Influence of Frame Weld on Mechanic Performance of Double-walled Shell

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Abstract. Weld type between parts will make a difference on structural performance, which is especially important for a double-walled shell. To get clear this problem, numerical simulation is conducted to investigate the influence of weld plans between frame and out shell on structural stress and stability. Numerical results show that the change of weld plan between frame and out shell is small in case of a 15MPa external pressure, stress of shell is below the critical value, and the ultimate bearing capacity changes a little. Thus, the weld plan of point weld for frame and out shell could be applied while the double-walled shell is under construction.

1. introduction

Double-walled shell is one typical structure of ship structure, and it has widely application in ship design, submarine structures. Many works have been done on the characteristics of double-walled shell. Zhang et. al. [1] analyzed the effect of perforation on the sound transmission through a double-walled cylindrical shell. Then, Zhang et. al. [2] extended their work to study the Sound transmission through micro-perforated double-walled cylindrical shells lined with porous material. Xie et. al. [3] give an analytical method to predict the vibration of double-walled cylindrical shell. Lee and Kim [4] conducted an experiment to get clear the Sound transmission through a double-walled cylindrical shell. Cacciolati [5] established a theoretical model for direct sound transmission loss of double-walled shell. Recent works are mainly on the vibration and sound radiation of Double-walled shell. Besides, in the view of construction, the complex structure elements make its construction to be quite difficult. In ideal case, the outside shell, frames and inner shell should be welded together perfectly. But, in fact, the weld work for Double-walled shell is very hard. Usually, frames are firstly welded to inner shell. Then the weld between frame and outside shell is to be done, which is especially difficult. To solve this problem, point weld along the frame could be applied, if the change makes little difference on mechanism of Double-walled shell. In this work, to investigate the influence of frame weld on mechanic of double-walled cylindrical shell, numerical simulation is conducted on in case of different frame weld plans, comparative analysis on shell stress and stability is also carried out. This work will lay foundation for the building and construction of Double-walled shell.

2. Numerical model

2.1 geometry

The Double-walled cylindrical shell is shown in Fig.1. the shell is of length 720mm, it’s made up of the out shell, frame and inner shell. The out shell is 3.2mm thick, the inner shell is 2.7mm. The frame is 2mm thick, the height is 18.8mm, and distance is 26.67mm, and 25 circular frames are concerned in the model. One half sphere of 15mm thickness is attached to each ends of the shell.

Fig. 1 Model for the double-walled shell

2.2 frame weld plans

1) all weld
In this case, the frame is all welded to out shell. During the numerical simulation, frame and out shell is set to be bounded, and node merging is applied in other words.

2) point weld
In this case, the frame is point welded to out shell, and diameter of wed point is 3mm, and 8 weld point is distributed along the circular direction at each frame. In numerical simulation, at the weld point, the out shell and frame is node merging, and no separation is applied a other place besides the weld points, and the friction factor is set to be 0.25.
3) contact only
In this case, the frame is not welded to the out shell, and friction contact only is applied. During numerical simulation with ANSYS, contact between frame and out shell is friction contact, and the friction factor is 0.25. Material for Double-walled shell is titanium alloy, the elastic module is 108GPa, the Poisson’s ratio is 0.3, the yield stress is 865MPa.

3. Numerical results

3.1 All weld
In the case of all weld, the stress of out shell, frame and inner shell is displayed in Fig. 2 under an external hydrostatic pressure 15MPa, the stability curves is also given in Fig. 3. It’s noted that the maximum stress in out shell, frame and inner shell is 781MPa, structure is safe under 15MPa external hydrostatic pressure. It’s also noted from Fig. 3 that the ultimate bearing capacity of Double-walled shell in case of all weld is 19.96MPa.

3.2 Point weld
In the case of point weld, the stress of out shell, frame and inner shell is displayed in Fig. 4 under 15MPa external hydrostatic pressure, the stability curves is also given in Fig. 5. It’s noted that the maximum stress in out shell, frame and inner shell is 840MPa, structure is safe under 15MPa external hydrostatic pressure. The ultimate bearing capacity of Double-walled shell in case of point weld is 19.64MPa.

3.3 Contact only
In the case of contact only, the stress of out shell, frame and inner shell is displayed in Fig. 5 under 15MPa external hydrostatic pressure. It’s noted that the maximum stress in out shell, frame and inner shell is 783MPa, structure is safe under 15MPa external hydrostatic pressure. The ultimate bearing capacity of Double-walled shell in case of contact only is 19.60MPa.

3.4 Comparative analysis
Focused on the stability of double-layered shell, the ultimate bearing capacity of shell under external pressure is given in Table 1. It’s noted that, compared with the stability n the case of all weld, the change of weld plan on stability of shell is small, the ultimate bearing capacity of shell in case of point weld is 19.64MPa, the reduction is 1.59%; the ultimate bearing capacity of shell in case of point weld is 19.60MPa, the reduction is 1.77%. Therefore, contact only or point weld plan could be applied while the Double-walled shell is under construction.

<table>
<thead>
<tr>
<th>parameter</th>
<th>All weld</th>
<th>Point weld</th>
<th>Contact only</th>
</tr>
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<tbody>
<tr>
<td>$P_c$</td>
<td>19.96</td>
<td>19.64</td>
<td>19.60</td>
</tr>
<tr>
<td>Reduction</td>
<td>-</td>
<td>1.59%</td>
<td>1.77%</td>
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4. Conclusions
In this work, numerical simulation is conducted to investigate the influence of weld plans between frame and out shell on structural stress and stability. It’s shown that the change of weld plan between frame and out shell is small, under 15MPa external pressure, shell is safe in all cases, and the ultimate bearing capacity changes a little. Thus, the weld plan of point weld or contact only for frame and out shell could be applied while the Double-walled shell is under construction.
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References


