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Araştırma Makalesi / Research Article

Bitkisel Bir Kompozitin Yüzey Topografyası Basılabilirliğini Nasıl Etkiler?

Sinan SONMEZ[1], Garip GENC[2]*, Huseyin YUCE[3]

[1]*Marmara University, School of Applied Sciences, Department of Printing Technologies, Istanbul, Turkey*
[2]*Marmara University, Technology Faculty, Mechatronics Engineering Department, Istanbul, Turkey*
[3]*Marmara University, Technology Faculty, Mechatronics Engineering Department, Istanbul, Turkey*

[1]*e-posta: ssonmez@marmara.edu.tr https://orcid.org/0000-0003-3126-9590*
[2]*e-posta: ggenc@marmara.edu.tr https://orcid.org/0000-0001-7711-3845*
[3]*e-posta: huseyin@marmara.edu.tr https://orcid.org/0000-0001-5525-7733*

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Anahtar kelimeler
Kabak lifi; Bitkisel lifler; Biyo-kompozit; Basılabilirlik

Öz

Bu çalışmada, kabak lifi takviyeli bitkisel kompozit malzemelerin yüzey topografyasının basılabilirliğine etkisi incelenmiştir. Bu amaçla, takviye olarak kabak lifi ve matris olarak epoksi kullanılarak biyo-kompozit plakalar üretilmiştir. Daha sonra bu plakaların yüzeylerine çizgi ve nokta gibi baskılar serigrafi baskı yöntemi ile gerçekleştirilmiştir. Baskıdan önce ve sonra, üretilen biyo-kompozitlerin yüzey pürüzlülük değerleri, 3D temassız optik profilometre kullanılarak ölçülmüştür. Daha sonra bu ölçümleri doğrulamak ve baskı kalitesini kontrol etmek için 3D Optik Profilometre biyo-kompozit malzemelerin yüzey pürüzlülüğünü taramak için kullanılmıştır. Elde edilen sonuçlara göre, kompozit yüzey topografyasındaki gelişme, yüzey pürüzsüzlüğünü arttırmaktadır. Bu sonuç ile yüzey pürüzsüzlüğünün, elde edilen görüntü netliği için basılabilirliğin ana parametresi olduğu açıkça anlaşılmaktadır.

How Does the Surface Topography of a Green Composite Affect its Printability?

Keywords
Luffa fiber; Plant fibers; Bio-composite; Printability

Abstract

In this study, the effect of surface topography of luffa fiber reinforced green composite materials on its printability was investigated. For this purpose, bio-composite plates using luffa fiber as reinforcement and epoxy as the matrix were produced. Then, printing such as line and dot on the surfaces of these plates was carried out by the screen printing method. Before and after printing, the surface roughness values of the produced bio-composites were measured using 3D non-contact optical profilometer. Afterward, to validate these measurements and to check the printing quality, 3D Optical Profilometer was used to scan the surface roughness of bio-composite materials. According to the obtained results, the improvement of the composite surface topography is increase surface smoothness. With this result, it is clearly understood that the surface smoothness is the main parameter of printability for the resulting image clarity.

1. Introduction

In recent years, it has been observed that studies on bio-composite materials have continued intensively. As underlined by Cheung et al. (2009) in the literature the use of renewable resources such as plant and animal-based fiber-reinforced polymeric composites, has been becoming an important design criterion for designing and manufacturing components for all industrial products. The damage caused by chemical materials to nature and the concerns of recycling are the most important factors in the increase of these studies. Many of these studies are related to the characterization of new or green materials (Alemdar and Sain, 2008; Boynard and D'Almeida, 2000; Genc, El Hafidi, and Gning, 2012; Genc and Koruk, 2016, 2017; Wambua, Ivens, and Verpoest, 2003).

However, at this stage, studies focusing on the application of bio-composite materials have become important. In this sense, some studies when examined; Genc and Akkus (2018) studied, waste walnut shell reinforced bio-composite materials, and its machinability behavior to aim the recycle-able of natural waste materials and to find new usage fields of waste of natural materials. As presented in this study, they produced tea plates in order to prove the producibility of the product using walnut shells. Al-Oqla and Sapuan (2014), reported in their study that the feasibility of using the date palm fibers in the natural fiber reinforced polymer composites for the automotive industry. Behazin and et al. (2016) produced softwood chip biochars and characterized to evaluate their properties in light of potential alternative and novel applications.

In many engineering industrial applications, the exact characterization of the surface roughness is of great importance due to its significant impact on the functionality of the manufactured products. Also, the topographic method is the most applied method the evaluation of the surface quality of metallurgical or mechanical products (Deltombe et al., 2014).

