Preliminary Study of Epoxy Coating Process on Basketry Inlay with 3D Printed Model

Pholchai Chotiprayanakul
Department of Industrial Engineering, Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand

Atsushi NODA
National Institute of Technology, Anan College

Corresponding author: pholchai.ch@kmitl.ac.th

Abstract. In Japan and South-East Asia Countries, Basketry is a heritage handcraft made with natural material such as bamboo strip and wheat straw. Shape and size of basketry products are depended on the basketry pattern and now FDM (Fused Deposition Modelling) 3D printer is used to print the basketry pattern. This paper will present a bit further in epoxy coating on basketry products to make it more rigid and better shining appearance either while the coated basketry still have the 3D printing model inside as a structure or it will be taken off after coating epoxy. There are a lot of makers who try to use the 3D printed model for resin casting mold but many are fail to get the casted out of the 3D printed mold. Thus we do this preliminary study to investigate the adhesive strength of the casting epoxy resin holding on the 3D FDM printed model. An experiment was designed to find the effect of the curing time and the bamboo fiber adding for resin reinforce. In experiment, a flat dog-bone shape specimen for tensile testing is redesigned by separating into 2 identical parts and they are printed with ABS plastic filament. We glue epoxy resin on 12.5 X 10 mm. contact area in middle of the specimen. We left them cure and dry for 6, 12, and 24 hours before tensile testing then repeat the experiment again with bamboo strip added in between the contact area. The result of the experiment shows that bamboo strip reinforce and curing time affect the adhesive strength.

1. Introduction

In Thailand, basketry is a household industry mostly handcrafted which comes all range from low cost product until premium luxury product. To evaluate this industry with 3D printing method, 3D printed model is used as a pattern or an inlay structure of the basketry. By the other process, epoxy coating is one of effective methods to smoothen the surface of 3D printed model. Commercial as XTC-3D® [1] provide better smooth surface and strengthen the printed model. Shaker Alkaraki and et al. uses metalize spray coating a 3D printed antenna [2] make the model response to electromagnetic signal. Some researchers as Joseph T. Belter and Aaron M. Dollar [3] inject epoxy resin into the model’s lacunas to strengthen the 3D model for manufacturing. This paper intends to combine those two processes: basketry forming and epoxy coating together.

There are two possible combinations: 1) use 3D printed model as pattern when finish forming basketry and coated with epoxy, the pattern will be taken of the product 2) use 3D printed model as an inlay structure which is left and stay inside the basket as a rigid structure. Epoxy coating will effect on the
product if we want to get the 3D printed model off, or epoxy coat should be bonded on the 3D printed model strong enough for proper using. This paper presents the study of adhesive strength of the epoxy coating on 3D ABS printed model by setting a mechanical tensile experiment. First, we design test specimen and testing procedure. Finally, the test result will give the adhesive shear strength.

2. Flat Dog-Bone Specimen

In tensile test, specimens are designed to control the broken position. We select ASTM D 638 Type II for our dog-bone specimen with 6 mm. thickness and print it with XYZ Davinci for 0.3 mm. layer and 80% infill. Fig XXX shows the dog-bone specimen’s dimension and tensile tested. Result of pre-tensile test from 3 specimens gives the average tensile strength around 38 MPa where maximum force is at 2.8 kN.

2.1. Design of Flat Dog Bone Specimen

This maximum force is used for re-designing to the epoxy fused dog-bone specimen. The epoxy fused dog-bone specimen is divided to 2 identical parts which can be re-assembled back to dog-bone shape with epoxy fused at the joining area. Adhesives shear strength of epoxy is about 17 MPa (2500 psi) thus the joining area must smaller than 167 mm.² that gives the length of the joining area must less than 13.36 mm.. The length of the joining area is selected to be 10mm. as shown in Fig XXX.
2.2. Preparation of Flat Dog Bone Specimen

All specimens were printed with ABS plastic filament on XYZ Davinci 1.0 for 0.3 mm. layer and 80% infill. After specimens were printed, joining area of every specimen was inspected and polished until its surface flat, smooth, and dimension. Then A-B epoxy resin were mixed by weight proportion on weight scale and small amount of epoxy was fully filled on 12.5 X 10 mm. contact area in middle of the specimen and left them cure and dry for 6 hours, 12 hours, and 24 hours. After epoxy was set, the specimens were brought into tensile test to find the maximum force that epoxy can hold on the ABS specimen. Second test set, we added bamboo strip in between the contact area and cover with epoxy again also left the epoxy to set for 6, 12, and 24 hours and then repeat the tensile test.

