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Preparation and Research on Mechanical Properties of a Corrugated-Aluminum Honeycomb Composite Pale

Yu Yang[1,2], Shen Yi[1,2,*], Wang Xue[1], Zhang Shichao[1], Xie Feng[1,2], Yuan Mingxin[1,2], Zhu Peng[2]
[1](School of Mechanical and Power Engineering, Suzhou Institute of Technology, Jiangsu University of Science and Technology, Zhangjiagang 215600, China)
[2](Zhangjiagang Hongyang Petrochemical Machinery Co., Ltd., Zhangjiagang 215600, China)
*** Corresponding author.** E-mail: sheny456@hotmail.com

ABSTRACT: *In view of the impact of dynamic load on the impact of aluminum honeycomb panels, a new aluminum honeycomb composite pale is designed by adding corrugated board to the conventional aluminum honeycomb core. The effects of static and dynamic load impact on the aluminum honeycomb composite panels were analyzed based on ANSYS finite element software, and the results of their damage and deformation are compared with those of conventional aluminum honeycomb panels. The results show that under the same static load parameters, the larger the contact area, the higher the energy absorption coefficient, the higher the intensity. Under the condition of the same impact load parameters, the corrugated board added between the aluminum panel and the aluminum honeycomb core can effectively buffer the impact force of the aluminum honeycomb sandwich panel, which is a good solution to the impact of dynamic load on the aluminum honeycomb panels.*

KEYWORDS: *Aluminum honeycomb panels, Corrugated panel, Static load, Dynamic load, Finite element analysis*

I. INTRODUCTION

With the broad use of aluminum honeycomb panels in the fields of aerospace, defense equipment, construction and rail transit, the research on high strength aluminum honeycomb panels will help to meet the application of composite panel materials with high quality and light intensity in emerging industries, furthermore, it is of great significance to promote the progress and development of the design technology of aluminum honeycomb panels in our country. Therefore, the strengthening design of the aluminum honeycomb sandwich is not only related to the safety of aluminum honeycomb sandwich panels, but affects the performance of the products. Commonly used aluminum honeycomb sandwich reinforcement methods include three categories, namely stretching method [1], forming method [2], and finite element method [3]. Stretching method is to stick aluminum foil laminated, and then to stretch it into aluminum honeycomb panels, which cannot meet the application of some large equipment because of its low pass rate and small strength. The forming method is to fix the aluminum foil strips into a corrugated shape and then bond them together to form an aluminum honeycomb core. Based on the stretching method, Liu *et al.* [4] conducted an intensive design on the high-strength aluminum honeycomb. Compared with the stretching method, the aluminum honeycomb core manufactured by the forming method has a high pass rate and a larger strength than that of the aluminum honeycomb core formed by the stretching method. However, the forming method requires a lot of manual operations with low production efficiency and high costs. The finite element method is a modern optimization method based on the stretching method and the forming method. With the development of the finite element technology, this method has been widely used in the analysis and design of various important structures, especially honeycomb panels in recent years. Wang *et al* [5] carried out a low-speed impact simulation study on aluminum honeycomb sandwich panel using Ansys software, and tested its strength under different structures. In order to further improve the strength of the conventional aluminum honeycomb sandwich panel, the simulation study of the designed aluminum honeycomb composite panel based on the finite element method is also carried out. The simulation results verify the effectiveness of the designed composite board.

II. PREPARATION OF CORRUGATED - ALUMINUM HONEYCOMB BOARD

The aluminum honeycomb sandwich panel is the most widely used products of composite board material with light weight and high strength in the emerging industry, whose compressive stiffness, compressive strength, flexural rigidity, flexural strength are better. As the main energy absorption part, the aluminum honeycomb core structure accounted for more than 50% of the entire material area. Therefore, the structural parameters and properties of the aluminum honeycomb core have a direct impact on the overall performance and cost of the aluminum honeycomb sandwich panel. In view of this, we have carried out a new design on the conventional aluminum honeycomb sandwich, that is, a layer of corrugated board is added to the honeycomb core. The structural schematic figure is shown in Fig. 1.

