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Development Of Portable Multipurpose Computer Numerical Controlled Machine

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Abstract: The Main Objective Of The Present Work Is To Develop A Portable Multi-Purpose Computer Numerical Controlled (CNC) Machine Capable Of Carrying Out Multiple Operations Like 3D Printing, Laser Engraving And PCB Milling. The Machine Uses A CNC Controller, MKS Controller, Switch Mode Power Supply (SMPS), Stepper Motors For Its Effective Functioning. This Multi-Functional Modular Machine Can Be Used For New Product Development As Well As To Support The Day To Day Needs In Laser Cutting And Engraving. CNC Based Machine Operates With A Workspace Of 330 Mm X 330 Mm And Is Employed With A Precision Stepper Motor That Is Combined With Lead Screws In Moving The Axis Smoothly On Linear Bearings And Results In A More Precise Movement The Machine Will Be User Friendly And Lighter In Weight Than The Commercially Available Ones. In The Current Study, The Laser Engraving Parameters Combination Is Chosen Based On A Pilot Study Conducted Following 'One Factor At Time Experimentation.

Keywords: 3D Printing, Laser Engraving, PCB Milling, CNC Machine, One-Factor Experiment, Portable.

1. INTRODUCTION

According To The MSME Development Institute Report (2020-21), In The Coimbatore District, A Total Of 5,37,677 Industries Have Registered In The Manufacturing Sector, While 8,65,058 Industries Have Registered In The Service Sector. Motor Pumps, Cotton Textiles, Fabricated Metals, And Electrical And Electronic Components Are Among The Products Produced. Manufacturers In These Sectors, As Well As Textile Mills, Are Beginning To Implement Technological Advances In Their Fields To Increase Efficiency. The Market For Printed Circuit Boards (Pcbs) Has Risen As A Result Of Recent Developments In Electronics/Digitalization Implementation. Circuit Board Production Is The Most Important Part Of The Electronic Device Manufacturing Process, And It Must Be Customized For Different Products. PCB Milling Has Benefits For Prototyping As Well As Some Exclusive PCB Design. The Fact That Pcbs Do Not Require The Use Of Chemicals Is Perhaps The Most Significant Advantage. In-House Manufacturing Using The Wet Method Has Issues With Chemicals And Their Disposal. High-Resolution Boards Made With The Wet Process Are Difficult To Produce, And Once Completed, The PCB Must Still Be Drilled And Cut Out Of The Base Material. Without The Need For Wet Processing, CNC Machine Prototyping Can Provide A Fast-Turnaround Board Development Process. If A CNC Machine Is Already

Being Used For Drilling, It Could Complete Both Parts Of The Process, Drilling And Milling, On The Same Machine. While CNC Is Already Common Practice For Drilling The Sheets, Milling Is Unlikely To Replace Etching In Mass Production. Laser Engraving May Be Used To Sketch The Circuits In A PCB. Hence The Industrialists Are Approached To Get Their View On This. According To The Industrialist's Suggestions, A Multi-Purpose Machine That Is Capable Of 3D Printing, Laser Engraving, And PCB Milling May Be Useful For Small And Medium Scale Industries. All The Jobs Can Be Done By Switching The Tools Of The Multi-Purpose Machine. This Will Save Time, Money, Energy, Resources, And Working Space, Among Other Things.

