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Hardness Assessment of Hybrid Composite CFRP and GFRP

A. F. Ab Ghani, M.Y Yaakob, M.N. Salim, J Mahmud

ABSTRACT:This paper out of the blue surveyed the Hardness Properties of Hybrid Composite of Carbon Fiber Reinforced Polymer (CFRP) and Glass Fiber Reinforced Polymer (GFRP). These composites are generally utilized for some businesses, for example, aviation and car enterprises. Blend of the two composites to upgrade mechanical properties and lessen cost which results in progress, for example, elastic, compressive and shear properties has likewise influences other critical property, for example, hardness. Hardness testing with smaller scale hardness analyzer utilizing pyramid shape indenter at 136° had been performed to examine the connection and impact. The examples utilized were carbon fiber fortified polymer (CFRP), glass fiber strengthened polymer (GFRP) and cross breed piece of CFRP and GFRP utilizing seven different plan. All hardness information was set up to demonstrate the positioning of hardness esteem among the examples utilized. Hardness investigation was talked about to display the finding got. The point of the examination is to explore the distinctive game plan of CFRP/GFRP with respects of its hardness, and benchmarking with other mechanical properties, for example, Modulus of Elasticity, E and Tensile Strength, UTS of half breed composite, demonstrated that hardness esteem for mixture composite fall in the middle of the CFRP and GFRP hardness individually.

KEYWORDS:Hardness test, Hybrid composite, CFRP, GFRP, Micro hardness

1. INTRODUCTION

Half and half composite or distinctive structure of composite is the support of a typical network by at least two kinds of fiber. They have better adaptability contrasted with other fiber strengthened composites. Typically they join a high-modulus fiber with the one on low modulus fiber[1,2]. The high-modulus fiber gives the firmness and burden bearing characteristics, while the low modulus fiber makes the composite progressively solid and low in expense. The hardness think about is performed for half breed composite where cross breed contains at least two sorts of fiber.

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A. F. Ab Ghani, M.Y Yaakob Faculty of Engineering Technology,
Universiti Teknikal Malaysia Melaka,Locked Bag 1200, Hang Tuah Jaya, 75450 Ayer Keroh, Melaka, Malaysia
M.N. Salim Faculty of Mechanical Engineering,
Universiti Teknikal Malaysia Melaka,Locked Bag 1200, Hang Tuah Jaya, 75450 Ayer Keroh,Melaka, Malaysia
J Mahmud Faculty of Mechanical Engineering,
Universiti Teknologi MARA, 40450, Shah Alam, Malaysia, Malaysia

The benefits of one kind of fiber could supplement with what are deficient in the different when contrasted with CFRP and GFRP [3]. Hypothetically, unique piece of composite has hardness esteem at the center among CFRP and GFRP [3,4]. The progression in the utilization of half and half composite particularly CFRP/GFRP in different application including aviation, marine and foundation has further yield the enthusiasm to examine the upside of crossover composite mechanical properties when contrasted with ordinary composite [5]. The point of the examination is to research the impact of various layup plan of half and half composite CFRP/GFRP concerning its hardness esteem and correlation with its gauge constituent of CFRP and GFRP separately. Hardness is characterized as obstruction of a material to restricted distortion. The disfigurement can occur from space mode, bowing or slicing [6].Hybrid composite are relied upon to have better adaptability because of joined fiber fortified composites when contrasted with every constituent of composite. For example CFRP/GFRP half breed composite comprises of a high modulus of flexibility fiber (CFRP) and GFRP (low modulus of versatility fiber). The higher modulus of versatility fiber offers solidness and burden holding capacity while the low flexibility fiber makes the half and half composite stronger and more savvy. Amid smaller scale hardness test try, the spaces are insignificant and processed utilizing a magnifying instrument. Hardness of various miniaturized scale constituents can be estimated together with hardness slopes as experienced in the event that solidifying conduct [7,11].

2. HARDNESS TESTING

Hardness estimation can be partitioned into two segments that are large scale hardness and smaller scale hardness test[3].

a) Macro hardness

Full scale hardness estimation of materials is a strategy for get mechanical property information for the mass material from a little example. It is likewise generally utilized for the quality control of surface medicines forms.

b) Micro hardness

Microhardness is the hardness of a material as dictated by constraining an indenter, for example, a Vickers or Knoop

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indenter into the outside of the material under 15 to 1000 gf load. Ordinarily, the spaces are so little and they should be estimated utilizing a microscope[3,6].

