COMPARISON OF INJECTION MOLDED CORE LAYER AND ADDITIVE MANUFACTURED CORE LAYER FOR POLYMER SANDWICH PANEL

Min-Young Lyu, Jeoung Hyun Park, Serin Kim, Seoul National University of Science and Technology, Seoul, S. Korea
Jun Sun Hwang, Dong-Yeol Yang, KAIST, Daejeon, S. Korea

Abstract

Additive manufacturing or 3D printing is a new manufacturing process and its application is getting growth. In this study polymer sandwich panel having three dimensional core layer has been designed. And the core layer was fabricated by injection molding and additive manufacturing (AM). The shape of three dimensional core layer was pyramidal kagome structure with semicircle cross-section truss. The materials for core layer were PP for injection molding and ABS for AM. The material for face sheets in polymer sandwich panel were PP. Mechanical robustness has been examined for kagome core strips and polymer sandwich panels.

Introduction

Demand for lightweight material has been rapidly increasing as the price of energy soars and restrictions on carbon emissions are becoming stricter. A promising candidate is high strength polymer materials: engineering plastics and FRP (fiber-reinforced polymer) are examples of such materials.

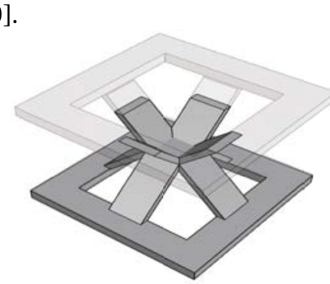
Even though previous approaches have had common objectives, they have been different in the sense that engineering plastics are produced by design at the nanometer scale (i.e. molecular design) while composite materials are produced by design at the micrometer scale (i.e. design of the micro-structure).

Interestingly, few studies have been done on the structural design of polymers at the millimeter scale. It is definitely possible that excellent mechanical properties could be achieved by proper structural design of polymer, which has not been estimated properly. Fortunately, various design schemes have been suggested for metallic cores such as tetrahedral cores [1, 2], dimple cores [3, 4] or corrugated cores [5]. While the weight-efficiency of structured cores has been analyzed and approved [6-8], many of the structures are not applicable to industrial use due to their complicated fabrication process.

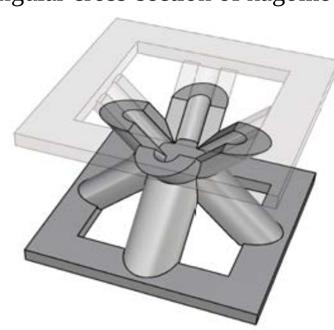
In this study pyramidal kagome core for plastic sandwich panel has been suggested. And the manufacturing method of pyramidal kagome core has been examined. Injection molding and additive manufacturing, so called 3D printing were used for the fabrication of plastic pyramidal core. Mechanical property of pyramidal kagome core strips were examined. Plastic panels with pyramidal kagome core strips were manufactured and then the mechanical characteristics were tested. Through these test injection molded and 3D printing manufactured products has been compared.

Experimental and Results

Pyramidal kagome core for three dimensional core layer in plastic sandwich panel was designed as shown in Figure 1 [9, 10].



(a) Rectangular cross-section of kagome truss



(b) Semicircular cross-section of kagome truss

Figure 1. Pyramidal kagome lattice

Pyramidal kagome core strips were fabricated by injection molding and 3D printing. Figure 2 showed injection mold and 3D printer, Connex 500 of Stratasys.

(a) Injection mold and molded product

(b) 3D printer and 3D printing manufactured product

Figure 2. Injection mold and 3D printer

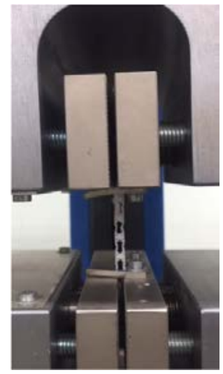
Figure 3 showed plastic kagome core strips fabricated by injection molding and 3D printer. PP supplied by Lotte Chemical was used for injection molding. In the 3D printing photo curing material, VeroWhitePlus RGD835 was used.

(a) Injection molded core strip

(b) 3D printing manufactured core strip

Figure 3. Fabricated pyramidal kagome core strip

Pyramidal kagome core strips were tested by Instron for the mechanical property. Figure 4 showed tensile test.



(a) Tensile test of injection molded pyramidal kagome core strip

(b) Tensile test of 3D printing manufactured pyramidal kagome core strip

Figure 4. Tensile test of pyramidal kagome core strip

Plastic sandwich panels were manufactured using pyramidal core strips fabricated by injection molding and 3D printing. Figure 5 shows plastic sandwich panel containing pyramidal kagome core.

