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DESIGN AND ANALYSIS OF 3D PRINTED PARTS DEVELOPED THROUGH FUSION OF COMPOSITE MATERIALS

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Abstract
New composite materials suitable for injection moulding machines are discussed in this report. Without first determining whether or not it includes iron powder or is the best on the market, the product performs tensile tests and measures waves, and then distributes samples and results based on the composition. Do your best 3D printing work and use your findings to form conclusions. Due to its dependability and ease of use, FDM has become one of the most popular methods of 3D printing. The material is extruded using heat in FDM. In addition, the cost of FDM 3D printers is reasonable. Because of this, FDM 3D printers have become the standard in the field of additive manufacturing. In order to supply quality data for product demands and in commercial printing operations, composite data has attracted the attention of business experts, especially in the aerospace and automotive sectors. The things printed by users may be both lighter and stronger than certain metals. A mixture is a combination of two or more substances with distinct physical and chemical properties. Among the several fusion materials available for FDM 3D printing, metal/nylon and metal/ABS are the most popular. FDM printers are also capable of printing with a wider variety of specialty materials, some of which have enhanced temperature, impact, resistance, and stiffness. There are new and improved materials that can be utilised in a variety of connections in addition to the traditional ones. This research confirms previous findings that increasing the composite's iron content reduces its tensile strength. Increasing the metal concentration also increases the heat conductivity of metal/polymer filaments. Metals and huge 3D sculptures may be printed using metal/polymer filaments without warping from thermoplastics' thermal expansion.

Key words: Additive Manufacturing, FDM, Metal / Nylon, Metal / ABS.

1. Introduction

Rapid prototyping, or 3D printing, is a computer-controlled assembly method that combines a wide range of materials and processes to create physical prototypes of items. With the help of 3D printing technology, virtual representations may be turned into tangible objects. In the late 1980s, around the same time as the introduction of CNC machines, this innovation arose. Although 3D printing is not as common as CNC, it has altered the way we approach architectural planning. This skill greatly influences output. Furthermore, 3D printing provides unique benefits in design, internal flow channel design, cavity design, thin walls, ribs, and other areas where it is challenging to get similar results using other technologies. To test the thermomechanical characteristics of the metal, a novel metal/polymer composite was created using the FDM technique. Thermoplastic acrylonitrile butadiene styrene (ABS) infused with copper and iron powder. Metal powder was loaded at various concentrations to test the fibres'thermomechanical qualities including tensile strength and heat conductivity after metal was added. To learn how flaws in the FDM process affect the final output, compression settings like temperature and volume were altered.

SR. NO.	VARIOUS PROCESS	VARIOUS 3-D PRINTIG ADVANTAGES
1	FDM	Inexpensive, resistant components are possible
2	SLA	Less material waste, Part with high precision as well as smooth finish can be produced
3	MSLA	High resolution, resulting in parts with a smooth surface finish
4	SLS	SLS is an excellent printing technology, but it has high barriers to entry
5	DMLS	Great for producing unique shapes and designs with stable mechanical and material properties
6	SLM	Slightly larger available build volume
7	EBM	Precise and distortion free
8	MATERIA L JETTING	Very low levels of material wastage and low energy use compared to conventional manufacturing methods
9	DOD	Reducing costs, less waste, reduce time, get an competitive advantage, reduce errors, confidentiality, production on demand
11	BINDER JETTING	Very low levels of material wastage and low energy use compared to conventional manufacturing methods

As a result of this research, it was confirmed that the tensile strength of the composite decreased with increasing iron content. In addition, the thermal conductivity of metal/polymer filaments is improved by increasing the metal content. It is believed that metal/polymer filaments can be used to print metals and large 3D (3D) models without deforming by thermal expansion of thermoplastics. [1] Due to its reliability and ease of use, FDM is one of the most widely used 3D printing technologies. FDM only uses heat treatment to extrude the material.

Also, FDM 3D printers are competitively priced compared to other 3D printers. This is the main reason why FDM 3D printers are commercialized in today's additive manufacturing industry.

2. Literature Survey

[1]Seyeon Hwang,1 Edgar I. Reyes,1 Kyoung-Sik Moon, Raymond C. Rumpf,3 And Nam Soo Kim1,4 “Thermo-mechanical Characterization of Metal/Polymer Composite Filaments and Printing Parameter Study for Fused Deposition Modeling in the 3D Printing Process”. Journal of ELECTRONIC MATERIALS, Vol. 44, No. 3, 2015, For the purpose of testing the thermomechanical characteristics of the Fused Deposition Modelling (FDM) method, a novel metal/polymer composite metal was developed. Particles of copper and iron were added to the thermoplastic acrylonitrile butadiene styrene (ABS). The thermomechanical characteristics of the fibres, such as tensile strength and thermal conductivity, were tested with varying amounts of metal powder added to confirm the influence of metal. The impact of FDM process-related defects on the final product was also investigated by adjusting compression factors including temperature and volume. This study demonstrated that raising the composite's iron content reduces its tensile strength.Increasing the metal concentration also increases the heat conductivity of metal/polymer filaments. Metals and huge 3D sculptures may be printed using metal/polymer filaments without warping from thermoplastics' thermal expansion. Electronic moulds and

3D printed circuits are two other uses for the material.

