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Effect of Number of Layer in Composite Sheet

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Abstract

Composite material is commonly used in most industries: it became a basic substance for generating electric energy in many industries, aircraft , automobile and air turbine Composite material is a big family and it is classified into many kinds like fiber glass which has been frequently used in production, therefore many researches and tests have been made by taking samples and making tensile compression, impact and fatigue test as well as determining the numbers of layers which are the best fiber tensioned resistant, this will be discussed in this research, chapter one is an introduction to composite material and identification of fiber glass and its uses and properties, as well as making a comparison between its strength and the strength of steel, while chapter two, presents the researches, conclusions of previous researchers in the same field, the chapter three includes theories and equations which are used to know the size and thickness of fiber glass, the chapter four is a tensile test that has been made for some samples, the chapter five includes the results of this test, and the future advices for making this test or other tests for fiber glass and other composite materials discussed also.

Key Words: fatigue failure, composite materials

تاثير عدد الطبقات على الصفائح المركبة

الخلاصة

ان المواد المركبة هي من المواد شائعة الاستخدام في معظم الصناعات حيث اصبحت مادة اساسية لكثير من اللصناعات مثل صناعة السيارات. الطائرات والتوربينات الهوائية لتوليد الطاقة الكهربائية وغيرها وهي عائلة كبيرة تتشعب الى عدة افراد منها الفيبر كلاس_Fiber glass الذي اصبح يستخدم بكثرة في الانتاج ولهذا اجرينا عليه هذا البحث وكذلك فحوصات باخذ عينات وجراء فحوصات الشدعليه ومعرفة عدد الطبقات الافضل مقاومة للاجهادات. ويتناول البحث

استخدام الالياف الزجاجيه وخواصه ومقارنته مع المعادن الاخرى كال Steel وهنا كجانب عملي لفحص العينات المصنعة من عدة طبقات كما يتضمن البحث مناقشة النتائج التي تم التوصل اليها.

1. Introduction

1.1. Introduction:-

Composites materials are made by combining two materials where one of the materials is a reinforcement (fiber)and the other material is a matrix(resin).The combination of the fiber and matrix provide characteristics superior to either of the materials alone. Some examples of composite materials are plywood, reinforced concrete, fiberglass versatile and are utilized in a wide variety of applications. The most widely used composite material is fiberglass in polyester resin, which is commonly referred to as just fiberglass. Fiberglass is lightweight, corrosion resistant, economical, easily processed, has good mechanical properties, and has over 50 years of history. [1]

Glass fiber is mean:-The raw material are mixed(silica sand, limestone, fluorspar, boric acid and clay) accounts for more than 50% of the total

1.2 Why use fiber glass composition

There are unique properties of Fiberglass, composites. That make them suitable and desirable for a wide range of product applications. These properties offer huge advantages over other types of construction materials. The advantages of Fiberglass, composites can be generally summarized in the following categories;-

A. Cost Effectiveness:-Fiberglass and composites are very affordable and cost effective solutions for almost any application, component, or part. The costs of engineering and prototyping are relatively low compared with other manufacturing techniques and mediums. Once plugs and molds have been created, parts can be easily duplicated in quantity at extremely cost effective price points. Production up scaling can be cost effectively accomplished by replicating molds and plugs and increasing the number of fabricators; no need to "ramp up" production by investing in expensive machinery and tooling plants in order to increase quantities or speed. Additionally, the non-corrosiveness and durability of fiberglass results in lower costs for maintenance and warranty work. Finally, the end product being lighter and stronger than alternative materials results in additional savings in shipping and storage.

B. Appearance: - This is not your father fiberglass. Today, fiberglass and composites can be gel coated right in the mold with a wide variety of colors and textures to achieve just about any desired look and feel. Fiberglass and composite parts can be finished in flat, semi-gloss, or high gloss. Although fiberglass components can still be painted, the available options for colors and textures virtually eliminate the need for after-production painting.

C. Special properties of Fiberglass:-Fiberglass is dielectric. This means that it is non-conductive and RF transparent. This makes fiberglass ideal for applications where metal housing can affect electronic performance of a product or where electrically conductive metal housings can pose a safety hazard to employ or components .Fiberglass is chemically inert. This means that it will not react chemically with other substances with which it may come into contact. This can prevent potentially hazardous and explosive situations that arise with other metallic or petroleum based materials. Fiberglass also has superior and more desirable acoustic qualities than plastic or metal. Under similar conditions Fiberglass and composites tend to vibrate less and remain quieter than sheet metals. This can reduce the overall operating volume of your machinery and even help you achieve acceptable or required sound levels for your equipment. For even more sound deadening capability. Fiberglass and composites can layered with matte material in order to achieve the desired level of acoustic deadening

