نشریه مهندسی مکانیک امیرکبیر

Amirkabir Journal of Mechanical Engineering

Amirkabir J. Mech. Eng., 55(6) (2023) 149-152
DOI: 10.22060/mej.2023.21839.7520

Numerical Investigation of Bending Strength of Composite Sandwich Panel with Grid Core for Use in PEM Fuel Cell Endplates

S. Hoseini[1], M. M. Barzegari[2]*, P. Pirali[1], J. Eskandarijam[1]

[1] Faculty of Material and Manufacturing Technologies, Malek Ashtar University of Technology, Tehran, Iran
[2] Northern Research center for science & Technology, Malek Ashtar University of Technology, Tehran, Iran

ABSTRACT: Endplates are one of the most important components of polymer electrolyte membrane (PEM) fuel cell that must apply uniform contact pressure distribution on the membrane electrode assembly (MEA). For this reason, these plates must have good bending rigidity. In this research, the bending behavior of composite sandwich plates has been investigated numerically To achieve a composite structure with high bending stiffness for use in the endplates of PEM fuel cells. For this purpose, the bending strength of composite sandwich panels with grid core was evaluated based on the type of material and relevant standards through numerical simulation. Numerical simulation has been performed in Abaqus software using the finite element method. The effect of different angles of fibers in three different geometries of square, triangular, and diamond grid core for C/Sic and E-Glass Epoxy materials on the bending behavior of composite sandwich panels were analyzed. The obtained results indicate the better performance of C/Sic materials in the stress test, as well as the more suitable bending behavior of triangular mesh geometry with fiber angles (0-45-90).

Review History:
Received: Oct. 08, 2022
Revised: Jun. 22, 2023
Accepted: Jun. 23, 2023
Available Online: Aug. 20, 2023

Keywords:
Polymer electrolyte membrane fuel cell
composite sandwich panel
endplate
bending strength
finite element method

1- Introduction

A fuel cell is an electrochemical system that converts the chemical energy of the fuel directly into electrical energy. Fuel cells are classified according to the type of electrolyte used in them, one of which is the polymer electrolyte membrane fuel cell (PEMFC), which is known by this name because of the type of polymer electrolyte [1].

One of the most important components of PEMFC is the end plates, which have the task of putting the individual cells of the fuel cell together, applying pressure to the system to reduce the contact resistance between different plates, providing the required force for sealing and increasing the efficiency of the system with applying uniform contact pressure over the active area of the PEMFC [2].

Yu et al. [3] presents the method to design and manufacture the sandwich endplates whose face and core are made of carbon fiber reinforced composite and honeycomb/foam, respectively. Paik et al. [4] investigated the mechanical properties of aluminum alloy sandwich panels with honeycomb core. The results of their research indicate that the start of plastic deformation is delayed and the ultimate strength and bending strength are increased due to the change in the shape of the core geometry and the increase in the thickness of the cells of the honeycomb core. Yu et al. [5] conducted a study on pre-curved composite end plates made of carbon fibers and glass as a replacement for metal plates under pressure from tightening the screws of fuel cell end plates, and the results show a more uniform contact pressure distribution on the plates.

The aim of this research is to obtain a composite sandwich panel with grid core with high bending rigidity to be used in the end plates of the PEMFC. In this regard, the effects of the parameters of grid core geometry, fiber angles and material type was investigated by numerical simulation and using finite element software. Evaluation of lattice core geometries, including triangular geometry, rectangular geometry and rhombic geometry, was done for C/Sic and E-Glass Epoxy materials. Moreover, the effect of fiber angles (0-45-90), (0-90-45) and (0-90-45) on the bending stiffness of the samples was also observed.

2- Problem definition

In this study, sandwich specimens consist of three face sheets with three different fiber angle (0-45-90, 0-90-45, and 45-90-0) and core configurations were fabricated. Fig. 1 illustrated the geometrical characteristics of sandwich plate.