2. LITERATURE REVIEW

Currently, A Lot Of Research Is Happening Around Building A Low-Cost PCB Prototyping With Higher Accuracy And Repeatability. The PCB Drilling Is A Tedious Process, Which Depends On Various Factors Such As Drilling Force, PCB Structure, Temperature, Process, Etc. Employed A Machine Vision System For PCB Drilling Operation-Using Robot. The Position Of The End Effector Was Aligned With The Work Piece And The Process Was Carried Out In Which The Vision System Calibration Was Not Required.. This Method Was Effective With Low Volume PCB Drilling. [1]Developed An Automatic PCB Drilling Machine With A Computer Vision System For Auto Aligning Of PCB And Capable Of Carrying Out The Inspection. The System Reported A Good Operating Efficiency With A Higher Repeatability Factor Of More Than 5 μm. [2] Developed An Automatic Open-Loop PCB Drilling Machine, Which Accepts The Inputs Via PCB Drawing Software. The Developed Machine Achieved A Time Cycle Of 90 Holes With 100 Mils Depth In An Average Time Of 5 Minutes, Which Was Efficient When Compared To Many Traditional Machines. It Was Observed That Further Efficiency Could Be Improved By Applying Changes In The Motor Step Angle. [3] Developed A New Method Of Creating A PCB Pattern Using Photopolymer Film Exposed To Ultraviolet (UV) Rays. The Transparent Photosensitive Film Was Placed Over The PCB And Then Subjected To UV Rays And Etched Using Sodium Carbonate Solution Was Analogous To The Photolithography Process. In This, The Resolution Of The Low-Cost PCB Fabrication Process Was Analyzed. Fabricated A PIC Microcontroller Based 3-Axis Automatic PCB Drilling Machine, Which Is Using Both Stepper Motor (X And Y-Axis) And Servo Motor (Z-Axis) To Perform The Drilling Operation. [4] Have Developed An Automatic PCB Drilling Machine With Travelling Salesman Problem (TSP) Algorithm. This Model Used A Camera System For Image Processing That Detects The Location Of The Holes And Mapped The Shortest Path Between The Holes. In Another Study, [5] Have Used The Euclidean TSP Method Of Optimization For Fabricating CNC PCB Drilling Machine With A Novel Friendly Approach. Atmega8535 Microcontroller Was Used Because Of Its Advanced RISC Architecture Availability. This Novel Approach Has Resulted In The Reduction Of Travelling Time Up To 10%. [6] Designed A PCB Milling Machine With Functional Modelling And Reported That Even Using Small Metric Threaded Bars, Without Precision Machines, A High Stage Of Repeatability Was Possible. The Major Problem Was With Aligning The Tool Concentric To The Spindle Axis. An Automatic Drilling Machine Using 8051 Microcontrollers With A Maximum PCB Size Of 12 Cm (L) X 20 Cm (W) Was Fabricated In Which The Stepper Motor Was Used To Move The Shaft In All Three Directions The Input Was Fed Through The Personal Computer (PC) With MAX 232, Which Acted As An Interface Between The PC And Microcontroller. This Machine Exhibited Better Performance Than The Previous

Systems. [7] Had Reviewed The Precision Improvement In The Micro-Drilling Process That Explored The Accuracy In Micro-Drilling Operations. [8] Proposed A New Method In Optimizing The Parameters, Such As Drilling Force, Temperature, High-Speed Photography And Vibration Signals In PCB Micro-Hole Drilling. [9] Had Reviewed The Modern Improvements In Micro-Drilling Techniques The Advanced Micro-Drilling Methods And Techniques, Recent Developments, Process Categorization And Further Requirements In This Area. [10] Had Fabricated A Multi-Functional Machine, Capable Of Performing Both PCB Milling And Wood Engraving. The Input Was Given Through The Software System, Which Was Then Converted Into Corresponding G-Codes.

The Invention Of Rapid Prototyping Has Resulted In A Remarkable Reduction Of Cost And Time In Developing New Products That Ended With Cycle Time Reduction. It Also Brings The Thought Of Engineers Into Reality. Tremendous Demand To Employ Additive Manufacturing In Various Manufacturing Sectors Can Only Be Realized By Involving More Students, Technologists And Academic Researchers In This Field. Recently Students And Alumni From IIT Madras Have Developed India's First 3D Printing Construction Technology For Low-Cost Housing.

