A Review on Optimization for Fused Deposition Modeling Process Parameter and Possible Material

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ABSTRACT - This review paper aims at gathering the available literature on composite materials and process parameters optimization for the fused deposition modeling. . Fused deposition modeling is the most significant technique in RP Technology that refers to the process where layers of material are deposited in a computer controlled environment to create a three dimensional object. The main problem in Fused Deposition Modeling (FDM) process in the industrial application are the limited range of material availability and parts produced by FDM are used mainly on demonstration parts rather than functional parts. Researcher have studied many ways in order to increase the range of materials available for the FDM process which resulted in the increase in the scope of FDM in many production industries. Most of the researcher are focused on the composite materials such as metal matrix , ceramic composite , natural fiber composites and polymer matrix composites. In this review paper focus on the research carried out so for in developing samples using different natural material scrape (which scrape is harmful for environment) is recycled and use as raw material. thereby obtaining environmental advantages through this new material based on the Fused Deposition Modeling technique.

Keywords –Fused Deposition Modelling, FDM, RP Technology.

I. INTRODUCTION

The utilization of composite materials has continually expanded amid the most recent decades. A few models demonstrate that composite materials have entered the business as a practical option in contrast to customary materials. Aviation and resistance businesses have been pioneers in this field yet the alluring execution properties of composite materials have before long set off their application for the generation of game gear, water crafts, support segments in structural building and vitality applications. In the vehicle business, flying machine configuration has led the pack and the latest air ships are made of composite for up to 60% of their weight. Car industry has been utilizing composites for extravagance and rivalry autos for quite a long while and it is currently utilizing them additionally in the arrangement creation of traveler vehicles.

Lately, added substance fabricating (AM) innovation has developed quickly and steadily moved the concentration from customary application techniques. Three-dimensional (3D) printing is utilized in different assembling segments, for example, aviation, vehicle to bio-designing. AM process offers the preferred standpoint in creating parts having complex shapes with shorter generation time and diminished expenses when contrasted with conventional assembling process.

AM innovation is broadly utilized in building applications for modified items, useful and model models. As of now, many AM frameworks are available in the market, for example, FDM, stereo lithography (SLA), particular laser sintering (SLS), ink stream demonstrating and specific laser softening. These frameworks fluctuate as far as greatest space required, cost, building layers and sort of materials utilized. At the point when previously presented in the mid-1980s, as SLA, quick prototyped parts created had indicated fundamentally sub-par mechanical properties when contrasted and parts made utilizing other customary assembling techniques. A large portion of the scientists had focused for the most part on the enhancement of the procedure parameters and were interested in examining the between connection between various procedure parameters and their impacts on the last item. Most research done as of late incorporates the parameters, for example, layer thickness measurement of spout, temperature of envelope temperature of expulsion speed, filler molecule estimate, raster introduction filling speed, raster edge, street width and raster hole. Every one of these parameters ought to be controlled to streamline the FDM procedure for accomplishing best attributes, for example, great quality, dimensional precision, less porosity, better mechanical properties and diminished misshapening in the last item.

II. MATERIALS AND METHODS USED BY RESEARCHER

As FDM is widely accepted as one of the promising technologies among industrial sectors in order to sustain

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the competition as it reduces development time and cost of the product which is the need of the hour, research is done in order to increase the variety of materials that can be processed using this technology.

Gang Chen, Ning Chen, Qi Wang [1] This work aims to realize the fused deposition modeling (FDM) process of poly (vinyl alcohol) (PVA), which is a multi-hydroxyl polymer with good comprehensive properties. However, achieving the FDM process for PVA is quite challenging due to its narrow thermal processing window. To address this problem, an ionic liquid (IL) was introduced to improve the thermal process ability of PVA. The materials, the FDM process and properties of the FDM products were systematically evaluated. The results indicated that the PVA/IL composites exhibited significantly improved thermal processing properties. The PVA/IL filament prepared with a suitable viscosity and modulus ratio showed good printability. The tensile strength of the FDM parts increased from 8.7MPa to 13.6MPa due to the difference in the interlayer bond strength when the nozzle temperatures ranged from 170 C to 200 C. The zero shear rate viscosity, the relaxation time and the surface tension at different printing temperatures were analyzed and provide theoretical insight into the diffusion of polymer chains at the interface during the FDM process. Interestingly, the 3D printed composites were flexible and exhibited tailored electrical conductivity with a strong dependence on the printing temperature, revealing the potential to be functional parts in the field of flexible electronics.

