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Prototype of Mechanisms using Fused Deposition Modelling Process

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Abstract

This paper presents a manufacturing of prototype of various Mechanisms using Fused Deposition Modelling (FDM) rapid prototyping process. The material used to produce various Mechanisms is Acrylonitrile butadiene styrene (ABS). The CAD files are used in Rapid Prototyping techniques for design and manufacturing of the various Mechanisms. The Rapid Prototyping process involves translation of the CAD file into .stl format. The model is sliced into multiple horizontal layers followed by layer by layer addition of material to form a prototype. Use of this CAD data in Rapid Prototyping Techniques minimize the time to market and further scope for research and development of time of new products.

Keywords: Rapid Prototyping (RP), Fused Deposition Modeling (FDM), Geneva Mechanism.

Introduction

Rapid prototyping is a new and developing prototype manufacturing technology used to create parts by layer by layer deposition of material. There are different Rapid Prototyping technologies to create a prototype. Among them, FDM is one of the leading processes used in manufacturing industries. It is an extrusion type, solid-based process. In this process the build material is melted in an extrusion head where the temperature is controlled. The semi-liquid material in a filament form is extruded from the extrusion head and it is deposited in layer by layer fashion. Then the final product is removed and cleaned. Current FDM systems can produce parts with the materials like polycarbonate (PC), Polyphenyl-sulfone and Acrylonitrile butadiene styrene (ABS) [1].

Due to the pressure of international competition and market globalization in the 21st century, there continues to be strong driving forces in the industry to compete effectively by reducing manufacturing times and cost while assuming high quality product and service however convectional machining methods is characterized by long lead time and high cost .It cannot meet the demand for rapid product development.

Rapid prototyping has emerged as a key enabling technology with its ability to shorten product development and manufacturing process that

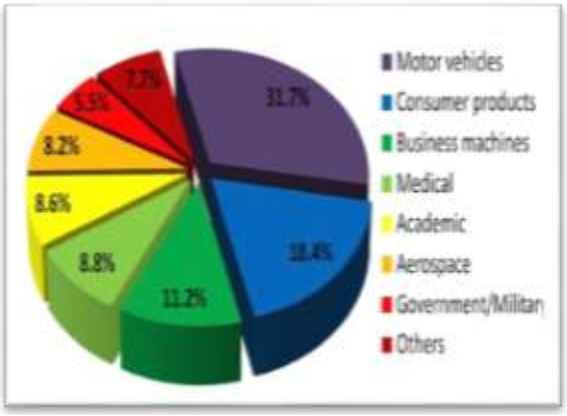

Fig.1 % Use of Rapid Prototyping

produces a physical prototype from a 3D cad model layer by layer which is also called as layer manufacturing .The first rapid prototyping technique stereo-lithography was developed by 3D system of Valencia, California, USA in 1986 since then number of different R.P technique have been developed till date.

Fig.1 explains the % use of Rapid Prototyping in various fields [4].

Fused deposition modelling

Fused deposition modelling (FDM) is a rapid prototyping process in which a Three Dimensional part is manufactured directly from CAD data by using computer aided design (CAD),

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computer numerical control (CNC), polymer science, extrusion technology, etc [1]. The first step in this process is to create a 3D model using CAD software. Then the CAD file is converted into Stereolithography (.stl) format. The .stl file is then slices into a number of layers from 0.01mm to 0.7mm thick, depending on the build technique.
.stl file of CAD model is imported into software known as Insight. Insight software generates all the data required for FDM machine. By using Insight software we can adjust model size according to requirement.

