CNC Hot Wire Foam Cutting Machine

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ABSTRACT

This research addresses the growing demand for intricate and creative wedding decorations. It proposes a CNC hot wire foam cutter design specifically for cutting Styrofoam. The machine offers precise control and automation, overcoming limitations of manual cutting for complex designs. This paper details the design process, including hardware and software components, and presents the results of cutting tests performed on various Styrofoam thicknesses and feed rates.

Keywords— Arduino Uno, CNC, Cutting Foam, Hotwire, G-code

INTRODUCTION

Weddings Elaborate wedding decorations are a key element in creating a visually stunning and memorable event. Skilled and artistic professionals are in high demand to fulfill clients' desires for unique and personalized decor. Styrofoam, a lightweight and easily workable material, has become popular for creating various decorative elements. However, achieving intricate cuts with traditional manual methods can be challenging and time-consuming.

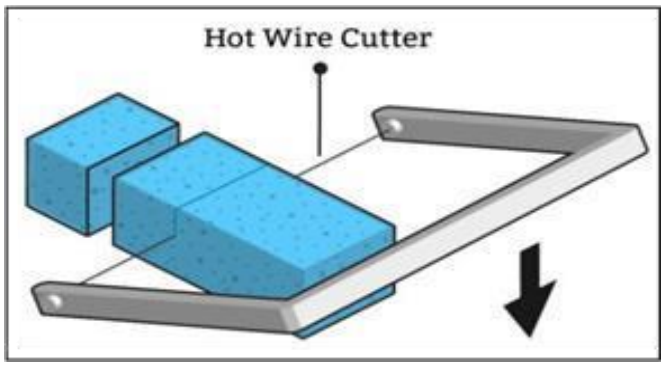

Fig 1.1 Isometric view mechanical design

Design and Functionality

This CNC hot wire foam cutter operates similarly to a reciprocating crank mechanism. Rotary motion from stepper motors is converted to linear motion through lead screws, driving the hot wire toolpath.

The design offers several advantages:

Precision Cutting: CNC control allows for highly accurate cuts, ideal for replicating intricate designs.

Automation: The machine automates the cutting process, reducing manual labor and production time.

Material Versatility: The hot wire can be adapted to cut various foam thicknesses.

CORE DESIGN CALCULATIONS:

1.Stepper Motor Selection calculations

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

- Fm = 4 * 9.81 = 39.24N
- Frictional Force
- Ft= mu^ * Fm = 0.2 * 39.24 = 7.848N
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Force required for pushing the wire into work piece for machining• Total Force: FT = Fm + Ft + Fc

Fc =20N(approx.)

= 39.24 + 7.848 + 20

= 67.088N

Formulae to calculate the Screw rod (M10) Force 3/5

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

- tan alpha =P/ (pi^ * d) =1.5/ (pi^ * 9.25) =0.0502 where alpha -\.>3 degree
- Dm = Do - (P / 2) = 10 - (1.5/2) = 9.25mm
- Tano = u/cosß = 0.2/cos15 = 0.2/0.966 = 0.207 where φ=11.69 degree
- T = torque in N-mm

Therefore:

- T=F^ * tan (alpha + var phi)
- T=67.088^ * tan (2.95 + 11.69)
- T = 17.525N - mm

Considering Factor of Safety of 3 Treq52.575N-mm Standard motor Torque available in market = 294.3N-mm.

From the calculations we've done, we get two key pieces of information for **selecting a stepper motor for your CNC Hot Wire Foam Cutting Machine:**

1.Required Torque: This is the minimum amount of torque the motor needs to overcome the total force acting on the system (including mass, friction, and cutting force). In your calculations, we determined this to be 52.575 Nm.

2.Safety Margin: By multiplying the required torque by a factor of safety (usually 2-3 to account for unexpected loads), we get the minimum acceptable torque for the motor. In our case, with a factor of 3, the minimum acceptable torque 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:

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. 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.

RESULTS AND DISCUSSION

Cutting tests were conducted to identify optimal settings for different Styrofoam thicknesses. The key findings include:

Voltage: A voltage range of 7.4-8.5V yielded the best cutting results for 2D Styrofoam with a thickness of 1 cm.

Feed Rate: For the same voltage (8.5V), a feed rate of 400 mm/min produced the cleanest cuts.

3D Cutting: Cutting 3D Styrofoam at 8.5V, a feed rate of 300 mm/min, and a thickness of 10 cm resulted in the best surface texture.

These findings suggest a direct correlation between heat generated by the wire and the feed rate. Slower feed rates allow for more heat transfer to the Styrofoam, resulting in cleaner cuts.

Use Inkscape Software (For Generating G Code):

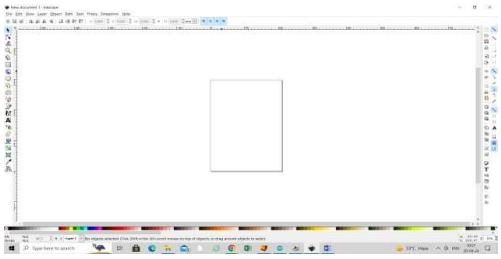

Fig. Inkscape Software Interface

Click on extension → 4XI draw tools → Generate G code tool → give path to save G code → click on apply

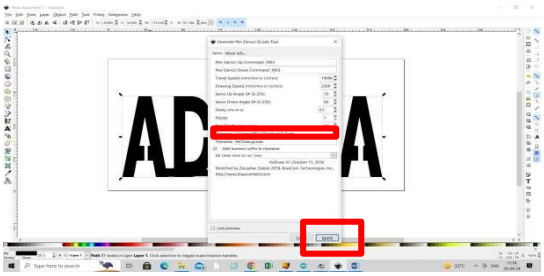

Fig. Generated G Code

Use Universal G code software (G Code execution)

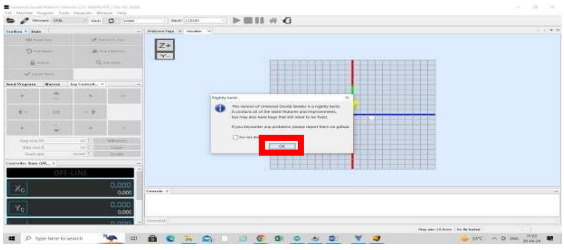

Fig. Universal G Code Software Interface

Click on connect option → connection done → Run G code

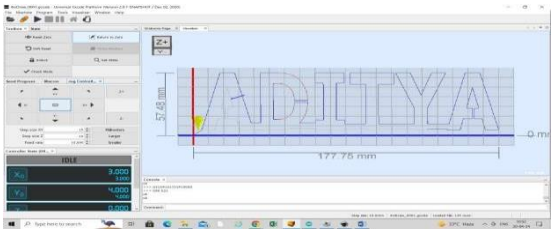

Fig. Requires Design Output

CONCLUSION:

The CNC hot wire foam cutter offers a valuable tool for wedding decoration professionals. Its ability to produce precise and intricate cuts from Styrofoam allows for the creation of unique and personalized decorative elements, enhancing the visual appeal of wedding venues. Future research can explore further optimization of cutting parameters for various foam types and explore the integration of 3D modeling software for design creation.

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