2.1 Microhardness Testing Method : Vickers Microhardness

Hardness analyzer utilized in this examination was Vickers Micro Hardness analyzer at Materials Testing Lab, Faculty of Mechanical and Manufacturing, Universiti Tun Hussein Onn (UTHM), Johor with indenter of pyramid shape at edge 136° as appeared in Figure 1 and Figure 2. Examples are cut at measurement 3cm X 3cm as appeared in Figure 3. The test load utilized for CFRP, GFRP and all kind of Hybrid Composite were 2.942 N (HV 0.3). The motivation behind why these heap utilized depends on space impact delivered for every case and dependent on preliminary outcomes accomplished after burden was connected. The pyramid shape indenter was applied superficially 3 chose purposes of all examples as shows in Figure 4. From that point onward, hardness esteem was recognized after indication of pyramid shape was framed on the outside of example utilizing HMV AD programming for example immaculate space was performed. This product assumes the significant job in ascertaining hardness esteem when hardness test was completed. The Micro hardness trial of ASTM E-384 indicates a scope of light loads utilizing a jewel indenter to make a space which is estimated and changed over to a hardness value[6,10]. The outcome is in a weight estimation. Vickers hardness is a proportion of the hardness of a material, determined from the measure of an impression delivered under burden by a pyramid-formed jewel indenter [6]. The higher the number on scales implies the harder the material. Nine (9) kinds of test dependent on various composite have been set up by utilizing prepreg restored at 120º Degree temperature and 6 Bar of weight. The course of action of half breed composites are appeared in organized structure in Table 1.

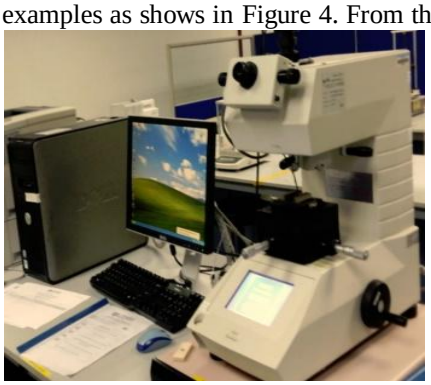

Figure 1: Microhardness testing machine

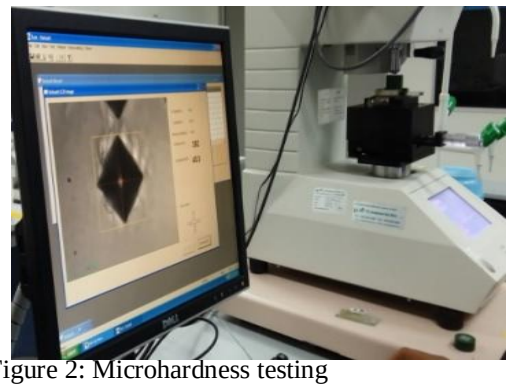

Figure 2: Microhardness testing which linked with inbuilt software

2.2 Configuration/Material Layup of Hybrid Composite

Table 1: Arrangement of composite material for Vickers microhardness test.

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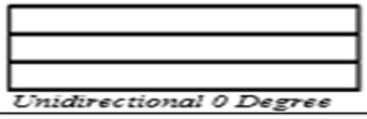
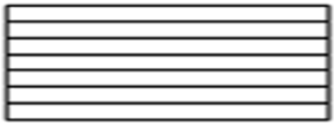
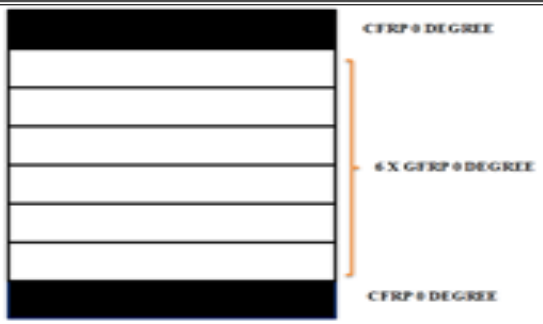
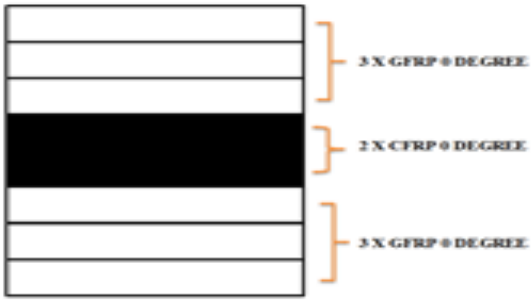
Composite	Arrangement of composite layup	Thickness (mm)
CFRP	 Unidirectional 0 Degree	1.2
GFRP	 7 X GFRP Unidirectional 0 Degree	1.1375
Hybrid A		2.3
Hybrid B		1.2875
Hybrid C		1.85
Hybrid D		1.72

