UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Investigation Based On Design of Experiment for Woven Composite Deformation

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering
(Manufacturing Process) (Hons.)

By

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BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **INVESTIGATION BASED ON DESIGN OF EXPERIMENT OF WOVEN FABRIC DEFORMATION**

SESI PENGAJIAN: **2013/14 Semester2**

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I declare that this report entitle “Investigation Based on The Design Of Experiment on Composites Deformation” is the result of my own research except as cited in the references.

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(Tengku Ahmad Dzilkarnain Bin Tengku Mohamad)

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Manufacturing Process) (Hons.). The member of the supervisory committee is as follow

…….

(Supervisor)

ABSTRAK

Projek tahun akhir yang bertajuk "Penyiasatan tentang tenunan komposit berubah bentuk berdasarkan rekabentuk eksperimen". Projek ini adalah untuk mengenal pasti perubahan bentuk bahan komposit selepas proses rawatan berdasarkan komponen kapal terbang dengan mendapatkan nilai sudut anjalan komposit. Bahan yang digunakan adalah bahan yang sama pada komponan menutup enjin turbin kapal terbang. Komponan menutup enjin kapal terbang itu berfungsi untuk menutup enjin kapal terbang dengan tepat dan jitu. Ujikaji ini adalah berdasarkan masalah utama yang timbul pada komponan kapal terbang di syarikat pembuatan pesawat. Masalah ini berlaku pada komponan pesawat selepas proses rawatan di dalam mesin autoclave di mana komponan tersebut akan berubah bentuk yang dipanggil kesan anjalan. Masalah ini mungkin berlaku kerana penggunaan peralatan yang tidak sesuai. Untuk menyelesaikan masalah ini, acuan daripada aluminum dan karbon dipilih untuk menganalisis kesan anjalan pada komponan. Satu eksperimen telah dijalanakan untuk mengkaji kesan perubahan bentuk komposit pada kemasan produk selepas proses rawatan. Kesan anjalan akan diukur untuk kesan proses taksiran. Berdasarkan pada kajian, penemuan penting yang akan mempengaruhi nilai anjalan pada komposit adalah saiz, ketebalan, orientasi tenunan dan jenis bahan acuan yang digunakan. Di mana orientasi (0, 90°) menghasilkan kurang sudut anjalan kepada komposit. Ketebalan komposit yang digunakan akan menyebabkan sudut anjalan lebih rendah disebabkan oleh peningkatan bilangan komposit yang digunakan. 16 helai komposit menghasilkan sudut anjalan yang lebih besar. Saiz komposit yang digunakan akan memberi kesan kepada kesan sudut anjalan. Produk yang bersaiz 300x300mm menunjukkan lebih besar sudut anjalan. Bagi jenis penggunaan bahan untuk acuan merubah bentuk komposit, nilai CTE adalah penting, di mana nilai CTE yang tinggi akan memberikan sudut anjalan yang lebih tinggi kepada komposit.

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ABSTRACT

This final year project entitled “Investigation based on Design of Experiment for Woven Fabric Composites Deformation”. The project is to define the material composites deformation after curing effect from aerospace component by getting the spring back angle of the composites. The material is made of same material on component cover engine of the airplane. The cover engine is function to cover up the turbine engine of the airplane with precise shape. This problem is carried out based on the highlighted problems of aircraft component at the aircraft manufacture company. The problems occurred on the component after the curing process in the autoclave where the components change the shape which is called spring back effect. This problem maybe occurs due to the unsuitable tooling usage. To solve the problems, the aluminum and carbon tooling was chosen to analyze the spring back effect. An experiment was conducted to study the effect of composites deformation on the finish product after curing process. Spring back effect will be measure for process effect evaluation. Base on the study, the significant finding of expected result is the size of the material, orientation, number of plies and different tooling will affect the spring back value. Where the orientation (0, 90°) of the part those produce less spring back angle to the composites. Thicker the part will provide angle of spring back lower due to the increasing of the number of plies use. The 16 plies part produce bigger spring back angle. The size of the part affected the spring back deformation of the part. The increasing in size will increase more contact area between part and tooling produced more spring back angle. The 300x300mm size part shows bigger spring back angle to the part. For the type of tooling use as mold for the composites deformation, the value of CTE are important, where the higher the values of CTE produces more spring back angle, Aluminum tooling produce highest value of spring back.

