



Experimental Study of Working and Process Parameters of a Wood Router Machine

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ABSTRACT

This paper elaborates study of CNC controlled wood router or cutting machine which is used to perform different operation such as drilling, engraving, cutting, reaming etc on wood material. They focused on building a machine using stepper motors where as microcontroller having memory to load or unload and modify program based on the design needed. Process parameters like spindle speed, tools diameter, feed rate, number of flutes or cutting edge on tool, workpiece materials, thickness of materials, depth accuracy, surface roughness, directional accuracy and the importance of clamping forces on material removal from workpiece. Also the designing and simulation software like ArtCam, Inkscape and their importance is discussed which forms a bridge between microcontroller and user, to design in CAD and use them directly by converting them to machine readable GRBL format and simulate tool path movement and material removal from work piece. influence of spindle speed and feed rate on thermally treated wood material is discussed. Experiment was done on different materials like acrylic and aluminum trihydrate and using ANOVA and it was found feed rate is most influencing factor of surface roughness of material.

Key words: Wood router, engraving, ArtCam

INTRODUCTION

A Wood Router Machine also called as Wood Engraving Machine is used for different can be used for carrying out different operations such as engraving, drilling, reaming, cutting on different materials such as wood, aluminum, PCB boards, acrylic etc. engraving when done by humans may cause errors and craftsmen find it difficult to make difficult designs, to tackle this problem wood router machines are used. These machines can be either NC controlled (Fixed Program) or CNC controlled (Programs can be loaded/unloaded and modified). Mostly these machine is made of cast iron which gives it ridged It consist of four steppers that causes motion in X, Y and Z direction (One each for X and Z direction and two for Y direction). The demand of customized and unique design with good surface finish and accuracy can be fulfilled with this machine. Based on the material we are working with, one must select and consider value of parameters such as spindle speed (RPM), Number of flutes on tool, Chip load, Efficiency, Duty Cycle, Material Removal Rate, Feed rate, Accuracy, Depth, Surface Roughness. The required design can be designed on computer software such as ArtCam and Inkscape which allows used to design shapes, select required process parameters such as tools to be used, spindle speed, feed rate, depth to be achieved and also to simulate tool paths and design. Assembly consist of a Control Box which has a Microcontroller (Microprocessor and memory), Teach Pendant (give different commands and cause moment with in work area) and Spindle speed control box (to control spindle speed).

BRIEF DISCUSSION ABOUT WOOD ROUTER MACHINE

Prashil N Patel et.al [1] Discussed about fabrication of 3 Axis portable CNC Router machine. The researches made use of three stepper motors NEMA - 17 with microcontroller adreno NANO and microprocessor IC 4988. The motor has maximum spindle speed of 6000 RPM and can perform operations like engraving, cutting, marking, drilling and milling on different materials of wood, PCB within working area of 280 X 170 x 65 mm. For designing they use software's like ArtCam, Inkscape etc, which can be used for designing and simulating the process. The design in form of G codes were sent to GRBL software and then transferred to Arduino. CNC control board which will give command to motor to perform machining on work piece. Machining operations like cutting, engraving, marking, depth, speed and accuracy test where done and time required for processes were noted. Form the experiment the researchers claimed that result obtained from the experimentation showed 100% and 99.99% accuracy in depth and carving respectively. They also claimed that this machine developed can be used for performing machining operation on different material to get accurate profiling.

K Bangse et.al [2] Discussed about fabrication of medium size CNC Router machine for wood craft mens in Bali, Indonesia. The researchers made use of stepper motor having spindle speed of 1200 RPM. They used microcontroller ATMEGA 328. They used linear guides and ball screw mechanism for movement in different directions. The machine was capable to work on work area of 800 x 500 X 130 mm area. The process begins with creating the design using CAD software which is in .stl format which is then converted to glucose using Mach 3 software and send to BOB (Breakout board) which prevents feedback signal to be sent back to the computer components. This signals in form of G code is then sent to the motor which performs required motion to engrave the design on the work piece. They claimed that the directional accuracy of machine in X and Y directions was 99.5% and that in Z direction was 96%. They claim that this machine can be used as a substitute for traditional operation which was built at low budget and was medium size router machine.