[11] Had Evaluated The Advantages In High-Throughput Development And Customizability In Terms Of Material Support And Device Operation, Printed Electronics Now Has A Large Share Of The Electronics Fabrication Market. Printing Of Traces And Interconnects, As Well As Passive And Active Components Like Resistors, Capacitors, And Inductors, As Well As Application-Specific Electronic Devices, Has Become An Increasing Subject Of Additive Manufacturing Research. New 3D Printing Technologies And Manufacturing Methods, Especially For Printed Electronics, Have The Potential To Revolutionize Flexible Electronics, Wireless Communications, Powerful Batteries, Solid-State Display Technologies, And Other Fields. Utilized A Laser Etching Machine To Stamp Different Pictures And Images On Various Materials. The Laser Etching Arrangement Is Profitable Because Of Its Low Operational Expense, Lightweight, Transportability And Simple-To-Learn Highlights. The Proposed Arrangement Has Been Applied To Glass Fibre Reinforced Plastics (GFRP) Composites, Plastics, Wood, Cardboard, And So Forth, To Yield The Wanted Profile, Form, Data, And Different Drawings. [12] 3D Printing Utilized As A Quick Explanation Of Conductive Polymeric Materials Onto Materials Uncovers To Be An Engaging Methodology In The Headway Of Utilitarian Materials. Nevertheless, The Conductive Fillers—Filled Thermoplastic Polymers By And Large Used In The Progression Of Utilitarian Materials Through 3D Printing Development And Most Unequivocally Through Fused Deposition Modeling (FDM) .

In This Era Of Industry 4.0 3D Printing, PCB Milling And Laser Engraving Has Become Mandatory For All Small Scale Industries And Research Facilities, But It Is Highly Expensive To Have All Three Machines. The Above Literature Depicts That There Are No Such Attempts Made. Hence In The Present Project Work, It Is Attempted To Design And Fabricated A Portable Multipurpose Computer Numerical Control Machine Employed With Multi Operations That Could Be Affordable To A Small Scale Industry.

3. FABRICATION OF THE MACHINE

Initially, The 3D CAD Model Of The Multi-Purpose Machine Was Developed (Fig. 1) Using Solid Works Software. Some Of The Components Are Procured For Assembly Whereas Some Are Designed Using The Software. The Weight Is Reduced By Building The Structure Of The Machine With 20 Mm X 20 Mm, And 20 Mm X 40 Mm Aluminium Extrudes. Stepper Motor Is Engaged For The Axes Movement And Linear Guideways Are Employed To Obtain The Necessary Precision. The Machine Is Integrated With Open-Source Programming That Can Generate The G Codes To Perform The Required Operations. The Maximum Print Speed Of 40 Mm/S Is Achieved For The 3D Printing Process. The Proposed Machine Is Financially Savvy Since Lightweight Parts And Open-Source Programming Are Utilized Which Are Uninhibitedly Accessible Which Makes It More Affordable.

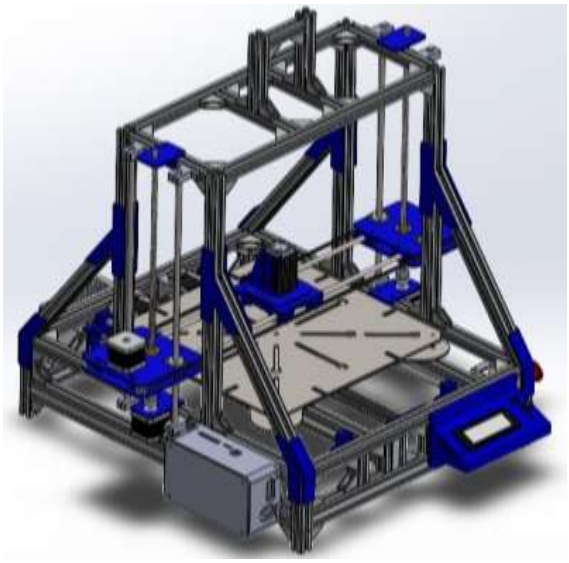

Fig. 1. Cad Model Of The Multi-Purpose Machine.

Based On The CAD Model, The Bill Of Materials Was Prepared And The Necessary Components Are Procured And The Fabrication Of The Physical Model Is Completed.

3.1 Components

The Major Components Used In The Fabrication Of Machine Are:

- Stepper Motor
- SMPS (Switch Mode Power Supply)
- MKS Controller Board
- Linear Bearing
- Coupler
- Aluminum Profile
- Smooth Rod Holder
- Timing Belt

With A Laser Light Power Of 2.5 W And A Wavelength Of 445 Nm, The High Power Laser For Engraving And Cutting Is Used In The Present Work (Fig. 2). Plastic, Wood, Plastic, PVC, PCB, Wood And Other Similar Materials Can Be Engraved.