[4] Anoop K. Sood a, Raj K. Ohdar b, Siba S. Mahapatra c, "Experimental investigation and empirical modellingof FDM process for compressive strength improvement". Received 11 October 2010; revised 18 April 2011; accepted 2 May 2011Available online 2 June 2011

Since fused deposition modelling (FDM) can produce complicated structures without the need for a tool and human-machine interaction, it has become more popular in the industrial sector. FDM design environments are sensitive to process error, which may be mitigated via careful monitoring of relevant variables. As a consequence of the material's anisotropy and brittleness, it is crucial to regulate the outcomes of the unloading process in order to preserve the integrity of the working environment. As a result, present studies conduct in-depth analyses to determine how five crucial factors—layer thickness, orientation of structural components, mesh angle, mesh width, and air gap—influence the compression stress process. This study not only provides a benchmark for performance, but also develops a formula for predicting precision.

QPSO, or the Quantum Optimal Behaviour technique, utilises this equation to determine appropriate parameter values. In order to estimate the stress and compare it to the expected equation, an artificial neural network (ANN) is used, since the FDM process is quite complicated and the failure process impacts the nonlinear response.

[6] C.S. Ramesha , C.K. Srinivas "Friction and wear behavior of laser-sintered iron–silicon carbide composite

Laser sintering is presently one of the most common technologies for generating novel materials for various high-tech industrial applications due to its capacity to generate complicated products in a short amount of time. So, academic publications have zeroed in on high-tech metal matrix production, with a concentration on laser sintering so as to produce a part without the need for time-consuming machining. In light of the above, the emphasis of the present effort is on manufacturing nickel-plated iron-silicon carbide equipment for direct metal laser sintering. We employed lasers travelling at 50, 75, 100, and 125 mm/s. Tests for friction and wear, as well as metallographic analyses, were performed on several alloys of base metals. Over the course of 30 minutes, we varied the load from 10 N to 80 N, and the slide speed from 0.42 m/s to 3.36 m/s. Laser sintering allowed for the incorporation of up to 7% by weight of SiC into the metal matrix.

[7]KurganovaYuliya, LopatinaYuliya, Yijin Chen "Evaluation of Filler Distribution in Particulate Reinforced Composites" Journal of Materials Science and Chemical Engineering Vol.3 No.7, July 2015. Xii

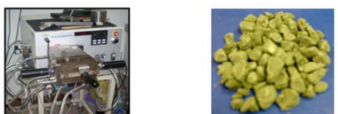
Although particle-reinforced composites made from aluminium have widespread use, keeping their performance consistent may be challenging. Energy dissipation in the matrix has a significant impact on the mechanical characteristics of metal matrix composites. This research looked at how well mixed powder metallurgy and stirred casting processes kept the SiC particles dispersed throughout the Al matrix. Quantitative metallographic image analysis is performed using both traditional and computational techniques. As an additional measure of the consistency of the synthetic material in the matrix, we also want to modify the hardness distribution of the sample cross-sections.

High-Fill Iron-ABS Composites for FDM Wire Filament Injection Moulding Mechanical Properties

[14]M. Nikzad 1 , S.H. Masood 2 , I. Sbarski3 , A. Groth45 th Australasian Congress on Applied Mechanics, Brisbane, Australia Thermo-Mechanical Properties of a Metal-filled Polymer Composite for Fused Deposition Modelling Applications ,

ACAM 2007 10-12 December 2007, Brisbane, Australia

Powdered acrylonitrile butadiene styrene (ABS) and metal are included in the product. In this experiment, ABS was used as the polymer matrix to see how metal powder would react in there. Experiments were conducted to determine the optimal volume percent (%v) compound ratios for different combinations of new PMCs. In terms of hardness, tensile strength, and flexural strength, the findings showed a skin Effect of metal filler increments. Through the injection moulding process, the PMC product gains hardness and tensile strength from the ABS composite's high filler metal content.



