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Review on Design and Development of Dual Extrusion 3D Printer

Georgy Paul[1], Joel John[2], Sharath Yadav[3], Arpit Kumar[4], Dr C K Nagendra Guptha[5]

[1]*Student, Industrial Engineering & Management, RVCE, Karnataka, India*
[2]*Student, Industrial Engineering & Management, RVCE, Karnataka, India*
[3]*Student, Industrial Engineering & Management, RVCE, Karnataka, India*
[4]*Student, Industrial Engineering & Management, RVCE, Karnataka, India*
[5]*Assoc. Prof. & HOD, Industrial Engineering & Management, RVCE, Karnataka, India*

Abstract – *Additive manufacturing, often referred as 3D printing, has the potential to vastly accelerate innovation, compress, supply chains, minimize material and energy usage and material waste. One of the main disadvantage is that the strength and durability of the produced specimen is low. In this report the main focus is on the design of 3D printer and the specimen made with carbon fibre and resin by alternating the layers. This increases the strength and durability of the specimen. The maximum size of the specimen produced can be (200×200×200) mm. The adopted methodology consists of seven steps which are market research, concept generation, design and analysis, concept selection, fabrication, assembly and implementation respectively. This study reports consists the detailed analysis of each of the methodology steps from market research in online forms, different concepts generated with abstract designs, analysis of the final design selected with a completed CAD model and finite element analysis(FEA), the fabrication and assembly parts are verified through the CAD design model and the implementation part is achieved through the use FDM technology which is the adopted process the project. Materials used are carbon fibre filament and epoxy resin. In this paper the design of a cost effective, easy to use dual extrusion 3D printer is reviewed. A dual extrusion 3D printer that is capable of producing composite materials using carbon fibre and resin is proposed. The structural stability of the design is also verified in both working and unplugged condition using FEA (finite element analysis).*

***Key Words*: 3d printer, dual extrusion, composite material, Epoxy resin, Carbon fibre.**

1. INTRODUCTION

When it comes to manufacturing, 3D printing is one of the driving technologies of 21st century that has huge potential and very low investment risks.FDM technology is been used as the adopted process. The materials used are carbon fibre filament and epoxy resin. The 3D printer is having two nozzles one for carbon fibre and the other for epoxy resin which are separated by a small distance. The first nozzle is used for making a carbon fibre sheet and the second is used to add a layer of epoxy resin which increases the strength and stability of the specimen. The goal for this project is to make a low cost affordable 3D printer with dual nozzle one of which can epoxy resin to increase the strength of the specimen produced. Currently, the FDM technologies used are too slow using tools that are less complex and hence the lead time is high when it comes to designing prototypes of components and parts. Also when it comes to small scale manufactures the cost of tooling is saved if they employ 3D printing as it is easier to create highly complex designs without using complex tools to produce it.

2. COMPOSITE MATERIALS

2.1 General Overview

Composites are made up of several different components. Composites are things that are made by combining two or more natural or non-natural elements to build something stronger as a team than different business stakeholders. Synthetic materials do not fully integrate or lose their identity; instead, they combine and provide their most beneficial features to improve the final product finish.

Composites are made because they have high strength, has high efficiency and is more durable. Composites are made up of a polymer matrix reinforced by a man-made or natural fibre such as silica, carbon, or aramid or other reinforcement materials. The matrix protects the fibres from different situational damage while also transmitting the weight. The fibres in turn give the matrix more strength and stiffness, making it more resistant to cracks and fractures.

2.2 Applications in different sectors

Aerospace - Composites are used in the aerospace industry to make up around half of the airspace. Composite components have two main advantages: they are lighter and easier to assemble. Composites are being used extensively in the current construction of copters, fighter planes, small and large transport planes, satellites, rockets, and launch vehicles.

Automobile - Composites are being investigated for low-weight, safer, and more fuel-efficient automobiles in the automotive industry. A composite is made up of a high-strength fibre embedded in a matrix substance i.e., epoxy polymer, has qualities that are superior to the component materials. Composite materials are used to make many components such as the leaf spring, engine cover, carpets, energy absorber, instrument cluster, interior and exterior panel, dashboard, hatch, seat.

Medicine - A composite, in medical industry is a ineffectual material that is put into practise in a Medicare

equipment to link with a system of life. Composite materials is being used in a various type of ways, thanks to advances in synthetic materials, surgical technique, and sterilisation technologies over the years

Sports- Composite material has break resistance, resistance in friction, resistance in abrasion, attenuation in vibration, very high thermo stability, as well as its high design freedom, high strength, and low weight, as well as its ease of processing and shaping, the composites are used in different sports equipment.

