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A REVIEW ON COMPOSITE DEFECTS, REMEDIES AND ITS DETECTION TECHNIQUES

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ABSTRACT

The present article focuses on the type of defects which assetduring processing of fiber composite laminate. There are different methods to manufacture composite such as hand-Layup, compression molding, vacuum molding etc. Number of defects in composite affects directly the mechanical and physical properties of material during its application. In other phase of this article, remedial strategiesto overcome or minimize the defects formation on composite has been suggested, which give an idea what precaution should be taken before processing of composite.Various NDT techniques have been discussed to detect defects in the composites.

Keywords: -*Composite, Defects, NON- destructive testing, Remedies, voids.*

I INTRODUCTION

There is wide availability of raw materials for composites in natural and manmade form at the cheap prices. Due to its towering mechanical properties, non -toxic and biodegradability, these composites are being used heavily in the various industries. The properties of Natural composite materials contend the properties of Synthetic composites in some applications. Many authors gave their contribution in research of mechanical strength and morphological study. Except this, some workin field of defectdetection during processing of composite has been done by various researchers. Shigang et al. [1]conveyed about the effect of manufacturing defects on mechanical properties of woven carbon-carbon composite. Manufacturing defects in a product directly affect the physical and mechanical properties of the product during its application. Many authors reported work on defect detection its remedies in composites. There are many types of defects which appear on outer portion of the finished product that could be easily detected with naked eyes. Besides, some defects lie inside the interfacial layer of fiber and matrix which can beanalyzed by scientific methods likenon destructives testingunder which there are number of techniquesuch as radiographic test, ultrasonic test etc.Gholizadeh [2] reported a review on the evaluation of composite defects by different NDT techniques. The defects formed generally due to wrong way of processing of matrix with fibers, ineffective wetting of fiber with matrix,twisting of fiber during poring of resin on it ordispersion of voids in finished products.Li et al. [3] also reported the effects of defects in graphene/epoxy composites and it had been investigated by using molecular dynamics simulations. Curing methodology is also animportant factor which introduces the various defects because curing decides the adhesionquality between matrix and reinforcement fiber. Therearealso some chemical treatments of fibers which are used to improve the surface of fabric and make those more adhesive with the matrix material. Khanet al. [4]reported a comparative result of treated and untreated jute-fiber composite. Treated fiberalso conquered the de-bonding defects of interfacial layer of matrix and fiber. Joffre et al. [5], concluded the effect of various defects on the tensile strength of short fiber composite material.Another critical infirmity in composite is delamination of composite laminate. Kappatos et al. [6] reported the theoretical assessment by different ultrasonic configuration to predict the delamination in composites. Porosity is normally having more chances to occur during the hand lay-up method which is a void present in matrix or trapped gases or air bubbles infiltrate during process. Smith [7] reported many factors of forming void defects in composites.Porosity is caused in matrix due to incorrect process parameter during curing such as pressure, temperature & bleeding of resin during vacuum. Porosity directly affects the mechanical performance parameters such as inter lamina shear stress. Yuexin et al. [8]found many defects observed in SEM images owed to defects in fabrics such as during the stitching of fiber bunches to hold those in place. A defect in material is not only produced during processing but it can also develop while it isin service.There are some smart composite materials havingan ability of self-monitoring during working period.

II COMPOSITE DEFECTS AND ITS REMEDIES

There are number of defectswhich may arise during processing of composites. Some of these defects with their remedies are focused in this article.

2.1 Porosity (voids)

Porosity is illustrated as small fraction of volume in a material that is not occupied with resin and fiber due to presence of trapped gases during processing. kastner et al. [9] examinedthe defects in carbon fiber composites by X-ray computed tomography. Void may also generate due to improper stitching of fibers resulting incomplete wetting with resin.Fernlund et al. [10] reported how to control porosity in prepregs.If precaution are undertaken during processing of composite, the void defects can be minimized. The following are the remedies to reduces the void defects in the finishedproduct.

- **Control of trapped gases.**During processing of composite, trapped gases must be removed by using roller in hand-lay-up method and in vacuum molding technique, proper vacuum should be maintained to remove trapped gases.
- **Appropriate pressure.** In different compression molding techniques, the pressure exerted on the composite layer, should be appropriate. The result of the optimized pressure exerted on the composite surface is the removal of all trapped gases with resin.