The most commonly used method for evaluating the surface quality of composites is the Stylus method, which provides the accepted numerical values (Ulker, 2018). Stylus devices are the most commonly used instruments for measuring surface texture today. A typical stylus tool consists of a pen physically contacting the measured surface and a converter used to convert its vertical movement into an electrical signal (Richard, 2001). Nowadays, contactless surface roughness has been measured by modern optical technologies.

Petroleum-based composites are widely used in the printing industry. The signboard is one of the main product in this industry. In this study, the printability properties of plant-based composites were investigated. The aim of this study, to find new usage areas for plant-based composites and reduce the fields of usage the petroleum-based composite materials.

2. Materials and Methods

Luffa cylindrica fiber was used as reinforcement, and the epoxy resin was utilized as a matrix to manufacture the bio-composite laminate specimens. The properties of the liquid epoxy resin are given in detail in Table 1.

Table 1. Properties of the Liquid Epoxy Resin.

Test	Method	Value
Color	Observation	Transparent
Density	DIN EN ISO 2811	1.15 kg/L
Viscosity	ASTM D1545-07	330 mPa.s
Pot life	DIN 16945	170 min.
Water absorption	DIN EN ISO 175	46.5 mg

Produced bio-composite specimens were cut using the CNC Router machine to prepare it for the printing process. The volume fraction of these bio-composite specimens was calculated as 0.6 using rules of mixtures.

2.1. Printing on the Surface of the Bio-Composite Materials

The screen-printing technique was used for printing on the surface of the bio-composite sample, as shown in Fig. 1.

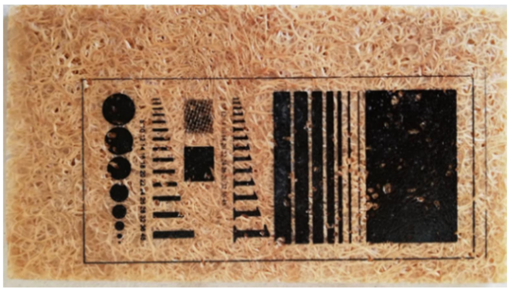


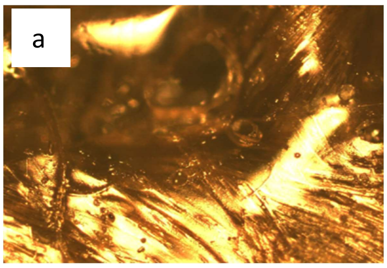
Figure 1. Printing on the surface of Bio-composite sample.

The used screen-printing machine is a semi-automatic. The mesh number of the print plate was 120 threads per cm (tpc), and the dot per cm was 40 (dpc). The angle of the squeegee was 45°, and the hardness of squeegee was 75 shore (Sonmez, 2017b). Solvent-based black ink was applied to the samples.

2.2. Measurement of the Surface Roughness of Bio-Composite Materials

In this study, the optical microscope for display and 3D profilometer was used to scan and measure the surface roughness. Surface roughness is that part of the irregularities on a surface left after manufacture which is held to be inherent in the material removal process itself as opposed to waviness which may be due to the poor performance of an individual machine. Surface roughness is generally examined in plan, i.e., sectional view with the aid of optical and electron microscopes, in cross- sections normal to the surface with stylus instruments and, in oblique cross-sections, by optical interference methods (Whitehouse, 2002).

Bio-composite plates were given 5X magnification and 10X magnification in 2D Optical Microscope images before printing as given in Fig. 2. In the images of before printing, the fiber structure of the bio-composite material is clearly visible. Bright areas are an epoxy image.



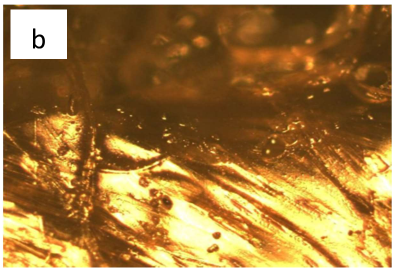


Figure 2. 5x (a) and 10x (b) images of bio-composite material under 2D Optical Microscope before printing.

3. Results and Discussions

Fig. 3 shows the solid pressure printed on the bio-composite material. It is seen that the loss of image in the ground pressure on the bio-composite surface is low. This bio-composite material shows that the ink adheres to the surface, providing good coverage.

Figure 3. Solid area printed on the surface of bio-composite material after printing.

Fig. 4 shows the images printed on the bio-composite material such as lines with different thickness, and dots with different diameters. It is seen to be printed the smallest 0.5 mm diameter dot and 0.5 pt. thickness line on the surface of the composite material. Both the lines and dots have good edge sharpness, but there are regional visual losses in the lines and dots due to the surface of the bio-composite material. The loss of image formed on the surface will cause the print quality to decrease, and this will result in the lack of perceived messages (Sonmez, 2017a).