DEDICATION

I dedication for this report to my family, especially:
To my late father, Tengku Mohamad bin Tengku Jalil and
My mother, Sobah binti Mahmud
For instilling the importance of patience, honest in work and hard work
To the families Bahrizal, Asri, Linawani, Syukri, Fathil, Faiz
and for my friends

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I also would like to extend my thankfulness to the most precious person in my life, my mother for all her moral support, financial support and also to my friends for never ending reminded me and also give suggestion about data analyze. Not forgotten for the entire lecturer at Faculty of Manufacturing Engineering (FKP), UTeM I very much appreciate for their entire kindness helping and teaching

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INTRODUCTION

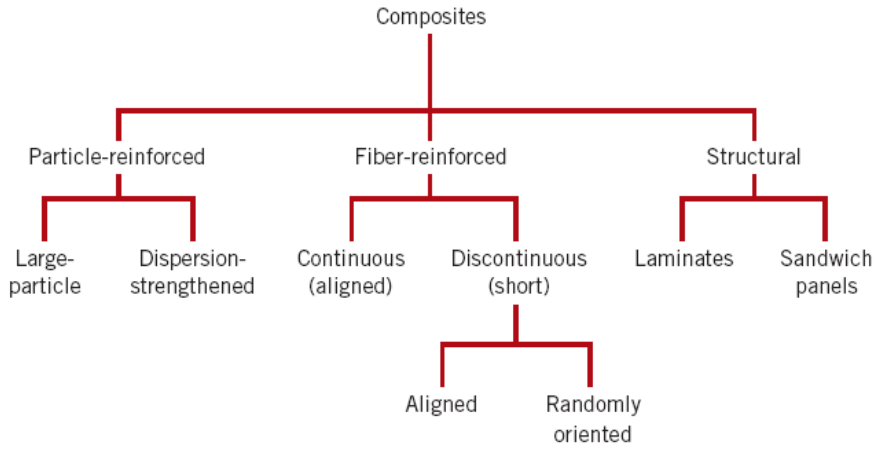
1.1 Composites

Composites are the advance materials began during the mid-20th century with the manufacturing of designed and engineered multiphase composites such as fiberglass-reinforced polymer. A composite is materials that consist of two dissimilar materials in which one material forms a matrix to bond together with other material that act as reinforcement. Composite materials can be made up from two materials that are not mixed in each other. The material can be called as a composites if satisfy the three criteria which is

a) Both constituents have to be present in reasonable proportions
b) When material constituent have different properties
c) The composite properties are noticeably different from the properties of the constituent

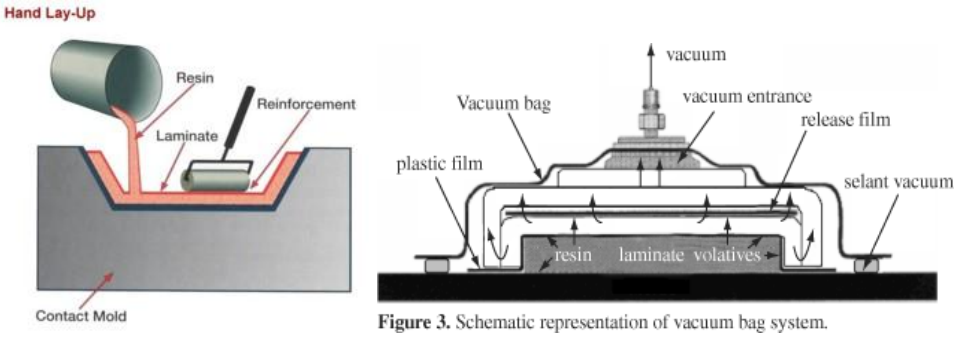
The composites are been created to improve the properties of material that have. For example formula 1 car need to go fast, so instead of using the metal for a race car, carbon fiber are advance material that been used to replace the metal because of the light weight and the toughness of the part and by reducing the weight of the car speed will increase instantly.

Composites can be classifies to several division which are, fiber reinforced, particle-reinforced and structural composites. The type of division are been distinguished depends on the, size, shape, concentration, distribution and orientation of the fiber used in the composites. (William D Callister, 2011). Figures 1.1 show the chart of the division under the composites type.



