Design And Development of Ardunio CNC hot wire cutter

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ABSTRACT

Abstract *A wedding without decorations is incomplete. Interior decoration companies shouldcreate a group of skilled and creative workers, improve the production skills of workersand offer customers a variety of decoration options. The newestmaterial used for decoration is polystyrene foam. The goal of this work is to createa CNC machine that achieves good results and precisely cuts polystyrenewith hot metal. This research also helps solve the problems of cutting polystyrene foam, an often detailed and complex task that can be solved with CNCmachine tools. The hardware design requires Bluetooth connectivity,stepper motor control, A4988 CNC screen control andheated iron voltage. Software development involves downloading the GRBL firmware,generating the G-code with Inkscape software, andconnecting the Android app to the CNC machine. The results showed that the best cut of 1 cm thick 2D foam was achieved between 7.4 and 8.5 V.Styrofoam was also tested at the same voltage of 8.5 V but with a different feed rate,and 400 mm/min and were found to work best. The 3Dfoam cutting results showed that 8.5 V voltage, 300 mm/min feed andfoam thickness of 10 cm achieved the best*

cutting hardness or softness compared to others. plastic foams. This shows that the heat produced by the welding metal is directly proportional to the speed of advance.

Key words: *Arduino Uno, CNC, Cutting Foam, Hotwire, G-code.*

1. Introduction:-

CNC hot metal cutting foam machines are used to cut and create 3D foam into predetermined shapes without complex tools or lasers. The type of cuttingused in the machine is called hot metal or special cutting metal(nickel-chromium metal), which gets very hot when an electric current is applied. Whenthe electric current is passed, the nichrome metal evaporates and dissolves the foam, so userscan easily get the image they want and enhance it. Our polystyrene uses CNC machines, which are rarely used for decorationthe foam cutting process. The most common applications are the use of CNC machinesfor PCB layout, laser engraving, 3D printing and many other applications. One of the most common problems ofhandmade electronics is human error, which makes thedecoration not beautiful and perfect, and some places are difficult to reach.To solve this problem,this study aims to achieve good results and create a CNC machineto cut polystyrene foam with high quality hot metal.

1.1 LITERATURE REVIEW

Syahriza, U Aulia, L Muspika Department of Mechanical and Industrial EngineeringDepartment of Engineering, Universitas Syiah Kuala, Darussalam, Banda AcehCutting foam by hand can result in inaccurate cuts and uneven shapes. To improve the quality of the product, a cutting polystyrene knife is needed. Therefore, the purpose of this work is to build a styrofoam cutting machine using a 2-axis CNC metal cutter,which can cut materials with CAD image modules and speed up the cutting process.

Optimizing Hot Wire CNC Machining Parameters to ImprovePlastic Foam CuttingHot wire cutting is one of the most important unconventional thermomechanical methodsfor cutting polymers, usually expanded foam and extruded foam, in small-scale production.Research and analysis of Hot-Wire cutting parameters play an important role in improving the quality and precisionode processes and products.

Overview Of research work

We did a data analysis and then researched different methods to reduce the timeand improve the cutting results currently used in the drone industry. We looked atmany scientific papers. We create our projects from CAD models and use Automatic CADFUSION 360. Then we did manufacturing and assembly. We tested our modelcutting different foams to reduce errors and overcome early limitations. We have also reduced thetotal cost, making it affordable for small-scale production. Manufacturers use a foammolding technique. This process is suitable for mass production and can produce manyidentical parts such as fuselage or wings (for RC models).

1. Hobbyists who want tobuild models at home with hand tools are often limited to simple shapes made by bendingthe same Styrofoam around multiple overlays.

2. Another method used is additive manufacturing technology (LOM) for rapid manufacturing. They create models fromthick (about 30-100 mm) layers of XPS that are cut and glued together withhot metal to create finished products. The hot metal (heated by electric current) mustfollow the cross-section made when gluing the models to both sides of each layer, this requiresskill and practical work to satisfy the need. The goal of Momentum's research is to create aframework that would satisfy (but not only) similar needs to that of a model airplane.A member of the RC groups forum built a CNC hot metal cutter that usesembedded foam software to cut a long piece of wing.

MATERIAL USED

Aluminum profiles - We used 20x20 mm and 30x60 mm aluminum profiles in this project. These profile dimensions are standard. This profile is made of high- strength heat-alloy Al 6063 - T5. The weight of a20x20 profile is about 0.74 kg. The thickness of the diagonal part is 1.5 mm.

L-Clamp - These L Clamps are durable and versatile. It is made of high- quality aluminum. The dimensions of L-clamps are 30 x 30 mm and can be used to lock aluminum profiles 30 x 30 mm. This is a straight angle corner and 8.8 x 5.9mm egg hole (+/- 0.05% accuracy).

Nema Stepper Motors:

Fig. Nema Stepper Motors

Stepper Motor Driver

Fig. Stepper Motor Driver

In this foam cutting machine, we have used motor drivers for the dynamic control NEMA 17 stepper motors. the stepper motor driver used is A4988, it is used to drive nema17 stepper motors. the power input of this motor is of range 9 ~ 40 V DC. The normal output current is 3.5A. The Peak output current is 4A and the micro steps Are 1, 2/A, 2/B, 4, 8, 16, 32. The stepper drivers are used to control direction and speed.