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Composite	Arrangement of composite layup	Thickness (mm)
Hybrid E	CFRP 0 DEGREE GFRP 0 DEGREE CFRP 0 DEGREE GFRP 0 DEGREE CFRP 0 DEGREE GFRP 0 DEGREE CFRP 0 DEGREE	2.39
Hybrid F	2 X CFRP 0 DEGREE 3 X GFRP 0 DEGREE CFRP 0 DEGREE	2.07
Hybrid G	CFRP 0 DEGREE 6 X GFRP 90 DEGREE CFRP 90 DEGREE	1.81

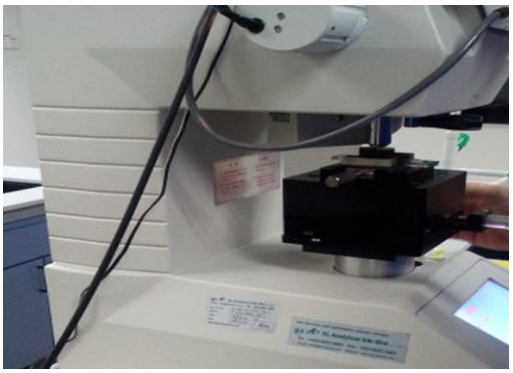

Figure 3: Sample undergoing microhardness testing

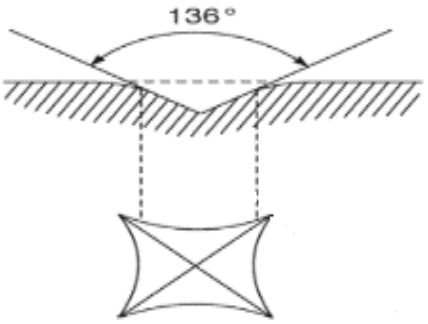

Figure 4: Pyramid shape indenter

The hardness stress is communicated as the mean weight on a surface-anticipated contact territory of distance across, d, got under a round ball indenter having measurement, D. The powerful strain is communicated as (d/D). The point at 136° of indenter from Vickers Micro hardness analyzer utilized is equivalent to alluring proportion of indention ball measurement (d/D = 0.375) in Brinell hardness test.

3. RESULTS

3.1 Hardness Result for all specimen - *Carbon Fiber Reinforced Polymer (CFRP)*

The hardness test was conducted at two specimen that are specimen one and specimen two. For each specimen, 3 points are taken as measurement point and two times for each point are taken then the values are averaged. 6 points labeled in the

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results correspond to point 1,2,3 for Specimen 1 and 4,5,6 for Specimen 2. This strategy is additionally proposed by other analyst where hardness was estimated at three distinct areas of the example and the normal esteem was determined [8]. The result for CFRP Hardness value is shown in Figure 5. The results show the value of all Vickers hardness (HV) at the range from 88.45 to 100.28. The indention of pyramid shape formed on the surface as seen on microscope was almost perfect. Carbon fiber reinforced polymer (CFRP) has orthotropic material properties and normally indention on isotropic body surface such as steel or metal can obtain perfect shape of indention[10].

