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Design and Development of Drill Jig Using Additive Manufacturing Technology

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Abstract: *This paper concern with design, analysis and development of drill jig. The fundamental objectives of manufacturing - improve quality, reduce costs, speed up throughout and increase production capacity are the primary reasons that jigs and fixtures are so abundant. the mass production is help to increase the productivity and increase the accuracy. Thereby, mass production can be achieved by the use of jigs. The conventional processes for jig could be lengthy, more tool wear hence drill jig life is less, Skill labor is required, the heavy weight of the final jig. These caused the final production cost of jig is high. To overcome these issues, additive manufacturing is one of the process between the manufacturing rate and high precision product. The goal of this project is to determine the efficiency of 3D printed jigs. The design of these jigs and how they function compared to conventional jig systems is analyzed. While machining custom jigs can be costly, 3D printing these jigs provides precision as well as reduces costs and setup time since they are designed for their specific application.*

Keywords: Jig, Reduce cost, Reduce weight, Conventional process, Additive manufacturing

I. INTRODUCTION

The Over the past century, manufacturing has made considerable progress. New machine tools, high performance cutting tools, and modern manufacturing processes enable today's industries to make parts faster and better than ever before. The mass production is done by reducing the set up cost and manual fatigue. Thus, mass production can be achieved by the use of jigs although work holding methods have also advanced considerably, the basic principles of clamping and locating are still the same. Jigs and fixtures form an important category of equipment that goes a long way in achieving productivity. A jig, however, guides the cutting tool. In the shop, drill jigs are the most-widely used form of jig. Drill Jigs are used for drilling, tapping, reaming, chamfering, counter boring, countersinking, and similar operations.

For large scale production of different materials, a lot of time is wasted in set up of the device and clamping the device. Drill jig increases productivity by eliminating individual positioning, marking and frequent checking. The main advantage of the jigs is interchangeability. The conventional process requires CNC machining and other metal fabrication equipment, as well as skilled employees to operate it.

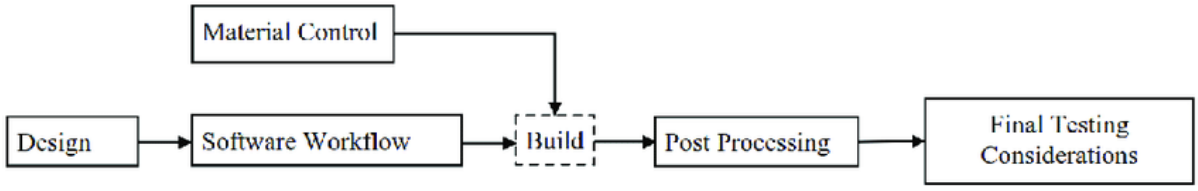

Figure 1: Steps in FDM additive manufacturing

Additive manufacturing (AM) is a process of joining materials to make parts from 3D model data, usually layer by layer, as opposed to subtractive manufacturing and formative manufacturing methodologies. Additive manufacturing is the formalized term for what used to be called rapid prototyping and the production process called 3D Printing. By supplementing current methods of making jigs and fixtures with AM, we can reduce the cost and accelerate delivery, reduce wastage and rework, decrease direct labor time, improve process throughput, improve process control and repeatability,

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reduce strain, Improve worker experience. Producing jigs and fixtures through an additive manufacturing process saves significant time and cost, reduce the weight, eliminating the skilled labor steps involved in machining process.

II. Literature Review

After reviewing research paper, it is found in the research gap that the target of the mass production is to increase the productivity and increase the accuracy. This is done by reducing the set up cost and manual fatigue. Thus, mass production can be achieved by the use of jigs. In drilling machine drill jig increases productivity by eliminating individual positioning, marking and frequent checking**.** The conventional processes for drill jig could be lengthy, more tool wear hence drill jig life is less, less surface finish, The accuracy of the components produce is dependent on the efficiency of the operator, skill labor is required, the heavy weight of the final jig. The personal necessity of the operator are reducing the production rates, Because of the large amount of manpower involved, the labor problem will also be high. These caused the final production cost of drill jig is high.

To overcome these issues, additive manufacturing (3D printing) is one of the process between the manufacturing rate and high precision product. 3D printing, however, is fundamentally different when compared to subtractive manufacturing technologies, as a part is created by adding layers of materials to an empty plate from bottom to top. The technology also allows for personal and mass customization in products and faster. Since models are created by adding materials, the technology ensures maximum material savings and optimal production costs. By using additive manufacturing (3D printing) method for making drill jigs, we can reduce the cost, reduce weight of drill jig, reduce scrap and rework, decrease direct labor time, improve process throughout, improve process control and repeatability, reduce strain, improve worker experience and accelerate delivery of drill jig.

