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My final year project is on FABRICATION AND THERMAL EVALUATION OF MICROWAVE ASSISTED ALUMINIUM PARTICULATES REINFORCED POLYMER MATRIX COMPOSITES FOR AEROSPACE APPLICATION was supervised by Dr. Engr. Charles Adeodu.

Firstly based on the product I worked on, Aluminium Powder Overview Aluminium powder is a light, silvery white to grey, odourless powder. It is a reactive inflammable material. Moist aluminium powder may catch fire in air, with formation of flammable hydrogen gas. It is also an inflammable dust. When aluminium is in contact with water, strong acid, strong base or alcohols, it releases flammable hydrogen gas. It can react violently or explosively with many inorganic and organic chemicals. Aluminium powder is essentially non-toxic following short-term vulnerability. There are two basic categories of aluminium powder, the flake type and the granulated type. For the purpose of this research, the flake type, known as pyro powder was used. It consisted of very small particles with less than 1 . Pyro powder is preferable for composite manufacturing due to the particle sizes, which eventually complements the weight of the composites. High demands for light weight components, majorly driven by the necessity to reduce energy composition in a variety of structural components.

Optical Cure Monitoring

Optical methods show clear advantages over more conventional techniques for monitoring the cure of resin system .These techniques give room for accurate determination of cure with the measurements achieved--by small scale samples. It provides exact data about a bulk matrix. Non-inversive methods of determine cure are more attractive, e.g. surface measurement of component or the use of optical fibre sensors. These measurements provide more insight into the component and the actual industrial process. Optical cure techniques are categorized into spectroscopy, optical ultrasonic method and optical fibre refractometry. Conventional optical sensing methods make use of spectroscopy to monitor the vibration energy exhibited by these molecular bonds as a guide to cure. As the cure progresses, the characteristic vibrations linked to a particular molecular bond species will grow or reduce with respect to cure time.

Composites Manufacturing Processes

This section introduces different composite manufacturing processes as a basis for curing. All the processes will be briefly discussed. Of interest in the work reported in this thesis is lay-up (hand and spray-up) method, and shall be fully discussed in the next chapter as related to unsaturated polyester reinforcement curing. The manufacturing of composite components seeks to combine the strength properties of the particulates network with the bulk and adhesive nature of the resin effectively creating a new material . The main manufacturing methods are Lay-up, Pultrusion and Liquid Injection Moulding (LIM), e.g. bag moulding and Resin Transfer Moulding (RTM).

Specification of Composites Samples

The next step after the mould design and fabrication was cleaning and preparation of the mould. The preparation was done before pouring the mixture. The plate surface was rubbed with a mould releasing agent (PVC) to facilitate easily removal of composite after solidification. Functionalization of the aluminium powder and the carbon black was done to remove any impurities due to manufacturing process of the conducting filters. This can be done through microwave heating, mainly performed by an electromagnetic cavity where the field homogenization can be efficiently achieved

Composite Samples Lamination and Cutting

The composite samples lamination was done with the fabricated mould. There are several methods to use in these stages e.g. Hand lay -up Moulding, Compression Moulding and Transfer Moulding. For this research Hand Lay-up moulding is appreciated.
Hand Lay -up Moulding is the method of laying down fabrics made of reinforcement and painting with the matrix resin, layer by layer until the desired thickness is obtained. Though time and labour consuming composite processing method,33 it has the advantage of aligning long fibres with controlled orientation quality due to the hand assembly involved in the layup procedure.
Another advantage of this method is the ability to accommodate irregular shaped product. Such advantages are utilized in low performance composites including Fibre- glass Boat, Aerospace, Bath tub manufacturing.
The following are the set of sequential steps that would be used for making hand lay-up Aluminium and Carbon black- Polyester resin composites.
1. The fabricated moulds are properly prepared and clean.
2. Correct amount of fillers (aluminium and carbon black) are weighed into containers
3. Correct amount polyester resin, hardener and other additives are weighed and mixed together.
4. Resin and filler are evenly and slowly mixed with the aid of mechanical blender inside a fume cabinet (for safety) in order to ensure a homogeneous composite mixture. 5. Each mixture is poured into moulds and transferred into the oven.

Mould Description

The mould used for the production of the composites is 3-gang 2x2 inches (50mm) mould, machined out of brass makes 3 compression test cubes at once. This mould cast cubes is a diagonal arrangement with a detachable brass base plate. Wing nut clamps lock the mould to the base while stainless thumb screws secure halves tightly together. Large screened of upper surface area makes this mould a preferred choice. Discretionary accessories include an all brass fitted top, or cover plate designed to pour molten substance capping compound down through taper hole for testing tensile strength. The fabrication processes involve all necessary manufacturing method including cutting, milling, drilling and grinding which are not involved in the scope of the research. These processes are carried out on different specialized machines.

| | |
|---|---|
| Shape | Flaky |
| Composition | $Al_2O_3$ due to strong affinity for oxygen, Polystyrene, Stearin. |
| Appearance | Silvery white and odourless powder |
| Particle Size (µm) | < 1µm |
| True Density ($g/cm^3$) | 2.7 |
| Boiling Point | 2467 |
| Melting Point | 660.1 |
| Molecular Weight (g/mol) | 29.92 |
| Specific Heat@$25^0$C (Cal/$g^0$C) | 0.215 |
| Thermal Conductivity @$20^0$C (Cal/s. cm.$^0$C) | 0.5 |
| Co-efficient of Expansion@20-100 deg.C | 24 |
| Modulus of Elasticity | 69 |
| Specific gravity | 2.6989 |
| Crystallography | Cubic structure, face centred |

| Percentages of Conducting Fillers (wt%) | Weight fraction of polyester resin (g) | Weight fraction of accelerator/catalyst (g) | Weight fraction of conducting fillers (Aluminium and carbon black) (g) | Composites |
|---|---|---|---|---|
| 10 | 394 | 56 | 50 | 500 |
| 20 | 320 | 80 | 100 | 500 |
| 30 | 262 | 88 | 150 | 500 |

Determination of Temperature Profile

The determination of the temperature profile is based on temperate control of samples and heating rate parameters. The temperature control and heating rate shows the response of the samples in both heating methods to heat as a function of time. It also determines the achievement of temperature stability and uniformity of heating with composite samples. The temperature was measured with 1200°C graduation scale laboratory thermocouple.

Determination of Cure Characteristic

CureCharacteristicmeasuresthedegreeofcure( )ofthesamplesusingthetwo heating methods. It measures the response of the samples through the cure cycle. It is also measured as a function of time.
Conventional differential scanning calorimetry is used to obtain degree of cure for both methods. The measurement is usually contrasted with a reference sample. It essentially provides data about

the exothermic and endothermic ^actions taking place by monitoring the amount of heat added or extracted from the samples to maintain a cure cycle temperature. Points of measurable heat flows indicate the phase transitions of the material. Differential Scanning Calorimetry was carried out at a particular time interval, throughout the curing processes (ref to Chapter 4). DSC scans were performed from same time interval with heating rate.