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Design and Development of CNC Foam Cutter

Dr. Abhinav P. Ninawe
abhinavpn59@gmail.com

Vijeet Khadilkar
vijeetkhadilkar@gmail.com

Mohammed Muzammil
muzzu3952@gmail.com

Nihal Mankar
nihalmankar3@gmail.com

Yash Tiwari
yashtiwarib0311@gmail.com

Ankit Thakre
ankit.thakre27@gmail.com

Pranay Bawankar
pranaybawankar03@gmail.com

Department of Mechanical Engineering, KDK College of Engineering, Nagpur, India

***Abstract*— Hotwire acting is a commonly used method to cut various types of foam in different shapes and sizes. Cut quality of foam depend upon variable cutting parameters of hotwire which affects the cutting process to achieve the needed cut, precise and accurate cutting parameters are needed to be set this research is done to develop 4 axis computer-controlled machine to perform precise and accurate foam cutting using hot wire and to identify suitable cutting parameters to improve foam cutting. This CNC has two mutually perpendicular axes controlled using a motor and micro controller. This design will aid UAV designers, Aero- modeller & hobbyist for rapid prototyping of wings, fuselage & different shapes, also it has wide application in RC modelling, signage, scale model & props, etc. this will save time, increase productivity and quality of cuts.**

Keywords— 4 axis computer-controlled machine, UAV designers, Modelling, Micro controller

I. INTRODUCTION

Development in the past Decade due its wide range of application in Defense, surveying, surveillance, photography, agriculture, disaster management, etc. Aeromodelling is one of the popular hobbies among all age groups across the world. This rapid development of RC aircraft happened due to the miniaturization of radio electronics, power systems, high power industry in India aeromodeller and UAV Designer need automated machines to cut this foam accurately precisely with no error also which will give them more time for iterating their design & get optimum results. This research aims to design & develop foam cutting Hobby aircraft Remotely piloted Aircraft and Unmanned Aircraft's vehicle has undergone significant r density batteries, and motors along with the availability of strong & lightweight & easy to use Foam polymers like EPS, EPP, XPS, polystyrene. Many aircraft models are made with these foams to achieve intricate shape for advanced Aerodynamics, stability, and performance. Manufacturers use foam molding processes. This is cost-effective for mass production. Hobbyists prefer to use hand tools or hand-hot wire cutters etc. for cutting these different shapes out of foam. Mostly in this emerging UAV and aeromodelling machines for the rapid prototyping of foam wing & other foam shapes.

A. *Overview Of research work*

To reduce cutting time and increase its efficiency for current use in UAV industries, we had done a literature review, then we studied different mechanisms. We took

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references from various research papers. We designed our project through CAD modeling and using AutoCAD FUSION 360. After that, we did fabrications and assembling. We tested our models by cutting different foams to reduce errors and overcome their earlier limitations. We also reduced the overall cost so that small-scale manufacturing industries can also afford it.

Manufacturers use foam molding processes. This process is suitable for mass production, to produce many identical parts, like fuselage or wings (in the case of RC models).

1. Hobbyists that prefer to make their models at home with hand tools are usually limited to much simpler shapes that are obtained via bending plain Styrofoam sheets around multiple cross-sectional elements.
2. Another method adopted is the layered object manufacturing (LOM) technique used for rapid manufacturing. They build their models from thick (approximately 30-100 mm) layers of XPS that were cut with the hot wire and glued together to form the intended object. Hotwire (heated with an electric current) must follow precisely contours of cross-sections which are achieved with templates glued on both sides of each layer; it needs skill and labor to achieve the desired result. The momentum research is an endeavor to fabricate a framework that can serve comparable requirements (yet not restricted to) of flying airplane modelers.
3. A member of RC Groups forum has made a numerically controlled hot wire cutter that uses diving Foam software for cutting long one-piece wings. Hans Seybold from Germany has made an NC hot wire cutter with 4 degrees of freedom. He used a unique mechanical layout where a bow with hot wire is positioned in space with 4 filaments of variable length controlled by 4 stepping motors. He likewise fostered a program to drive the bow along the ideal course which uses the plain content depiction of all directions of the shape. All information is available for free on the internet at Hot-wire cutter by Hans Seybold
4. Probably the most advanced technology is used in the Aero Tetris Company located in Russia. They use a 6 axis NC machine which allows achieving an accuracy of 0,09-0,5 mm with wire inclination up to 165 degrees. During the cutting process speed and temperature are varied. The organization sells sets of Styrofoam parts for building huge models.