Fig. 2. Laser Engraving Setup Modules For Multipurpose Cnc Machine.

The Multi-Purpose CNC Machine Has Three Major Components: A Laser, A Controller, And A Work Surface. The Laser Is A Medium For Drawing. The Controller Will Trace Patterns Onto The Surface Using The Laser's Beam. The Position, Strength, Speed Of Travel, And Distribution Of The Laser Beam Aimed At The Surface Are All Determined By The Controller. The Laser Beam Impinges On The Material During The Laser Engraving Process, Exposing It To A Great Deal Of Heat. The Resulting Laser Engraving Is Long-Lasting And Abrasion-Resistant. The Location On The Focal Plane Of The Laser's Optical Device Where The Laser Beam Contacts The Surface Is Commonly Referred To As The Focal Point. The Workpiece (Surface) Is Fixed In The Y Axis Movable Bed, But The Laser Optics Travel Around In Three Dimensions That Make An Engraving With Laser As Easy As Writing.

3.2 Experimental Study

To Find The Best Parameter Setting, A Pilot Study Was Conducted Following The 'One Factor At A Time' Method Of Experimentation. In This, The One But Remaining Factors Are Initially Chosen Arbitrarily And The One Factor Is Changed To Conduct One Set Of Experiment. For The Next Set, The Factor Whose Effect Is Studied Is Chosen For Its Best Performance. This Procedure Is Followed For All The Remaining Set Of Experiments. The Factors That Are Considered To Be Significant And Their Levels Are Shown In Table 1.

Table 1. Parameters And Levels Of The Laser Engraving Process.

Input Parameters	**Minimum Value**	**Maximum Value**
Laser Power (W)	100	200
Travel Speed (Mm/Min)	3000	4000
No Of Passes	1	4
Pass Depth (Mm)	1	3

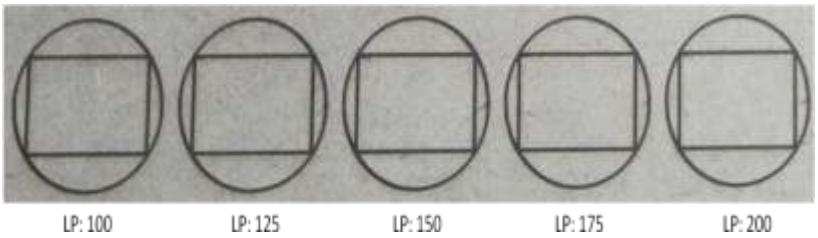

Fig. 3a. Output For Various Laser Power For The Travel Speed: 3000 Mm/Min; Pass: 1 And Pass Depth 1 Mm.

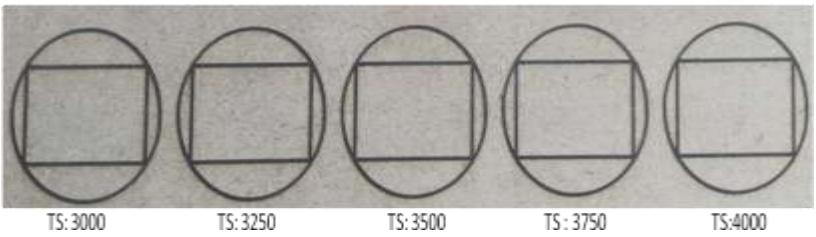

Fig. 3b. Output For Various Travel Speed For The Laser Power: 100 W; Pass: 1 And Pass Depth 1 Mm.

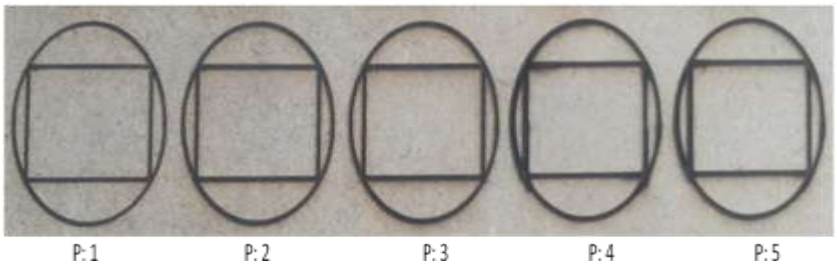

Fig. 3c. Output For Various Passes For The Laser Power: 100 W; Travel Speed: 3000 Mm/Min And Pass Depth 1 Mm.