3. Tensile Test

After specimens were prepared and left for epoxy to set, the specimens were pulled in universal tensile testing machine Testomatic model AX M500-100kN. For setting parameters, a pulling rate was set at 2.5 mm. per second and the force limit was set at 200N. In the test, maximum force was considered as the first priority parameter in order to calculate the adhesives shear strength of epoxy join the ABS plastic. The maximum force would be divided by the joining area which is $12.5 \times 10 \text{ mm}^2$ that is given the adhesives shear strength of adhesives shear strength of epoxy join the ABS specimen.

Figure 3. Universal Tensile Testing Machine Testomatic AX M500-100kN
4. Result

For tensile testing, two control variables are investigated as curing time and bamboo strip reinforce. For curing time, there are 3 sets of curing time different and each set contains 3 samples. The test were repeated with adding bamboo strip reinforce in between joining area in middle of the specimen. The bamboo strip thickness is thinned to 0.3 mm. by sandpapering and measuring it with vernier calliper. From tensile tester, the machine gives report as graph of stress-strain and value of maximum force that specimen can take before break apart. Figure 4 and Figure 5 show the some testing results which are test set of 12 hours curing time and with and without bamboo strip reinforce.

![Figure 4](image1.png)

**Figure 4.** A tensile test result of curing time 12 hours and without bamboo strip reinforce, average maximum force at 81.4863 N.

![Figure 5](image2.png)

**Figure 5.** A tensile test result of curing time 12 hours and with bamboo strip reinforce, average maximum force at 135.485 N.

| Curing Time | without Bamboo Strip Reinforce | with Bamboo Strip Reinforce |
|-------------|---------------------------------|-----------------------------|
| 6 Hrs       | 52.2611                         | 93.611                      |
|             | 55.56                           | 85.74                       |
|             | 64.8249                         | 57.9597                     |
|             | 49.6134                         | 105.667                     |
| 12 Hrs      | 76.9456                         | 132.37                      |
|             | 81.48                           | 135.48                      |
|             | 104.555                         | 80.6491                     |
|             | 62.9584                         | 193.437                     |
| 24 Hrs      | 80.2432                         | 126.529                     |
|             | 87.35                           | 140.58                      |
|             | 97.435                          | 152.533                     |
|             | 84.3792                         | 142.695                     |
Figure 6. Result of the Tensile Test with 2 Variables Bamboo Reinforce and Curing Time

Table 1 and graph in Figure 6 show as expect for curing time by the recommend of 200AB epoxy that it will fully cure by 24 Hours. Also data illustrations that the effect of the bamboo strip reinforces will increase the adhesive shear strength because the bamboo strip makes epoxy more rigid than only epoxy coat. When specimen with only epoxy can be easy deform and wobble losing it contact in some area (not sudden completely tear apart), this will make longer strain as seen in graph of Figure 4 and Figure 5.

In this study, the ultimate adhesive shear strength for epoxy and ABS plastic can be calculated by the maximum force of fully cure epoxy by experiment divided by the contact area (12.5 × 10 mm.) that given adhesive shear strength for epoxy-ABS equal to 0.65N/mm.² and epoxy-ABS reinforce with bamboo strip equal to 1.12N/mm.²

5. Conclusion

This preliminary study aims to find effect of epoxy curing time and bamboo strip reinforce on adhesive shear strength. When we put epoxy resin coating on the surface of 3D FDM printed model or on the basketry which has 3D FDM printed pattern inside. An experiment was designed and implemented. Result of the experiment shows the magnitude of adhesive shear strength of AB epoxy and ABS plastic model. The bamboo strip is used to mimic the basketry is tested. The testing result shows the epoxy with bamboo strip reinforce is slightly stronger sticky on the ABS plastic than put on epoxy only. This means, we will use more effort to take epoxy-coated basketry of the ABS pattern, or the epoxy-coated basketry with ABS structure inside is stronger than coating only epoxy.

References

[1] Smooth-On XTC-3D, https://www.smooth-on.com/product-line/xtc-3d/, access on March 2019
[2] Shaker Alkaraki and et al (2018), Compact and Low-Cost 3-D Printed Antennas Metalized Using Spray-Coating Technology for 5G mm-Wave Communication Systems, IEEE Antennas And Wireless Propagation Letters, Vol. 17, No. 11, November 2018
[3] Joseph T. Belter and Aaron M. Dollar (2015), Strengthening of 3D Printed Fused Deposition Manufactured Parts Using the Fill Compositing Technique, PLoS ONE 10(4): e0122915. doi:10.1371/journal.pone.0122915, Nicola Pugno, Università di Trento, ITALY.
[4] Stephen Burke Driscoll (1998), The Basics of Testing Plastics: Mechanical Properties, Flame Exposure, and General Guidelines, Astm Intl, June 1, page 20-24