1.3. Compare between steel conduit and fiber glass conduit

Rigid steel and PVC- coated rigid steel conduits are principally made from hollow , carbon steel tubular with either zinc , organic or a combination of zinc organic coatings applied for corrosion protection. An interior and exterior coating of zinc or of PVC (organic) coating provide superior corrosion protection for the base steel tube . Rigid steel conduit with a PVC coating over galvanize is used in many corrosive applications to provide increased protection for the base metal. The choice of three rigid steel conduit products is available for application in the specified corrosive environment and all three products are assembled into a conduit system with threaded connections. Superior electrical conductivity makes rigid metal conduit useful for electrical shielding and safe operation. Fiberglass conduit is made from an epoxy and fiberglass hollow tubular fabricated with high-speed winding equipment and high temperature curing ovens. Since the epoxy and fiberglass do not oxidize like metals, supplemental coatings are not required for corrosion protection. Although fiberglass conduit does not oxidize like metal, it will deteriorate in some application environments such as sulfuric acid, hydrochloric acid and sodium hydroxide on the epoxy blend and the corrosive concentration. Fiberglass conduit sections are fabricated with several different end designs that are joined with an epoxy adhesive. Underwriters Laboratories and the Canadian Standards Association evaluate the performance and list conduit according to the respective metal and fiberglass conduit standards. Since the products are different, the standards and tests required to list fiberglass and metal conduit are significantly different. Listing means that the fiberglass or metal conduit meets the specifications for its respective standard. It is the responsibility of the user or designer to select the appropriate conduit for the specific application. The national Electric Code(NEC) contains references to a number of listed conduit types, but it is not a design manual. This paper provides additional aid to help with the decision. [2]

1.4. Differences exist between the physical properties of rigid steel and fiber glass conduit:-

A partial listing to compare the physical property differences between rigid steel or PVC-coated rigid steel and fiberglass conduit appear in the table at the top of the next page. With the exception of the corrosion protection coating, the PVC- coated steel conduit and rigid steel conduit have the same physical properties. The values in the table are typical values published by steel and fiberglass conduit manufacturers. Obviously steel and fiberglass are different materials and have significantly different properties. These differences must be evaluated in light of the conduit system function. One must determine which conduit system provides the best protection for the enclosed wiring or cable system in the application environment and under the application conditions. The corrosives present in the environment; the physical properties required; and the economic factors should be carefully considered. Properties of fiberglass:-

a. Installation:-

Commercial equipment and trained, contractor personnel familiar with the bending procedures are readily available for steel conduit. steel conduit offsets have been successfully implemented for years in an infinite number of installation in numerous application. special bending equipment is required to make offsets for fiberglass conduit .training and special skills are required to make fiberglass conduit field offsets

b. Weight:-

Benefits that fiberglass conduit cannot Fiberglass conduit is lighter weight than rigid steel or PVC-coated rigid steel conduit. This property offers an advantage when designing the support system; however, the added weight of steel conduit provides significant application benefits including better fulfillment of the primary goal, protection of wiring from physical damage. As outlined above the steel conduit and the coupling method will protect better against unexpected impact. Loads. It also provides security provide without additional measures.

c. Corrosion protection:-

corrosion protection is unique the environment, but a comparison of the published corrosion resistance tables for fiberglass conduit and PVC coated steel conduit show that PVC coated steel conduit has application in several environments not recommended for fiberglass conduit. An example where PVC coated conduit is better than epoxy fiberglass is sulfuric acid dependent on the temperature and concentration. This is a function of the corrosives that appear in the application environment and is unique to the application. Corrosion protection must be evaluated for the specific application.

d. High tensile strength:-

Fiber glass is one of the strongest textile fibers, having greater specific tensile strength than steel wire of the same diameter ,at low weight .

e. Impact strength:-

Impact test loads are normally expressed in ft-lbs or in-lbs; the published impact value for trade size 4 fiberglass conduit is 180 lbs. at -40F (-40C). It is unclear from the published data exactly how the impact resistance of fiberglass conduit was determined or reason it is not expressed in ft-lbs or in-lbs. Trade size 4 rigid steel conduit has a confirmed test impact resistance of 375 ft-lbs. If the published fiberglass value of 180 lbs is actually 180 ft-lbs, then the rigid steel conduit has twice the impact strength of similar size fiberglass conduit.

f. Dimensional stability:-Fiber glass has low elongation under load, generally 3%or less. Glass fiber produce fabrics with excellent dimensional stability under various type of condition.

g. High heat resistance:-Fiber glass has excellent heat at relatively low cost fiber glass retain of approximately 50% of room temperature tensile strength 700F;25% at 900%,with a softening point of 1555F and a melting pointof2075F

h. Failure Modes;-

The failure modes of fiberglass and steel conduit are significantly different. The primary function of the conduit system is to protect the wire or cable contained therein. A large impact load will dent the steel conduit; under a similar impact load fiberglass conduit will probably fracture. The fracture will expose the internal wiring to the environment. Water and other corrosive elements now have direct access to the fiberglass filaments and water will wick along the individual filaments causing additional damage. If the dented area on coated steel conduit has penetrated the PVC coating, the galvanize coating on the conduit will continue to offer protection. Touch-up compound can be painted over the damaged area to provide additional protection The effect of increase and decrease of perlon and fiber glass layer on mechanical and physical properties are examined subjected the eight two manufacturing sample of the different fourteen group of lamination to tensile and flexural test.[3]

