STUDIES ON PROCESS PARAMETER OPTIMIZATION OF FUSED DEPOSITION MODELLING FOR COMPOSITE RAW MATERIALS

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Abstract: Fused deposition modeling is very widely applied in additive manufacturing or Rapid prototyping field to meet the Industrial requirements for reducing the design effort and to improve the product development by reducing the lead time. The products produced through this technique are used as prototypes for concept conveying and fluid analysis.

In this present work the application of Fused Deposition Modelling products are analyzed towards the enhancement of its applications. Products produced are expected to have better mechanical properties and thermal characteristics. This is achieved by the advanced composite raw materials used in FDM. The printed models are subjected to standard tests towards tensile properties, Thermal characteristics, and Mechanical behaviour. The composite ratio is optimized for the better enhanced results from these tests. The FDM process parameters are optimized for the newly developed composites.

The printed final model is expected to have the better characteristics that of the non-reinforced products. The results are compared with the injection molding components. The testing of each specimen would be done according to the ASTM standards. The desirable characteristics achieved by the adequate ratio is optimized and recommended for manufacturing.

In present rapid prototyping industry the Nylon and Aramid combinations are never tried. So in this present work we are using Nylon reinforced with aramid based on the weight ratio and output characteristics are evaluated by conducting the subsequent tests.

Key Words: Rapid Prototyping, Fused Deposition Modelling, Composite Materials

I. INTRODUCTION TO PROTOTYPING

Prototyping is a technique or an alternative way to identify the design ability, unexpected problems, asthecity, test results and rectifying the performance of an end product before it actually manufacture.

Prototyping is defined as the 3D object of an end product with a dimensionally scaled down to show the demonstration and physical appearance of the component.

There are three types of prototyping.
1. Prototype by Manual Method: A worker who having skill in a craft work is prepares a model per design based on his experience and skill. This is old practice from many centuries.
2. D curves and surfaces: The prototypes are prepared based on 3D curves and its surfaces with a exact material and its properties of a end product.
3. Rapid Prototyping (RP) : Rapid prototyping is a new technology by layer-by-layer material deposition per 3-D model provided by the system.

II. OBJECTIVES

a) To enhance the strength of R P components.
b) To Optimize the Dimensional accuracy of the R.P components.
c) To Optimize the Material Composition

d) Study on Thermal Behaviour of R.P components

e) To improve productivity

f) R.P components can be used for practical application not for only Demo purpose or prototype

g) Reducing the Tolling cost

III. BLOCK DIAGRAM FOR EXPERIMENTAL STUDY:
We have followed the following steps to conduct Experimental study.

**Fig. Experimental Study**

SELECTION OF FIBER MATERIALS: Now a day’s ABS, Polystyrene, Nylon, PLA etc are most commonly used raw materials in Rapid Prototyping. The prototypes made by these materials have moderate physical properties hence these are limited to prototyping rather than actual application.
The strength of the RP models are much inferior to that of the conventional manufacturing methods. Henceforth new combination of materials to satisfy the strength requirement and thermal ability are explored.

APPLICATIONS: These prototypes are used in CFD models, Architecture models and for Concept design. In the present study we are selected Nylon-6 to investigation on its properties before and after reinforcement.

Selection of Reinforcement Material: As per the literature review, significant materials are reinforced with nylon to achieve the desired characteristics. The reinforcements used consists of Carbon black, Organically Modified Monto morillonite, carbon nano fibre, Poly Ether Keotene, Carbon Fibre, High density Poly Ethylene and the achieved properties are towards the enhancement of electric conductivity, Thermal stability/Mechanical Properties, Tensile strength/Flexural strength/Young’s modulus, Decreases the flow ability of the powder, Thermal stability/ flexural modulus, Elastic modulus/Ultimate strength. Nylon is blended with the Aramid Fibres that have better strength and physical properties. The combination of this material is never been tried in the Rapid prototyping technology. The aramid fibres are available in the form of fabric, spools, long fibres and powder state. The fabric form of aramid is shown in figure.

We had selected a strong and heat resistance synthetic fiber as Aramid. This is mainly used in aerospace and defence application, for ballistic-rated body armor fabric and ballistic composites, in bicycle tires, and as an asbestos substitute. The name is a portmanteau of "aromatic polyamide".

Preparation of Nylon Pellets: The commercially available Nylon-6 spool purchased from the market and chopped into the 4 mm long pellets manually. Nylon-6 pellets are shown on above figure.

Mixture of Fibre and Reinforcement Based on Weight: After preparing the Nylon (Fibre) and Aramid (Reinforcement) Pellets both are mixed in terms of weight ratio as the minimum quantity is required for the extrusion of wire spool. In this investigation we have mixed as 2% and 4% by weight ratio.

Collection of Raw Materials
Nylon and Aramid
IV TESTING

The following tests were conducted to evaluate the desirable parameters from the given specimen.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Tests</th>
<th>ASTM Standards</th>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Thermo gravimetric Analysis (TGA)</td>
<td>ASTM D 3850</td>
<td>As a function of Physical and chemical properties of materials are to be measured with increasing temperature (with constant heating rate).</td>
</tr>
</tbody>
</table>

Specimen Details: As per survey Nylon 6 and Aramid is used a specimen and TGA is a destructive type of analysis so there is no constraint to prepare specimen geometrically.

V RESULTS

<table>
<thead>
<tr>
<th>S.No</th>
<th>Tests</th>
<th>ASTM Standards</th>
<th>Material Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Thermo gravimetric Analysis (TGA)</td>
<td>ASTM D 3850</td>
<td>0% Aramid + Pure Nylon</td>
</tr>
<tr>
<td>2</td>
<td>Thermo gravimetric Analysis (TGA)</td>
<td>ASTM D 3850</td>
<td>2% Aramid + Pure Nylon</td>
</tr>
<tr>
<td>3</td>
<td>Thermo gravimetric Analysis (TGA)</td>
<td>ASTM D 3850</td>
<td>4% Aramid + Pure Nylon</td>
</tr>
</tbody>
</table>

VI CONCLUSION

Fused deposition modelling is very widely used in the field of Rapid Prototyping to meet the industrial requirements for reducing the design effort and to improve the product development. The products produced through this technique are used as prototypes for concept conveying and fluid analysis. The quality of the parts produced was accessed in terms of dimensional accuracy and surface finish.

In present work we have obtained the thermal characteristic of the Nylon and Aramid fibre material. The testing of each specimen would be done according to the ASTM 3850 standards. The desirable characteristics achieved by the adequate ratio is optimized and recommended for manufacturing.

From TGA Pure nylon material, when temperature reaches 140˚ to 160˚ the mass of the material is starts reducing and when temperature reaches at 439.45° almost all the material is evaporate.

From TGA Nylon+2% aramid material, when temperature reaches to 190˚ the mass of the material is starts reducing and when temperature reaches at 440° almost all the material is evaporate.

So we have concluded that the composition of Nylon and Aramid material stable when the temperature is 180°, so that we decided to print the component using the Nylon and aramid composition at the temperature of 180°. So that we will get a high accuracy parts from this composition.

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