G. Cicala [a], ***E. Pergolizzi*** [a], ***F. Piscopo*** [a], ***D. Carbone*** [b], ***G. Recca*** [b][2] Bioepoxy based monomers were formulated with a cure inhibitor and a cleavable amine to obtain a recyclable epoxy system suitable for resin infusion at room temperature. Hybrid flax/carbon fiber layup were used. Tensile, flexural and dynamo-mechanical properties for the composites were studied. The cured laminates were chemically recycled obtaining from the epoxy matrix a thermoplastic. The recycled was processed by fused deposition modeling (FDM) and injection molding after mixing with short kenaf fibers.

Andrew N. Dickson, Keri-Ann Ross, Denis P. Dowling [3] A novel technique for the fabrication of woven composites using Additive Manufacturing (AM) is presented and evaluated. To-date fibre reinforced composites deposited by AM exhibit highly anisotropic properties as the individual layers do not interact, this study helps address this by printing of a 0/90 woven structure into one layer to aid in stress distribution. A fiber path generator was created utilizing G-code to emulate the Weft-Warp components of a woven construction using a continuous carbon fiber filament. This new pathing technique also allows for a woven structure to be integrated with features (such as notches) previously only possible through destructive machining processes. In order to evaluate the performance of the printed composites, open hole tensile studies were carried out in which 6 mm holes were routed into the composite structure and the resulting part's mechanical performance were compared with specimens which had been die punched as well as an unnotched control group. The latter exhibited strengths equivalent to 49% that of unnotched specimen. In contrast the specimens with woven holes exhibited strengths which were 44% higher, just 7% lower than the strength achieved for the unnotched specimens. Digital image correlation (DIC) analysis also demonstrated significantly reduced strain concentration around the printed hole perimeter, compared with that for the die punched hole.

Yah Yun Aw ID , Cheow Keat Yeoh ID , Muhammad Asri Idris, [4] Fused deposition modelling (FDM) has been widely used in medical appliances, automobile, aircraft and aerospace, household appliances, toys, and many other fields. The ease of processing, low cost and high flexibility of FDM technique are strong advantages compared to other techniques for thermoelectric polymer composite fabrication. This research work focuses on the effect of two crucial printing parameters (infill density and printing pattern) on the tensile, dynamic mechanical, and thermoelectric properties of conductive acrylonitrile butadiene styrene/zinc oxide (CABS/ZnO composites fabricated by FDM technique. Results revealed significant improvement in tensile strength and Young's modulus, with a decrease in elongation at break with infill density. Improvement in dynamic storage modulus was observed when infill density changed from 50% to 100%. However, the loss modulus and damping factor reduced gradually. The increase of thermal conductivity was relatively smaller compared to the improvement of electrical conductivity and See beck coefficient, therefore, the calculated figure of merit (ZT) value increased with infill density. Line pattern performed better than rectilinear, especially in tensile properties and electrical conductivity. From the results obtained, FDM-fabricated CABS/ZnO showed much potential as a promising candidate for thermoelectric application.

Carola Esposito Corcione a, Elisabetta Palumbo b, Angela Masciullo c [5] Lecce Stone is an attractive and appreciated natural material, as well as a non-renewable resource. For thousands of years people have extracted it from the Salento quarries for use as an ornamental, celebrative or building material. The production chain of this stone, from extraction through to the finished product, results in a great deal of scraps produced in both solid and muddy form. In recent decades a new attitude toward stone scraps has gradually taken hold, namely an eco-design approach. Already adopted by some companies, it consists of reusing industrial scraps to produce innovative manufacturing products. Nowadays, in fact, only a small

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percentage of Lecce Stone (LS) scraps is recycled and used as raw material in other fields, while a significant portion is taken to the landfill, as in the case of the scraps produced in laboratories by Apulian artisans.

Sithiprumnea Dul, Luca Fambri and Alessandro Pegoretti [6] This paper presents a mechanics model for predicting the forces of cutting aluminum-based SiC/Al2O3 particle reinforced MMCs. The force generation mechanism was considered to be due to three factors: (a) the chip formation force, (b) the ploughing force, and (c) the particle fracture force. The chip formation force was obtained by using Merchants analysis but those due to matrix ploughing deformation and particle fracture were formulated, respectively, with the aid of the slip line field theory of plasticity and the Griffith theory of fracture. A comparison of the model predictions with the authors‟ experimental results and those published in the literature showed that the theoretical model developed has captured the major material removal/deformation mechanisms in MMCs and describes very well the experimental measurements.