2. previous researches

Gul Hameed Awan1et,al: Unsaturated polyesters are important matrix resins used for glass fiber reinforced composites/ plastics. The strength of fiber glass reinforced polyester composite is mainly related to the glass content of the material and the arrangement of glass fibers.[4]
H.Y.Yeh et,al :Study investigated the Yeh -Stratton Failure Criterion with the stress concentration on fiber reinforced composites materials under tensile stresses. The Yeh-Stratton Failure Criterion was developed from the initial yielding of materials based on micromechanics[5]
Kulkarin SM, Kishore et,al :There has been significant increase in use of glass fiber reinforced composites as structural materials in naval mine countermeasure surface ships. Sea mines when detonated emit underwater shock waves, which could impart severe loading to naval ship structure; there are attempts to model the response of a ship structure to this loading[6]
N.vaidya, B.pourdeyhimi et,al **:**The potential for manufacturing a non woven perform for composite using blends of glass and low melting polyester or bi component sheath\core (polyester\polyethylene) fiber is demonstrated .Wet-lay webs were hydro entangled to form strong, flexible perform that could be easily manipulated for the production of compression molded composite[7]
Scott W. Davey et,al: With the increase use the fiber reinforced polymer (FRP)composite in civil engineering structure , the is growing realization of the need developed new structural systems which can utilize the unique characteristics of these material in more efficient and economical manner[8]
Gwangjin et,al **:**The objective of these study is to investigate the tensile behavior and fracture toughness of glass fiber reinforced aluminum hybrid laminates in association with fracture process using plain coupon and singl-edge-notched specimen[9]..Y.SHAN, K.LIOA: Unidirectional glass fiber and carbon fiber (glass to carbon fiber volume ratio (3:1) epoxy matrix composite tested at 85% of average ultimate tensile strength (UTS), The detrimental effect of water become apparent at lower stress level of cycle when loaded in water, hybrid showed better retention in structural integrity under environmental fatigue for live up glass carbon hybrid composite. [10]

3. Theory

Mechanics of a unidirectional ply

Ply or lamina is the simplest element of a composite material an elementary layer of unidirectional fibers in a matrix (Fig1) formed while a unidirectional tape impregnated with resin is placed on the surface of the tool providing the shape of a composite part.

3.1. Ply architecture

As the tape consists of tows (bundles of fiber) the ply thickness (whose minimum value is about 0.1 mm for modern composites) is much higher than the fiber diameter (about 0.01 mm). in an actual ply , the fibers are randomly distributed as in (Fig2) Because the actual distribution is not known and can hardly be predicted, some typical idealized regular distributions, square(Fig3) hexagonal (Fig4) and layer-wise (Fig5) are used for the analysis.
Composite ply consists of two constituents: fibers and matrix whose quantities in the materials are specified by volume ,v , and mass, m, fractions.

$Vf = Vf / Vc$,$vm=Vm/Vc$ …. (1)

$Mf =Mf/Mc$, $mm=Mm/Mc$…. (2)

Here, V and M are volume and mass, while subscript "f", "m", and "c" correspond to fibers, matrix, and composite material, respectively. Because $Vc= Vf+Vm$ and $Mc=Mf+Mm$, we have

$Vf+Vm=1$, $Mf+Mm=1$ ….(3)

There exist the following relationships between volume and mass fractions $vf=pc/pf*mf$,

$vm=pc/pm*mm$ ….(4)

Where *pf*, *pm*, are *pc* are densities of fibers, matrix ,and composite. In analysis, volume fractions are used because they enter the stiffness coefficients for a ply, while mass fractions are usually measured directly during processing or experimental study of the fabricated material.

3.2. Fiber –matrix interaction

3.2.1. Theoretical & actual strength

The most important property of advanced composite material is associated very high strength of a unidirectional ply accompanied with relatively low density .This advantage of the material is provided mainly by fibers. Correspondingly a natural question arises as to how such traditional light weight material like glass or graphite that were never applied as primary load –bearing structural material can be used to make fiber with the strength exceeding the strength of such traditional structural material as aluminum or steel. The general answer is well known : strength of a thin wire is usually much higher than the strength of the corresponding bulk material. This `is demonstrated in the wire strength increases while the wire diameter is reduced.