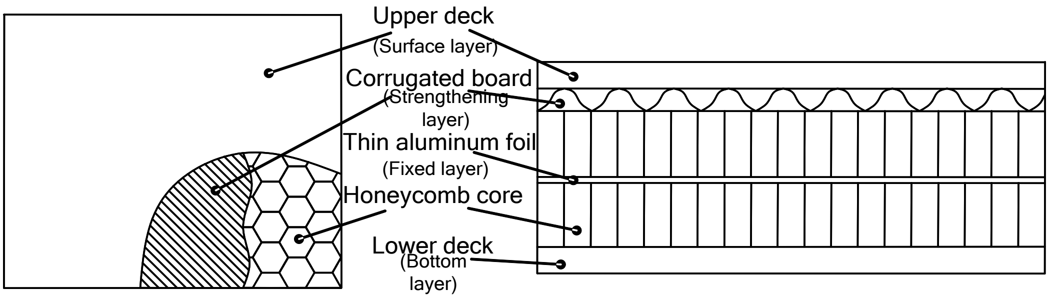


Fig.1 Honeycomb composite panel structure

III. ANSYS SIMULATION ANALYSIS OF NEW ALUMINUM HONEYCOMB COMPOSITE PANEL UNDER STATIC LOAD

A. **Simulation model and parameters :** In order to test the designed aluminum honeycomb composite panel, we carry out the ansys simulation analysis under static load, and compare the test results with those of conventional aluminum honeycomb panel. Fig. 2(a) shows the numerical simulation finite element model of conventional aluminum honeycomb panel. Fig. 2(b) shows the numerical simulation finite element model of aluminum honeycomb composite panel with corrugated board. The size of the aluminum honeycomb sandwich panel is 1000mm ×1000mm. The length and height of the honeycomb core are both 6mm, and its wall thickness is 0.06mm. The thickness of the aluminum panel is 1mm, the height and the wave pitch of corrugation are 3mm and 23.6mm, respectively. The aluminum alloy is used as the material, and its density, elastic modulus, Poisson's ratio and yield stress are 2700kg / m ^ 3, 71Gp, 0.3 [6] and 280Mpa, respectively. Since the aluminum honeycomb structure is very thin and its thickness is only 0.06mm, the shell unit is therefore used to construct the finite element model. The shell181 unit is used to extract the aluminum honeycomb solid model and the shell model is then constructed. The bottom is fixed and a static load of 500N is applied downward to the top of the aluminum honeycomb sandwich panel.

(a) Conventional aluminum honeycomb panel (b) New aluminum honeycomb composite panel

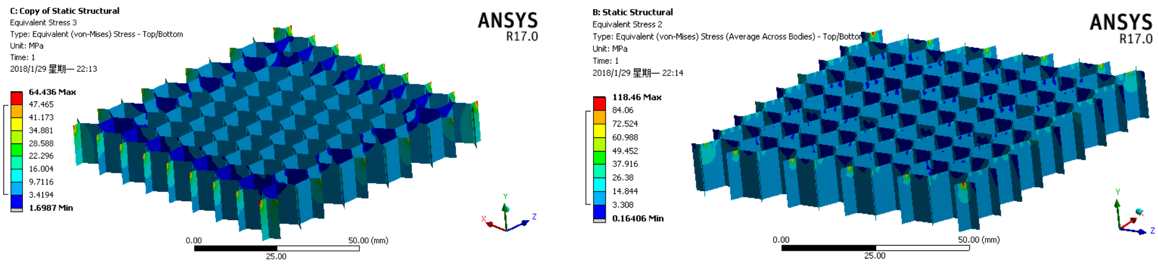
Fig. 2 Finite element model for numerical simulation

B. **Simulation results analysis :** The maximum deformation and the maximum equivalent stress of the aluminum honeycomb sandwich panel are calculated using ansys software by applying 500N load downward to the top of the aluminum honeycomb sandwich panel with its fixed bottom. The final analysis results are given in Table. 1.