Huseyin Pelit et.al [3] discussed about influence of various parameters on surface roughness. They used two different tools, i.e; straight mil and spiral mil tool. Experiment was carried on three different wood i.e; scotch pine, eastern beach and Linder wood. All samples were thermally treated which, drying of sample at 0% moisture and heating them at different temperature at 170, 190 and 210 °C. Then temperature is dropped and moisture is brought to 4 to 6% by spraying water on the sample. Process was carried out using spiral and straight and mill tool at spindle speed of 12000, 15000 and 18000 RPM with feed rate of 3000, 4000 and 6000 mm per minute. 4 test using both tools in radial and tangential directions where carried out followed by machining at varying temperatures, spindle speed and feed rate as mentioned above. For measuring surface roughness they used surface tester TIME TR200. They claimed that spiral tool gives rough surface when compare to the work piece machine by straight mill tool. They also claim that with increase in spindle speed and feed rate surface roughness decreases by 15% and 21% respectively.

Aniket Suryawanshi et.al [4] Discussed about building an open architecture based CNC Router machine for engraving operation. They use stepper motor NEMA 23 for moment in X and Y direction and NEMA 17 for moment in Z direction which provides high accuracy at low speed. The work area was 200 x 200 x 75 mm. For x and y axis they use 12mm ball screw and nut assembly supported by pillows block bearing at the end and 10mm linear guide rails for Z direction motion. They use adreno Uno microcontroller which has USB connector to load and modify data, 16 Mhz ceramic resonator was used for signal generation, ICSP header to loads and boot audrinal for online sources and a reset button. Make image in SCG format, which is then send to make a cam which convert the image to G codes. These G codes are sent to you GS platform where codes are converted geometric profile motion so that the required motion is carrot smoothly. This build machine was able to give accurate result with few micron deviation.

CNC Router bits [5] Discussed about the influence of parameters like spindle speed, feed rate number of flutes on tool, chip load. They gave relation and showed feed rate is is having direct impact on number of fluids chief load and spindle speed they give equation $feed = N \times T \times X \times Z$. They claim that as speed of spindle increases feed rate will increase if other parameters are kept unchanged also if chip load is kept constant and feed rate is increase it will affect the value of spindle speed or number of fluids. It will either increase or decrease. They carried out calculation showing influence of number of cutting edge chip thickness on spindle speed also influence of cutter diameter on chip thickness of different materials like hardwood, soft wood, particle board, soft plastic, hard plastic and Aluminium. They claim that when machining is done on non-ferrous material depth of cut must be equal to the cutter diameter to get good results and also to start machining at low feed and plunge rate.

Mohammad Yousef Samench et.al [6] Discussed about developing a routing machine to perform engraving on wooden material. This machine structure contains set of three stepper motor that causes motion in X, Y and Z direction. It has limit switch so that motor cause movement in particular direction is up to certain boundary so that the overall structure

does not get damaged. Home switch so as to bring all the component at one set position called origin of the machine. Emergency switch to disconnect power supply to the machine if something goes wrong or need not to continue the process further. Optocouplers are installed in between microcontroller to isolate computer from the signals coming to computer form emergency stop button are limit switches. Also it consists of bipolar stepper motor control circuit relay circuit to power on and off the spindle of motor. Using following component day build a CNC routing machine which was capable of doing smaller capacity jobs of engraving on wooden material as well as plastic material

S Suharto et.al [7] Discussed about building a CNC routing machine to engrave on hard material like granite or marble. Their objective was to find influencing parameters that affect surface roughness of engraved part. They studied parameters like cutting speed, speed feed rate and depth and their interrelationship. They use artcam software with Mark 3 software to obtain necessary machine understandable G codes to perform motion on work part. King area of 600 X 400 X 150 mm which has maximum spindle speed of 18000 RPM. They use 6mm end mill tool which was made up of carbide material. It was found that with increase in spindle speed surface roughness is much lower and vice versa. Also with increase in feed rate surface roughness increases. They also claim the optimal value of engraving will be at cutting speed of 30m per minute at 12000 RPM and 2000 mm per minute feed. They claim that with higher value of feed rate surface roughness will increase.

Sugiharto et.al [8] Discussed about developing a router machine with NC microcontroller and use servo Motor instead of stepper motor for creating moment in different direction within work area. Servo Motor system consists of three part i.e. motor control system and encoder. Encoder provide information whether the desired location of spindle is reached. Also servo Motor provides high value of spindle rotation and torque as compared to stepper motor. Construction consists of microcontroller ATMEGA 8 328 which act as bridge between computer system and motor. In between they made use of PWM (pulse width modulation) drivers which amplify signal that comes from microcontroller. Files in form of BMP format is imported to CAD cam software which is then converted to G code which is sent to the microcontroller which then sends the signals to the motor which performs desired motion on work area and engraved design on the work piece. They also claim that use of servo Motor with N C program can be used to engrave on work material which is more efficient than using stepper motor.