3.2.2. Stress diffusion in fiber interaction through the matrix

The foregoing discussion concerned individual fiber or bundles of fiber that are not joined together. This is not the case for composite material in which the fiber are embedded in the matrix material. Usually the stiffness of matrix is much lower than that of fiber and the matrix practically does not take the load applied in the fiber direction. But the are fact that the fiber are joined with the matrix even having relatively low stiffness changes the mechanism of fiber interaction and considerably increases their effective strength. To show this the strength of dry fiber bundled can be compared with the strength of the same bundled after they were impregnated with epoxy resin and cured . Composite bundles in which fiber are joined together with matrix demonstrated significantly higher strength and the moderate the fiber sensitivity to damage, the higher is the difference in strength of dry and composite bundles. The influence of matrix on the variation of strength is even more significant, (Fig6)

3.3. Micro mechanics of a ply

Consider a unidirectional composite ply under the action of in-plane normal and shear stresses in (Fig7). Because normal stresses do not change the right angle between axes 1 and 2, and shear do not cause elongation in the longitudinal and transverse direction 1and2.[11]

4. Experimental Investigation

4.1. Introduction:-

Two different can be used to lay-up primary reinforcement on tapered scarf joint .One different is to lay-up the smallest ply first with each successive ply being slightly larger. The plies should butt up to the scarf. Each ply should be cut slightly oversize so that it can be trimmed as it is being laminated in placed. Avoid using undersized plies, as this would create the resin rich pocket along the bond line resulting in weaker joint. A second different is to plies parallel to the scarf. This approach tend to required more finishing work to blend the repair in to the existing laminated , repaired done with the largest ply first will produced a superior secondary bond for heavily loaded repair.

4.2. Manufacture in process:- The most common manufacturing process for fiberglass is the wet lay-up process using an open mold. the shape of the part is determined by the shape of the mold, and the mold surface is typically in contact with the exterior of the part. Mold release is first applied to the mold to prevent the fiberglass part from adhering to the mold. Then gel coat, which is pigmented resin, is applied to the mold give the part color. Fiberglass and resin are then deposited on to the fiberglass is compressed by rollers, which evenly distributes the resin and removes air pockets. Multiple layers of fiberglass are deposited until the desired thickness is achieved. When the resin is cured, the part is removed from the mold. Excess material is trimmed off, and the part is ready for paint and assembly. There are also closed mold processes for making fiberglass parts. using the tooling in the manufacturing process.[12]

4.2.1 Mold:-

Molds are used to define the shape of the fiberglass parts. The fiberglass part will pick up all shapes and features of the mold; therefore the quality of the part is heavily influenced by the quality of the mold. The molds can be either male or female. The female molds are the most common and they will produce a part with a smooth exterior surface while a male mold will produce a smooth for very short production interior surface thruns (less than 10 part), temporary molds can be made from wood, foam, clay or plaster. These molds are economical and can be fabricated quickly, which foam, clay or plaster. These molds are economical and be fabricated quickly, which will allow inexpensive prototype parts to be fabricated. For larger volume production, molds are typically made with fiberglass. These molds have a life expectancy of 10+ years and 100+ cycles. Fiberglass molds are inexpensive and usually cost(5 to 10)times the price of the part.[13]

4.2.2 Glass Fiber:-

Glass fiber type E-glass is among the most versatile industrial materials known today. They are readily produced from raw materials, which are available in virtually unlimited supply. All glass fibers described from compositions containing silica.[14]

4.2.3 Epoxy resins:-

Are a class of thermosetting materials (**Epoxy 110**) used extensively in structural and specialty composite. Applications because they offer a unique combination of properties that are unattainable with other thermoset resins available in a wide variety of physical forms from low-viscosity liquid to high- melting solids, they are Epoxies offer high strength, low shrinkage, excellent adhesion to various substrates, effective electrical insulation, chemical and solvent resistance.

5. Results and Discussion:-

5.1 Introduction:-

The Yield strength is define as the stress yield strength A value called applied to the material at which plastic deformation start to occur while the material is loaded.
And the Ultimate one of the properties you can determine about the material is the (UTS). This is the maximum load the specimen sustain tensile strength during the test. The (UTS) may or may not equate to the strength at break. This all depend on what type of material you are test, brittle or substance that even exhibit both properties and sometime ductile a material may be ductile when test in lab, when placed in service and exposed to extreme cold temperature it may transition to brittle behavior.

5.2Results:-

The tensile test .were made to study the influence of the layer distribution and extension. Plotted the (Fig8) are the force loading obtained for the one-layers and (2mm) thick. The curve represent the average data of tension test for a given test condition. The result is shown that the material has linear to elastic regain behavior. This behavior is strongly the matrix and shown the sample is need the lower force to break of sample and obtained the result of yield (1%), max stress(18.29 Mpa), extension is (1.5mm). (Fig9) shown the 2nd sample and loading curve obtained for the two-layers and (2mm) thickness, the curve represent the average data of tension test it was clear that the sample is need the medium force to break of sample and obtained the result of yield(0.94%), max stress(24.44Mpa), extension is (1.91mm). (Fig10) shown that the 3rd sample shown and loading curve obtained for the three-layers and (2mm) thickness, the curve represent the average data of tension test it was clear that the sample is need larger force to break of sample and obtained the result of yield (1.21%), max stress (36.8Mpa), extension is (1.95mm), The last result it was explain the third-layers was strongest the sample in test of fiber glass.