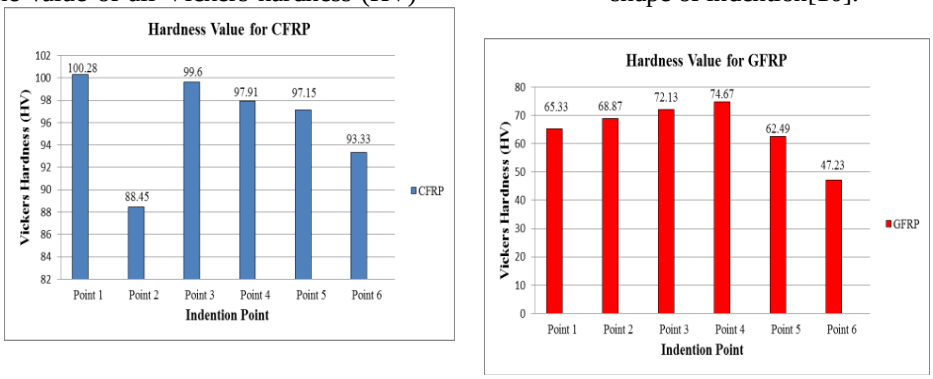

Figure 5: Hardness Value for CFRP and GFRP

Glass Fiber Reinforced Polymer (GFRP)

The value of both specimens was calculated as average hardness value. The number of layers used was shown in Table 1. The result of hardness is shown in Figure 5. The results show the value of all Vickers hardness (HV) at the range from 47.23 to 74.67.

3.2 Hybrid Composite Hardness

The hardness test was carried out at two specimen that are specimen one and specimen two. The value of both specimens was calculated as average hardness value. Then, all result shows in Figure 4.3. The results show the value Vickers hardness (HV) at the range from 67.67 to 76.28 for Hybrid A as depicted in Figure 6. Hybrid B produces the value Vickers hardness (HV) at the range from 71.03 to 75.67 as shown in Figure 7.The results of Vickers hardness (HV) for Hybrid C is at the range from 74.76 to 80.27 as per Figure 8. The results for Hybrid D show the value of Vickers hardness (HV) at the range from 57.41 to 62.91 as shown in Figure 9. Vickers hardness (HV) for Hybrid E is at the range from 68.9 to 79.12, Vickers hardness (HV) for Hybrid F is at the range from 70.32 to 76.92 and Vickers hardness (HV) for Hybrid G is at the range from 71.42 to 76.29 are all depicted in Figure 9, Figure 10 and Figure 11 respectively.

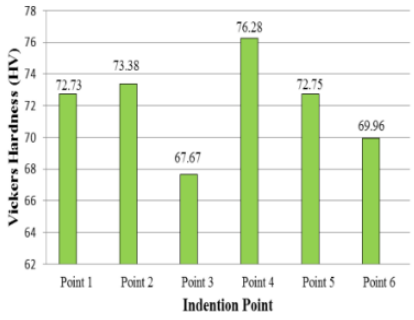

Figure 6: HV for Hybrid A

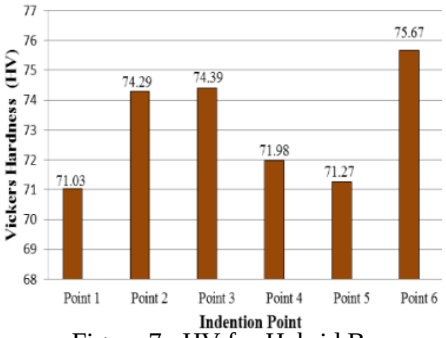

Figure 7: HV for Hybrid B

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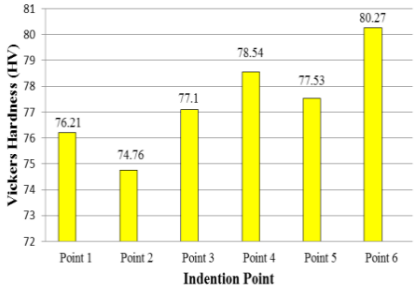