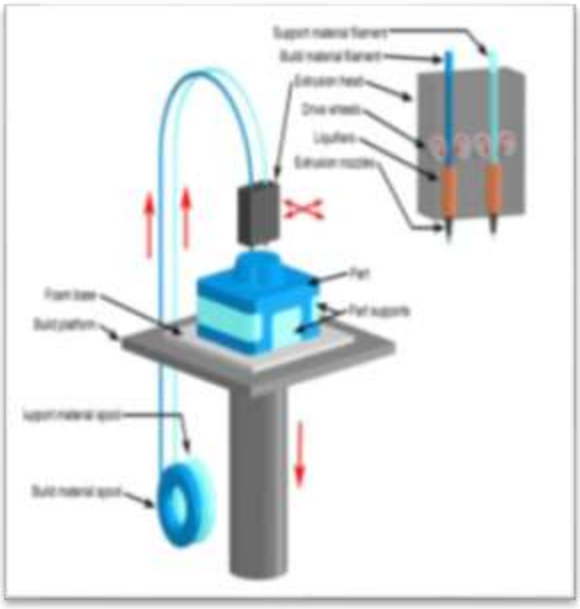

Fig.2 Schematic diagram of the FDM process

Fig. 2 shows the schematic diagram of the FDM process [2]. In the FDM machine, the liquefier head plays a major role, which is the key to the success of fused deposition modelling technology. The material in the filament form is pulled or pushed with the help of drive wheels which is attached to the electric motors and then enters into the heating chamber. The material flows through the liquefier tube and is deposited through an extrusion nozzle. The nozzle reduces the diameter of the extruded filament to allow for better detailed modelling. The extruded plastic bonds with the previously deposited layer and hardens immediately. The chamber, in which the entire system is held, is kept at a temperature just below the melting point of the plastic used, which aids the bonding process. Finally the part is removed from the chamber and no post processing is required in FDM [1].

Fig.3 Photo of FDM Machine

Fig.4 Photo of Extrusion Head

Design of mechanisms

The following mechanisms are selected for manufacturing their prototype.

Geneva Mechanism

The Geneva wheel is cam like mechanism that provides intermittent rotary motion & is widely used in both low and high-speed machinery. Although originally developed as a stop to prevent over winding of watches, it is now extensively used in automobile machinery, e.g. where a spindle, turret or worktable must be indexed.

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The Geneva Wheel Mechanism designed in this project has following design specification:
Number of Slots= 04
Radius of Crank= 39 mm
Distance between centers of Geneva Wheel and Crank = 72.66mm
Radius of circular locking part = 5 mm
Slot width = 12mm
Length of slot = 20.5mm
Shaft diameter = 20 mm

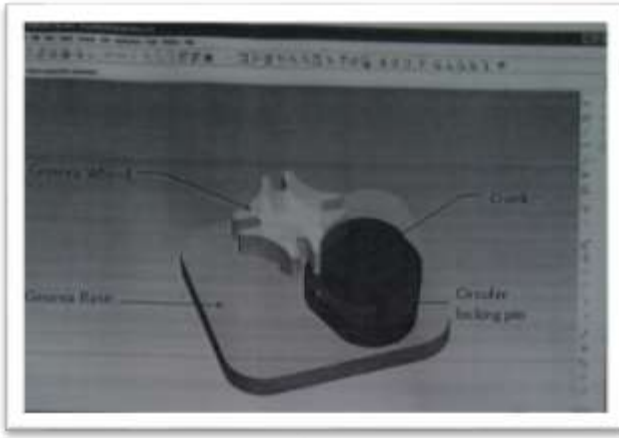

Fig.5 CAD model of Geneva Mechanism

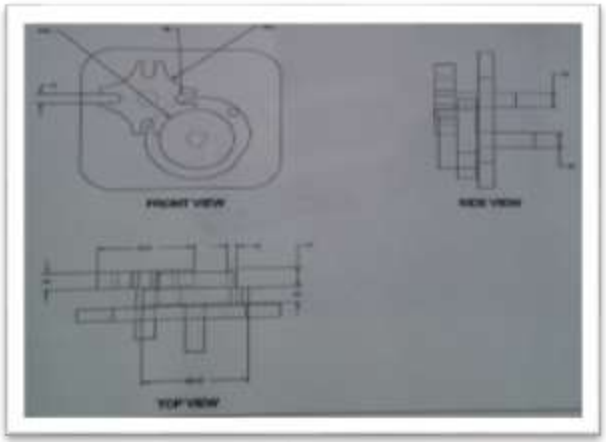

Fig.6 Views of Geneva Mechanism

Rotary to Linear motion transfer mechanism
This mechanism is used to transfer the rotary motion into linear motion. In this one rotary star shaped wheel is used for rotary motion.
Rotary to Linear motion transfer mechanism designed in this project has the following design specifications:
Length of base = 420mm
Breadth of base = 120mm
Total height = 140 mm
Shaft diameter = 7.5 mm
No. of Blades = 3