(Fig11) shown that the 4th sample shown and loading curve obtained for the one-layers and (3mm) thick the average data of tension test it was clear that the sample is need medium force to break of sample and obtained the result of yield (0.57%), max stress(15Mpa),extension is (1.4mm). (Fig12) shown that the 5th sample shown and loading curve obtained for the two-layer and (3mm), the curve represent the average data of tension test it was clear that the sample is need larger force to break the sample and obtained the result of yield(1.2%), max stress(24Mpa), extension is (2.25mm). (Fig13) shown that the 6th sample shown and loading curve obtained for the three-layer and (3mm), the curve represent the average data of tension test it was clear that the sample is need lower force to break the sample and obtained the result of yield(0.6%), max stress(7.83Mpa), extension is (1.1mm). The last result it was explained the two-layer was strongest the sample because it was need larger force to failure. (Fig14) shown that the 7th sample shown and loading curve obtained for the one-layer and (4mm), the curve represent the average data of tension test it was clear that the sample is need larger force to break the sample and obtained the result of yield (2.2%), max stress(30.17Mpa), elongation is (2.7mm). (Fig15) shown that the 8th sample shown and loading curve obtained for the two-layer and(4mm), the curve represent the average data of tension test it was clear that the sample is need medium force to break the sample and obtained the result of yield (0.9%), max stress (25.7Mpa), extension is (1.4mm). (Fig20) shown that the 9th sample shown and loading curve obtained for the three-layer and (4mm), the curve represent the average data of obtained the result of yield(2.9%), max stress(19.26Mpa), extension is (5.21mm).The result it was explained the one –layer was strongest the sample because it was need larger force and stress to failure, shown table (1).[16]

6. Conclusion and recommendations

It is necessary to use composite material in industries for its privileges like availability of its resources in nature and cheapness of its cost and environment resistance .As a result, it became an economic and consumptive material and it was easily used in industries. Fiber glass which is a title for my research is a cheap material and it is easily manufactured, it could be manufactured by splash or lay-up and other methods. Matrix which helps in fastening is available like polyratharame polyester which is frequently used in Iraq; it is one of the best materials that are used in strengthening and electro thermal isolation.

1- In my research, it found that it is not difficult to explain in details the properties of this composite material but it is interesting for the availability of many resources.

2- Apart from that, nobody is ignorant about the composite material; there is no office or house that does not have a device or machine that is manufactured of composite material.

3- In the future, advise another researcher to investigate on another material like (poly wood, reinforcement) and make another tests like (compression, fatigue, impact), and it is possible to make tensile test on a three-dimension sample, while a one-dimension sample has been used in my research

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Table 1: The nine samples with loads

sample	Thickness (mm)	Width (mm)	Yield MPA	Yield%	Max Stress MPA	Extension mm
2mm thickness,1-Layer	2.600	15.20	18.29	1.000	18.29	1.5
2mm thickness ,2-Layer	2.300	14.80	16.69	0.940	24.44	1.91
2mm thickness,3-Layer	2.700	14.70	28.76	1.210	36.89	1.95
3mm thickness,1-Layer	2.200	15.20	10.61	0.570	15.00	1.4
3mm thickness,2-Layer	3.200	15.30	15.01	1.200	24.00	2.25
3mm thickness,3-Layer	3.300	16.00	7.83	0.680	7.83	1.1
4mm thickness,1-Layer	3.800	14.90	30.02	2.220	30.17	2.7
4mm thickness,2-Layer	2.700	15.50	23.33	0.950	25.72	1.4
4mm thickness,3-Layer	3.200	15.30	13.79	2.910	19.26	5.21

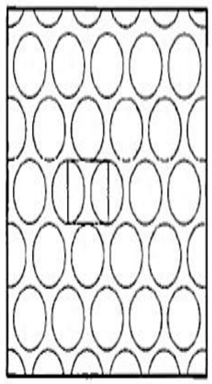


Fig 5 layer-eise fiberdistribution the cross-section of aply(vr=0.65)