Figure 8: HV for Hybrid C

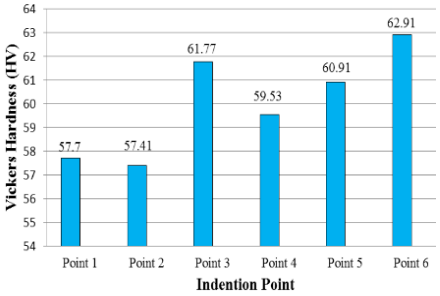

Figure 9: HV for Hybrid D

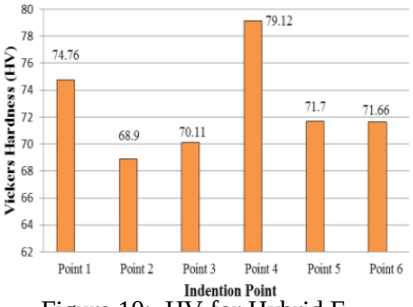

Figure 10: HV for Hybrid E

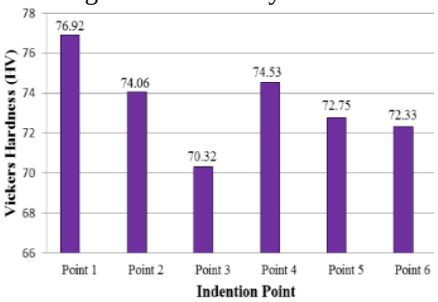

Figure 11: HV for Hybrid F

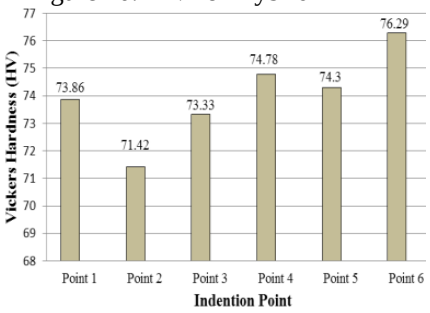

Figure 12: HV for Hybrid G

Table 2: Summary of Hybrid Composite Hardness Value

Type of Composite	Stress (GPa)	Strain (d/D)	Rank
CFRP	0.9830	0.375	1
Hybrid C	0.7870	0.375	2
Hybrid E	0.7759	0.375	3
Hybrid F	0.7544	0.375	4
Hybrid G	0.7482	0.375	5
Hybrid A	0.7481	0.375	6
Hybrid B	0.7421	0.375	7
GFRP	0.7323	0.375	8
Hybrid D	0.6170	0.375	9

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4. DISCUSSION

4.1 Comparison on all Sample Hardness Result

Based on the result, hardness value of carbon fiber reinforced polymer (CFRP) is highest that is 100.28 HV. Besides that, the glass fiber reinforced polymer (GFRP) has 74.67 HV. This is anticipated due to the fact that modulus of elasticity of CFRP (120-130GPa) is far higher than GFRP(45-65GPa) which related to resistance of material to deformation under indentation behavior[1,7].The average value of Vickers Hardness values for all composite under testing is shown in Figure 13. The results for hybrid composite hardness values obtained lies between the range of CFRP and GFRP. This is related to the fact that for modulus of elasticity theory for hybrid composite computed using theoretical technique (CLT with inclusion of extensional matrix [A], coupling matrix [B],bending matrix [D]) will yield that it range in between the values of CFRP single composite and GFRP single composite[2,5].This is also in parallel with findings obtained from [4,8] where they found that hardness of CFRP has high higher value than hybrid composite (CFRP/GFRP) and GFRP alone. They further obtained the difference between percentage of incremental of carbon content in the hybrid composite towards contribution on hardness is very moderate which is similar in pattern for results obtained in this experiment[4,8]. There is phenomenon occur whereby some points produced small value of hardness as compared to the other points, due to many factors such as interface region of matrix/fiber, proximity of matrix with fiber etc. This is explained due to existence of resin rich region on certain place in composite and difficulty in getting perfect homogenization in composite material[2,9]. Based on previous research [9] in their research obtained the value 0.25-0.35 GPa Hardness Stress for 3-4 GPa modulus of elasticity for epoxy resin. This is reason why some of the values at certain points in the sample recorded lower value of HV.The difference of HV values between all the hybrid composite (C,E,F,G,A,B) are quite close with each other except Hybrid D. The arrangement [14] of Hybrid D is such way that GFRP is on external layer where the indentation is applied and reaction forced is taking place (on the other side).The decrement in the hardness [13] in the composites is the indication of poor bonding between the matrix and the reinforcement materials [2,6]. It is due to thermal curing during preparation for the panel that produced uneven curing due to little thickness of GFRP layers on top and bottom layup. This is also depicted similarly in terms of Hardness Stress value as computed and shown in Figure 14. Conversion between Vickers Hardness into SI unit MPa and GPa could be made in order to represent the hardness in the form of stress value. Vickers hardness (HV) to hardness stress in MPa unit is multiplied by 9.807 and into hardness in GPa unit is multiplied by 0.009807.The strain used was constant that is d/D = 0.375. Then, the stress unit used in GPa[6]. The findings of hardness variation [15] for hybrid composite CFRP/GFRP are quite parallel with pattern obtained from plot shown in Figure 15 where increasing amount of CFRP tend to increase slightly the value of hardness of hybrid composite.