Rui Guo, Zechun Ren, Hongjie Bi, Yongming Song, Min Xu [7] This study was aimed at improving the toughness and interfacial properties of poplar wood flour/polylactic acid (PLA) composites by Fused Deposition Modeling. The effect of toughening agents was discussed. The results showed that, the addition of thermoplastic polyurethane (TPU) significantly increased the impact strength of composites by 51.31%.Comparing to other toughening agents, such as polycaprolactone (PCL) and poly (ethylene-co-octane) (POE), the compatibility between wood flour and PLA was superior when TPU was used. With the addition of TPU, the complex viscosity and the storage modulus of the composites were highly increased. The graft copolymers (GC), synthesized by free-radical melt grafting using glycidyl methacrylate as a graft monomer and dicumyl peroxide as an initiator, were used as compatibilizers in the composites. With the addition of 5wt% wood flour loading, the grafting degree of GC was enhanced by 61.54%. At a 2wt% loading of the GC, the impact strength and tensile strength of composites increased by 7.75% and 8.39%, respectively, and the interfacial adhesion of the ternary composites were improved.

Wenfeng Haoa,b, Ye Liua, Hao Zhouc, Haosen Chenb,∗, Daining Fangb [8] In this study, continuous carbon-fiber reinforced thermosetting composites were prepared using 3D printing followed by characterization of their mechanical properties. First, a 3D printing platform was fabricated to prepare the composites based on Fused Deposition Modeling (FDM). Then, the composites lamina and grids were manufactured using a FDM-based platform. Finally, the mechanical properties of the composite lamina were characterized. The results showed that the mechanical performance of the 3D printed thermosetting composites was superior to that of similar 3D printed thermoplastic composites and 3D printed short carbon fiber reinforced composites.

J. Justo, L. Távara , L. García-Guzmán, F. París [9] Additive Layer Manufacturing (ALM) process is used in the present investigation to manufacture long fiber reinforced composite parts using the Mark One 3D-printer. In ALM, a continuous filament (including a tow of fibers) of composite material is injected by the printer, at high temperature, over a plain tool, forming the part while the material is cooled down. The used composite filament is formed by a PA (Nylon™) matrix and carbon or glass fiber reinforcements. Previous works have shown an improvement on the mechanical properties of a part, when some zones include a nylon based composite reinforcement using ALM. Nevertheless, the characterization of fully made nylon-based ALM composite material parts has not been reported. Thus, the aim of this investigation is the experimental characterization of composite nylon-based coupons. The plane strength and stiffness properties of the composites are obtained, both for tensile and compression load states. Results showed that the obtained mechanical properties for ALM composites are not yet comparable to those obtained by traditional methods. This fact may be explained by the high porosity found in ALM coupons as well as a low fiber volume obtained. Nevertheless, the mechanical properties improvement in comparison to non-reinforced nylon parts is remarkable.

Mirko Kariz, Milan Sernek, Murcoˇ Obucina,´ Manja Kitek Kuzman [10] The effect of wood content in 3D printing materials on the properties of 3D printed parts was investigated. Six filaments using polylactic acid (PLA) with varying loading levels of wood particles from 0 % to 50 % by weight were produced and used for 3D printing. The density of the filaments and 3D printed parts used in this study slightly decreased with increasing wood content. The tensile strength of the filaments increased from 55 MPa to 57 MPa with an addition of 10 % wood, but decreased with higher levels of wood content to 30 MPa for filaments with 50 % wood content. The surface of the parts printed from the filament without the addition of wood was smoother and the printed part had no voids within the structure. With increasing wood content the surface becomes rougher, more voids were present, and had visible clusters of wood particles (due to wood particle clustering and clogging in the printer nozzle). Higher wood content in 3D printed parts decreased the storage modulus measured with tensional loading on a remoter, but did not change the glass transition temperature.