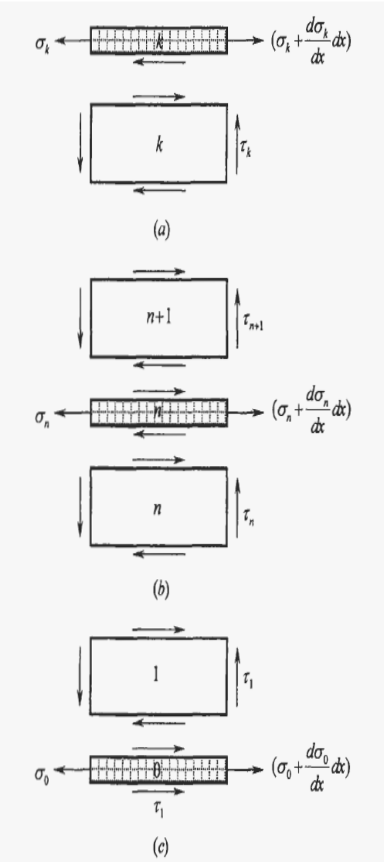


Fig. (6): Stresses acting in fibers and matrix layers for the last (a). arbitrary n^th^ fiber (b). and the central n=0 fiber (c)

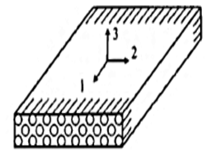


Fig 1 Aunidirectional ply

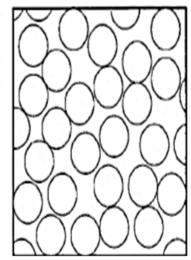


Fig 2 Actual fiber distribution in the cross-section of aply v_f=0.65

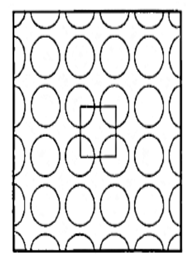


Fig 3 Square distribution the cross-section of aply(vr=0.65)

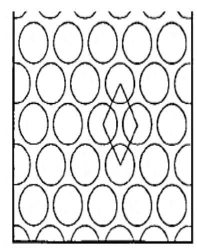


Fig 4 Hexgonal fiber distribution the cross-section of aply(vr=0.65)

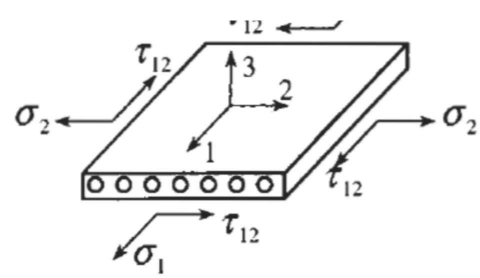
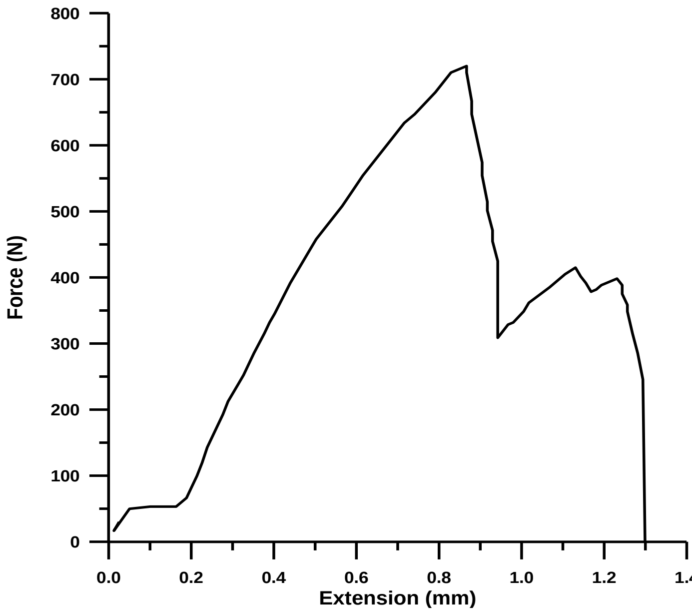
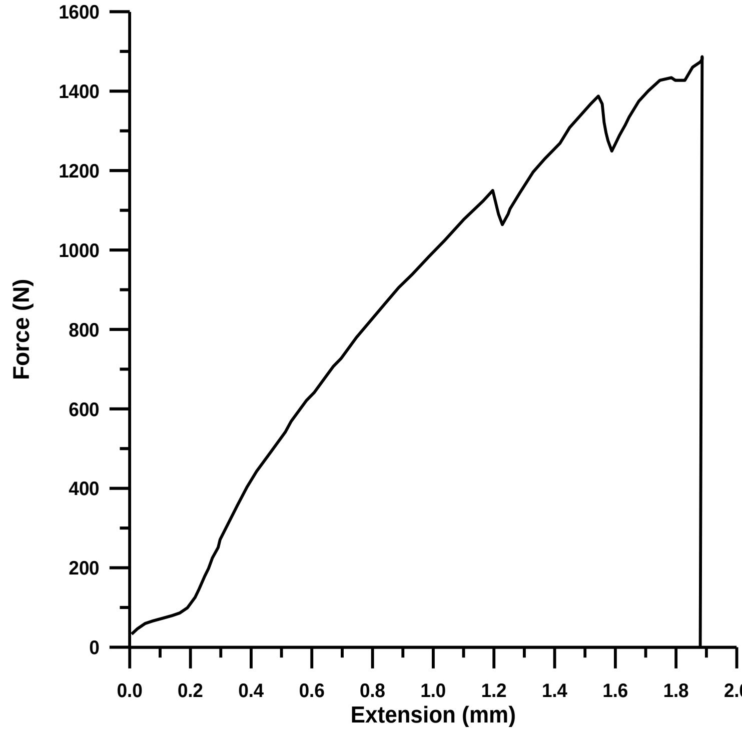


