology. Computer-Aided Design, 40(7), 812-827.

Frank Nanfara, Tony Uccello, DerekMurphy. (2001, 17 May). The CNC workshop.Prentice Hall 2nd edition.

Nur Suraini Binti Hashim. (2012, 1-3 June).Design of mini CNC machine. Faculty Of Manufacturing Engineering, Unıversıtı Malaysıa Pahang.

Asif Hussain Ansar Md., Mohd Abdul Hussain , Shaik Mahmood Alamoodi, Shanila Mahreen, Taskeen Sultana, and Mohammed Abdul Rahman Uzair. (2016).Features and applıcatıons of CNC machınes and systems. International Journal of Science, Engineering and Technology Research (IJSETR),5 (3), March.

Mike Lynch. (1996) .Managing computer numerical control operations. Society of Manufacturing Engineering.

Kutlu, M. (2006). Üç eksenli masa tipi CNC freze tezgâhı tasarım ve imalatı. Yüksek Lisans Tezi, Afyonkarahisar Kocatepe Üniversitesi, Fen Bilimleri Enstitüsü, İstanbul, 53-77.

Art Soft Using Mach II Mill http://www.machsupport.com/docs/Mach3Mill_6.11.pdf