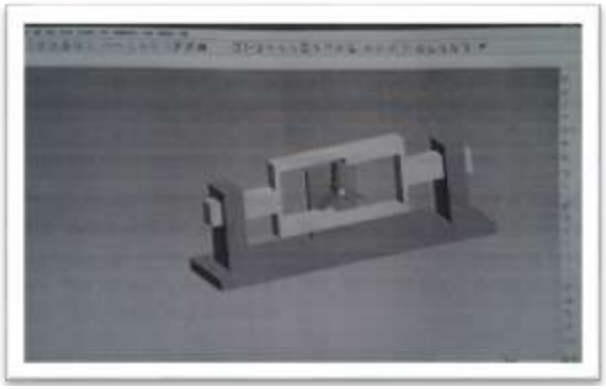

Fig.7 CAD model of Rotary to Linear Mechanism

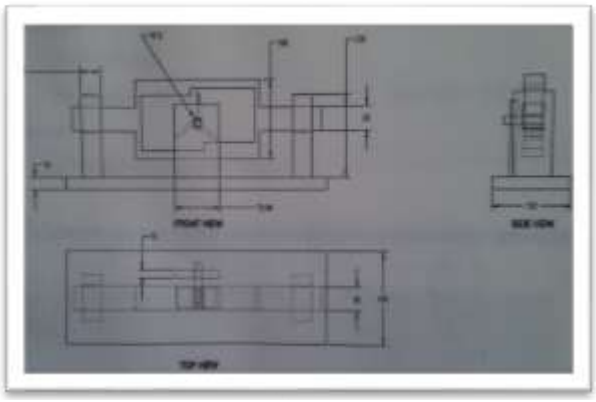

Fig.8 Views of Rotary to Linear Mechanism

Procedure & result

The Rapid Prototyping Process has five steps.

1. Create a CAD model of the design
2. Convert the CAD model to .stl format
3. Slice the .stl file into thin cross-sectional layers
4. Construct the model one layer atop another
5. Clean and finish the model

Create a CAD model
Computer Aided Design (CAD) is the technology concerned with the use of computer system to assist in the creation, modification, analysis and optimization of design.
First, the object to be build is modeled using a Computer Aided Design (CAD) software package. Solid modeler, such as Pro/ENGINEER, tends to represent 3D object more accurately than wire-frame modeler such as AutoCAD, and will therefore yield

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better results.
The designer can use a pre-existing CAD file or may wish to create one expressly for prototyping purpose.

Convert the CAD model into .stl format

The .stl file format is widely used for Rapid Prototyping and Computer Aided Manufacturing. Using an algorithm in the solid modelling package, a .stl file is generated. The surfaces of the original CAD model are translated into array of triangles. The tessellated model represents the original model. The generated .stl file consist of the X, Y, Z coordinates of the vertices of each triangle and an index that indicates the normal of the each triangle.
The next step involves creating supports that hold the object in place during the build process.
.stl file describe only the surface geometry of a three dimensional object without any representation of color, texture or other common CAD model attributes.

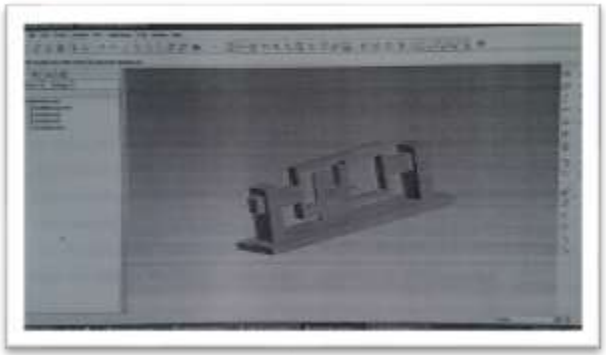

Fig.9 File after converted to .stl

Slice the .stl file

In the third step, a pre-processing program prepares the STL file to be built. The pre-processing software slices the STL model into number of layers from 0.01 mm to 0.7 mm thick, depending upon the build technique. The program may also generate an auxiliary structure to support the model during the build.
.stl file of CAD model is imported into software known as Insight. Insight software generates all the data required for FDM machine. By using Insight software we can adjust model size according to requirement.

Fig.10 Slicing & Support Generation

Fig.11 Tool Path Generation

Fig.12 Control Center

Construct the model

The fourth step is actual construction of the part. Using one of the several techniques RP Machine build one layer at a time from polymers, paper or powdered metal. Most of the machines are fairly autonomous, need little human intervention.

Clean and finish the model

To remove the support, model is sinking into ultrasonic tank which consist the solution of Sodium Hydroxides and water.

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Fig.13 Prototype of Geneva Mechanism

Fig.14 Prototype of Rotary to Linear Mechanism

Conclusion

So simply it conclude that CAD simulation provide safer way for designing any component or system. The accuracy obtained from such simulation is tremendous so chances of failure reduce. The reliability of component or system enhances.

Rapid prototyping is necessary before carrying out any mass production process because it reduces the losses after manufacturing. Hence to be at the top it is better to use these ways which save time, losses, money, failure and definitely provide accuracy and impart outstanding features to develop a durable product.

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