Narendra Kumar1 • Prashant Kumar Jain1 • Puneet Tandon1 • Pulak M. Pandey2 [11] The applications of electrically flexible conductive polymer composites are

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rapidly growing over the time due to their widespread use in fabrication of health monitoring devices, sensors, and flexible displays fabrication, etc. Various tech-niques have been explored to develop electrically conductive polymer composites. In the recent past, fused deposition modeling (FDM) process has been gained tremendous attention to fabricate electrically conductive parts considering rigid polymers along with conductive filler particles. This allows to avail all advantages and benefits of additive manufacturing in the fabrication of complex electrically conductive parts. However, FDM process faces challenges of filament buckling while fabricating flexible parts. Hence, there is need to develop an economically viable and simplified process to fabricate the flexible electrically conductive polymer composite objects.. The ethylene vinyl acetate (EVA) and graphite (Gr) particles have been used as the polymer matrix and conductive filler material respectively. Solvent and melt blending techniques have been employed to develop EVA/Gr composites. Three-dimensional flexible electrically conductive objects have been fabricated successfully. The experimental result shows the remarkable improvements in electrical conductivity of EVA polymer by incorporation of graphite particles. The outcome of the presented approach may help to fabricate flexible electrically conductive complex structures for soft robotics and electronics applications.

Guangxin Liao, Zhixiang Li, Yuchuan Cheng, Dingding Xu,Dingchun Zhu, Shenglong Jiang, Jianjun Guo, Xinde Chen,Gaojie Xu, Yuejin Zhu [12] This paper reports the thermal and mechanical properties of carbon fiber (CF) reinforced polyamide 12 (PA12) composites for fused deposition modeling (FDM) process. The printable filaments of carbon fiber/PA12 composites with different mass fraction were fabricated and applied in FDM. The results indicate that the tensile strength and flexural strength of 10 wt.% CF/PA12 composites are enhanced by 102.2% and 251.1% respectively. The laser-flash diffusivity analysis measurements exhibit remarkable improvements on thermal conductivity (λ) of carbon fiber/PA12 composites. Moreover, the carbon fiber/PA12 composites mechanical properties are greatly improved. Our work presents a kind of anisotropic high performance composite for FDM.

Chunchuan Liu a, Xingjian Jing n,a,b, Steve Daley c, Fengming Li d [13] Micro-vibration caused by disturbance sources onboard spacecraft can severely degrade the working environment of sensitive payloads. Some notable vibration control methods have been developed particularly for the suppression or isolation of micro-vibration over recent decades. Usually, passive isolation techniques are deployed in aerospace engineering. Active isolators, however, are often proposed to deal with the low frequency vibration that is common in spacecraft. Active/passive hybrid isolation has also been effectively used in some spacecraft structures for a number of years. In semi-active isolation systems, the inherent structural performance can be adjusted to deal with variation in the aerospace environment. This latter approach is potentially one of the most practical isolation techniques for micro-vibration isolation tasks. Some emerging advanced vibration isolation methods that exploit the benefits of nonlinearity have also been reported in the literature. This represents an interesting and highly promising approach for solving some challenging problems in the area. This paper serves as a state-of-the-art review of the vibration isolation theory and/or methods which were developed, mainly over the last decade, specifically for or potentially could be used for, micro-vibration control.

Wenbo Liu, Nan Wu, Kishore Pochiraju [14] The shape recovery characteristics of SiC and Carbon filled (poly) lactic acid (PLA) filaments extruded for use with Fused Deposition Modeling (FDM) and parts printed with FDM have been analyzed. The SiC/C /PLA composite filaments were made with particle loading up to a maximum weight fraction of 60%. The shape recovery characteristics of the filaments and printed parts were tested with bending and tensile loads. Two parameters, recovery rate and recovery time were defined and monitored during the shape recovery process. This study shows that the recovery time can be correlated to the thermal conductivity of the material. The results show a viable method for tailoring the recovery time. Furthermore, tensile specimens were 3D printed and the shape recovery behavior can be observed in the printed structures. This paper describes fabrication methods, SMP composite response results and a correlation of SMP response with the composite thermal conductivity.

Cristian Lopez a, Wei Zhong a, *, Siliang Lu b, Feiyun Cong c, Ignacio Cortese a [15] Vibration signals are widely used for bearing fault detection and diagnosis. When signals are acquired in the field, usually, the faulty periodic signal is weak and is concealed by noise. Various de-noising methods have been developed to extract the target signal from the raw signal. Stochastic resonance (SR) is a technique that changed the traditional denoising process, in which the weak periodic fault signal can be identified by adding an expression, the potential, to the raw signal and solving a differential equation problem. However, current SR methods have some deficiencies such us limited filtering performance, low frequency input signal and sequential search for optimum parameters. Consequently, in this study, we explore the application of SR based on the FitzHug-Nagumo (FHN) potential in rolling bearing vibration signals. Besides, we improve the search of the SR optimum parameters by the use of particle swarm optimization (PSO). The effectiveness of the proposed method is verified by using both simulated and real bearing data sets.