Figures 1.1: type of division in composites (Source: Materials Science and Engineering, 2011)

The common processes in manufacturing composites are hand lay-up, autoclave processing, filament winding and others. The process is selected based on the application. Figures 1.2 (a) show the hand lay-up process while figure 1.2 (b) show Vacuum Bag process for composite manufacturing.



(a) (b)

Figure 1.2: (a) Hand Lay-up process (source: FLEIX DYNAMIC,2012) (b) Vacuum Bag Process (Source: SCEILO Material Research, 2008)

1.1.1 Hand Lay-up Process

Hand lay-up process is the simple method of contact molding. The material is placed on the mold which is been brushed with the resin and shaped according to the mold by hand using a roller. The reinforcement on the mold may consist of various shapes, including prepregs and the orientation can be change according to the application characteristics. The choices of material that can be used using this method are limited. The shape of the product made by Hand lay-up process are based on the mold that been create weather using a CNC machining or fiberglass itself. (SeropeKalpakjian, 2010).

Hand lay-up process is commonly to make a low volume production of product. The laying-up of the material and squeezing the trapped air bubbles while compacts the part will taking a bit of time. In the small air craft production, this type of processing still taking place to make several part of the product.

1.1.2 Vacuum Bag Process

The vacuum bag system is used by the Formula 1 manufacture race car where the part of the car is usually made from composites which are basically known as the carbon fiber. Most of the part of the Formula 1 car are been made using this system. Have some similarity with the hand lay-up process where the prepregs are been lay up on the mold to form the desired shape, then by covering the part with the plastic bags the material are been pressurized by the vacuum to developed a good bonding. Then the curing takes place in the room temperature or in the autoclave depends on the material characteristics.(Kalpakjian, 2005).

1.1.3 Carbon Fiber

Carbon fiber reinforced polymer is type of composite that widely use on aerospace manufacture. The aerospace technologies commonly use the material because of the lightweight and toughness of the carbon fiber composite. Usually the binder use in the carbon fiber is epoxy. The properties of the composites can be affected by the type of additives use to the resin. This expensive material is evenly used on the automobile industry because of the special properties to help in performance of the car.

1.2 Problem Statement

Even though there are much studies and literatures on composites deformation, but, the studies on effect of material characteristics on composites deformation is less explored. Most of the time, the literature are more focusing only on proposed a parameter for evading the composites spring-back effect. So, this topic is selected to address this gap. This project is focusing on establishing the relationship between material sizing on process of manufacture the material and spring-back deformation.

1.3 Scope

The scope for this project is limited to usage of composites as the material of the part using the lay-up process to manufacture L shape product with study the effect of the spring-back effect after curing process. The experiment starts from producing the specimen until measuring the deformation using CMM machining and collecting the data of the spring back angle.

1.4 Objectives

The objectives of this project are:

1. To investigate the relationship and effect of material orientation, size and number of plies of the fiber in influencing shape deformation of composite parts using different tooling material on layup process.
2. To determine what the correlation between types of tooling material due to same process used on same condition and the composites fiber for spring-back effect after curing process.

CHAPTER 2
LITERATURE REVIEW

2.1 Composites

William D. Callister (2011) describes composites as a different classification of materials began during the mid-20th century to manufacture composite intentionally designed and engineered multiphase composites such as fiberglass. In the other hand, Serope Kalpakjian (2010) define that composites is the combination of two or more insoluble phase and chemically purpose with a recognizable interphase, in such way that the properties and performance are powerful to those constituent acting independently. The combinations of the composite material are known as metal-matrix and ceramic-matrix composites.

Composites materials have increasingly wider applications in air craft, space vehicle, satellites, piping, boats, sporting goods and vehicle. The combination of the material as the fiber reinforcement significantly improve the strength, stiffness and creep resistance to plastics, particularly their strength to weight and stiffness to weight ratio. Composites can be describe as the most general sense, can be thought of a wide variety of material such as cermet, two-phase alloy, natural material and general reinforced or combined material.(Serope Kalpakjian, 2010).

