

Investigation of Tensile properties of composite feed stock filament for Fused Deposition Modeling: A Review

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Abstract: Additive manufacturing (AM), also known as 3D printing, is defined as a process of adding materials to fabricate objects from three-dimensional (3D) models (CAD models) in successive layers, versus traditional subtractive manufacturing methods. FDM, a prominent form of rapid prototyping, is used for prototyping and rapid manufacturing. Rapid prototyping facilitates iterative testing, and for very short runs, rapid manufacturing can be a relatively inexpensive alternative.

Key words: AM, FDM, Composite Materials, ABS.

INTRODUCTION

Normally FDM process uses ABS, polypropylene, Polylactic acid as base material for making 3D models. We hereby try to use the **Natural fibre** than using **Synthetic fibre**. To make it ecofriendly and use the natural properties of the fibre. Numerous novel AM processes have been developed in more than 20 years of AM development with applications in aerospace, automotive, biomedical, digital art, architectural design, etc. There was an exponential increase in AM technologies in recent years and they continue to grow due to its versatility and low cost for rapid prototyping and manufacturing applications. All these features combined with AM's customizability to fabricate complex monolithic structures and geometries, with micrometre resolution helped AM grow to a multibillion-dollar industry.

FDM uses the thermoplastics PLA, ABS, polyphenylsulfone (PPSF), polycarbonate (PC), PETG and Ultem 9085, among others. These materials are used for their heat resistance properties. Ultem 9085 also exhibits fire retardancy making it suitable for aerospace and aviation applications.

FDM is also used in prototyping scaffolds for medical tissue engineering applications.

LITERATURE SURVEY

Andrew.N.Dickson[1] et al. have conducted work on Continuous glass, carbon and Kevlar fibers reinforced nylon composites. They were fabricated in AM up to 6.3 fold and 5-fold enhancement in tensile and flexural strengths. The nylon composite strength was in the following order: Carbon fiber > Glass fiber > Kevlar fiber. Jianlei Wang[2] et al. have suggested thermal treatment to reduce the voids between deposition lines so as to improve the mechanical properties.

Results indicate that appropriate thermal treatment exerts a positive effect on tensile and inter laminar property. Weihong zhong [3] et al. have investigated the processability of properties of ABS composites for use as a feedstock filament in FDM. Glass fiber was found to significantly improve the strength of an ABS filament at the expense of reduced flexibility and handling. Halil.L.Tekkalp[4] et al. have prepared Carbon fiber containing ABS resin feedstock and these feedstock materials were used to successfully fabricate specimens by both FDM printing and compression molding process. Weilong Cong [5] et al. have fabricated Carbon Fiber Reinforced plastic feedstock filaments from plastics parts and Carbon Fiber Powders. By adding Carbon Fiber tensile strength firstly prepared from Carbon fiber tensile strength and Young's Modulus increase but may decrease, toughness, Yield Strength and ductility. Lu Wang[6] et al. have identified that with proper selection of the printing process parameters, can produce PLA possessing higher impact strength than those directly from injection molding. Dul, S., Fambri[7] et al. have done the work on Compounding of graphene nano-platelets by using solvent free process. Thermo mechanical properties are compared by various processing routes such as compression moulding extrusion. Dario Crocchio[8] et al. have performed Experimental tensile test according to ASTM.D638 Standard. The numerical values been calibrated and validated by comparing them to experimental outcomes. G.De.With[9] et al. have used CNT and PBT material in desktop 3D prints. PBT is used as base polymer. The analysis showed that PBT/CNT 3D printed structures have better functional properties as well as esthetics than the PBT printed structures. O.S.Carneiro[10] et al. have worked on Polypropylene pellets which were used for filament production. Two types of PP were evaluated a glass fiber reinforced and neat non-reinforced one. Wang Xin [11] et al. have proposed to overcome the severe wrapping, deformation and crack during fabrication of large size thin walled parts. Using the pre- and post- laser-assisted heating, increasing the speed ratio to 0.75 and decreasing the layer thickness to 0.25 mm would be favorable to achieve better bonding quality and shape accuracy. David Bourell[12] et al. have studied materials in perfect feedstock which have acceptable service properties. Attention is focused on understanding the origin of defects in AM parts. Abdul Manaf Abdullah[13] et al. have found that mechanical properties of highly ceramic filled polyamide 12 were lower than initially expected. Deniz Sera Ertay [14] et al. have system optimized the feed while respecting the heater limit and the jerks acceleration and velocity limits of the machine tools. The varying extrusion rate is kept proportional to tangential