III. Design of Jig

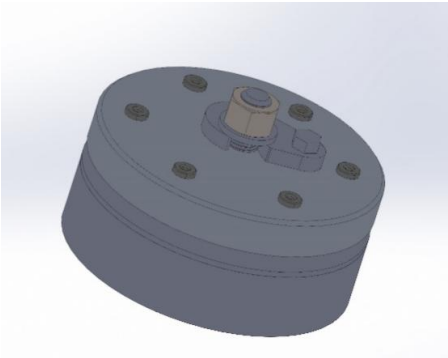

Figure 2: Isometric view of drill jig assembly

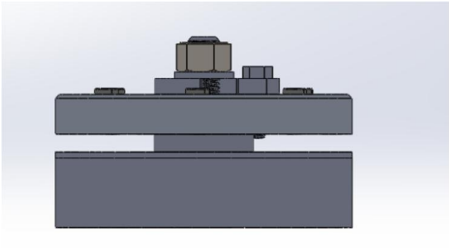

Figure 3: Front view of drill jig assembly

Spindle speed

N [rpm] = 12 [in/ft] × V [sfm] / (π × D [in])

= 12 * 250 / (π *0.15748)

= 6063.815 RPM

Where, N is the rotational velocity of the tool

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D is the diameter of the tool
V is the recommended peripheral velocity for the tool being used
For the Aluminium take surface feet per minute=250

Cutting speed

Vc = (π × D × N) /1000
= π *4*6063.8/1000
= 76.19 m/min

Where, Vc = Cutting speed m/min
N = the rotational velocity of the tool (RPM)
D = Drill diameter

Drilling time (Tc)

Tc = (ld*i)/(n*fr)
= (3*6)/(6063.8*0.002)
= 1.4842 min for 6 holes

Where, Tc = Drilling time (min)
ld = Hole deapth (mm)
i = Number of holes
n = Spindle speed
Fr = Feed per revolution

Table 1: Dimensions of drill jig

Components	Dimensions
Base plate	OD - 150mm ID – 16mm HEIGHT – 35mm
Jig plate	OD - 150mm ID – 16.05mm HEIGHT – 18mm 8mm hole on 110 PCD (6 hole)
Bush	OD - 8mm ID – 4mm LENGTH – 20mm

IV. ANALYSIS OF DRILL JIG ASSEMBLY

Figure 4: Stress Analysis of drill jig assembly

Table 2: Assigning of material to components

Components	Material
Base plate	PLA
Jig plate	PLA
Washer	Aluminum 6061

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Workpiece	Aluminum 6061
Latch washer	Aluminum 6061
Bush	Mild steel

Table 3: Results for assigning material

Results	Minimum	Maximum	Unit
Stress (Von Mises)	0	0.3576	Mpa
Strain (Equivalent)	0	1.907E-05	Mpa
Reaction force	0	0.7527 N	N
Displacement	0	5.106E-05	mm

V. EXPERIMENT WORK

Figure 5: Details view of drill jig

Figure 6: Assembly view of drill jig

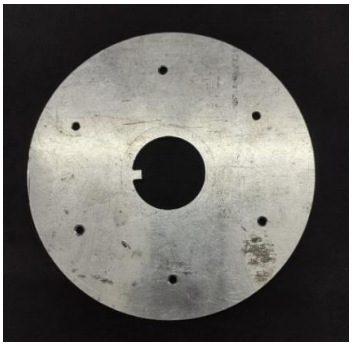

Figure 7: After performing drilling operation on workpiece through drill jig

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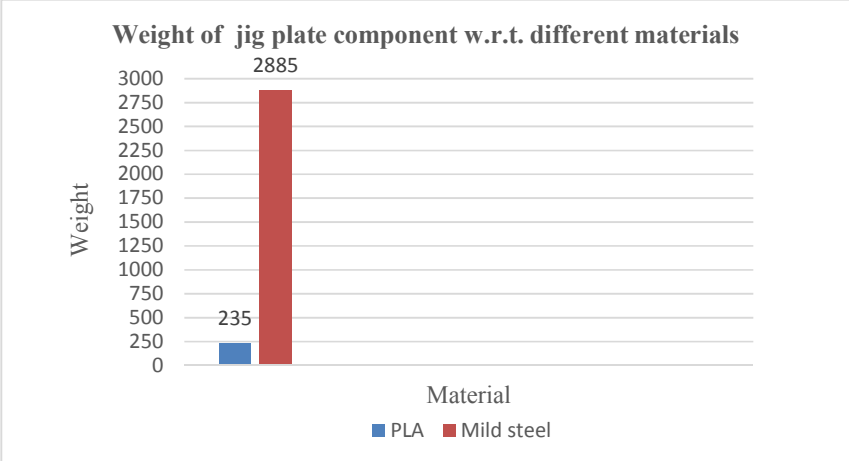
Figure 8: Weight of PLA jig plate with latch washer and bush

Figure 9: Weight of MS jig plate

- By assigning mild steel material to component jig plate in solidworks software it's shown the result as 2681 gram which is nearly to actual weight of part 2885 gram.
- By assigning PLA material with same dimension to jig plate the solidworks software shown result nearly to actual.



- The drill jig assembly - jig plate and base made of PLA material and latch washer, washer, Workpiece are made with aluminum and other components standard threaded stud, hex bolt and nut the overall actual weight is 745gram.

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VI. Result And Conclusion

- After performing drilling operation on workpiece and by measuring the dimension of hole with the help of vernier caliper the average accuracy is more than the 97%.
- From the experiment it's shown that the drill jig made from the PLA material is lighter with compare to conventional material like mild steel material.
- A manufacturing time can be reduced.
- A mild steel material is normally corrosive material and the part made from this is easily corrosive while PLA material is resist to corrosion, By using this material we can improve the life of the jig.

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