B. Formulation of the problem

This research aims to overcome existing problem & to implement new methods

1. To improve Precision & accuracy of foam cut using hot wire foam cutting
2. Try to use open-source programs for controlling CNC foam cutter
3. Try to make it cost-effective for hobbyist, designer
4. Use easily accessible parts

a. Finding out the need of the project

1. To save time build time-prototyping for designer
2. To make machine using accessible parts
3. Easy to use machine based on open-source software
4. To help UAV designer to design aircraft design with less expensive material like foam

b. Development of new prototype modal

To overcome and meet the objectives of the project. We had designed the machine from scratch using CAD software. This design will include 3d printed parts for motor mounting, frames, smooth rod for providing structural rigidity, threaded rod & Stepper motor mechanism for linear movement of Cutting tool i.e. hot wire. This complete assembly will be controlled using Micro controller and Stepper Drivers on G-CODE command generated using open-source software like http://www.diyrcwings.com/ or wing g code generator software

II. RESEARCH METHODOLOGY

A. Introduction of the proposed machine

The proposed machine can be introduced as a CNC Hot wire foam cutter. It has two pairs of vertical and horizontal arms attached. This pair of vertical arms hold the cutting tool i.e. hot wire at a certain distance. These vertical arms are mounted on horizontal arms which are controlled using a Stepper motor. Motor speed and feed rate of the Cutting tool is controlled using a microcontroller through G Codes. Proposed machine intends to save the time of maker, give them good quality cuts, to bring out suitable cutting parameter for foams

B. Need of this Project

To find suitable cutting parameters like the temperature of Hotwire, feed rate, etc. for different foam. To make this project cost-effective by using easily available material, also 3d printed parts for custom part design. To increase precision accuracy & minimize gross errors. This machine will cut three types of foam like EPS, XPS, HDPE.

C. Identification of problems

Two major parameters that are responsible for the smoothness of cut and their accuracy

The temperature of Hotwire Feed rate in mm/s The temperature of hot wire is regulated using a variable power supply, a cutting tool for foam. The current-carrying wire will vaporize the foam. Feed Rate is the speed of a cutting tool i.e. hot wire at which it is moving this is controlled using a Stepper motor via G code & microcontroller. In the cutting process, a hot wire heated by passing current is directed through a block of Foam. The wire is heated at 200°C, as polystyrene foam melts at around 200°C, but attains its flowing state at 100°C. This heated wire vaporizes the foam at the cutting location. This slightly melts the surface of foam & leaves an open gap at the cut location. This gap is called a kerf. The width or thickness of Kerf depends upon the cutting temperature and cutting speed. It varies with variations in temperature and cutting speed. Kerf is directly proportional to temperature and cutting speed. Kerf can be controlled using the CNC system implemented in this project.

D. *Development of prototype model using CAD software*

This prototype is made using a 3d printed part, aluminum extrusion, threaded rod, smooth rod, stepper motor, microcontroller, stepper drivers. The 3d models are made using Autodesk Fusion 360.

Length of horizontal arm = 500mm

Length of vertical arm = 250mm

Length of wire = 500 mm

Microcontroller

Figure 1. Setup model

Figure 2. Assembled Setup

III. TESTING OF THE MODEL

Testing was done to find out Kerf's width. It is the width of the gap between foam parts that are separated by the cut. From Testing it is pointed out that the kerf width value varies with the amount of time and current supplied to the wire. Kerf values vary with the thickness of cutting wire for the proposed model .4mm nichrome wire is used. The temperature of the wire is needed to set according to material properties i.e., foams.