3- Numerical simulation

In order to predict the mechanical behavior and failure modes of studied sandwich structures, a 3D FEM was

*Corresponding author's email: barzegari@mut.ac.ir

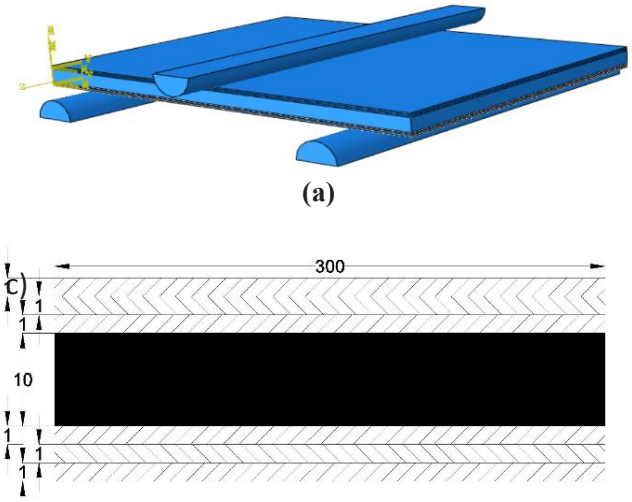

Fig. 1. Geometry of the present study with dimension (a) 3D view with boundary conditions (b) cross-section of different core configurations and their geometrical characteristics

developed using commercial finite element software ABAQUS/Explicit, release 16.14.

4- Results and discussion

In this paper, firstly the effects of different core shape and fiber angle for C/SiC composite was investigated (Figure 2(a) and Figure 2(b)). According to this figure, composite plate with fiber angle 0-45-90 and triangular core has a better bending behavior. Then, the energy-strain curves of C/SiC composite with fiber angle 0-45-90 and triangular core for different face sheet thickness under static three-point bending test was reported (Figure 2(c)). As shown, similar to the C/SiC composite, with fiber angle 0-45-90 and triangular core and face sheet thickness 1.8mm has a more load-bearing capacity.

Furthermore, the optimal results from the last section were compared for C/SiC and E-Glass Epoxy. As shown in the Figure 3 the C/SiC composite with fiber angle 0-45-90 and triangular core has a more load-bearing capacity.

5- Conclusion

In this study, the effects of, different types of core shapes, different fiber angles, and different face sheet thicknesses of sandwich plates with grid core under a static three-point bending test were numerically investigated. According to the result, the C/SiC composite plate with fiber angle 0-45-90, triangular core and face thickness 1.8mm has a best bending behavior and load-bearing capacity and it is suitable for fuel cell end plates.

