Effect Of Shot Peening on Mechanical Properties (Module of Elasticity, Ultimate Stress and Poisson’s Ratio) Behavior of Natural Composite Material

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ABSTRACT

In this research, the variable shot peening time and solidification time on the mechanical properties of natural composite materials (cotton, jute and polyester) was investigated. The experimental work included manufacturing samples of natural composite materials (cotton, jute and polyester) and applied different shot peening time (0, 5, 10, 15, 20, and 25) minutes with different time of solidification (2 and 6) days and the tensile test start to found the mechanical properties (module of elasticity, ultimate stress and poisson’s ratio). The results show that the increasing of the shot peening time till 15 minutes and solidification time till 6 days affect on the mechanical properties, where the maximum value of the mechanical properties (module of elasticity, ultimate stress and poisson’s ratio) is at 15 minutes of shot peening and 6 days of solidification time, and then these mechanical properties start to decrease after 15 minutes of shot peening, because of the sample weakness and fragmentation.

KEYWORDS

Solidification, composite materials, fragmentation, mechanical

INTRODUCTION

Shot peening may be used to increase the stiffness, efficiency and effect of mechanical properties of natural composite materials samples. To reach this goal, a number of post-impact mechanical tests have been done. In this study it was been used composite material samples of cotton and entered the effect of shot peening and solidification at a various time (0 to 25) minutes and (2 and 6) days, respectively. W Luan, 2009, Studied residual stress loosening in the surface layer shot peened with lead on TiB2 / aluminum composite under cyclic and static loading [1]. The relaxation of the residual stresses in the transversal direction is less substantial than the one in the longitudinal direction. They presented The results showed that under the applied tensile stresses the compressive residual stresses were alleviated. Under cyclic loading, occurred in the first few circles the rapid relaxation of residual stresses. The primarly cause of loosening residual stresses is heterogeneous local plastic deformation due to the presence of a large number of reinforcement particles in the matrix through applied charges. K. Rajasekar, 2014, [2]. Used composite materials combine two distinct materials to acquire enhanced characteristics. Composite materials are as old as natural jute fiber for reinforcement material with polymer materials matrix. He found a sample product of such a composite will be developed through layer-by-layer process at a particular temperature to suit the methods. The composite will be tested for its mechanical characteristics using conventional testing machines and the results will be recorded. The resulting characteristics would help to distinguish the suitable applications for this composite. Lechun Xie, etc. 2016 [3], Performed like a substantial treatment of the surface process, shot peening can effectively enhance the surface characteristics.

Ying-K. etc. 2017 [4], Studied that an alloys based on magnesium have
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premium mechanical and physical characteristics to many applications. They studied microstructure and abrasion behavior of the sprayed coating as a work of particle content in the precursor shot peening. It has been found that by introducing an in situ filler effect using shot peening particles (SP), the plastic distortion of deposited particles is greatly developed, in this way causes an all-thick aluminum covering. Scanning electron microscope noticing detect that no shot peening particle at optimum spray parameters is deposited in aluminum coating. The shot peening particle content increases from 20 to 60 volume% as the porosity of the covering decreases dramatically from 10.7 to 0.4% . The abrasion of electrochemical experiments detect that this cold spraying with the help of new on-site shot peening is effective in depositing all-thick aluminum covering during which aqueous solution is impermeable and thus can supply exceptional protection of the materials based on magnesium from abrasion.

EXPERIMENTAL WORK

Composite Materials Used in This Work and Preparation of Specimens

Cotton
The cotton was used in composite material with Polyester resin which had been used in this work as shown in figure 1 as reinforcement material.

![Figure 1](image1.jpg)

**Figure 1.** The cotton fiber and the physical properties of cotton fiber as shown in table 1.

<table>
<thead>
<tr>
<th>Table 1. Cotton properties [5].</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of fiber</strong></td>
</tr>
<tr>
<td>Density (kg/m3)</td>
</tr>
<tr>
<td>Tensile strength (GPa)</td>
</tr>
<tr>
<td>Modulus of elasticity E (GPa)</td>
</tr>
<tr>
<td>Tenacity (gm/den)</td>
</tr>
<tr>
<td>wet strength %</td>
</tr>
<tr>
<td>elongation at break %</td>
</tr>
<tr>
<td>Specific gravity</td>
</tr>
<tr>
<td>Standard moisture regain (%)</td>
</tr>
</tbody>
</table>

Jute
The other fiber used in this work with Polyester resin in composite material is jute, as shown in figure 2.