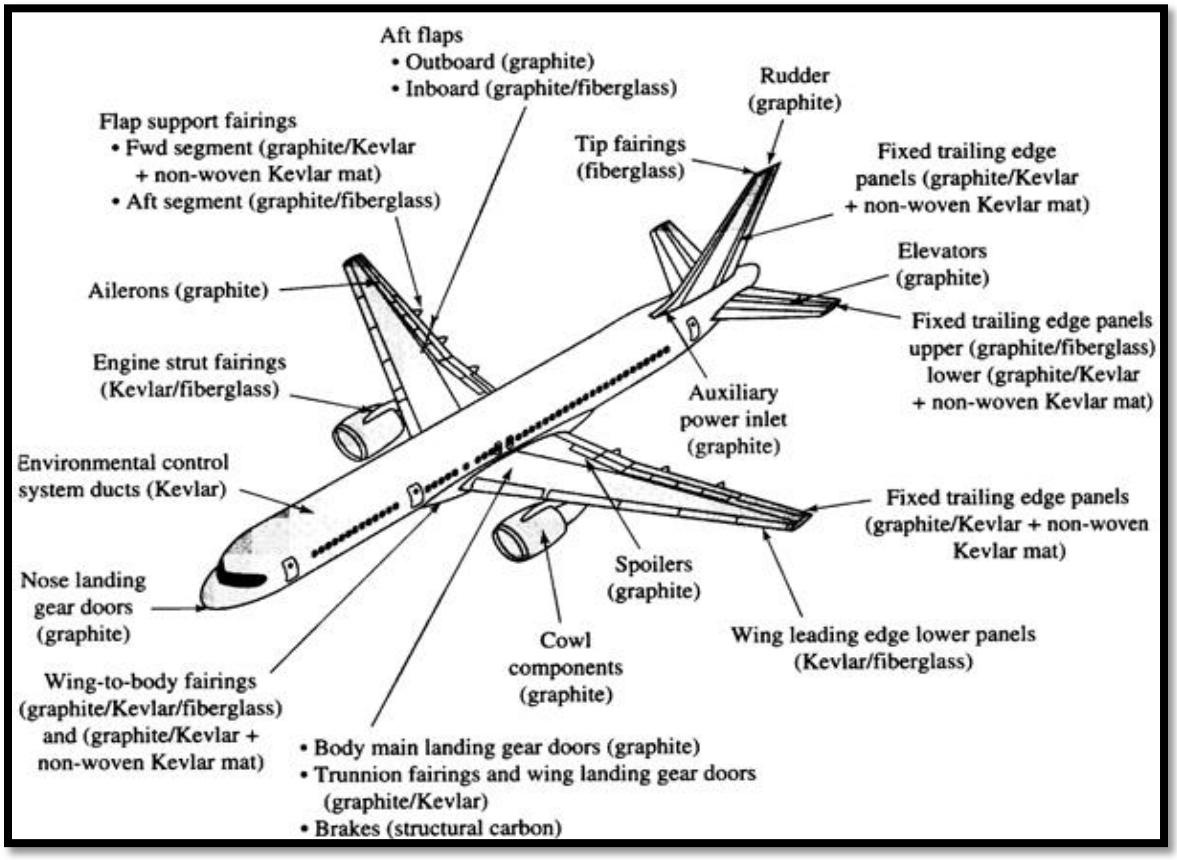


Figure 2.1: List of Composite parts in the main structure of the Boeing 757-200 aircraft. (Source: Boeing commercial Airplane Company)

In the composites there is several different structure of material combine with other material for different purposes. Reinforced Plastic, or known as Polymer-Matrix Composites (PMC) and Fiber Reinforced Plastic (FRP) consists of fiber in a polymer matrix. The difference of structure provides different properties to the composites. The fibers in the FRP are strong and stiff, and they have high specific strength and specific stiffness. The PMC or Reinforced Plastic is easy to design, fabricate and repair. In addition, reinforced-plastic structures have improved fatigue resistance, greater toughness, and higher creep resistance than the unreinforced plastics. From this structure of FRP, the structures are divide with several type of arrangement of the fiber which is discontinues or dispersed and phase (Serope Kalpakjian, 2010).

2.1.1 The Structure Of Reinforced Plastics

Composites structure is a combination of the fiber, matrix, cores and inserts and adhesive. From three type of materials are combining to produce the composite. F. L. Matthews and R. D. Rawlings (1994) deliberate that the reinforcement of the composite came from the fiber or particle use. The foundation philosophy in the design of fiber composite materials is to find or to make the fiber material of high elastic modulus and strength, and preferably low density, and arranging the fiber in a suitable manner to produce useful engineering properties to the final product. Figure 2.2 illustrate the condition of fiber in the composites material.