Table 1 The force aluminum honeycomb sandwich panel suffers under a fixed load

Performance parameters	Maximum Deformation (mm)	Maximum equivalent stress (Mpa)
Conventional aluminum honeycomb panel	0.0156	64.436
New aluminum honeycomb composite panel	0.0170	118.46

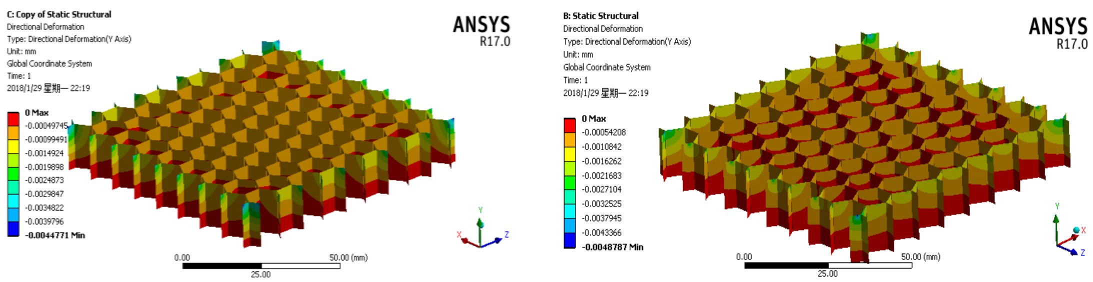
From Table 1, it can be seen that the maximum deformation of the aluminum honeycomb composite panel is slightly larger than the deformation of the conventional aluminum honeycomb panel, and the maximum equivalent stress of the aluminum honeycomb composite panel is much larger than that of the conventional aluminum honeycomb panel structure.



(a) Conventional aluminum honeycomb panel (b) New aluminum honeycomb composite panel

Fig. 3 Partial stress cloud of two types of aluminum honeycomb sandwich panels under static load

Fig. 3 shows the partial stress cloud of two types of aluminum honeycomb sandwich panels under static load. From Fig. 3(a), it can be seen that the top board of the conventional aluminum honeycomb panel directly contacts with the aluminum honeycomb core, and the contact surface is surface contact. From Fig. 3(b), it can be seen that the corrugated board and the aluminum honeycomb core contact each other crossly, and the contact surface is point contact. If the top of the aluminum honeycomb sandwich panel structure is compressed, the contact area of the point contact area is smaller and the contact area of the surface contact area is larger. Therefore, the honeycomb core of the new aluminum honeycomb composite panel has a greater stress concentration than the honeycomb sandwich of the conventional aluminum honeycomb panel under the same load. And this is why the maximum equivalent stress of the new aluminum honeycomb composite panel structure is larger than that of the conventional aluminum honeycomb panel.



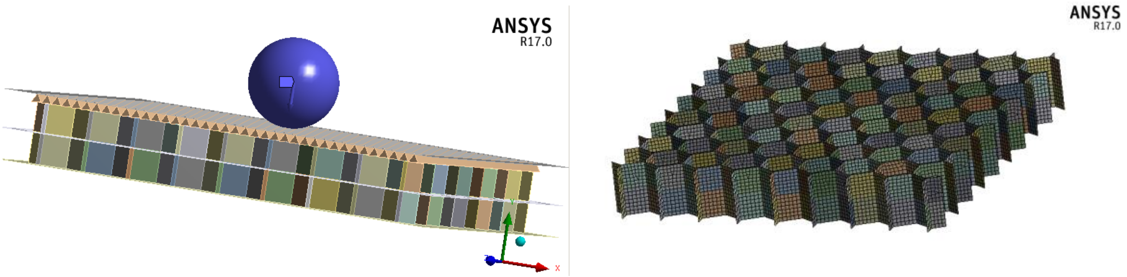
(a) Conventional aluminum honeycomb panel (b) New aluminum honeycomb composite panel

Fig. 4 Part of the Y-direction displacement cloud of two types of aluminum honeycomb sandwich panels under static load

Fig. 4 shows part of the Y-direction displacement cloud of two types of aluminum honeycomb sandwich panels under static load. All red areas of stress concentration are also where the aluminum honeycomb core is in contact with part of the top or corrugated board. Compared with Fig. 3, it can be seen that the Y direction stiffness of the conventional aluminum honeycomb structure is greater than that of the new aluminum honeycomb composite structure. The new aluminum honeycomb composite structure is equivalent to the stiffness of corrugated board and the aluminum honeycomb core in series, so the total stiffness is less than that of the conventional aluminum honeycomb panel structure. In summary, through the analysis and comparison of the two structures, we can see that the Y-direction stiffness of the latter structure is slightly smaller than that of the former structure. Under the static load, the structure of the new aluminum honeycomb composite panel is easier to destroy than the structure of conventional aluminum honeycomb panel. The damaged area must occur at the contact position between the corrugated board and the aluminum honeycomb core. The contact point at the edge position is the first to be destroyed.