![Figure 2](image2.jpg)

**Figure 2.** The jute fiber and the physical properties of jute fiber as shown in table 2.
Table 2. Jute fiber properties [6, 7].

<table>
<thead>
<tr>
<th>Type of fiber</th>
<th>Jute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (kg/m3)</td>
<td>1300</td>
</tr>
<tr>
<td>Tensile strength (GPa)</td>
<td>0.39-0.72</td>
</tr>
<tr>
<td>Modulus of elasticity E (GPa)</td>
<td>26.5</td>
</tr>
<tr>
<td>Tenacity (gm/den)</td>
<td>3-4</td>
</tr>
<tr>
<td>elongation at break %</td>
<td>1.7</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>1.5</td>
</tr>
<tr>
<td>Standard moisture regain (%)</td>
<td>13.75</td>
</tr>
</tbody>
</table>

Polyester

The resin used in composite material in this work is Polyester, as shown in figure 3.

Figure 3. The Polyester resin and the physical properties of Polyester resin as shown in table 3.

Table 3. The polyester properties. [8, 9]

<table>
<thead>
<tr>
<th>Type of Rison</th>
<th>Polyester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (kg/m3)</td>
<td>1135</td>
</tr>
<tr>
<td>Tensile strength (GPa)</td>
<td>0.05</td>
</tr>
<tr>
<td>Modulus of elasticity E (GPa)</td>
<td>3</td>
</tr>
<tr>
<td>Viscosity (cps)</td>
<td>475-675</td>
</tr>
<tr>
<td>specific gravity (g/cc)</td>
<td>1.13</td>
</tr>
<tr>
<td>Gel time (minutes)</td>
<td>15-20</td>
</tr>
<tr>
<td>peak exotherm (centigrade)</td>
<td>150-165</td>
</tr>
<tr>
<td>elongation (min)</td>
<td>2.5%</td>
</tr>
</tbody>
</table>

Molding of composite plates

Hand layup is the method that was used for preparing the mold of composite plates, woven cotton and woven jute is 17*17 cm for each, the polyester is mixed with the hardener with a ratio (100:1) getting a homogeneous mixture. first we pour a polyester layer then we put a woven cotton or woven jute [10,11,12], there is a polyester layer between every two woven layers and this process is repeated till the plate is completed at the last we put a glass mold over the plate and this mold is fixed by two fixative as shown in figure 4, there are two types of plates which each of them have a certain number of woven layers (6,12) mm, the thickness of the woven cotton layer is (3mm) and thickness of the woven jute layer is (1mm) [13,14].
Shot Peening and Solidification

Shot peening is a method which is cold working used to adjust the metals mechanical properties and produce a pressed residual stress layer. It entails influencing shot the surface with (round particles made of ceramic, glass, or metal) with a enough power to create deformation of plastic [15,16], as shown in figure 5. Make shot peening and solidification as shown in figure 6 at a various time (0 to 25) minutes and (2 and 6) days, respectively.

Figure 4. Molding of composite plate

Figure 5. Shot peening machine
Figure 6. Solidification test

Tensile Test

The sample that are needed to do the tensile test has cut with (CNC) machine according to the standard specifications of d638 ASTM as shown in figure 7 and 8 [17,18].

Figure 7. Standard specifications of d638 ASTM
RESULTS AND DISCUSSIONS

This report and discusses the results of the experimental work on cotton composite samples. The results shows the shot peening effect on the mechanical properties. Figure 9 shows during shot peening time (0 to 25) min the value of module of elasticity of cotton composite material samples at different time of solidification (2 and 6) days. It was observed that, the value of module of elasticity of the sample with 2 days solidification time is less than the value of module of elasticity at 6 days solidification time sample [19,20,21]. The value of module of elasticity at (2 days) solidification time is less than the module of elasticity at (6 days) of solidification time in 15 minutes of shot peening time is approximately 11%.

![Figure 9. Experimental relationship between the module of elasticity and the time of shot peening for cotton composite material during 2 days and 6 days of solidification time](image-url)
Figure 10 shows the value during time of shot peening (0 to 25) min of module of elasticity of jute samples of composite material, one of these sample solidification time (2 days) and second (6 days). The module of elasticity value of the sample with (6 days) solidification time was the best of the value of module of elasticity in (2 days) sample of solidification time, it means that, greater solidification time lead to the greater value of module of elasticity till that happens in the 6th day solidified [22,23]. Notice that, he difference of module of elasticity value between six days and two days of solidification time in 15 minutes was best time of shot peening is approximately 15%.