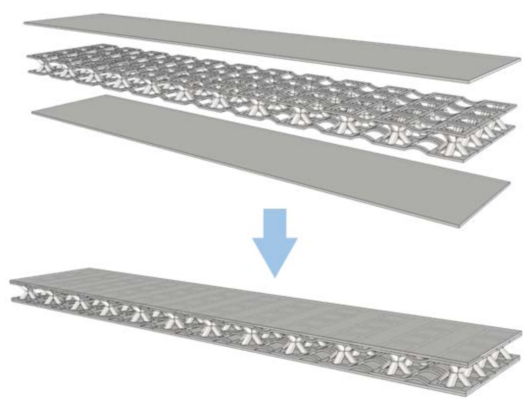
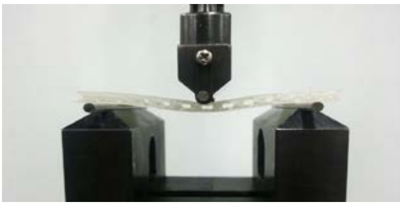
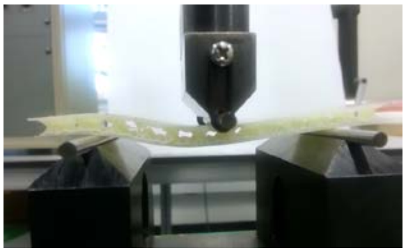


Figure 5. Plastic sandwich panel with pyramidal kagome core

3-point bending test (Compression test) for plastic sandwich panel was performed as shown in Figure 6. Through this test performance of core layer fabricated by injection molding and 3D printing was compared.



(a) Plastic sandwich panel having core layer fabricated by injection molding



(b) Plastic sandwich panel having core layer fabricated by 3D printing

Figure 6 3-point bending test of plastic sandwich panel

Figure 7 shows result of 3-point bending test for plastic sandwich panel which contains pyramidal kagome core layer. Plastic sandwich panel with injection molded core showed higher maximum load than that of the Plastic sandwich panel with 3D printing manufactured core. Plastic sandwich panel 3D printing with manufactured core showed higher stiffness than that of the plastic sandwich panel with injection molded core by 30%.

3D printing manufactured pyramidal kagome core strip has a brittle property and weak mechanical property. However, plastic sandwich panel with this core layer showed reasonable mechanical property. Pyramidal kagome core layer has a role for increasing moment inertial rather than giving a mechanical strength itself.

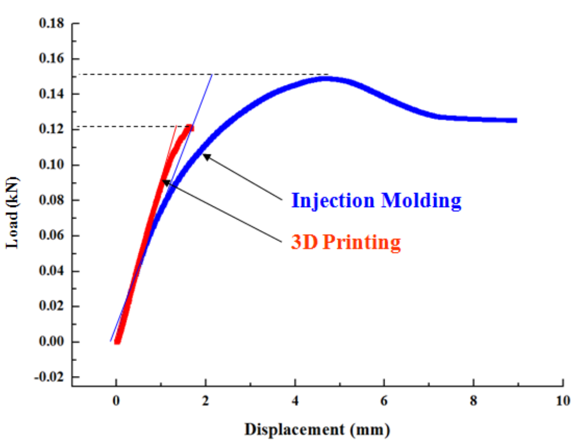


Figure 7 Result of compression test of plastic sandwich panel

Conclusions

Through this study pyramidal kagome core has been designed. Pyramidal kagome core strips were fabricated by injection molding and 3D printing. Mechanical characteristics of two types of pyramidal kagome core strips were compared. 3D printing manufactured pyramidal kagome core showed brittle and weak property compared with injection molded pyramidal kagome core. Plastics sandwich panels have been manufactured by using pyramidal kagome cores that were fabricated by injection molding and 3D printing. Mechanical characteristics of plastic sandwich panels have been examined using 3-point bending test. Plastic sandwich panel with pyramidal kagome core fabricated 3D printing showed higher stiffness than that of the plastic sandwich panel with pyramidal kagome core fabricated injection molding. Plastic sandwich panel with pyramidal kagome core fabricated 3D printing showed reasonable mechanical property even though the 3D printing manufactured pyramidal core strip showed weak mechanical property. The important role of core layer is providing space between face sheets of sandwich panel and it gives high momentum of inertia to the sandwich panel. 3D printing can give a diverse design for the manufacturing of three dimensional complicated core layers. Subsequently it gives a high mechanical property on the plastic sandwich panel.

References

1. Chiras S, Mumm D, Evans A, Wicks N., et al., *International Journal of Solids and Structures*, **39**, 4093 (2002).

2. Kooistra GW, Queheillalt DT, and Wadley HN, *Materials Science and Engineering: A*, **472**, 242 (2008).

3. Seong D, Jung C, Yang D, Kim J., et al., Scripta Materialia, 63, 81 (2010).

4. Seong D, Jung C, Yang D, Nam G., et al., *Journal of Sandwich Structures and Materials*, **13**, 445 (2011).

5. Cote F, Deshpande V, Fleck N, and Evans A., *International Journal of Solids and Structures*, **43**, 6220 (2006).

6. Seong D, Jung C, Yang D, Moon K., et al., *Materials & Design*, **31**, 2804 (2010).

7. Seong D and Yang D., *International Journal of Mechanical Sciences*, (2012).

8. Ahn D-G, Nam G-H, Jung C-G, and Yang D-Y., *International Journal of Precision Engineering and Manufacturing*, **10**, 107 (2009).

9. June-Sun Hwang, Tae-Gyun Choi, Dongyoung Lee, Min-Young Lyu, Dai Gil Lee, Dong Yol Yang, *Composite Structures*, **131**, 17 (2015).

10. June-Sun Hwang, Tae-Gyun Choi, Min-Young Lyu, Dong Yol Yang, *Composite Structures*, **134**, 10 (2015).