Hot Wire

Fig. Hot Wire

Foam can be cut using various cutting modes. Different dimensions of foam cutting depends on the nickel-chromium wire material, wire gauge, wire cutter air, wire cutter speed, and kerf width. There are mainly two types of nickel-chromium wire foam cutting, thermal mechanical shearing and unique heat cutting methods. We use thermal mechanical shear. temperature by using different diameters such as 0.6 and 0.32.

Arduino Uno

Fig. Arduino Uno

The microcontroller used in Arduino uno is Atmega328p. working voltage is 5v. working voltage between 7-12V. It has 14-digit IP and OP (inclusive) point. There are six analog input points. The powder sander uses the main control board for the motor. 32 kb memory Eve belongs to the family controller. This controller has 14 digital input/output points, 6 of which provide pulse width modulation. Arduino SRAM 2 KB and EEPROM 1 KB. Arduino Uno runs at 16 MHz clock speed. It has one USB port and one power adapter port. The board draws power from both ports. It is loaded using USB port software.

CNC Shield This is mainly a CNC controller shield used to control the 3-axis machine. The CNC controller has a stepper motor drive. It consists of x-axis, y-axis, z-axis and joint head (extruder). The CNC shield operates on a 12-v dc supply. It also includes reset button, driver enable pin, XYZ step module driver and reference point, step module drive and direction, and power supply. The CNC shield connects to the Arduino, and the data comes from the Arduino. This is full step control using a CNC lathe.

Hot Wire Limit Switch

A limit switch is an electromechanical device. if acted on by some physical force, it fits. The limit switch consists of NC, OK, COM. In this case, the limit switch is used to limit the

movement of the arrow and is also used for cover. A limit switch is connected to the CNC shield. When the motor is running and the limit switch is pressed once, the circuit opens and the motor stops. Basically, it controls the cutting of the hot wire.

SMPS Power Supply

All power supplies for this foam cutting machine are provided by SMPS 24V 20A power supply. It rectifies AC voltage to DC voltage and provides a constant power supply. It also includes a power switch cable. Power cable included.

Design of Foam Cutter Mechanical CAD Design

Design is one of the most important stages of production, where there are manyadjustments and the factory is chosen as a model to produce the design. Frame design is made using desktop software.

Part	Material	Dimensions (mm)
Base Plate	Mild Steel	1720*310*10
Lead Screw	EN8	Ø 25,Pitch5 having double start
Lead Screw Nut	EN8	Ø 50
Rail support	Chromium plated Steel	Ø25
Nut Plate	Mild Steel	2*Ø 5
Slider	Mild Steel	200*120*5
Bush	Aluminum	Ø 5
Tool Plate	Mild Steel	100*55*5
Tool	Iron carbide	Ø 5

Motor Plate	Mild Steel	205*150*5
Washer	Mild steel	Ø5, Ø 12
Key	Mild Steel	4*4*35