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Swapnil Magara, Nitin K. Khedkarb, Satish Kumarc [16] In fused deposition modelling built up orientation of the model is one of the critical factor affects economic feasibility of the models includes, main material, support material, and built up time. Built up orientation is used in the layer by layer manufacturing of the prototype which is in the semi-molten plastic filament form and built up on the platform from bottom to top. Various experimental analyses show that built orientation has also significant affect on the tensile, impact and total cost of the FDM parts. Metal plastic composite parts of ABS and bronze, Al powders were produced and tested for various mechanical properties. This paper investigate the effect of built in orientation in combination with other factors such as orientation angle, type of layer, supporting material and temperature during FDM operation on various mechanical properties. Finding of this study will help the manufacturing firms to decide on proper build orientation, so that FDM parts can be fabricated at minimum manufacturing cost with good mechanical properties

M.R. Mansouri, H. Montazerian, S. Schmauder, J. Kadkhodapour [17] Co-continuous multi material composites are novel types of multifunctional structures. This study focuses on numerical and experimental investigation of the mechanical behavior of 3D periodic single-material cellular D-structure and the corresponding co-continuous composite. Different volume fractions of desired geometry were fabricated by multimaterial fused deposition modeling (FDM) technology and compressive mechanical properties of the samples were obtained by mechanical tests. It was observed that embedding a hyper elastic material to the cellular structure dramatically hindered the shearing bands in localized regions to develop, thereby made it feasible for composite material to undergo larger deformations without failure. Furthermore, it was demonstrated that the soft phase in multi material composite induces a homogeneous deformation to cellular structure, which enhances the load-bearing capacity and flexibility of the whole composite. In this paper, it was shown that the co-continuous multi material composite provides a well-balanced approach between desired flexibility and load-bearing which is referred to as compliancy. A strain recovery between 82~93% was also measured when unloading for multi material composite.

Sherri L. Messimer 1,, Albert E. Patterson 1,2,*,, Nasiha Muna 3,, Akshay P. Deshpande 1 and Tais Rocha Pereira [18] One of the most essential components of the fused deposition modeling (FDM) additive manufacturing (AM) process is the build plate, the surface upon which the part is constructed. These are typically made from aluminum or glass, but there are clear disadvantages to both and restrictions on which materials can be processed on them successfully. This study examined the suitability of heated aluminum-polycarbonate (AL-PC) composite print beds for FDM, looking particularly at the mechanical properties, thermal behavior, deformation behavior, bonding strength with deposited material, printing quality, and range of material usability. Theoretical examination and physical experiments were performed for each of these areas; the results were compared to similar experiments done using heated aluminum and aluminum-glass print beds. Ten distinct materials (ABS, PLA, PET, HIPS, PC, TPU, PVA, nylon, metal PLA, and carbon-fiber PLA) were tested for printing performance. The use of a heated AL-PC print bed was found to be a practical option for most of the materials, particularly ABS and TPU, which are often challenging to process using traditional print bed types. Generally, the results were found to be equivalent to or superior to tempered glass and superior to standard aluminum build plates in terms of printing capability.

Mohammed Ali Osman and Mostafa R.A. Atia [19] The purpose of this paper is to present the development of a cost- effective acrylonitrile butadiene styrene (ABS)-rice straw (RS) composite filament for use in fused deposition modelling (FDM) and the effect of RS content on the mechanical properties of the developed filament. Design/methodology/approach – RS and ABS were processed and mixed at varying fibre content (5-15 per cent). Filament using each mixture was produced using a single screw extruder. Tensile, flexural and water absorption specimens were prepared using a FDM machine. The mechanical properties were then tested following ASTM standards. Scanning electron microscope images of the specimens were also taken.Findings – Tensile properties decreased as the RS content increased. However, specimens with a 0° raster angle showed better tensile properties than the 45° raster angle specimens, indicating that tensile properties of FDM parts are anisotropic. Flexural properties decreased as fibre content increased but increased at 15 per cent fibre content. Water absorption of the composite increased as the fibre content increased. Originality/value – This paper highlights a new method of disposing of rice straw waste, by producing an ABS-RS filament for FDM. The resultant filament is cost-effective and can be used to produce cheap prototypes. This paper is the first that studies ABS-RS composites in FDM.