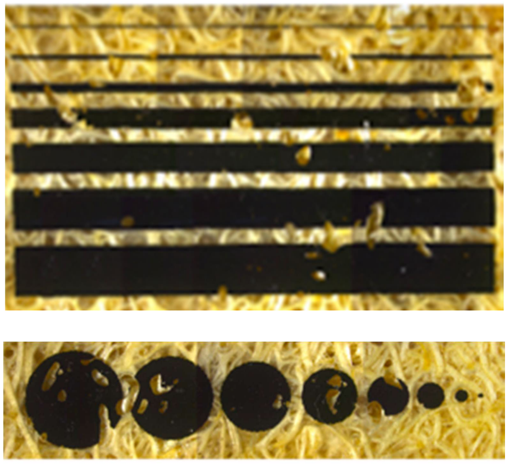


Figure 4. Lines and dots printed on the surface of bio-composite material after printing.

The images of the ink on the bio-composite surface after printing were obtained, as shown in Fig. 5. The image in Fig. 5.a shows a straight line in the printing, while the image in Fig. 5.b shows a cross-section of the scanning square area of the dots.

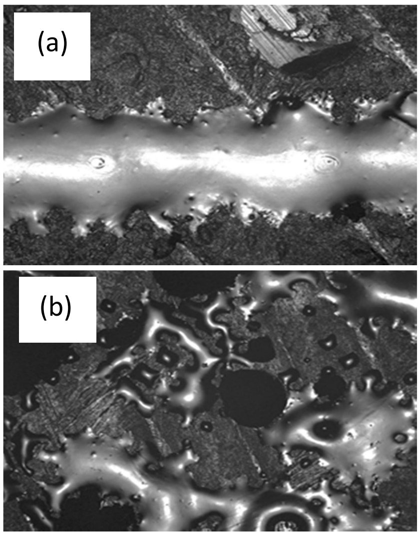


Figure 5. 20x (a) and 10x (b) images of the printed line (a) and the printed screen dot (on printed bio-composite material under a 2D optical microscope.

The interaction of the bio-composite material with the ink is clearly visible in Figure 6. Optical profilers are interference microscopes and are used to measure height variations – such as surface roughness – on surfaces with great precision using the wavelength of light as the ruler.

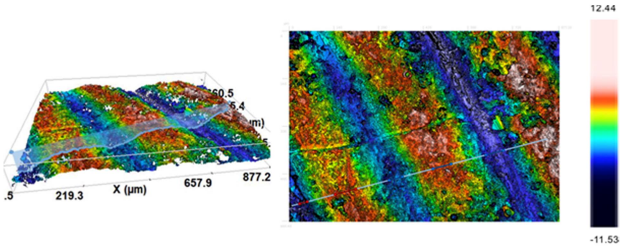


Figure 6. 3D and 2D topography images of bio-composite surface before printing.

The same method was used to scan and measure the surface roughness of the bio-composite material after printing. An EPI 20X v35 lens was used to measure the surface profile.

Optical interference profiling is a well-established method of obtaining accurate surface measurements (Pandey, 2018).

In this study, SENSOFAR Lynx 3D non-contact optical profilometer is used to scan and measure the surface roughness of composite boards. The 3D Optical Profilometer was used to scan the surface roughness of the obtained composite material. Interferometry method was used to measure the surface profile. A sample area of 0.8x 0.6 mm^2 on the sample was scanned. Measuring range in Z-axis was 70 µm. 3D surface topographic image is shown in Figure 6. In Figure 7, the profile of the surface was measured. Points 1 and 2, ΔZ values were found to be 7.5 µm and 7.3 µm, respectively.

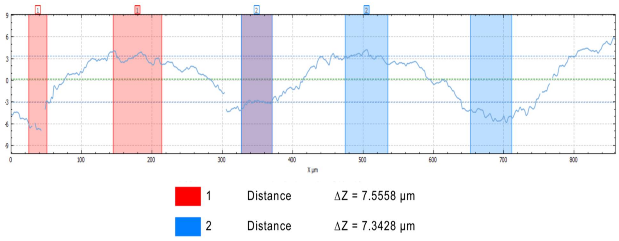


Figure 7. Profile of bio-composite material before printing.

Roughness and surface parameters of the material were determined according to ISO 25178. Table 2 shows the results obtained according to ISO 25178. These parameters involve only the statistical distribution of height values along the z-axis.

A sample area of 0.8x0.6 mm^2 on the sample was scanned. The measuring range in Z-axis was 80 µm 3D surface topographic image is shown in Figure 8. Also, ΔZ, ΔL, and angular changes between the measuring points for the bio-composite material after printing are given in this Figure.