Chemical Manufacturing- Composites have been popular in the chemical sector due to their fire resistance qualities, lightweight, moldability, and chemical resistance. For alkaline and acidic conditions, composites are widely utilised in structural supports, exhaust stacks, ducting, piping, scrubbers, columns, industrial gratings, pumps & blowers, storage tanks, reactors, and other applications.

2.3 Properties of composite materials

Greater definite strength and definite modulus of composites are significant advantages. Carbon fibre reinforced resin composites, for example, have a definite modulus of five multiplied times that of aluminium alloy and steel, and a specific strength of three multiplied times that of aluminium steel & alloy.

Greater resistance to fatigue - The notch and stress concentration are less sensitive in fibre composites, particularly resin matrix composites. Furthermore, the juncture between the matrix and the fibre might be dull or modify the orientation of the spreading fracture, so preventing rapid fracture development.

Resistance to fractures - When a negligible quantity of fibres break owing to excess load and other factors, the excess load is shifted to other fibres which aren't disintegrated, ensuring that the components are not ruptured in a little amount of time. As a result, the composites exhibit a higher degree of toughness in fracture.

Excellent damping properties - The inherent frequency of a structure is proportional to the square root of the specific modulus of the material and is connected to its mass and shape. Early fracture and Resonance can be prevented if the material's inherent frequency is high.

2.4 Concepts of composite material 3D printing

Co-extrusion - During 3D printing, the two components of the final composite (reinforcing material and plastic matrix) are mixed to create a composite material and a part at the same time. Dry reinforcing fibres are applied to the hot plastic within the nozzle by many businesses on the market.

Continuous Fibre 3D Printing Technology - A continuous dry fibre is impregnated with a quick curing thermosetting resin, which is deposited by the print head, in this automated production method. Moulds, ovens, and autoclaves are not required, resulting in a higher material yield at a reduced cost.

Selective Lamination Composite Object Manufacturing - Multidirectional woven or custom made thermoplastic reinforced unidirectional are the range used in this process. The composites can be tailored for exceptional greater strength to weight ratio, vibration dampening, toughness, low flammability characteristics, environmental resistance and high wear resistance.

Directed energy deposition - Directed Energy Deposition 3D printing, also known as Direct Energy Deposition, makes parts by melting materials directly and depositing them layer by layer on the workpiece. Metal powders or wire source materials are commonly employed in this additive manufacturing technology. Laser engineered net shaping, directed light manufacturing, Laser Deposition Welding (LDW), direct metal deposition, and 3D laser cladding are some other synonyms for DED.

Composite-based additive manufacturing –This is designed for carbon fibre and fibreglass composites combined with Nylon and PEEK. It uses high-speed inkjet printing techniques. To put it another way, long-fibre carbon or glass fabric sheets are automatically joined with thermoplastic powders to create composite 3D objects.

3. METHODOLOGY

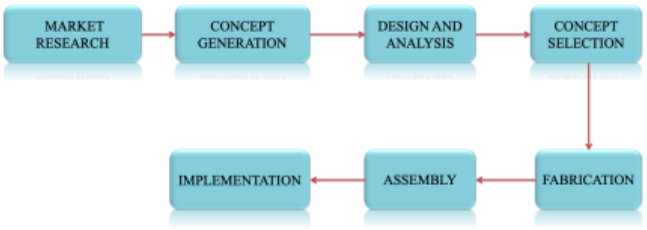

Fig -1: Proposed methodology

The first step is to identify the need for an emerging market for portable, low-cost, standard-purpose, dual extrusion 3D printers. The problem with the existing FDM 3D printers on the market is that they are very expensive and not cheap for many interested parties. Then a market survey is done to find out who the potential customers are. And how much are they willing to pay for the new FDM 3d printer if available for purchase. Then the design and operation is visualized with a 3D printer available in IEM department and mechanical department and research is done on various MSME's Bangalore using 3D printers to make parts and fast prototyping. Observations and studies are also done with web resources and magazine papers published on FDM 3D printers. The feature considerations and targeted specifications that needs to be achieved in the final product are done. The next step was to amend the Bill of All Materials, Electronics and other materials needed to build a FDM 3d printer and to conduct market research when available on the market at a low price. Thereafter assembling and inspecting various electrical and electrical equipment such as control boards, circuits, power supply unit drivers, actuators etc. Eventually it combines electronic components with

various mechanical and structural elements and is tested and finally begins to use the machine to make the necessary materials.

