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Fabrication and Performance Analysis of an Arduino-based Mini CNC Machine with Drilling and Engraving Tool

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Abstract: ***The present work focuses on fabrication of a low cost numerically controlled machine with easily available materials and devices. The machine has been primarily fabricated to carry out a few low duty mechanical applications in a short period of time as well as at a minimal cost. Engraving tool of diameter mm and drill bit of diameter mm are used in our operations. Foam, Plywood, Aluminium sheet and Wood have been used as work-piece material. Study has been carried out to observe performance analysis on the above work-piece materials. Mathematical analysis has been done for different operating parameters like cutting speed, feed, depth of cut, machining time and MRR (Material removal rate) . It has been observed that for low duty applications, small size numerically controlled machines are more effective as well as advantageous compared to conventional large size cutting machines.***

Keywords: CNC Machine, G-code, Engraving, Drilling, MRR, Machining Time

I. INTRODUCTION

Now a day's CNC machines have been playing a huge role especially in the manufacturing sector. High accuracy, quality product, small machining time and the safety of the workers are some of the remarkable advantages of CNC machining. CNC machines are extensively used in manufacturing industries for processes such as milling, turning, drilling, grinding, and laser cutting. Multi-axis adaptability, Faster spindle speeds, advanced tooling options for diverse materials and real-time monitoring systems for improved control are some of the advanced features of CNC machining. Arduino-based mini CNC machines are becoming increasingly popular due to their affordability, versatility, and ease of use. CNC machine can be used for mechanical work such as cutting, engraving and marking on wood, formation of 2D or 3D objects with 98.5% carving accuracy and 100% depth accuracy. G-codes are extensively used in CNC programming for whole system operation. G-code is a programming language in which instructions are generated in computer to carry out different machining operations by the machining tools. Proper design and development of CNC machine with the integration of customized processes is of top priority in today's age. They must be better in design, construction and must be more accurate than conventional machine.

With the increasing demand for small scale high precision parts in various industries, the market is also showing a substantial growth. Using small machine tools to fabricate small scale parts can provide both flexibility and efficiency in manufacturing operations and reduce investment cost, which is beneficial for small start-ups. For CNC technology, there is a remarkable increase in the quality of products as well as it offers high flexibility. It also increases the productivity and reduces the lead time. Stefan Koprda et.al (2016) presented a low-cost solution for CNC machine design and implemented a 3D model based on laser engraver where arduino has been used as a microcontroller .Vikas S. Mane et.al (2017) carried out research work on growth of CNC technology and revolutionary change in the world of digital electronics and microcontroller. They presented idea of CNC pen plotter using built PLC.

II. MATERIALS AND METHODS

Aluminum profile was machined with heavy duty chop saw to construct the frame. Stepper motor is connected to the aluminium extrusion profile with the help of a holder which is adjustable. Lead screw is fitted on the middle of the CNC bed with the help of a linear bearing rail support. Arduino is connected to cnc shield along with the stepper motor, limit switches and laptop through a usb port. A DC motor is used separately for power supply.

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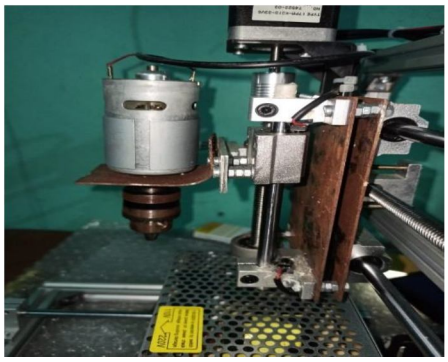


Fig i: Arduino based CNC mini machine

A. Specification of Main Components

Aluminium Extrusion Profile	Length 250mm, Weight 27 gram
Stepper motor	Holding torque 4.2 kg/cm, Weight 300 gram
DC motor	Torque-4kg/cm, speed 3000rpm,Weight-400 gram
Power supply	Input AC 100-264V,50/60hz Output DC 12v ,5A and 60W
Arduino UNO	Operating voltage 5V, Input voltage 7-12V Analog input pins-6, Weight 28 gram
CNC Shield	Width 52 mm, Height 18mm, Weight 30 gram
Drill bit	Material: HSS and MS
Engraving tool	Material: MS
Work-piece materials	Plywood, Wood, Foam, Aluminium sheet

B. G-Code used for Machining

G00 = Rapid Travers
G01 = Linear Interpolation
G02 = Circular Interpolation Clockwise
G03 = Circular Interpolation Anticlockwise
G54 = Hole Drill Code
G90 = Absolute Coordinate
G91 = Incremental Coordinate
G17 = XY Plane Selection
G18 = XZ Plane Selection
G19 = YZ Plane Selection
G94 = Feed Per Min
G95 = Feed Per Revolution

III. RESULTS AND OBSERVATIONS

A. Engraving Operation

CNC engraving is the modern version of engraving whereby automatic CNC technology guides the engraving tool with high accuracy and precision control. It has been observed that engraving operation is more favourable in wood and plywood compared to foam and aluminium sheet.