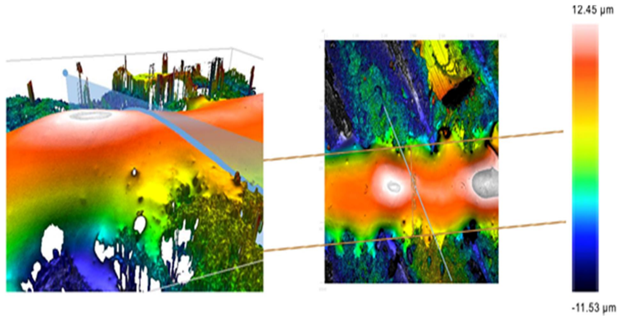


Figure 8. 2D and 3D topography images of one of the line on the surface of bio-composite after printing.

Table 2. Height parameters of the surface of the bio-composite specimen.

Arithmetical mean height of the surface (Sa, μm)	2.5
Kurtosis of height distribution (Sku)	28
Maximum height of peaks (Sp, μm)	21.3
Root mean square height of the surface (Sq, μm)	2.95
Maximum height of valleys (Sv, μm)	14.2
Maximum height of the surface (Sz, μm)	35.6

The trace, which is the smallest print on the surface of the bio-composite material, is also measured. A sample area of 1.5x 1.1mm^2 on the sample was scanned. In Figure 9, the profile of the surface was measured. Points 2 and 3, ΔZ values were found to be 9.5 µm and 10.4 µm, respectively.

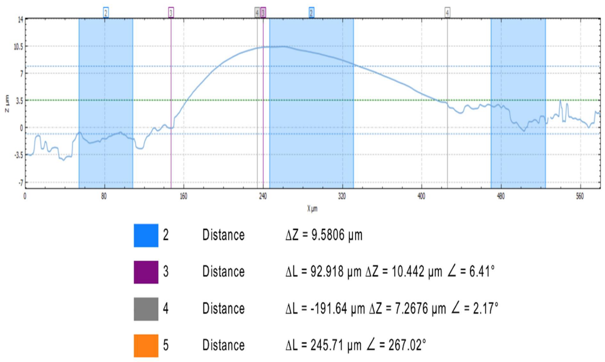


Figure 9. Profile of bio-composite material after printing.

Measuring range in Z-axis was 70 µm. 3D surface topographic image is shown in Figure 10. Also, the profile measurement of the surface given in Figure 11. ΔZ values, were found to be 21.1 µm by measurement in this area while the measured diameter (Dxy) was 0.9 mm, Area (Axy) was 0.76 mm^2.

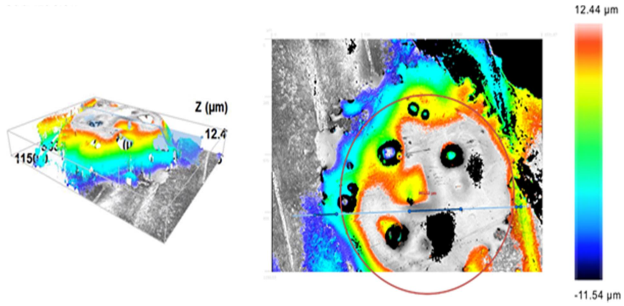


Figure 10. 2D and 3D topography images of the smallest print trace in the surface of bio-composite material after printing.

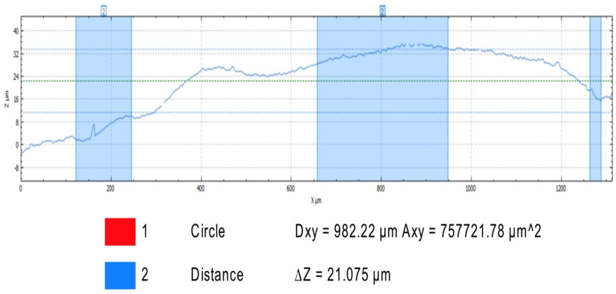


Figure 11. Profile of the smallest print trace in the surface of bio-composite material after printing.

5. Conclusion

Non-contact surface roughness measurement method is used, and very successful results were obtained in this study. In particular, the use of ISO 25178 standard introduces a new perspective in the study of surface roughness parameters of the composite material surfaces. Surface smoothness is an important parameter in obtaining quality printing. As the surface smoothness increases, the edge sharpness of the images to be obtained indicates that the print quality is at the desired level. Although the finest details were obtained in the pressures on the prepared bio-composite material, image losses were determined due to the volume fraction of resins. This problem can be eliminated by increasing the volume fraction of resin.

Consequently, it has been found that the improvement of the composite surface topography increased surface smoothness, which is the most important characteristic of printability.

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