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Design and Analysis of Moulding Tool for the Preparation of FRP Components

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Abstract

Fiber reinforced plastics (FRP) molding is a relatively new technology developed in recent years. Tooling for fabrication of FRP components calls for a critical examination of the process, design, and problems. The reliability of the process leads to the reliability of the product essential for vital aerospace applications. This project covers the ablative applications in airborne defense and space rocketry. This study presents the problems encountered and remedial measures suggested during the production of FRP components. The requirement of high surface finish homogeneous structure, high strength and closed dimensional control was tooling for any other material. The designer gets from tools precisely what he put in them. The other design aspects like material, accuracy, and ejection system have also been discussed incidentally; the use of solid works is a recent addition to this field. In a sense, the tooling for reinforced plastics is no different from article highlights the simplification made in order to get a cost effective tooling fabricated in a short lead time, although it may not be really suitable for mass production. Besides, it presents in detail the various design factors such as the method of mould heating, mould size, material, pressure applied to the mould, accuracy and surface finish of the mould, type of pinch off edges, die and punch clearance, type of guide pins, and method.

Keywords: Solid works; ANSYS; FRP; Modeling

1. Introduction

In nature there are many materials available and each material has its own advantages and disadvantages in terms of properties like mechanical, thermal, electrical and optical properties. Materials are classified according to their nature of bonding of atoms, into different categories like metals, polymers, ceramics and composites. Due to properties like anti corrosive, lightweight and high strength composite gain more attention if it comes to aerospace structures like aircraft body, wing, radoms and missiles.

1.1About fibre reinforced plastics

Fibre reinforced plastics are composite materials made of polymer metrics reinforced with fibre. These fibres are usually silicon (glass), carbon although other fibre such as paper or wood or asbestos has been used. The polymer is usually an epoxy, polyester, thermosetting plastic; phenol formaldehyde resins are still in use.

1.2Advantages of FRP

a. Higher strength
b. Light weight
c. Higher performance
d. Longer lasting rehabilitating existing structures and extending their life
e. Seismic upgrades
f. Defence systems
g. Space systems
h. Ocean environments
i. Longer lasting rehabilitating existing structures and extending their life.
j. Seismic upgrades

1.3 Objectives of present work

This study presents modelling and production of moulding tool used to manufacture of FRP components. The modelling of the moulding tool is carried out using modelling software solid works.

Manufacturing involves selection of tool material, types of machining, surface finish required, tooling etc. All these aspects of the manufacturing discussed below.

2. Fabrication Methods of FRP Composites

Various methods of fabrication are used to produce the composite structure based on the nature of resin, fibre and shape of the component. Laying up method is used for staking of different layers one on another for making sheet moulded composites. Auto clave is one of the curing method is used for fabrication of composites in case of volatile composites.

2.1 Compression moulding

Compression moulding is a thermo setting moulding process this uses expensive but durable metal dies. It is used when large number of parts exceeding 10,000 parts as many as 2,00,000 parts can be produced with one set of forged steel dies, using sheet moulding compound(SMC) and also a composite sheet material made by sandwiching chopped fibre glass between two layers of thick resin paste. This is a transfer moulding process.

3. Modelling and Manufacturing

Modelling is a model cantered approach for use of autonomous intelligent software models, particularly the efficiency of models. It also considers the interaction and integration into distributed autonomous intelligent systems. The aim of modelling is to show how to efficiently simulate sophisticated products and processes in mechanical engineering in view of their continuously increasing complexity

List of Modelling Software

a. Auto cad
b. PTC -CREO parametric/pro-engineering
c. CATIA
d. Solid works
e. NX

3.1. Product design

Solid works offers a number of tools for generation of complete digital representations of the component designed. It also has capability to generate geometry of the other integrated designs.

A no of designed tools that can provide front Industrial design concept which can be used for processing the engineering product. It can vary from conceptual industrial design sketches, reverse engineering with point cloud data and comprehensive free from surface.

4. Manufacturing

Manufacturing involves the selection of raw materials, type of machining, surface finish required, tooling etc. All these aspects of manufacturing are discussed in them in brief below.

.4.1.Mild and low carbon steel

Mild steel is a plain carbon steel which is the most common form of steel because of its low cost. Mild steel has a relatively low tensile strength and is ductile and malleable. It is cheap and easy to form.

4.2 Tooling

By using fundamental abilities of the software with regards to the single data source principle, it provides a rich set of tools in the manufacturing environment in the form of tooling design and simulated CNC machining and output. Tooling options covers specially tools for moulding, die-casting and progressive tool design.