(a) (b)

Fig. 3(a) Brabender Mixer (b) Compounding of Iron-ABS Material

Fig. 1 ABS Pallet

Fig. 2 Iron Powder

Table I. Characteristic of compounding material

Sr.No.	Components	Melt Temperature (°C)	Density (g/cm 3)
1	Iron	1539	7.86
2	ABS	266	1.1
3	Nylon	256	1.14-1.15
4	Copper	1085	9
6	PP	327	0.90-0.92
7	SrTiO3	105-125	5.09
8	Al2O3	2072	3.987
9	Jute Fiber	105-125	0.935

3. Problem Identification

There is a limited selection of commonly used mixes to which newer, more effective composite materials may be added. The primary goal of this study is to develop FDM printers that are capable of printing in a wider variety of materials, including those with improved heat resistance, impact resistance, chemical resistance, and stiffness. Iron/Nylon, Iron/ABS, and their many mixtures, are the most frequently used FDM 3D printing materials. Printing with additional specialised materials, such as those with increased heat resistance, impact resistance, chemical resistance, and stiffness, is possible with more modern FDM printers. Less attention is paid in this research on increasing the tensile strength of products made via different 3D printing procedures using filaments material (Iron/Nylon, Iron/ABSetc.).

OBJECTIVE:

1) To make the material stronger.

2)The many variables involved in the 3D printing process

- Sized nozzle
- Filament size
- Meltingtemperature
- Bed temperature
- Printing speed
- Layer thickness
- Infill geometry
- Infill density

3) Fix process parameters for development of 3D printed product using composite material.

4) Identification of tensile strength of product

5) Fluctuation strength

Sample Details	:	3D Printed Tensile Samples
Sample Description	:	ABS+10% Fe Powder+5%Tritonx
Quantity	:	5 No's
Packing Details	:	Good
Test Required	:	Tensile Strength

Sample Details	: 3D Printed Tensile Samples
Sample Description	: PLA+10% Fe Powder+5%Tritonx
Quantity	: 5 No's
Packing Details	: Good
Test Required	: Tensile Strength

4. Methodology

Due to its dependability and ease of use, FDM has become one of the most popular methods of 3D printing. In FDM, the material is extruded by only being heated. In addition, the cost of FDM 3D printers is reasonable. Because of this, FDM 3D printers have become the standard in the field of additive manufacturing. To deliver efficient 3D printing outcomes, it is necessary to analyse data, identify the best materials, conduct tensile and wave tests on research findings, samples, and tests based on composite materials, and make conclusions.

These days, it's not uncommon to see a 3D printer in a lab. Despite its disruptive potential, 3D printing is constrained by its restricted power sources and the limited scope of the materials it can print. The introduction of the material with specialised goods and/or the combination of materials with differet products to build high performance composites is of interest for the purpose of enhancing and distinguishing the product of general printed materials. Products made using 3D printing composites have several uses, including those in the medical, mechanical, electrical, thermal, and optical improvement industries. The benefits of quick design, including the capacity to generate complicated geometries at cheaper prices, have contributed to the rise in popularity of 3D-printed composites.

5. Conclusions

Research, data analysis, material selection, tensile and wave measurements based on research results, sample creation, and measurement based on composite materials are all required to ensure effective 3D printing. FDM has quickly become one of the most used 3D printing techniques because of its reliability and user-friendliness. The material is heated and then extruded in FDM. Furthermore, FDM 3D printers are affordably priced. This is why FDM 3D printers have become the norm in the AM industry.

Although many compounds, including those that are routinely used, are becoming more scarce, research and study of new materials continue, as do efforts to enhance current ones. Research in this area is predicated on the idea that many FDM printers can use a broad range of speciality materials with improved thermal, impact, chemical, and hardness properties

TEST RESULTS

S. No	Sample Details	Test Parameter	UOM	Results
1	ABS+10% Fe Powder+5%Tritonx	Tensile Strength	MPa	20.94
2				21.70
3				21.50
4				20.90
5				22.51

Equipment Details: Universal Testing Machine, Make: FIE-40T, Model: UTES-HGFL-40.
Test Method: VMS/MECH/SOP/01, Customer Specification.
Disclaimer - 1: This report relates only to the particular sample submitted for test.
Disclaimer -2: Sampling is done by customer.

END OF THE REPORT

TEST RESULTS

S. No	Sample Details	Test Parameter	UOM	Results
1	PLA+10% Fe Powder+5%Tritonx	Tensile Strength	MPa	28.79
2				31.71
3				31.27
4				25.78
5				32.09

Equipment Details: Universal Testing Machine, Make: FIE-40T, Model: UTES-HGFL-40.
Test Method: VMS/MECH/SOP/01, Customer Specification.
Disclaimer - 1: This report relates only to the particular sample submitted for test.
Disclaimer -2: Sampling is done by customer.

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