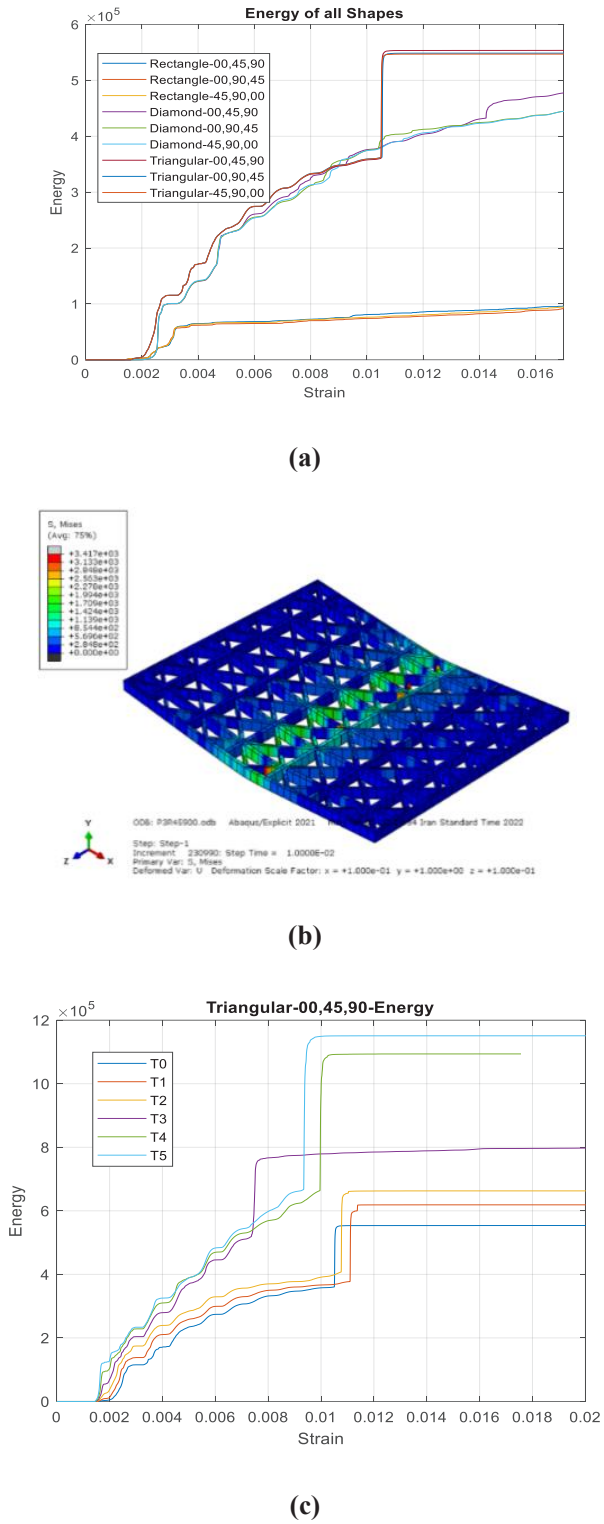

Fig. 2. (a) The energy-strain curves of C/SiC composite with different fiber angle under static three-point bending test. (b) Fatigue failure for optimal case, (c) The energy-strain curves of C/SiC composite with triangular core and different face sheet thickness under static three-point bending test.

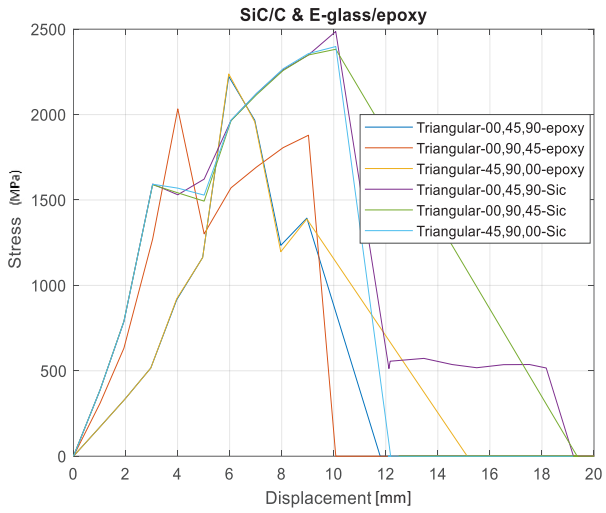

Fig. 3. Stress as a function of Displacement for C/SiC and E-Glass Epoxy for triangular core and different fiber angle under static three-point bending test.

References

[1] Y. Wang, D.F.R. Diaz, K.S. Chen, Z. Wang, X.C. Adroher, Materials, technological status, and fundamentals of PEM fuel cells–a review, Materials today, 32 (2020) 178-203.

[2] P. Lin, P. Zhou, C. Wu, Multi-objective topology optimization of end plates of proton exchange membrane fuel cell stacks, Journal of Power Sources, 196(3) (2011) 1222-1228.

[3] H.N. Yu, S.S. Kim, J. Do Suh, Axiomatic design of the sandwich composite endplate for PEMFC in fuel cell vehicles, Composite Structures, 92(6) (2010) 1504-1511.

[4] J.K. Paik, A.K. Thayamballi, G.S. Kim, The strength characteristics of aluminum honeycomb sandwich panels, Thin-walled structures, 35(3) (1999) 205-231.

[5] H.N. Yu, S.S. Kim, J. Do Suh, Composite endplates with pre-curvature for PEMFC (polymer electrolyte membrane fuel cell), Composite Structures, 92(6) (2010) 1498-1503.

HOW TO CITE THIS ARTICLE

S. Hoseini, M. M. Barzegari, P. Pirali, J. Eskandarijam, Numerical Investigation of Bending Strength of Composite Sandwich Panel with Grid Core for Use in PEM Fuel Cell Endplates, Amirkabir J. Mech Eng., 55(6) (2023) 149-152.

DOI: 10.22060/mej.2023.21839.7520