Figure 7: A unidirectional ply under in-plane loading



Figure(8): 2mm thickness, 1-Layer



Figure(9): 2mm thickness, 2-Layer

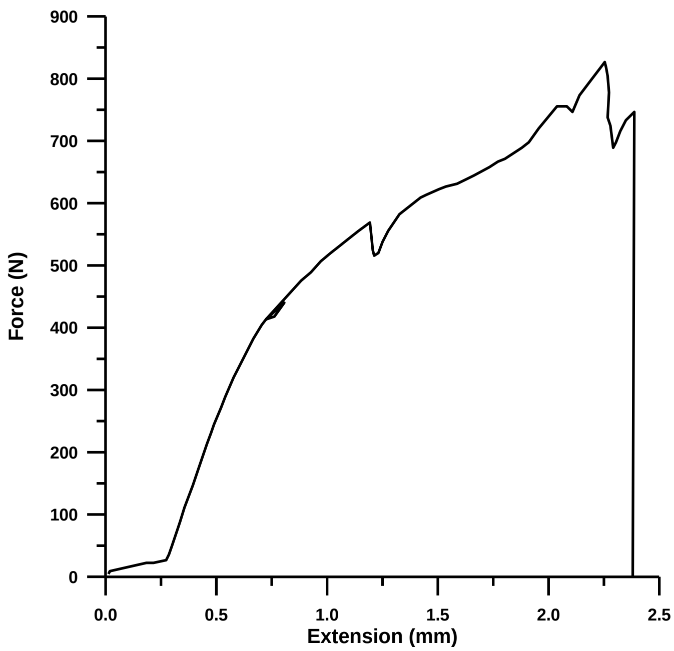


Figure (10): 2mm thickness, 3-Layer

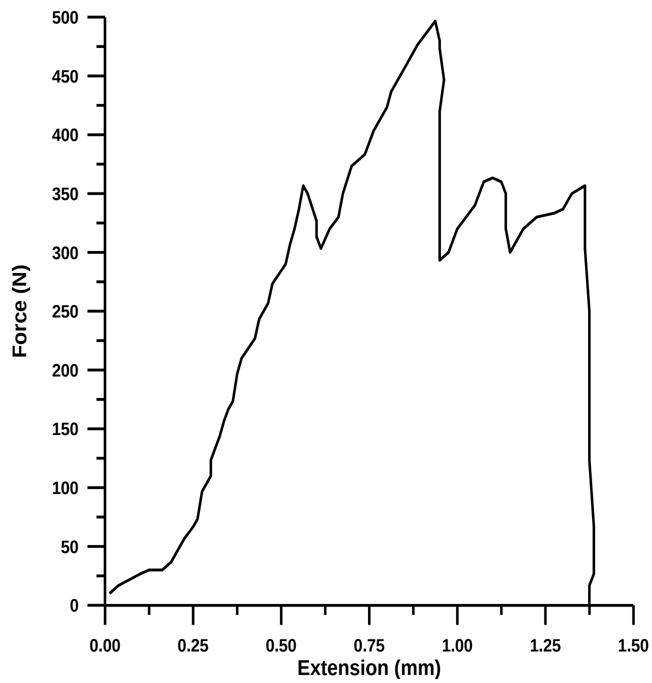


Figure (11): 3mm thickness, 1-Lay