velocity. C.A.Griffiths[15] et al. have identified that Optimization of tensile properties, the infill level and no. of sheets are only significant and should be maximized. Build parameters depend on the relative importance of each output in the objective. Dimitris Karalekas and Antreas kanturos[16] The experimental results show that their magnitude is significant and sensitive to the investigated process parameters. Fiber Bragg Grating (FBG) sensor in their mid plane were fabricated using two important processing parameters, layer thickness and build orientation. W. Kempin [17] et al. have used the fluorescent dye quinine as a model drug to visualize drug distribution in filaments and implants. Homogeneous guanine distribution in the filaments and model implants were observed by fluorescence microscopy. Lili Zheng [18] et al. have performed the three dimension numerical simulation to design and optimize the deposition substrate placement in furnace. Computational model has been developed capable of describing heat and mass transfer. J. Wang [19] et al. have proposed FDM process to achieve anti-gravitational printing process by means of designing a magnetic platform. There are magnetic and thermal properties without sacrificing mechanical properties. Rupinder Singh [20] et al. have fabricated alternate reinforced FDM filament with special focus on grinding application of artificial polymeric dentures. Due to reinforcement Al₂O₃ particles in Nylon-6 matrix the resistance of composite specimen against wear has been improved significantly. Walter.C.Smith and Richard.W.Dean [21] have produced two series of tensile test specimens on a stratasys vantage SE FDM Machining. The values of polycarbonate in bulk form one of two optimistic to be used in design. S.S.Mahapatra [22] et al. have made a functional relationship between processed parameters and wear determined by using response surface methodology. Parametric considered are layer thickness, orientation, raster angle, raster width and air gap. Luiz Ferreira RT [23] et al. have produced Mechanical testing and SEM micrography of materials produced by 3D-printing based on FFF (Fused Filament Fabrication). The short carbon fibers increase a lot the tensile modulus of the reinforced PLA+CF, in comparison to same property of PLA. Li, Nanya [24] et al. have measured the mechanical and thermal properties by using the electronic testing machine and dynamic mechanical analyzer(DMA). The novel nozzle and path control methods were designed to satisfy the demand of continuous carbon printing. J.S., Dawson [25] et al. have showed that increase in the volume of fiber reinforcement results in an increase in stiffness and ultimate stress of the test samples. A volume averaging stiffness has been developed in order to predict the tensile proper of the fiber reinforced 3D printed samples. S. Ahmed [26] et al. have taken Micro images of carbon nano tubes under microscope for various concentration.The images are converted in to multi physics numerical code and thermal field is computed to arise the thermal characteristics of the mixture. Chi Zhou [27] et al. The microstructure analysis demonstrated no visible void content and excellent interfacial bonding.Proposed method is evaluated by lap shear strength and peel strength testing. The prepreg tapes were heated by CO₂ laser and bonded by Compaction roller. Zixiang Weng[28] et al.Result showed that mechanical properties of AbS improved by OMMT no matter what process.Linear shrinkage ratio and thermal stability were improved. Wang L[29] et al. Results indicate with proper printing process control, the 'PP' specimen can have similar

ized impact strength as injection method PP.If extrusion temp is high and smaller layer height lead to smaller cell size attributed to high diffuser.Manu Srivastava [30] et al. Deformation with respect to the direction of force is reduced by replacing default ABS by proposed FGM.This research is based on Tailoring material properties. Anup Kumar Sood [31] et al. It is found that shrinkage always dominant along the length and thickness is always more than desired. Song H[32] et al. The approach proposes to exploit small sub layer 2-motions to better reproduce gently sloped areas.It considers within layer nozzle interference, splitting and reordering paths to minimize its detrimental effects. R.Singh and S. singh [33] Al as matrix and Al₂O₃ as reinforcement offers better mechanical properties. In this Al / Al₂O₃ Composite as FGM has been developed using alternative reinforced FDM putting in IC process. R.Singh and S. singh [34] AMC's developed via this rate reinforced the surface but inner surface remained soft.It can be treated as FGM because the surface hardness have improved its mechanical properties. Schutyser[35] et al. Flow behavior of sodium caseinate mixtures was reasonably well described by a modified Poseuille equation assuming .Power law behavior. Terrence E . Johnson [36] et al. In case of 0 horizontal and side build specimens, the cross section appear almost exactly same or similar.Fractographic analysis shows that the side build specimen makes better use of the geometry of the raster to fill the voids between rows. Z. Ortega[37] et al. Exact critical value depends strongly on the geometry of extrusion device.Results from this study is recommend shear stress rates below 1000 s⁻¹ for PCL and 10000s⁻¹ for PLA to obtain homogeneous morphology of the filaments. S.H Masood [38] et al. Injection tool and inserts made out of this material on FDM demonstrate a higher stiffness comparing to those made out of pure polymetric material. Mostafa Nikzad [39] et al. New composite with 10% iron particles filled in ABS polymer matrix has been successfully obtained.FE Analysis is done to investigate main flow parameters such as temp, pressure drop, velocity using two CFD 1)for 2D and other for 3D. Melocchi[40] et al. When the disks formed by these polymers are used as barriers they performed as promptly soluble swellable / erodible, slowly permeable insoluble gastro resistant layer consistent with the nature of their polymeric components. Asaf Levy[41] et al. Complex-shaped TiC_x ceramic performance with a gradient of carbon content in the titanium carbide phase were fabricated for first time by Binder Jet 3D printing technology.

GAP ANALYSIS

There are lots of materials which are used in fused deposition modelling but most of them are synthetic materials like carbon fibre, glass fibre, Kevlar, polypropylene,etc. So there is a scope of work left in the field of natural fiber reinforcement as composite materials.

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