Lincy Pyl, Kalliopi-Artemi Kalteremidou, Danny Van Hemelrijck [20] Now that the design freedom of printing of continuous fiber- reinforced polymers has become available, the recommendations on the specimens' geometry and tab configuration to experimentally determine the elastic properties of conventionally manufactured composites are reviewed. To explore this design freedom, tensile tests for five types of specimen geometry and tabs were investigated. Continuous carbon fibre-reinforced Nylon specimens were printed using a Mark Two commercial 3D printer. Dumbbell shape

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specimens according to ASTM D638-14 with proposed radius dimension, 76 mm, and with enlarged radius, 244 mm to reduce stress concentrations at the fillet and avoid crack initiation were tested. Rectangular specimens according to ASTM D3039/3039M-14 outperform other specimen geometries. The effectiveness of printed end tabs was investigated. Even although 3D printing offers facilities for printing end tabs, there is no convincing evidence that the performance of specimen gripping is better and the printing is more time consuming and expensive. Rectangular specimens with paper end tabs work best and that is why they were used in the further characterization. The effect of alternating Nylon layers was also investigated and shows drastic reduction in stiffness. In a next step, the tensile properties of a set of eight rectangular specimens with 0° unidirectional layup were characterized and compared with conventionally manufactured composites. The tensile properties for different fibre orientations were also determined. The effect of fibre location and microstructure was studied bringing important insights to the promising 3D printing but also revealing challenges to overcome (e.g. in homogeneity in fiber distribution) to be able to fully explore the design freedom.

Matthew A. Ryder, Diana A. Lados, Germano S. Iannacchione, Amy M. Peterson [21] This study investigated the novel fabrication of polymer-metal composites using fused deposition modeling (FDM), and evaluated the mechanical and physical properties of the new materials. Specifically, an acrylonitrile butadiene styrene (ABS) – 420 stainless steel (SS) composite system was used, with 10, 15, and 23 wt% SS powder additions, and the resulting properties were compared to those of base ABS prepared using the same printing conditions. A new methodology to fabricate the composites was developed. The resulting materials were extruded into composite filaments, which were used to print test specimens. Tensile testing, modulated differential scanning calorimetry, and scanning electron microscopy were employed to characterize the composite materials and evaluate the effects of different print conditions. The results demonstrate, for the first time, the feasibility of using FDM to prepare ABS-SS composites that maintain or enhance mechanical properties as compared to the base polymer, while adding increased functionality.

D.P. Schmitza, L.G. Eccoa,b, , S. Dulb, E.C.L. Pereirac, B.G. Soaresc, G.M.O. Barraa, A. Pegorettib [22] 3-D printed samples based on acrylonitrile-butadiene-styrene (ABS) loaded with multi-walled carbon nano tubes (CNT), carbon black (CB) and a 50:50 hybrid combination (CNT/CB) were manufactured via fused deposition modeling (FDM). The electromagnetic interference shielding efficiency (EMI SE) of resulting FDM specimens was assessed. Different amounts of CNT, CB and CNT/CB were dispersed in an ABS matrix by melt compounding using an internal mixer. On the basis of the rheological behavior a weight fraction of 3% was selected for the filaments production. The filaments were prepared using a twin-screw extruder and used to feed a commercial FDM machine for 3-D printed specimen's preparation along three different growing directions. The electrical conductivity, the EMI SE and the mechanical properties of the resulting extruded filaments, as well as the 3-D printed specimens, were measured and, they are discussed in terms of the type of filler and growing directions. In general, the conductivity, EMI SE and mechanical properties of 3D printed parts were markedly dependent on the growing direction. Through the experimental findings of this work, an appropriate choice of a polymer nanocomposite formulation alongside the 3-D printing parameters could lead to components manufactured via FDM with optimized EMI SE and mechanical properties.

Ravinder Sharma, Rupinder Singh, R. Penna, F. Fraternali [23] In last two decades fused deposition modeling (FDM) has emerged as a standout amongst the most broadly utilized process for fabrication of 3D functional parts in bone tissue engineering. However this technique is still facing substantial problems to produce porous structure having sufficient mechanical strength. In this present research an exertion has been made to develop a bio-compatible FDM filament which has been further used to fabricate 3D porous structure. The results of the study highlighted the effect of FDM process parameters (infill percentage, infill speed and layer thickness) on the tensile properties (percentage elongation at peak, percentage elongation at break and yield stress) of the 3D functional prototypes. It has been observed that infill percentage has major contribution i.e. 92% towards peak elongation, 91% towards break elongation and 80% towards yield stress. The remaining two parameters have very less contribution towards mechanical properties of the 3D structures. For microscopic analysis the microphotographs of scanning electron microscope (SEM) have been taken to ensure the structure produced is porous enough and can be used in a variety of engineering and biomedical applications.