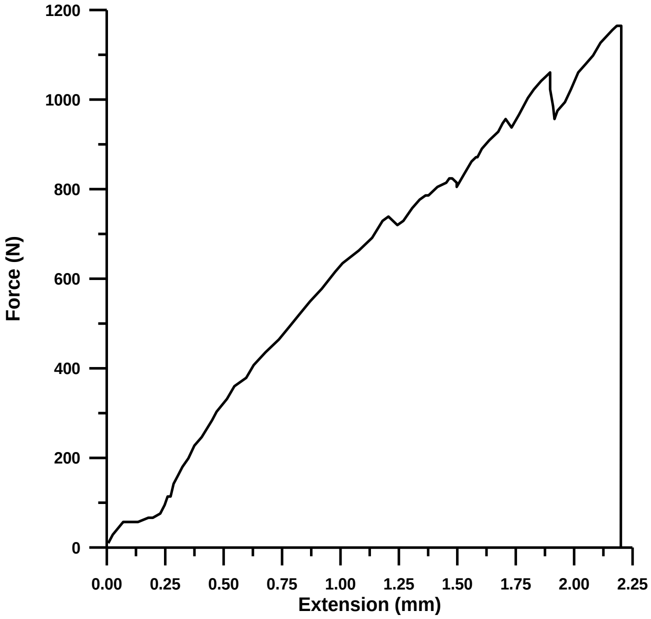


Figure (12): 3mm thickness, 2 Layer

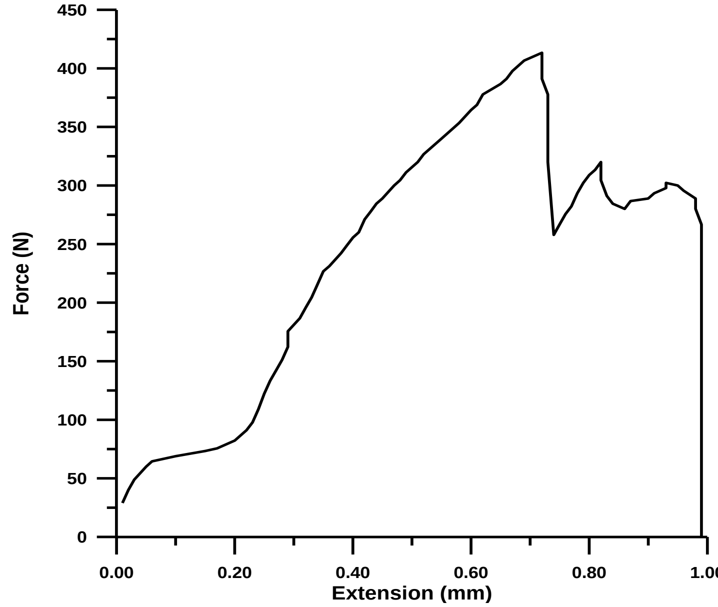


Figure (13): 3mm thickness, 3 - Layer

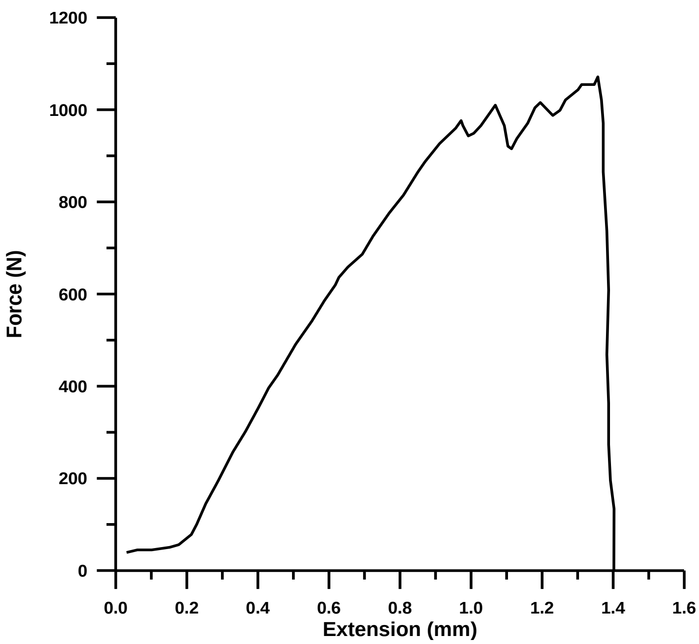


Figure (14): 4mm thickness, 2- layer

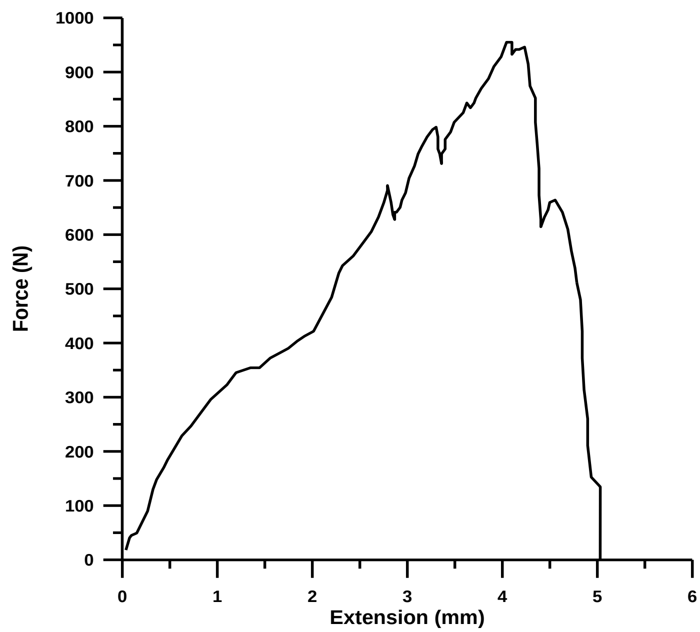


Figure (15): 4mm thickness, 3- Layer