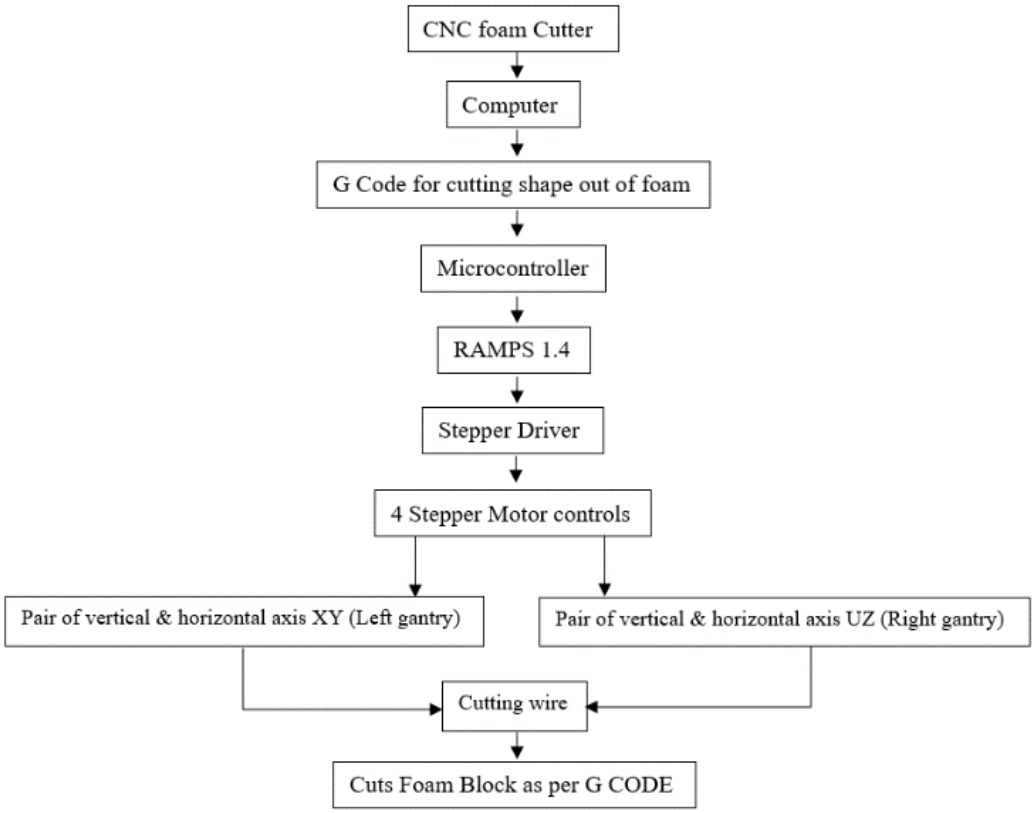

Figure 3. Working Chart of CNC Foam Cutter

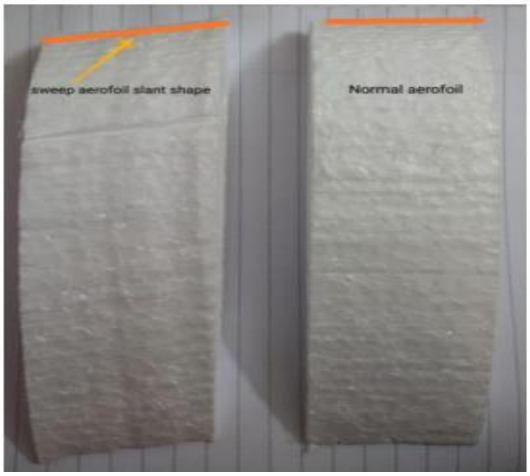

Figure 4. Aero foil Cut Sample

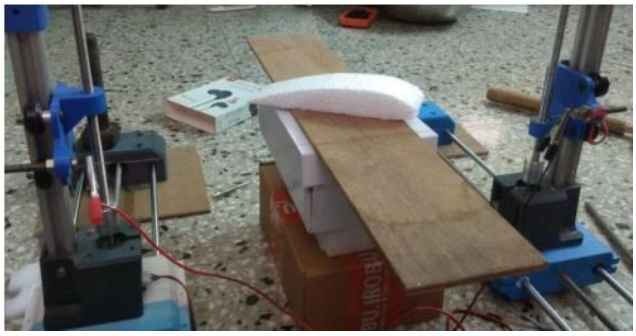

Figure 5. Testing Setup

Characteristics of CNC Foam Cutter

[1] Foam Cut Volume

500mm x 500mm x 250mm

[2] No. of Axis motor

4 stepper motor XYUZ

[3] Cutting methodology

Thermomechanical cutting

[4] Cutting tool

Nichrome wire twenty-six

[5] Machine Size

5500mm x 500mm x 2500mm

[6] Machine Weight

8 Kg

[7] Power offer

12V, 30Amp

[8] Connectivity

USB

[9] Foam Material

Polystyrene, XPS, EPP

[10] Cutting instruction file

G-codes

IV. Conclusions

We have designed and fictitious the most structure (body) of CNC Foam cutter it is four axis system that management movement of hot wire in keeping with G code. This machine cut foam exploitation Thermo mechanical cutting mode during which hot wire is passed through foam with sure cutting speed that creates a spot in foam. This gap is made because of melting of froth done by hot wire. Multiple cutting trials were done on foam before thesis. Material used for cutting trials was vinylbenzene (thermacol). completely different power input & completely different cutting speed were modified in G code. completely different values like kerf, tension in wire, additionally surface texture was discovered while cutting. From these trials we've got come back up with outcome once exploitation constant current cutting the cutting mechanisms amendment over the length of the cut.

The surface texture on a sample cut with constant current changes reckoning on the cutting force gift at that position. High cutting forces lead to a wavy surface. Low non-zero cutting forces give the smoothest surface because the wire shears the adjacent liquified plastic filling within the cell boundaries. once cutting forces area unit zero the wire is sufficiently hot to soften the froth previous the wire resulting in a granular surface texture because of discriminatory melting at the cell boundaries. This cutting force & temperature may be controlled by finding out properties of fabric & exploitation feedback system. This machine will cut desired shape of wing. The preliminary study yielded necessary results concerning dominant and planning a numerically controlled hot wire cutting with high accuracy and reliability.

UAV is rising technology in Asian country and Aeromodelling is hobby of all time. These field uses foams as for prototyping, production, mildew creating of recent model. The machine designed and fictitious will deliver quality of froth move amateur and makers. it's necessary accuracy & exactness in cut if all parameter of cutting is set accurately. it's price effective & simple to use system for beginner.

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