Grzegorz et.al [9] discussed about parameters that influence surface roughness when milling operation is done on work piece. They claim that variation of particles of wood material are one of the influencing factor. They carried out experimentation on three samples of wood i.e; brich, beech and ash wood. Objective of studying 3 sample was to determine effect of spindle speed and feed rate on surface roughness and effect of variation of structure of wood. Rotation speed was 9500, 12000, and 14500 RPM and Feed rate of 2, 4, 6 m/min with maximum and minimum cutting diameter of 99 and 78 mm with number of cutting edges or flute on tool 2. According to the experimental values they claim that brich wood for both spindle speed and feed rate showed slight effect on surface roughness. For breach wood spindle speed had effect on surface roughness but there was no effect of feed rate for influencing surface roughness. In case of ashwood both spindle speed and feed rate showed great effect. Show the researchers concluded that with influence of spindle speed and feed rate of machine the structure of particles of would also shows great influence for overall surface roughness of the wood work piece.

Dhruv H Patel et.al [10] Discussed influence of different machining parameters like spindle speed, depth, feed followed by using Taguchi method and ANOVA. Experiments were carried out on composite materials made of acrylic resin and aluminium trihydrate which is mostly used for decorative and furniture work. Tool used was 6mm end mill cutter which was made up of HSS. Experiment was done on work piece having dimension 254 X 44 mm where 9 experiment by making grooves of 6 X 3 mm were done. Spindle speed was kept 8000, 10000 and 12000 RPM with feed rate of 1000, 2000 and 3000 and depth of cut to be achieved was 0.75, 1 and 1.5 mm. With aid of Taguchi methodology set of nine experiments where created in MINITAB by using above mentioned values of spindle speed feed rate and depth of cut to be achieved. Surface roughness was calculated by using instrument called handy Surf E 35 A roughness tester. Researchers found the optimal value of surface roughness to be 0.79 micrometre. And from ANOVA concluded that feed rate is the most influencing parameter for the surface roughness.

Kajal J Madekar et.al [11] discussed about fabricating a mini CNC machine at low cost which performs operations like drilling and drawing operation on PCB. They use stepper motor NEMA 23 having 1.8 degree step angle for motion in X Y and Z direction. Computers provide design in form of G code which can be loaded in FTDI (Future Technology Devices International Limited) module, USB which helps to load data from computer to microcontroller by converting signals to ASCII value. Microcontroller used was ATMEGA 32 28 which was then connected to stepper motor which cause motion overworking area and performs operations of drilling and drawing on PCB. They concluded that this low

cost Mini CNC machine gives good accuracy and operating such small machine is more flexible for operation of drilling and drawing on PCB.

R Ginting et.al [12] discussed design of a 3 Axis CNC Router machine to perform machining operation like cutting engraving marking on materials like wood acrylic and PCB. This machine consists of three NEMA 17 stepper motor which causes motion within work area. This motor has maximum spindle speed of 12000 RPM. They used ATMEGA 328p microprocessor with IC4988 microcontroller. Files with .gcode extension from computer was sent to microcontroller with saint signal to all three stepper motor to move in desired direction to perform operation on work piece. Machine can perform machining in X Y Z direction for for maximum reach of 33.5 X 31 X 44 cm. The software used to load and modify program in microcontroller was Xloader. The tool used for machining was 3 mm V B 60-degree drill bit which was capable of performing cutting engraving and marking operation on work piece at maximum spindle speed of 12000 RPM. According to the value obtained from experimentation they found that machine showed 98.5% and 100% accuracy during calving and depth test respectively.

CONCLSION

- Feed rate found to be most significant factor on surface roughness of engraved material.
- Closed packing of material particles influences surface roughness. For closely packed particles surface roughness will be good.
- Change in feed rate in feed rate direct proportional to number of cutting edge, chip load and spindle speed.
- Higher spindle speed results into good surface finish and with lower spindle speed surface finish becomes inferior
- Roughness of engraved material is totally based on type of tool used and density of particles in material.
- Using servo motor for NC program was found to be more efficient than stepper motor
- Based on use of dencely packed partical wood shows greater depth accuracy than that of medium and low packed wood
- Flatness and perpendicularity of material is important to carry out efficient material removal and achieve correct depth on workpiece.
- Use of designing and simulation software like ArtCam Inkscape etc can give more designing comfort and to design difficult drawings and simulate tool paths and final product

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