4. RESULTS

There is significant reduction in material wastage when compared to the conventional method of hand layup process as the resin is sprayed from the nozzle compared to manually applying by hand in hand layup process which can result in significant wastage of resin. The use of the resin between the layers of the material, greatly improves the strength of the material which is highly useful in different applications like Aerospace industry, and other industries where strength to mass ratio is a prime factor for design considerations. The use of the resin opens the gate for innovation and development in the field of multi-nozzle FDM 3D printers. Composites are known for excellent strength-to-weight ratio along with good stiffness-to-weight ratio and hence it has huge potential for disruption.

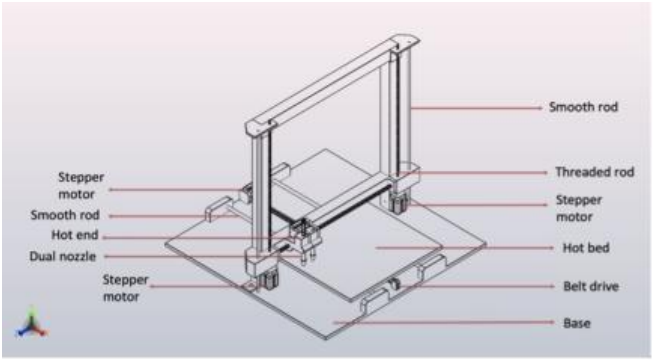

Fig –2: CAD drawing with labelled parts

FE Analysis -Stress analysis on the frame is done as shown in fig -3. And the first image on the shows the results that have been obtained. The frame is made up of aluminium 6061 which has yield strength of 290 MPa. FOS, factor of safety is taken as 2. A load of 120 N is applied. On the left side of the first image, the maximum stress is shown as 0.9 MPa, which is not even 0.5% of yield strength of aluminium. Hence the design is safe. The areas of stress concentration are visible in fig -3, which is around the joints.

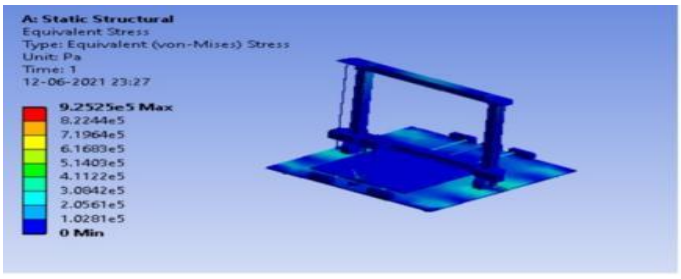

Fig -3: Static stress analysis using Ansys

5. CONCLUSIONS

FDM technology is been used as the adopted process. The materials used are carbon fibre filament and epoxy resin. The 3D printer is having two nozzles one for carbon fibre and the other for epoxy resin which are separated by a small distance. The first nozzle is used for making a carbon fibre sheet and the second is used to add a layer of epoxy resin which increases the strength and stability of the specimen. The goal for this project is to make a low cost affordable 3D printer with dual nozzle one of which can epoxy resin to increase the strength of the specimen produced.

One of the main aims of this paper is to model the design of a less expensive 3D printer using more readily available and more efficient materials. The proposed model succeeds in reducing costs to about 10-15%. The electrical and electronic components used such as driver boards and actuators were the most widely used items in DIY projects, available at an affordable price in the market. This has enabled us to design and design a portion of the FDM 3D printer at a low cost of Rs. 30000 according to the first estimate. This makes the FDM 3D printer more economical compared to what is available in the market now.

REFERENCES

[1] S.Arun Kumar., Abburi Lakshamankumar., KolliBalasivaramareddy, and B.Ramprasath.: 'Fabrication and study on carbon fiber with epoxy and vinyl ester resins', IOP Conf. Series: Materials Science and Engineering 402 (2018) 012160 doi:10.1088/1757-899X/402/1/012160.

[2] BinXiaowei., XiaoTong Yi., YongjianXiong., Jinmei He., Yongping Bai.: 'The preparation and characterization of a carbon fiber-reinforced epoxy resin and EPDM composite using the co-curing method' RSC Advances., Issue 35 , 2020.

[3] G. Ramprasasd., Dr. B.V. Ramana Murty.: 'Experimental Investigation of Mechanical Behaviour of Carbon Fiber and E-Glass Fiber Reinforced with Epoxy Resin', IJERT, Volume 8, Issue 10 October (2019).

[4] Jagadish S P., Dr A Thimmana Gouda., Dr K R Dinesh., Dr N Prashanth., Dr Neeta PN., Bharath Desai.: 'Analysis of mechanical properties of carbon fiber polymer Composite materials used as orthopaedic implants'. IJMER, B5810916, Volume 5., Issue 8, Version-1.

[5] Jian shi., Yuji Yamamoto,. Chunhong Zhu.: 'Interfacial performance enhancement of carbon fiber/epoxy composites by a two-step surface treatment'. Article., 10-1007, 15 January 2021.