IV. ANSYS SIMULATION ANALYSIS OF NEW ALUMINUM HONEYCOMB COMPOSITE PANEL UNDER DYNAMIC LOAD

C. **Simulation model and parameters :** Fig. 5(a) is a numerical simulation finite element model for dynamic load. Fig. 5(b) is a finite element model of the sandwich structure. The aluminum alloy material is used, and its density, elastic modulus, Poisson's ratio and yield stress are 2700kg / m ^ 3, 71Gp, 0.3 [6] and 280Mpa, respectively. Like the static load simulation model, the shell unit is used to construct the finite element model. The shell181 unit is used to extract the aluminum honeycomb solid model and the shell model is then constructed. The impact condition is: A steel ball whose diameter is 20 mm strikes the top center of the aluminum honeycomb panel at a speed of 1m/s. The finite element model uses a shell185 element and the model is defined as a rigid material. The density elastic modulus and Poisson's ratio of the steel ball are 7850kg/m^3, 210GPa and 0.3, respectively.



(a) Finite element model for dynamic load (b) Finite element model of sandwich structure

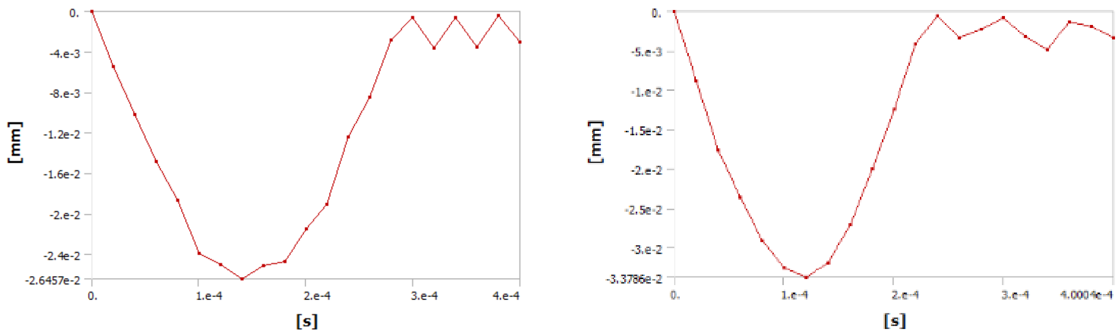
Fig. 5 Finite element model of honeycomb sandwich panel

D. **Simulation results analysis :** A steel ball with a diameter of 20mm hits the center of the top of the aluminum honeycomb sandwich panel at 1m/s speed. Through continuous experiments, the final analysis results are obtained in Table 2.

Table 2 Performance comparison under dynamic load

Performance parameters	Y-direction deformation (mm)	Maximum equivalent stress (mm)
Conventional aluminum honeycomb panel	0.0265	254.36
New aluminum honeycomb composite panel	0.0338	233.98

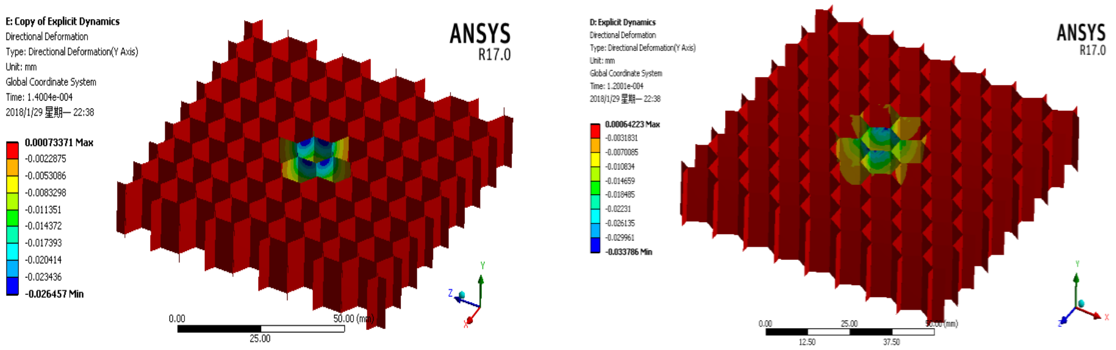
From Table 2, it can be seen that the maximum Y-direction deformation of the new aluminum honeycomb composite panel is larger than that of the conventional aluminum honeycomb panel. Fig.6 shows the maximum deformation of two types of aluminum honeycomb sandwich panels over time in Y-direction. From the figure, it can be seen that the displacement of the new aluminum honeycomb composite panel reaches -3.2 * 10 ^ 2mm when the dynamic load impact time reaches 1 second in the same material and structural parameters of the aluminum honeycomb sandwich panel, and the displacement of the conventional aluminum honeycomb panel reaches -2.41 * 10^ 2mm.