4.3 Machining process

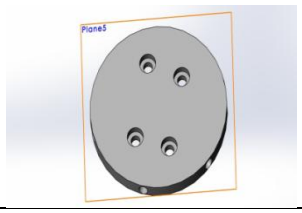
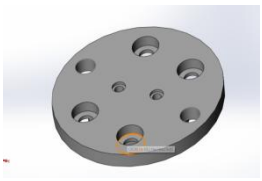
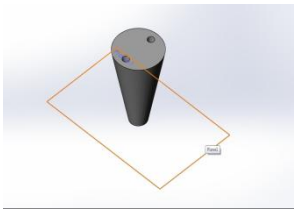
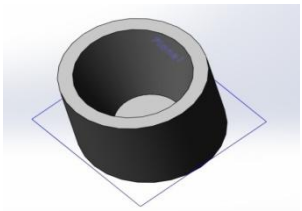
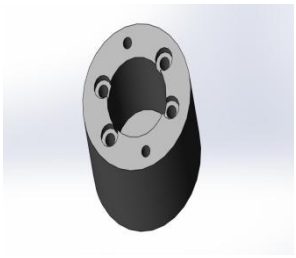
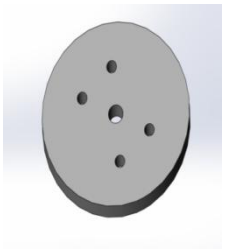
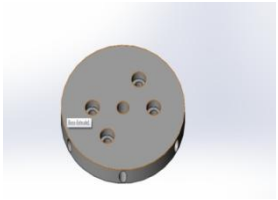
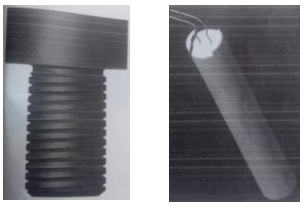
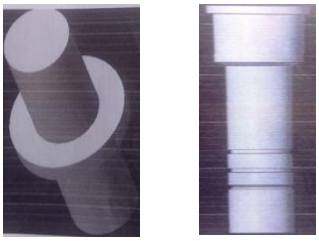
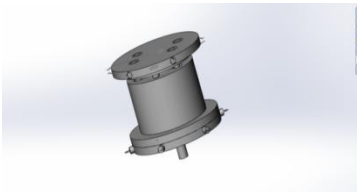
The molding tool is produced with the help of CNC machining to obtain required accuracy and good surface finish.CNC machines include lathe, milling, machining center, electro discharge machine etc.

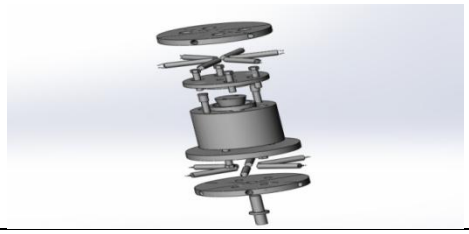
4.4 Parts manufactured

The compression moulding tool parts are manufactured in CNC machine with high degree of finish. The following are the list of components manufactured in CNC machine.

1. Top plate
2. Punch holder
3. Conical and cup shaped punches
4. Conical and cup shaped die holders
5. Die
6. Guide pillars
7. Spacer
8. Bottom plate
9. Ejector
10. Counter bore screw & cartridge heater

1. Tool assembly

	
Top plate	Punch holder
	
Conical shaped punch	Conical shaped die
	
Die holder	Spacer
	
Bottom plate	Counter bore and screw cartridge heater
	
Ejector and guiding pillar	Tool assembly



Exploded view

Figure 1. Detailed components of tool

Design Factors for Moulding Tools

Following factors are to be considered during design of moulding tool.

1. Mould heating temperature
2. Mould material
3. Surface finish
4. Pinch off edges
5. End of clearance
6. Guide pins
7. Parts removal methods

Process Control Parameters

a. Moulding pressure
b. Closing speeds
c. Charge pattern and placement

6. Design Analysis

6.1. Introduction to Finite Element Analysis

It is a process in which the body or a structure is divided in smaller elements of finite dimensions called finite elements. Then the body is considered as assembly of these elements connected at a finite number of joints called nodes or nodal points. Some simple functions are selected to approximate displacements over each finite functions are called shape functions. The displacement within the element represents in the term of displacement at the nodes of element.

6.2 Introduction to ANSYS

ANSYS is software which enables engineers to perform the following task

1. Build computer models or transfer CAD models of structures, products, components or systems
2. Apply operating loads or other design performance conditions
3. Study physical responses, such as stress levels, temperature distribution, or elector magnetic fields.
4. Optimize a design early in the development process to reduce production cost
5. It does prototype testing in environments where it would be undesirable or impossible.
6. The ANSYS program has a comprehensive graphical user interface (GUI) that gives users easy, interactive access to program functions, commands, documentation, and

reference material. A graphical user interface is available throughout the program, to guide new users through the learning process and provide more experience users with multiple windows, pull-down menus, dialogue boxes, tool bar and online documentation.

