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0.Analysis of Fabrication of Nylon Filament by FDM 3-D Printer in a Closed Environment

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Abstract— Fused Deposition Modeling (FDM) is an additive manufacturing process in which parts are produced by layer by layer addition. Model is made by using software like CAD, solid modeling and software like CURA divided the model into number of layer by slicing. Today 3-D printing is growing in all sectors like automobile, automotive, aerospace, medical science and in other sectors. In all these fields it is proven because of effective cost. In this research work parts will be manufactured according to ASTM standards. The material chosen for this work was Nylon. Usage of Nylon in AM not only opens new mechanical opportunities but also reduce the parts weight.
Nylon is highly hygroscopic. It can absorbed 10% water of its weight. Also nylon has a warping issue because of its fast cooling nature. In an open atmosphere there is uneven cooling, uneven binding of layers, there is also a high chance of dust enter in parts during manufacturing which may effects on surface finishing and mechanical properties of part. I have studied research paper on nylon used as a filament and conclusion made that nylon has high strength with durability and can opened good opportunities in industry specially for making gears.

Keywords—3d printing, fused deposition modeling, tensile strength.

I.INTRODUCTION

Fused Deposition Modeling is a next generation technology in which material layer by layer to form 3D parts [1,2]. It does not require moulding/pattern and other various tools. AM techniques open up new chances of greater productivity, lower cost and improved quality in leading production areas [3]. It differs from subtractive manufacturing like casting, grinding, milling, etc. [4-5]. Inconventional process products are manufactured either by plastic deformation as in forging process or by subtractive method as in milling ,drilling, grinding etc. but in rapid prototyping method no plastic or subtractive method required [6-13] . 3D printing can build a structure of greater strength and furthermore complex shape, so it attracts the attention of industries and find the various applications because it uses a variety of applicable substances like ceramics, thermoplastic polymer etc. [14]. e. Stereolithography was the first method in additive manufacturing developed by Charles hull in 1986, which uses ultraviolet light to solidify liquid polymer. In the 1980s and 1990s, other various techniques were developed like fused deposition modeling, EBM, selective laser sintering, etc. and these techniques can be divided into seven divisions [15-17]. No person has imagined that one day researchers will use 3D printing for constructing parts / components for aerospace, medical, fashion, artificial jewellery, electronics, tool / mould making, pattern for casting which might be manner greater complex [18-20]. 3D printing is now used in the improvement of latest surgical tools and drill guides, orthopedic transplants, and prosthetics as well as the advent of patient's specific splint replicas, blood vessels and organs [21-23].

FDM 3D printer produces parts with a lower cost when compared with other techniques with higher Dimensional Accuracy, minimum wastage of material, complex shape can be easily produced ad no machining required. With such of advantages, 3D printing unable to accomplish still to be placed accordingly. There is much more potential of this technology which is yet to be discovered as it lacks capability and knowledge that may offer evaluation in detail. Number of research are required to make this technology powerful divisions [24-25]. Main drawback is poor surface finish and it take more time to print aproduct . Since 3d printer is used in an open atmosphere there is high chance of poor

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surface finishing even dust and small particles present in open atmosphere may get embebbed in part during manufacturing which can effect on the properties [26]. Although there are number of filaments used in FDM 3-D printer but I studied the nylon filaments by studying the number of research paper.

II. PROPERTIES OF NYLON

Nylon has high durability with good mechanical strength which make it alternate to standard filaments ABS and PLA. It has less weight, high chemical &wear resistance.Nylon has high melting point and less coefficient of friction so it generally used to print gears. Nozzle temperature is taken from 220 -270 and bed temperature was 75 -90 . Print speed was 40mm/s. it's impact resistance is high. It also flexible and warps mildly[27].

III.PROBLEMS FACED WHILE USING NYLON AS A FILAMENT

There are two general problems which are faced. These are:-

Hygroscopic nature:

Nylon has great ability to absorb moisture when placed in an open atmosphere. It can absorbed water of around 10% of its weight which make its mechanical properties weak. Also when nylon material melt during printing moisture burst which left poor surface finishing on products. Remedies: Nylon filament should be preheated in oven before used. Preheated temperature is 70 -80 and time required is 4-6 hours [28-35]

Warping Issue:

Nylon has warping issue. It means layer bend because of uneven cooling. It is due to nylon has ability to cool fast.Bed temperature is not enough. It should be greater than 80℃.Glue not stick to bed good [36-40]