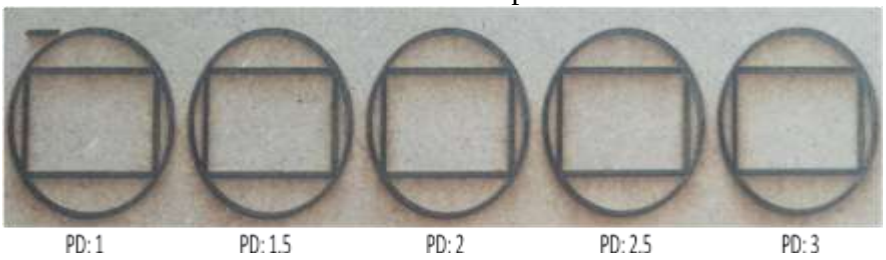

Fig. 3d. Output For Various Pass Depth For The Laser Power: 100 W; Travel Speed: 3000 Mm/Min And 2 Passes.

The Figures Above (Fig. 3a-3d) Are The Samples Made On A Wooden Board. From The Set

Of The Experiments Conducted The Best Output Based On The Time Of Engraving Is Chosen.

4. RESULT AND DISCUSSION

The Quality Of The Cut Is Inspected With Naked Eyes Only. But The Cleanliness Of The Cut Can Be Better Judged With The Appropriate Instrument And That May Give A Different Result From That Is Presented In This Paper. The Best Output Among The 20 Samples Is Presented Below And The Corresponding Parameters Set Are Also Tabulated (See Table 2).

Table 2. Parameters And Levels Of The Best Output

Parameter	Values
Laser Power(W)	100 W
Travel Speed (Mm/Min)	3500 Mm/Min
Pass	2
Pass Depth (Mm)	1 Mm
Time (Min:Second)	01 Minute 27 Seconds

Upon Increasing The Laser Power It Is Observed That The Kerf Appearance Is Reducing Even Though There Is A Reduction In The Engraving Time. For A Lower Travel Speed Again The Burning Is Observed To Be High And The Continuity In The Cut Is Getting Reduced When The Travel Speed Is Increased Beyond 3500 Mm/Min. The Single-Pass Maybe Because Of The Minimum Laser Power Of 100 W, Is Unable To Produce A Clear Groove When Compared To The Double Bass. More Number Of Passes Deteriorated The Quality Of Cut. Finally, A Pass Depth Of 1 Mm Is Found To Be Better As The Depth Is Increased That Increases The Kerf Width At The Top And Results In Inferior Quality. The Set Of Parameters That Provide A Better Engraving Is Depicted In (See Fig. 4).

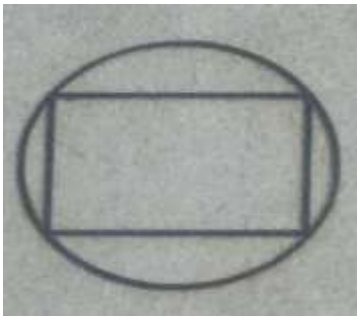

Fig. 4. Best Output From The Pilot Study Samples.

4.1 Advantages Disadvantages Of Laser Engraving

Advantages. The Main Advantages Of Engraving Are Low Weight, Monetary Creation Or Ease, Simple To The Arrangement And Easy To Understand, Naturally Protected, Bigger Field Of Utilization, Non-Contact Strategy, No Apparatus Wear, Most Extreme Accuracy And Best Subtleties.

Disadvantages. It Can't Be Utilized For The Handling Of Exceptionally Hard Or High Liquefying Point Metals And If The Metal Is A Lot Of Sparkles, The Etching Gets Extreme Due To The Reflection Attributes Of The Metal.