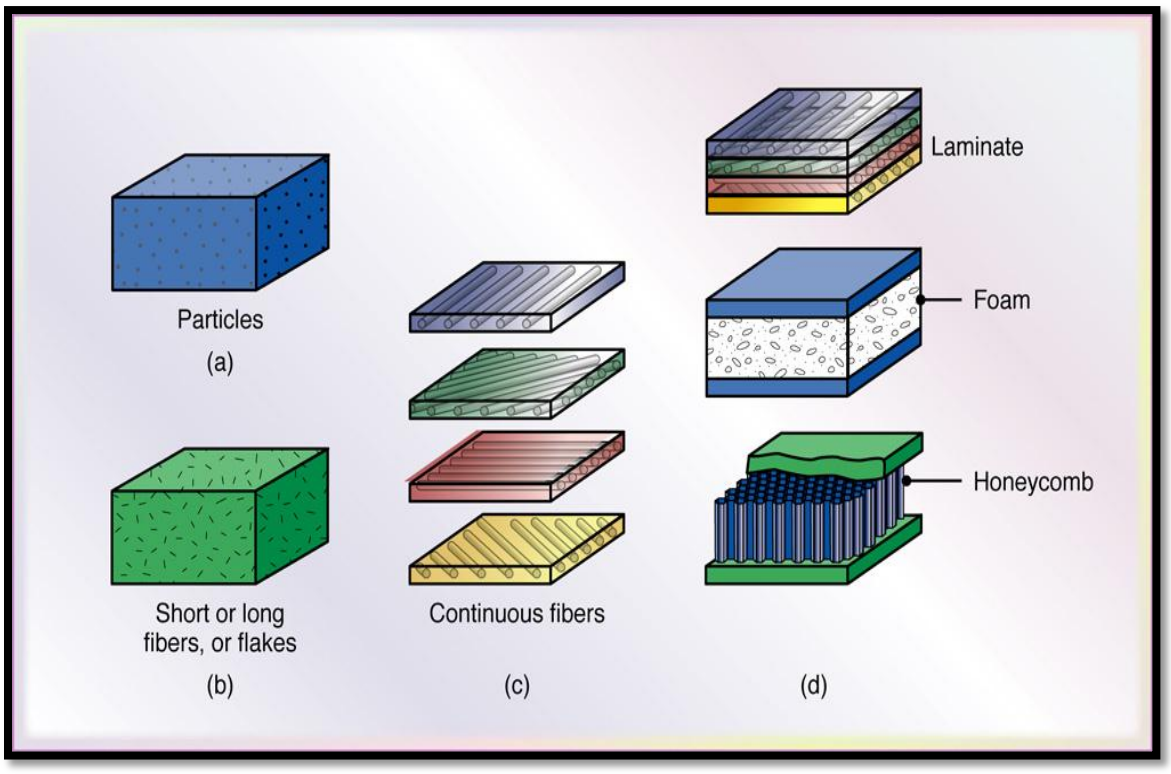


Figure 2.2: Schematic illustration of methods of reinforcing plastics (matrix) with (a) Particles, (b) short or long fibers, or flakes, (c) continuous fiber, (d) the laminate structure that can be produce either with foam or honeycomb(Source: SeropeKalpakjian, 2010).