2.2 Bonding defects

Bonding defects, cause due to the lower adhesion force between matrix and fiber.Johnson et al. [11]reported variousreasons for bonding defects in composites. Bonding defects reduce the flexure and impact strength of composite material. The disbonding of matrix and fibercan be clearly in SEM imagesof fractured samples.Chaudhary et al. [12] also discussed bonding adhesion between fiber and matrix in different bio-composites through SEM micrographs. Adhesion betweenfiber and matrix depends upon the surface of fiber.To improve adhesion efficiency between fiber and matrix, following remedies are adopted:

Chemically treated fiber. Different chemical treatment processes for natural fiber are alkali-treatment,acetylated-treatment,Cyanoethylated-treatment etc., to make fiber surface free from foreign bodies and make them rough for better wettability with matrix.Rong et al. [13] compared the different mechanical properties of treated, untreated fiber composite and concluded that the chemical treated fiber composite showed better strength compared to untreated fiber.

Proper selection of Additives in resin. The interfacial adhesion between matrix and polymer is affected byproper selection of additives in resin for curing. If the curing time of resin is very fast,fiber is not properly wetted before curing of resin.Therefore, use of additives for curing must be compatible with fiber for good wettability.

Alignment of fiber. Wrinkling of fibers should be avoided and every fiber should be properly aligned to minimize void formation the composite.Qian et al. [14] reported the dependency of fiber reinforcement composite on fiber alignment.

2.3 Residual stresses

If curing temperature is higher than the room temperature, there is possibility of thermal expansion of matrix and fiber which results in residual stress in the composite. Zhang et al. [15]studied the effect of residual stresses on mechanical properties of composites. If the thermal expansion mismatch is toohigh, then residual stresses can lead to matrix cracking during cool down processes. The temperature during curing of matrix should not be too high than the processing temperature of matrix material to avoid residual stresses.

2.4 Fiber defects

The defects which are present in raw fiber is called fiber defects like break in filament of fiber, faulty fiber due to misalignment of fiber filament, wrinkles in fiber, moisture present in raw fiber and impurities present in raw fiber. All these shortcomings in fibers directly affect the adhesionefficiency between fiber and matrix and so mechanical performance of composites.Therefore, it is required to choose suitable raw fiber before processing with matrix. Use of baked fibers, chemically treated fibers and use of wrinkleless fiber filament are some of the remedial strategies to minimize these types of defects in fibers.

III DEFECTS DETECTING TECHNIQUES

There are number of techniques to detect the defects in composites, but the best techniques of defect detection arenon-destructive testing. There are number of methods in non-destructive testing to identify the defects in composite. The selection depends upon thetype of defect to be identified in composite. NDT used todetect both type of defect, that is on the surface or within the material.

3.1 Visual inspection. It is very basic technique to check the defects on the surface of composite such as pin holes and cracks with the naked eyes.

3.2 Liquid penetration test (LPT). LPT is popular in welding to check the presence of flux in joints during welding. Similarly, LPTis also used in composites to check the minor crack on the surface. In LPT, first clean the surface with cleaner or thinner then, red die is sprayed on the surface of composite and cleaned. Finally,developer is sprayed on the surface which develops the colored spots on the surface of composite, whichconfirms the presence of crack on composite surface.

3.3 Ultrasonic Methods Ultrasonic testing is one of the best NDT techniques to detect bonding glitch between fiber and polymer in composite. Adams [7] reportedthat during ultrasonic testing,sound waves reflection response detected the defects incomposite material.Nesvijski [17]reported that ultrasonic testing results evaluated the defects affecting the mechanical properties of composites. Ultrasonictesting generally finds the imperfection and crack inside the material which are not visible.

3.4 Radiography testing Radiography is also a defects detection technique, it consists x-ray and film during the operation. Crane [18] found modifications necessary to enhance the contrast between composite flaws. Radiographic testing involves exposing a media to x-ray radiation that has penetrated the specimen, developing an image from the media, and interpreting the image developed.

IV CONCLUSION

Defects in the composites directly affects the mechanical performance and limits its applicability. Processing parameters should be optimized to fabricate defect free composites. After fabrication, right defect detection technique enables to arrest any flaw present in the composite. Present review article summarized various defects, its causes, remedial action and testing techniques.

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