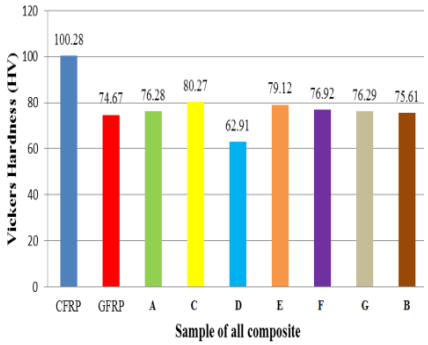

Figure 13: Vickers Hardness Value for all composite

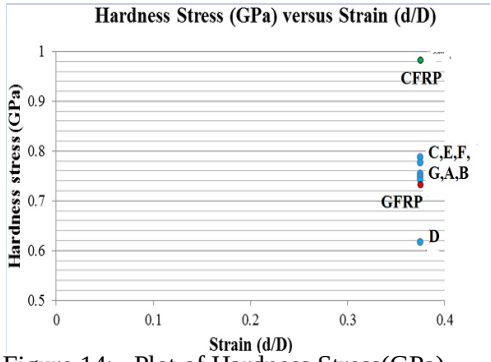

Figure 14: Plot of Hardness Stress(GPa) against Strain(d/D)

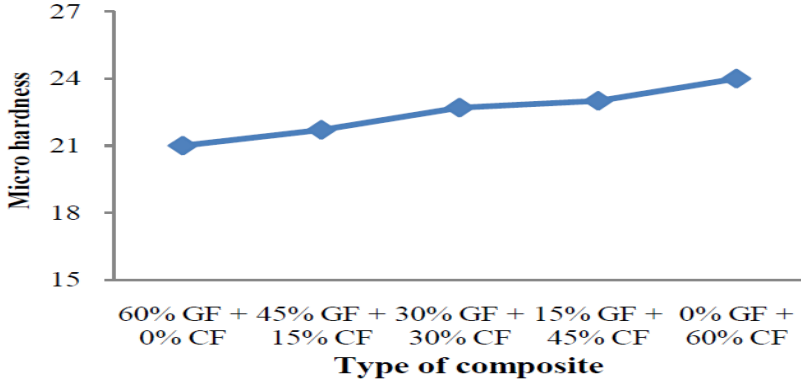

Figure 15: Effect of reinforcement on micro hardnessof the fibers reinforced composites [12]

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5. CONCLUSION

The hardness test on CFRP, GFRP and hybrid composite (CFRP/GFRP) have been performed using Vickers Microhardness Test and results for all type of composite have been discussed. The value of CFRP hardness depicts the highest and hybrid composite computed values in between CFRP and GFRP which is parallel with findings obtained in literature. The influence of modulus of elasticity on indentation behaviour is paramount from theory and CFRP which shows highest hardness also have highest modulus of elasticity. Small difference recorded for Vickers Hardness between all the hybrid composite tested except Hybrid D. Some values in the specimen accounted small values drastically in specific point on the composite surface due to possibility of indentation on matrix which is resin that has far lower modulus of elasticity than fiber constituent. This examination gives knowledge on hardness point of view of cross breed composite and gives plausibility of expanding the exploration work into zone, for example, discovering connection of half and half composite with other mechanical properties, for example, Tensile Strength, Yield Strength and so forth. The other zone that should be possible likewise in the limited component demonstrating where further investigation on stress variety, strain estimation and so on which is mind boggling because of composite orthotropic nature yet fascinating to contemplate.

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