5. CONCLUSION

A Cost Capable Reduced Multipurpose CNC Machine Is Arranged And Made By Working On The Cost For Preparing Of PCB With Surface Mount Advancement. The Machine Is Made With Unobtrusive And Business Open Source Programming And Hardware Fragments And Can Be Changed And Advanced For Future Essential. The Laser Module Is Presented And Can Be Handedly Brought Into The Activity. It Is Fundamental To Use Cautious Goggles To Ensure The Eyes The Multipurpose CNC Machine Works With A PC Numerical Control That Makes And Read G-Codes Direction To Make A Beeline For Make Leaves Behind A Proper Material Clearing Rate. In The Current Work, A Pilot Study Is Done To Track Down The Best Boundary Settings To Go With Laser Etching. In Spite Of The Fact That The PCB Processing And 3D Printing Modules Are Additionally Tried For Their Underlying Presentation Still The Work Is Proceeding To Advance The Machine Boundaries Of Every One Of The Three Offices With An Efficient Methodology.

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6. REFERENCES

[1] Y. Shan, C. Xu, And Q. Jiang, "Based-On Computer Vision Auto-Aligning Drilling Machine For PCB," Proc. 1998 Conf. Autom. Opt. Insp. Ind. Theory, Technol. Appl. II, Sept. 16, 1998 - Sept. 19, (1998).
[2] H. Ferdinando And I. Sandjaja, "Automatic Drilling Machine For Printed Circuit Board," No. JANUARY (2005). Http://Puslit2.Petra.Ac.Id/Eportfolio/Artefact/File/Download.Php?File=147837&Amp;View=12087.
[3] J. Ou, "ELECTRONICS I LABORATORY," (2014).
[4] W. C. E. Lim, G. Kanagaraj, And S. G. Ponnambalam, "PCB Drill Path Optimization By Combinatorial Cuckoo Search Algorithm," Sci. World J., Vol. (2014).
[5] Z. Tahir, N. A. Abu, S. Sahib, And N. S. Herman, "CNC PCB Drilling Machine Using Novel Natural Approach To Euclidean TSP," Proc. - 2010 3rd IEEE Int. Conf. Comput. Sci. Inf. Technol. ICCSIT 2010, Vol. 5, Pp. 481–485, (2010).
[6] R. Basniak And M. F. Catapan, "Design Of A PCB Milling Machine," ABCM Symp. Ser. Mechatronics Sect. VIII - Sensors Actuators, Vol. 5, No. (2006).
[7] X. Hyacinth Suganthi, U. Natarajan, And N. Ramasubbu, "A Review Of Accuracy Enhancement In Microdrilling Operations," Int. J. Adv. Manuf. Technol., Vol. 81, No. 1–4, Pp. 199–217, (2015).
[8] R. Qiu, M. Lin, B. Qin, Z. Xu, And J. Ruan, "Environmental-Friendly Recovery Of Non-Metallic Resources From Waste Printed Circuit Boards: A Review," J. Clean. Prod., Vol. 279, P. 123738, (2021).
[9] M. Hasan, J. Zhao, And Z. Jiang, "A Review Of Modern Advancements In Micro Drilling Techniques," J. Manuf. Process., Vol. 29, Pp. 343–375, (2017)
[10] R. Choudhary, Sambhav, S. D. Titus, P. Akshaya, J. A. Mathew, And N. Balaji, "CNC PCB Milling And Wood Engraving Machine," Proc. 2017 Int. Conf. Smart Technol. Smart Nation, Smarttechcon 2017, Pp. 1301–1306, (2018).
[11] A. H. Espera, J. R. C. Dizon, Q. Chen, And R. C. Advincula, "3D-Printing And

Advanced Manufacturing For Electronics," Prog. Addit. Manuf., Vol. 4, No. 3, Pp. 245–267, (2019).

[12] P. A. Eutionnat-Diffo, A. Cayla, Y. Chen, J. Guan, V. Nierstrasz, And C. Campagne, "Development Of Flexible And Conductive Immiscible Thermoplastic/Elastomer Monofilament For Smart Textiles Applications Using 3d Printing," Polymers (Basel)., Vol. 12, No. 10, Pp. 1–31, (2020).