[6] Zhiyuan Yu., Rongchang Li., Zhenghua Peng., Yonglian Tang.: 'Carbon Fiber Reinforced Epoxy Resin Matrix Composites'. 230064866, (2017); 1(1): 1–6.

[7] Nannan Hu., Ke wang., Hongming Ma., Wanjiang Pan., Qingqing Chen.: 'R&D on glass fiber reinforced epoxy resin composites for superconducting Tokamak'. 308408985. DOI:10.1186/s40064-016-2995-6.

[8] K.Natarajan., Padma C Balasubramanya.: 'Study Of Mechanical And Morphological Properties Of Glass

FiberReinforced Modified Epoxy Composites'. IJERT, volumes, 2014v03, IJRET20140301001.

[9] Danish Ahmad Reshi., G.Velmurugan., Mansoor Ali Khan., N.Vijayakumar., Piyush Kumar.: 'Mechanical Testing Of E-Glass Fiber With Epoxy Resin Reinforced Matrix'. IJASER, journal file, 1526622855. Volume 3 , Issue 8, 2018.

[10] Suman B., Tejas S., Manish Bhoomkar M.S., Nayana B.R., Sandip M.S.: 'Fabrication, Testing and Evaluation of Mechanical Properties of S-Glass Fibre Reinforced Epoxy Composites. ISROSET , Vol.6, Issue.1, pp.18-25, October (2019).

[11] A Abilgaziyev., N Raissov., Md Hazrat Ali.: 'Design And Development Of Multi-Nozzle Extrusion System For 3d Printer' IEEE Conc., 15604468 , 15-18 June 2015.

[12] M.K.S.Sai.: 'Review of Composite Materials and Applications', IJLTET Trans, Commun., Vol. 6 Issue 3 January 2016., ISSN:2278-621X.

[13] Dilip Kumar.: 'Research and development of fibres composite materials and properties', IRJET , e-ISSN:2395-0056., p-ISSN:2395-0072.

[14] Gourav Gupta., Ankur Kumar., Rahul Tyagi.: 'Application and Future of Composite Materials: A Review', DOI:10.15680, IJIRSET.2016.0505041., ISSN:2319-8753.

[15] MohdAlfaduly Bin Mohamad Saleh., 'The Study Of Impact Response Of Composite Material', Report for Btech., University Malaysia Pahang., November 2008.

[16] Vinod G. Gokhare., Dr. D. N. Raut., Dr. D. K. Shinde.: 'A Review paper on 3D-Printing Aspects and Various Processes Used in the 3D-Printing', IJERT., IJERTV6IS060409., Vol. 6 Issue 06, June – 2017.

[17] Michelle L Smith., James F X Jones.: 'Dual-extrusion 3D printing of anatomical models for education', Anat Sci Educ., 2018 Jan; 11(1):65-72. doi:10.1002/ase.1730.Epub 2017 Sep 2014.

[18] Omar Jumaah., Doctoral Candidate,: 'A Study on 3D Printing and its Effects on the Future of Transportation', The State University of New Jersey., CAIT-UTC-NC 2019.

[19] Samuel OsekaforeAttoye.: 'A Study Of Fused Deposition Modeling (Fdm) 3-D Printing Using Mechanical Testing And Thermography', Report of MTech., Purdue University., December 2018.

[20] Dominic AdaoizaOnimowo., Mohammed Gohrabian., Tinku Sharma., Hassan Shirvani.: 'A desktop 3D printer with dual extruders to produce customised electronic circuitry', Research Article., 05 March 2018.

[21] Sandeep., Deepak Chhabra.: 'Comparison and analysis of different 3d printing techniques', ResearchGate Article., DOI:10.21172., 1.841.44.D. Kornack and P. Rakic, "Cell Proliferation without Neurogenesis in Adult Primate Neocortex," Science, vol. 294, Dec. 2001, pp. 2127-2130, doi:10.1126/science.1065467.

[22] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[23] R. Nicole, "Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.

[24] K. Elissa, "Title of paper if known," unpublished.

BIOGRAPHIES

Final year student from Industrial Engineering & Management department of RV College of Engineering, Bangalore, India

Final year student from Industrial Engineering & Management department of RV College of Engineering, Bangalore, India

Final year student from Industrial Engineering & Management department of RV College of Engineering, Bangalore, India

Final year student from Industrial Engineering & Management department of RV College of Engineering, Bangalore, India

Assoc. Prof. & HOD, Industrial Engineering & Management. Educational qualifications: Ph. D in Faculty of Mechanical Engineering Sciences, Visvesvaraya Technological University; M. Phil in Management, Bharatidasan University; M.E.M. in Engineering Management, Mysore University.