![Figure 10](image_url)

**Figure 10.** Experimental relationship between the module of elasticity and the time of shot peening for jute composite material during (2 and 6) days of solidification time

Figure 11 appear the value of ultimate stress during time of shot peening (0, 5, 10, 15, 20, and 25) min of cotton composite material samples one of them has a solidification time (2 days) and the other (6 days). The value of ultimate stress of the sample with (6 days) of solidification time is greater than the (2 days) solidification time sample. Where the greater value of ultimate stress occur at 15 minutes of shot peening time then it starts to decrease till the 25 minutes of shot peening because the fragmentation of the outer surface of the sample [24,25]. The difference between the (6 and 2) days solidification time values of ultimate stress is approximately 11% at 15 minutes of shot peening time.

![Figure 11](image_url)

**Figure 11.** The relationship between different time of shot peening and the ultimate stress of cotton composite material samples with two and six days of solidification time (Experimental)
Figure 12 views the value during time of shot peening (0 to 25) min of ultimate stress for samples of jute composite material at a different time of solidification (2 and 6) days. It was noted that, the value of ultimate stress of sample with solidification time (6 days) is higher than ultimate stress value of (2 days) time of solidification sample [26,27]. Where the higher value of ultimate stress was occur in 15 minutes time of shot peening where the difference in that point between the (6 days) of solidification time value of ultimate stress and the (2 days) value of solidification time of ultimate stress is approximately 7%, then it starts to decrease till the sample outer surface fragmentation happens in the 25 minutes of shot peening.

![Figure 12](image)

**Figure 12.** The relationship between different time of shot peening and the ultimate stress of jute composite material samples with two and six days of solidification time (Experimental)

Figure 13 views the relationship between poisson’s ratio and the time of shot peening (0, 5, 10, 15, 20, and 25) min of cotton composite material samples at a different solidification time (2 and 6) days. The poisson’s ratio value of the sample with (6 days) of solidification time is higher than the poisson’s ratio value at (2 days) sample. The greater poisson’s ratio value occur at 15 minutes of shot peening time then it starts to decrease till the fragmentation happens to the outer surface of the samples in the 25 minutes of shot peening time [28]. The difference between the poisson’s ratio value of (six days) solidification time and the poisson’s ratio value of (two days) of solidification time is approximately 2% at 15 minutes of shot peening time.

![Figure 13](image)

**Figure 13.** Experimental effect of solidification time (2,6) days and different time of shot peening on poisson’s ratio for cotton composite material samples
Figure 14 appears the relationship between the time of shot peening (0 to 25) min and poisson’s ratio of composite material of jute samples one of these sample solidification time (2 days) and the second sample (6 days). The poisson’s ratio value of the sample with (2 days) time of solidification is lower than poisson’s ratio value with (6 days) sample. It means that, the higher time of solidification and shot peening time lead to the higher value of poisson’s ratio that happens in 6th day solidified and 15 min shot peening. Where the (6 days) of solidification time poisson’s ratio value is higher than poisson’s ratio value in (2 days) at 15 min time of shot peening sample in that point by approximately 1%, then it biging to decrease till fragmentation was happen in 25 minutes of shot peening.

**Figure 14.** Experimental effect of solidification time (2 and 6) days and different time of shot peening on poisson’s ratio for jute composite material samples

**CONCLUSIONS**

The major conclusions are:

- Increasing of shot peening till 15 minutes lead to increase in module of elasticity, ultimate stress and poisson’s ratio of natural composite materials (cotton, jute and polyester).
- Shot peening after 15 minutes the module of elasticity, poisson’s ratio, and ultimate stress of the sample (cotton, jute and polyester) decrease in an observed way because of the sample weakness and fragmentation.
- Solidification time increasing till 6 days give the maximum value in module of elasticity, ultimate stress and poisson’s ratio of natural composite materials (cotton, jute and polyester).
- Maximum value for the natural composite materials (cotton, jute and polyester) module of elasticity, ultimate stress and poisson’s ratio with shot peening and solidification together occur at (15 min and 6 days), respectively.
- Through the charts it can be observed that, the mechanical properties (module of elasticity, ultimate stress and poisson’s ratio) for the jute composite material is greater than the cotton composite material in 15 minutes of shot peening and 6 days of solidification time.

**ACKNOWLEDGMENTS**

The authors (Rabeea Ghalib Ali, Fadhel Abbas Abdulla) would like to thank Mustansiriyah University (www.uomustansiriyah.edu.iq) Baghdad-Iraq for its support in the present work.
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