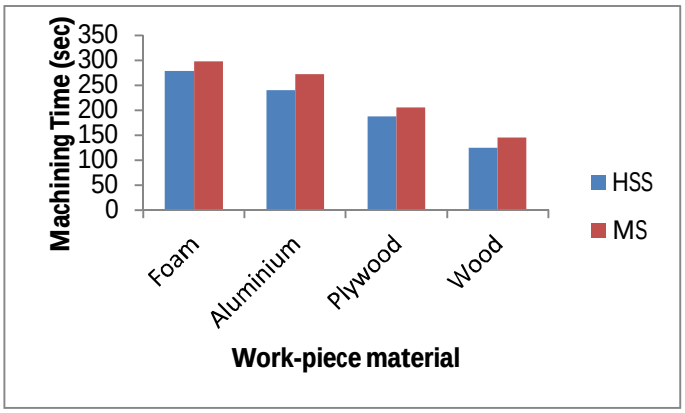


Fig ii: Performance analysis of engraving operation



Fig iii: Engraving in wood Fig iv: Engraving in foam

From the above figure it is clearly evident that engraving operation is highly effective on wood. In foam material the final shape is not crystal clear but surface quality is comparatively finer than wood and plywood.

B. Drilling Operation

CNC drilling is a very fast and accurate machining process. In our study we have chosen drill bit made of HSS and MS. Recommended feed values were used during machining operation and continuous liquid cooling was supplied to overcome unnecessary heat generation as well as friction problem. It has been observed that in case of foam material MRR value is very high, while it is lowest in case of aluminium. Contrary to it, machining time is highest in case of aluminium and in case of foam material it is lowest.

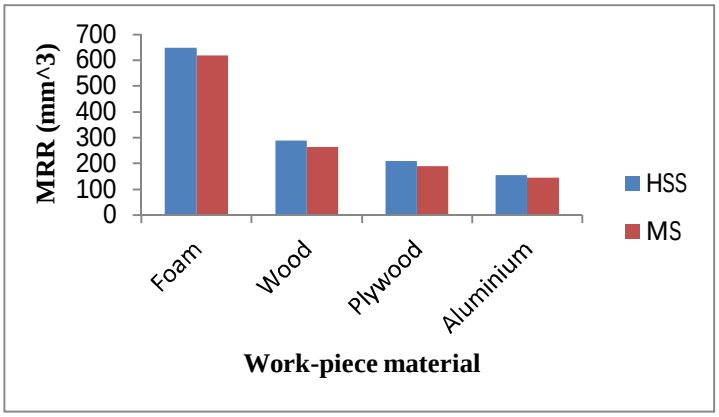


Fig v: MRR in different work-piece materials

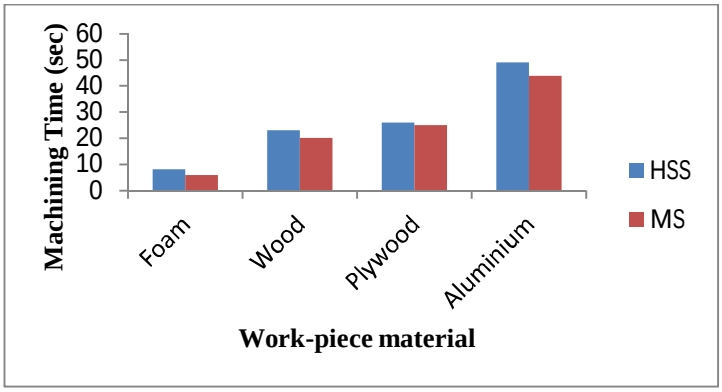


Fig vi: Machining Time for different work-piece materials

In case of drilling, conventional process and CNC process have their own advantages. Generally for large diameter holes, conventional process is more favourable while for more precision and accuracy, CNC drilling is advantageous.

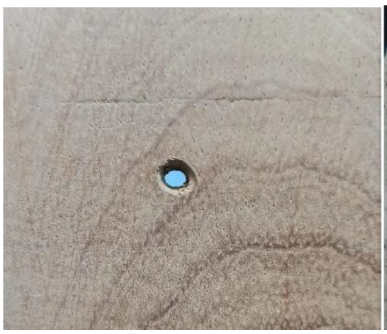



Fig vii: CNC drilling in plywood Fig viii: CNC drilling in Aluminium

The above figures have shown the CNC drilling in plywood and aluminium. In case of aluminium, the accuracy and finishing is more superior compared to plywood. Material properties also play an important role in CNC drilling. While different operating conditions like cutting speed of drill bit, feed between drill bit and work-piece material, depth of cut are also crucial factors.