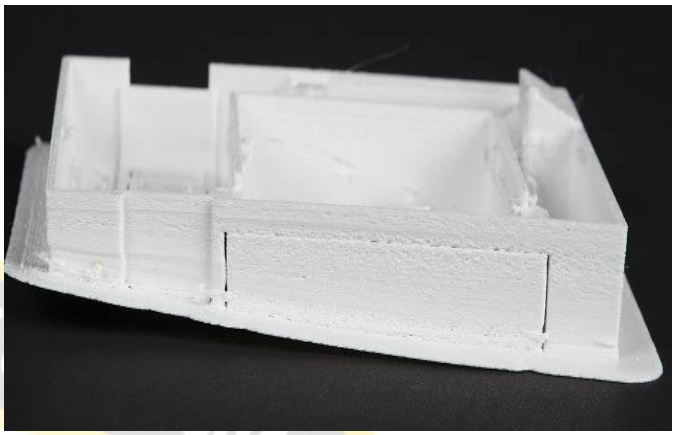

Figure1. Warping issue

IV. LITERATURE SURVEY

Process capability of Fe-Nylon 6 is greater than 1 and conclusion was made that fe-nylon-6 filament is able to make fabrication parts within tolerance according to ISO-286 [41]. Parts manufactured by nylon 6,ABS and PLA by FDM process and injection molding and found that 108% more absorbed by FDM specimens. Nylon 6 specimen show only small difference in the mechanical as well as physical properties when specimen manufactured by both injection molding and FDM as compared to PLA &ABS . Toughness, modulus of elasticity, deformation and impact strength of samples produced by FDM are found 0.48, 0.5, 0.48 and 0.78 times respectively lower as compared to injection molding[42]. Coating of nylon is done to reduce the effect of moisture and then mechanical properties & failure of nylon specimens studied . When nylon is left in open atmosphere it absorbs water and reduce mechanical properties .They coated nylon with polyurethane elastomeric&silicon and experiments was studied at different raster angle .It was found that coated specimens has low strength and stiffness as compared to uncoated specimen. Specimens [43]. Five spur gear are manufactured by five different materials. These are Nylon 618, Nylon 645, alloy 910, onyx and markforged nylon. It was found that Nylon 618 give good result when low to medium torque applied as compared to injection modeling gear and wear occurs only on the pitch line. Gear tooth surface melted but no material peeled out from the tooth made by Nylon 618 shows good thermal as well as wear resistance [44]. 3-D Infill density has

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a great influence on mechanical properties of nylon. At 100% FD UTS, flexural and shore D hardness are at maximum value. Layer height also has a good effect on mechanical properties, it give best result when LH set at 0.1mm while shore hardness D increased at 0.3 mm LH. However print speed has no effect on properties but at high speed wrapping problem face [45].

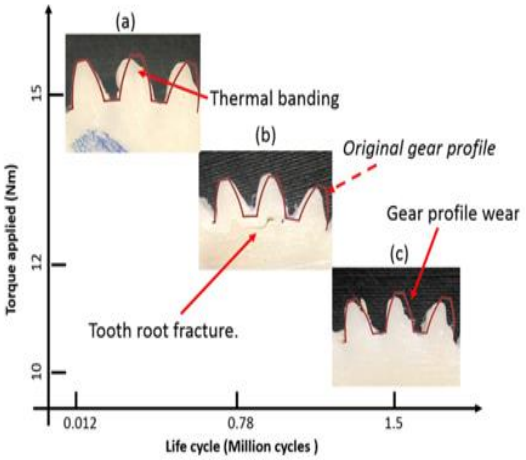

Fig. 2.Failure mechanism of nylon 618 during wear test.

In this electrical and mechanical .properties of 3D printed by Nylon 6 for RF/ Microwave electronic applications was studied. By using different infill density and pattern wide range of relative permitivity is obtained with different dielectric behaviour. Results show that as infill density decrease tensile and compressive strength of the material decrease [46].At 0.2mm layer height, 15° orientation angle and 1.2mm shell thickness ultimate tensile strength is maximum for ABS while for Nylon 0.1mm LH, 30° orientation angle and 1.2mm shell thickness. At 0.2mm LH, 30° Orientation angle and 0.8mm shell thickness better dimensional accuracy found for ABS while for Nylon. 0.3mm LH, 15° orientation angle and 0.4 mm shell thickness [47].They studied the wear resistance of 3D printed Al_2O_3 reinforced Nylon. Al_2O_3 is used single, double and triple size particles as reinforcement in nylon 6. It was found that double size particle show better wear resistance followed by triple size particle based composite Nylon 6 show good wear resistance as compared to ABS/Nylon6 [48].

V.CONCLUSION

Strength of nylon filaments is good but it is highly hygroscopic.Nylon specimen made by FDM process absorbed 108% more water as compared to specimen made by injection molding process.There is no effect of coating of polyurethane elastomer and silicon on nylon in case of moisture absorption.Wear resistance of nylon specimen increase by using Al_2O_3 as composite material.Many researcher works on recycle of Nylon-6 waste.Spur gear made by nylon 618 shows good thermal as well as wear resistance.Infill density has a great effects on mechanical properties of nylon specimen made by FDM.By increasing the print speed warping problem face.Nylon components give wide range of relative permittivity with different dielectric behavior.Researchers are working on evaluating the potential as well as limitations of this advanced manufacturing technology as it lacks the capability and experience.

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