Mohan, P. Senthil, S. Vinodh & N. Jayanth [24] Recently, most of the manufacturing industries are focussing on developing infrastructure for executing research on FDM technology as it possess huge potential for changing the manufacturing scenario by generating huge profits without compromising on product quality. These future works will help in improving the FDM process further and making it an ideal AM process for various manufacturing applications including bio-medical with high part quality, dimensional accuracy and other desired properties. Overall, literature review revealed that current research is

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being done to increase the range of materials available for FDM and this range must be scaled up for future research.

III. DISCUSSION (RESEARCH GAP)

From the writing survey, it is apparent that the improvement of new materials that are reasonable/perfect with the FDM innovation in expanding since the most recent decade. In the examination ponders, advancement of new material for FDM is done alongside enhancement of the procedure parameters which is a basic measure for accomplishing quality parts with improved material, mechanical and warm properties. At present, there are distinctive sorts of FDM machines accessible in the market with determinations in regards to the stream capacity of the material to be utilized for best outcomes. Because of this confinement, numerous scientists while growing new material, at first concentrated the rheological properties and made the MFI of the new material equal to the determinations of the machine for better procedure capacity. The impacts of procedure parameters and between connection between at least two parameters ought to be contemplated completely to improve the learning on mechanical and material properties of the FDM-handled parts. A large portion of the exploration is accomplished for improving the mechanical properties of the FDM part which is made of the materials that are most broadly utilized in FDM, for example, ABS and PLA by advancing one or blend of the procedure parameters. Be that as it may, in the ongoing years, because of the expanded challenge and innovative headways, analysts are chipping away at growing new materials for FDM innovation which builds the field of utilization, for example, tissue designing and furthermore improve the mechanical properties than the present materials. Adequate research has not been done on the relationship of the procedure parameters on the material and mechanical properties for various types of materials that are utilized in the FDM procedure. According to accessible writing, very little research has been finished considering ecological conditions, for example, temperature, stickiness and commotion factors which may influence the part precision. The majority of the materials that are as of now utilized in the FDM procedure, for example, ABS and PLA may get influenced by these variables which may influence the components of the FDM manufactured part. Thus, research ought to be done on different materials that are as of now accessible and new materials that will be created by considering the environ-mental variables.

IV. CONCLUSIONS

This paper exhibits an audit on research works that are done on improvement of new materials for FDM procedure. This study will provide the knowledge that contributes to the industrial businesses to produce robust end-parts that able to perform in real conditions. one of the main limitations facing RP manufacture of parts for end use is the material properties of the parts produced. Improvement in material properties most notably with FDM have allowed an increasing range of uses of FDM. however further improvements particularly with respect to stiffness, strength and toughness are required to expand the envelop of application. post processing allows for improvements in material properties and performance of RP parts.

By making more materials good with this FDM innovation, the extent of utilizing items fabricated utilizing FDM for different applications will be expanded and causes makers to continue the challenge. A few research thinks about on advancing procedure parameters, for example, raster edge, air hole, layer thickness, manufacture introduction and raster width for various materials were investigated. This writing audit likewise shows the work dependent on enhancement strategies, for example, Taguchi, RSM and ANOVA examination which are fruitful for functional applications. This audit demonstrates that there is a need to create streamlining strategies and scientific models to incorporate ecological and clamor factors which may influence the part precision just as surface completion as present techniques does exclude these elements. Now a days , in fact only a small percentage of scrap (Natural material as well as non - renewable resource) is recycled and used as raw material for eco design approach in composite material for RP technology. There is need to study this type of material which have content a positive effect of mechanical resistance properties such as strength, modulus, stiffness and ductile properties also.These future works will help in improving the FDM procedure further and making it a perfect AM process for different assembling applications with high part quality, dimensional exactness and other wanted properties. In general, writing survey uncovered that ebb and flow inquire about is being done to build the scope of materials profit capable for FDM and this range must be scaled up for future research

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