7. Results and Discussions

The modelling of the moulding tool has been completed in solid-works software and the modelled tool is analyzed using the ANSYS software. Considering the dimensions of the model from the cantilever beam and applying load in the form of uniformly distributed load. Both the static and thermal analysis conducted on the moulding tool was successful.

7.1. Static Analysis:

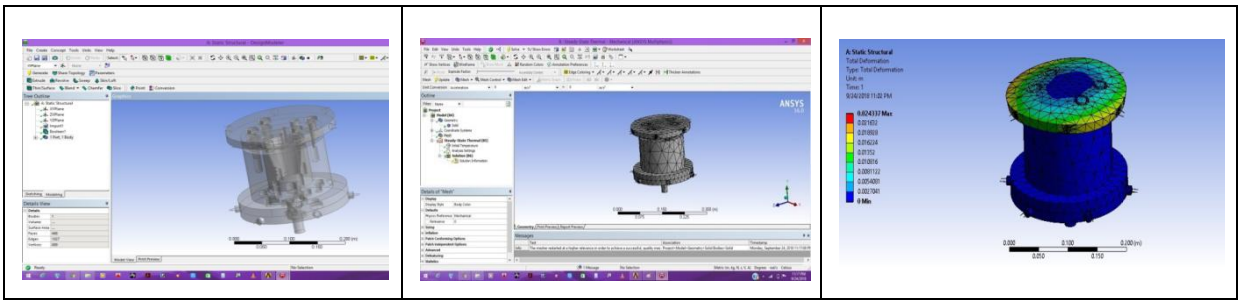


Figure 2. Meshing of moulding tool by using FEA method

Static analysis of the mild steel is constrained and the load is applied on the top surface of the tool.

7.2 Thermal Analysis

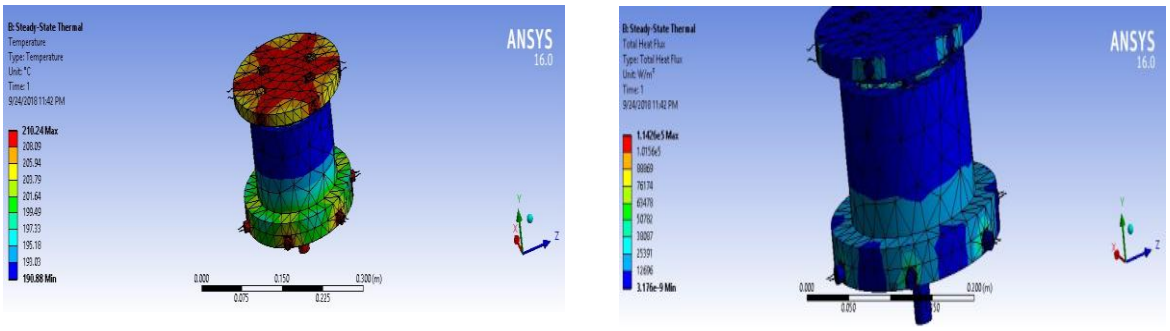


Figure 3. Meshing of moulding tool by using ansys.

8. Conclusion

1. It has been experienced that moulding of FRP components is a skill and experiences of the shop or an art rather than theoretical know how. Though a lot of technical literature is available it provides only guide lines

2. The quality of the components is to be achieved by trials and based on the previous experiences on the same type of the materials, mould and components. Further refine is required in the tool

3. The tool manufactured is used for the production of smaller components and it is also very economical as the numbers of the process are less here when compared to the other manufacturing techniques, which saves the process cost the tool and manufacturing.

4. Static analysis and thermal analysis has been carried out on moulding tool the minimum load applied in static analysis is 0-1N and the maximum load applied is 30N minimum distortion occurred is 0 m to 0.024337 m in mild steel and the minimum distortion occurred in structural steel is -16632 pa and the maximum distortion is 29026 pa as their poisons ratio and young's modulus are similar there is quite distinction of distortion ratio in both metals.

5. The minimum temperature is calculated at room temperature minimum deflection caused is 3.176e-9 w/m2 maximum and the maximum distortion is noted as 1.1426e5w/m2 at 210.24C.

9. Future scopes

The tool which we are using now is a basic moulding tool. The productivity of the tool is limited to few number of FRP component and the tool is also operated manually by press. So, in future work productive and automatic mould tool is to be designed and manufactured.

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