IV. CONCLUSION

Arduino based CNC machines have been found useful in huge amount now a days as it is well adaptable to the ongoing demand of computerized machining products and accessories with a minimal cost as well as greater accuracy compared to conventional CNC machines. Barring from few vibration problems there is not any other major issues occurred while machining. The authors have observed that with advanced machining and designing software highly effective optimized machining can be done.

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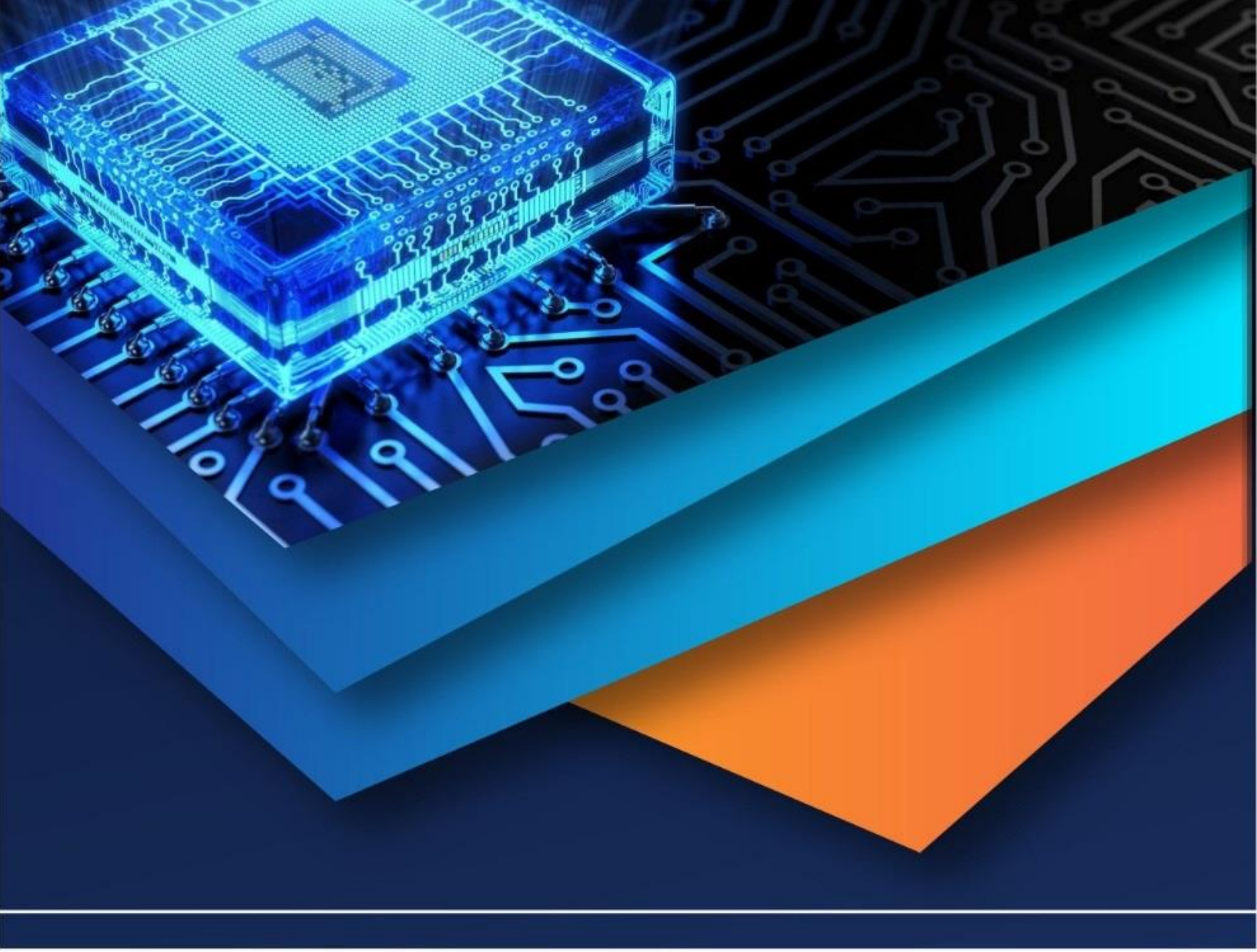
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I hereby declare that no funding was received to assist with the preparation of this manuscript as well as for conducting this study.

The work entitled “Fabrication and Performance analysis of an Arduino-based mini CNC machine with drilling and engraving tool” is an authentic record carried out by the authors. The work has not been submitted elsewhere for a similar purpose.

Dipankar Chetia

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