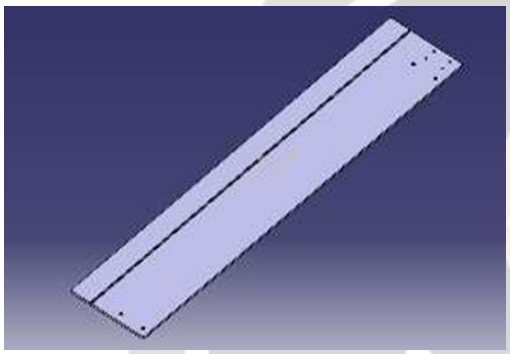

Fig Base Plate

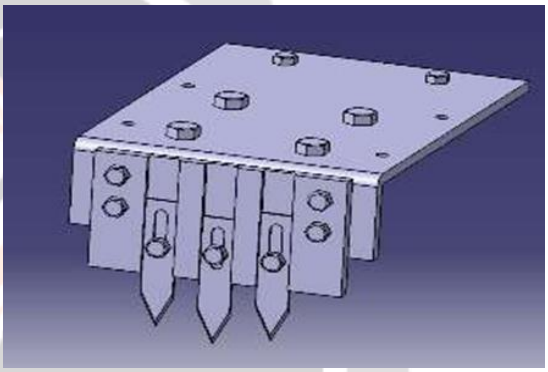

Fig Mounting

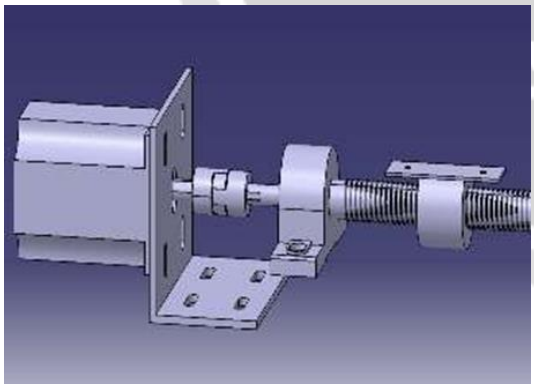

Fig. Motor mounting

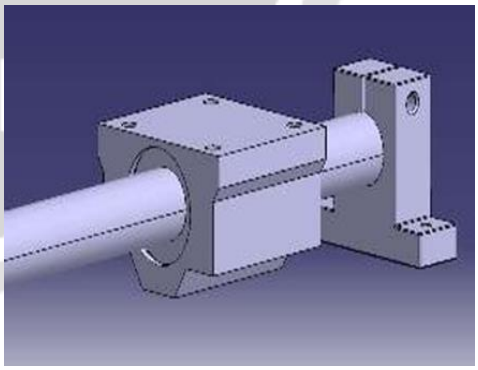

Fig LM Guide

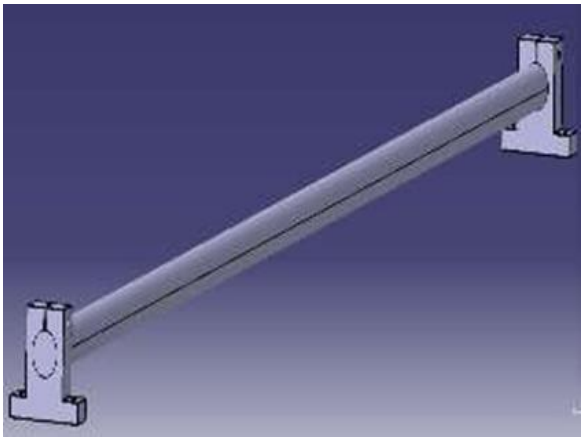

Fig. Rail Support

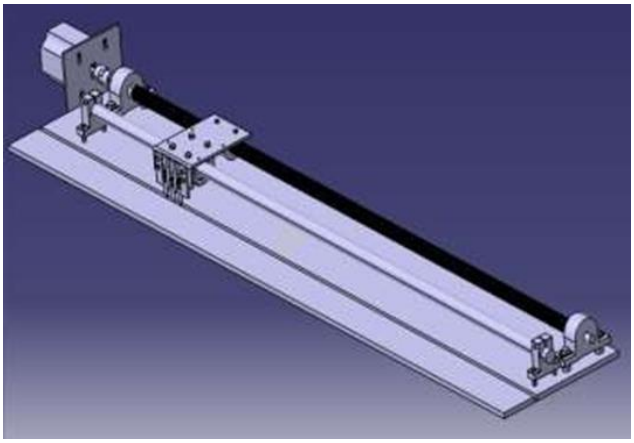

Fig. Final Assembly

Design Calculations:

Stepper Motor Selection Calculation

Mass of components including engine (approx.): 4Kg

Fm = 4 * 9.81 = 39.24N

frictional force

Ft = mu ^ * Fm = 0.2 * 39.24 = 7.848N

The force required to push the wire into the work piece to work

Total force: FT = Fm + Ft + Fc Fc = 20N (approx.)
= 39.24 + 7.848 + 20 = 67.088N

The formula for calculating the drill rod (M10) is 3/5 strength T = F^*(tan (alpha + var phi))

tan alpha = P/(pi^*d) = 1.5/(pi^*9.25) = 0.0502, where alpha -\.> 3 degrees

Dm = Et - (P/2) = 10 - (1.5/2) = 9.25mm

Tano = u / cosß = 0.2 / cos15 = 0.2 / 0.966 = 0.207, where φ = 11.69 degreesT = Torque in N-mm: Therefore:

T = F^* tan (alpha + var phi)

T = 67.088^* tan (2.95 + 11.69) T = 17,525N – mm

Consider safety factors

Treq = 52.575N-mm Standard motor torque in the market = 294.3N-mm

From our calculations, we derive two important pieces of information for choosing a stepper motor for your CNC hot wire foam cutting machine:

Required Torque: This is the minimum amount of torque required to overcome the total force (including mass, friction and shear) acting on the system by the motor. In your calculations, we set this to 52,575 Nm.

Safety margin: By multiplying the required torque by the safety factor (usually 2-3 to account for unexpected loads), we get the minimum acceptable torque for the motor. In our case, the minimum torque accepted by factor 3 is 157,725 Nm (52,575 Nm * 3).

However, the calculations don't directly tell you the exact motor to choose. Here's what we do the next:

1. Compare minimum acceptable torque to available motors: Look for stepper motors commercially available and compare their rated torque to your minimum acceptable value (157.725 Nm in our case). Chosen a motor with a torque rating higher than this value. our calculations show a readily available motor with 294.3 Nm which provides a good safety margin.
2. Consider motor speed and duty cycle: While torque is important, also look at the motor's speed (affects cutting speed) and duty cycle (continuous operation time without overheating) to ensure they meet our project's needs. By considering all these factors, we had selected a stepper motor that provides sufficient power, speed, and endurance for your CNC Hot Wire Foam Cutting Machine project.

CONCLUSION

CNC hot wire foam cutting is a versatile and cost-effective method of creating precise shapes from various foam materials such as EPS, XPS, EPP and EVA. Its applications range from architectural modeling to labeling and package design. However, a common challenge in this process is thread tension..

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