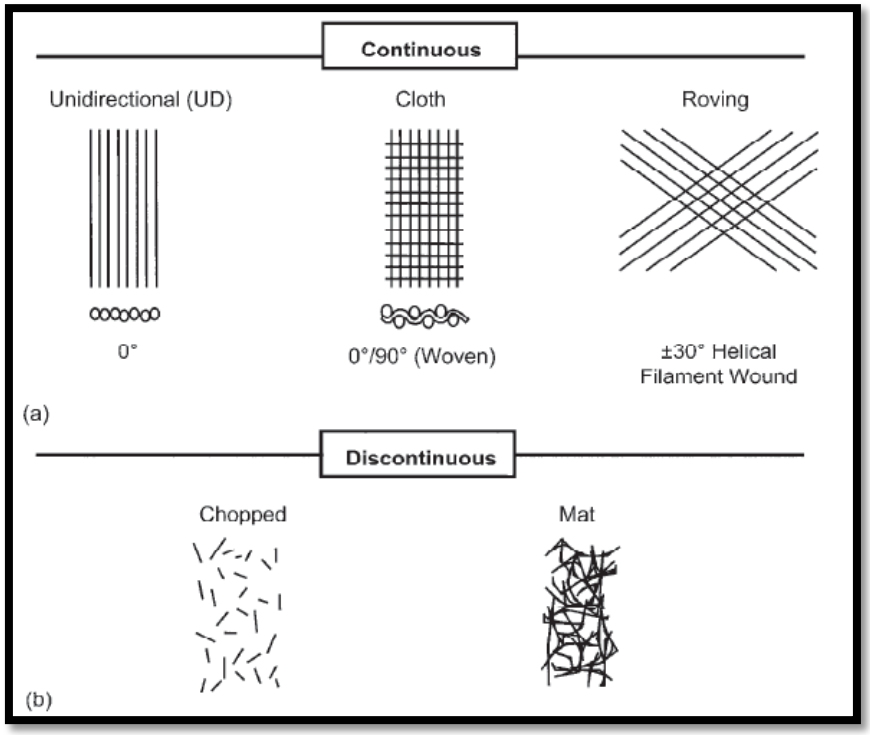


Figure 2.3: the orientation of the fiber (Source: Adrian Petru Pop,2010)

Each material brings its own characteristic such as low strength and stiffness for polymers, medium strength and stiffness but high ductility for metals, and high strength and stiffness but brittle for ceramics.Polymer, metal or ceramic can be restricted as matrix which in continuous phase, the matrix provide some critical acts like keep fibers in the proper orientation, spacing and protect the fibers from abrasion. The matrix transfer loads to the fibers by shear loading at the interface that occurs in polymer and metal matrix composites which formed strong bonding between fiber and matrix. While ceramic matrix composites upgrade the toughness compared to the strength and stiffness, so it produce low interfacial strength bond. The final properties is described by the type and quantity of the reinforcement as shown in figure 2.3 which continuous fiber composites offers highest strength and modulus. (Adrian Petru Pop, 2010)

2.1.1.1 Laminar Composites

A laminar composite is consists of two-dimensional sheets or panels that have a preferred high-strength direction. This laminar composites structure can be found in wood with the similarity of the continuous and aligned fiber-reinforced plastics. The layers are stacked and subsequently cemented together such that the orientation of the high-strength direction varies with each consecutive layer as shown in Figure 2.4 The laminar composite has relatively high strength in a number of directions in the two-dimensional plane because of thelaminations also be constructed using fabric material such as cotton, paper, or woven glass fibers embedded in a plastic matrix. However, the strength in any given direction is, of course, lower than it would be if all the fibers were oriented in that direction. (Msc. ShaymaaMahmood, 2003)

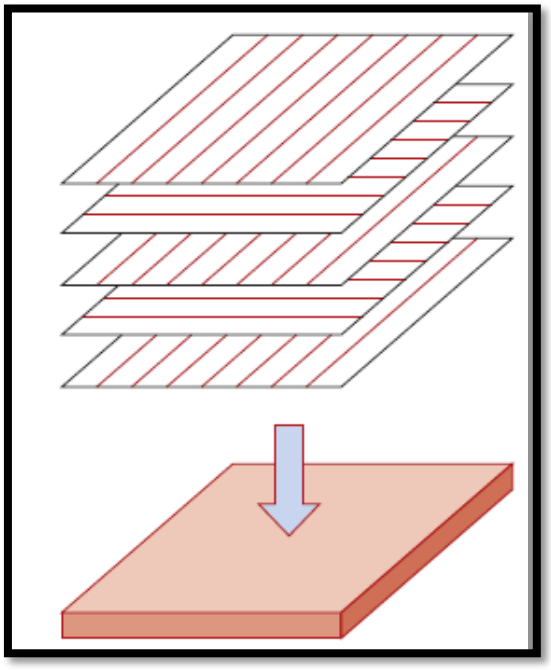


Figure 2.4 The stacking of successive oriented, fiber-reinforced layers for a laminar Composite. (Msc. ShaymaaMahmood, 2003)