(a) Conventional aluminum honeycomb panel (b) New aluminum honeycomb composite panel

Fig.6 Maximum deformation of two types of the aluminum honeycomb sandwich panel over time in Y-direction

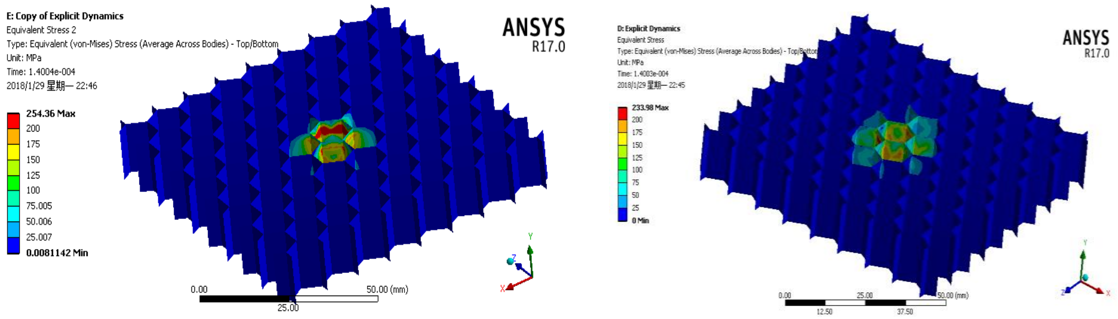
Fig. 7 gives part of the Y-direction displacement cloud of two types of aluminum honeycomb sandwich panels under dynamic load. From the figure, it can be seen that the maximum Y-direction deformation of the new aluminum honeycomb panel is slightly smaller than that of the conventional aluminum honeycomb composite panel structure. From the moment corresponding to the peak curve in Fig. 6, the contact time of the collision of the new aluminum honeycomb composite panel structure is smaller than that of the conventional aluminum honeycomb panel structure. That is, if the steel ball contacts the top at the same time, the structure of the new aluminum honeycomb composite panel bounces the ball ahead of the conventional aluminum honeycomb panel.



(a) Conventional aluminum honeycomb panel (b) New aluminum honeycomb composite panel

Fig. 7 Part of the Y-direction displacement cloud of two types of aluminum honeycomb sandwich panels under dynamic load

Fig. 8 gives partial stress cloud of two types of the aluminum honeycomb sandwich panels under dynamic load. From the figure, it can be seen that the maximum equivalent stress of the conventional aluminum honeycomb panel structure is larger than that of the new aluminum honeycomb composite panel structure. Relative to the conventional aluminum honeycomb panel structure, the contact time that the steel ball impacts new aluminum honeycomb composite plate is shorter.



(a) Conventional aluminum honeycomb panel (b) New aluminum honeycomb composite panel

Fig. 8 Partial stress cloud of two types of the aluminum honeycomb sandwich panels under dynamic load

V. CONCLUSION

Through numerical simulation and analysis of new aluminum honeycomb composite panel based on ANSYS, we can draw the following conclusion:

(1) The ANSYS finite element software can simulate the process of static load and dynamic load impact on the aluminum honeycomb sandwich panel more accurately and accurately, which can provides a reference for the follow-up experiments.

(2) Under the static load, the structure of the new aluminum honeycomb composite panel is easier to destroy than that of the conventional aluminum honeycomb panel. The damaged area must occur at the contact position between the corrugated board and aluminum honeycomb core. The contact point at the edge location is the first to be destroyed.

(3) Under the fixed dynamic load impact, the deformation of the composite board is mainly concentrated in the contact collision area. Because of the absorption and buffering effect from corrugated board, the new aluminum honeycomb composite board can withstand the impact of dynamic load.

(4) The sandwich structure of the new aluminum honeycomb composite panel plays a crucial role in the process of dynamic load impact, which not only effectively relieves the impact force but also absorbs some impact energy.

VI. ACKNOWLEDGEMENTS

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