ANALYSIS BUS BODY STRUCTURE COVER BY USING ANSYS WORKBENCH SOFTWARE

PHÂN TÍCH KẾT CẤU VỎ BAO KHUNG XE BUÝT BẰNG PHẦN MỀM ANSYS WORKBENCH

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ABSTRACT

Cover of bus body for forming the shape and structure of vehicles. There are made from thin plates often use cutting, stamping, bending to shape. In the process of working vehicle, thin plates are subjected to complex loads that are scattered, compressed in the direction of the edges boundary, subjected to bending and twisting due to the load on the sheet surface. Plates calculation aims to best determine the size of the thickness and the composite material of the thin plates.

The paper, finite elements analysis is performed using ANSYS Workbench software (version 18.2) on thin plates of bus with varying thickness and materials is of composite. The uniformly distributed and centralized load loading conditions are considered. The analysis result of deformation, stress and oscillation frequencies for different thicknesses. These results are compared analysis of the simulation accuracy.

Keywords: *Automotive Bus body, thin plate, Static analysis, Modal analysis.*

TÓM TẮT

Vỏ của kết cấu khung xe buýt định dạng hình dáng của phương tiện. Chúng được chế tạo từ tôn tấm sử dụng công nghệ cắt, dập, uốn để tạo định dạng. Trong quá trình làm việc của xe buýt, các tấm mỏng phải chịu tải trọng phức tạp bị phân tán, nén theo hướng của ranh giới các cạnh, chịu uốn cong và xoắn do tải trọng trên bề mặt tấm. Tính toán các tấm nhằm xác định tốt nhất kích thước của độ dày và vật liệu tổng hợp của các tấm mỏng.

Nội dung của bài báo phân tích các phần tử hữu hạn được thực hiện bằng phần mềm ANSYS Workbench (phiên bản 18.2) trên các tấm vỏ mỏng của xe buýt với độ dày khác nhau và vật liệu là hỗn hợp. Các điều kiện tải trọng phân phối đồng đều và tập trung được xem xét. Kết quả phân tích biến dạng, ứng suất và tần số dao động cho các độ dày khác nhau. Những kết quả này được phân tích so sánh độ chính xác mô phỏng.

Từ khóa: *Khung xe buýt, tôn mỏng, tải trọng tĩnh, phương thức phân tích.*

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1. INTRODUCTION

Thin plates is used on the body of the vehicle to form the outer cover of the body, also to make the beams. Thus thin plate has a major influence on vehicle shape design, in addition to account for a large weight in proportion of both volume and value of the vehicle. Traditional materials for making cover body are steel plates. Using thin plates with composite materials will have many strong advantages to help reduce production costs because it is unnecessary to use high-priced stamping machinery, reduce vehicle weight, thus reducing fuel consumption and increasing durable due to not rust like steel plates, reducing noise in the vehicle compartment. About the effect of reducing vehicle mass on the overall fuel economy, generally speaking, a 100kg savings in vehicle mass will result in a fuel savings of 0.3 - 0.5L per 100km and 0.85 - 1.4kg CO_2 per 100km (12 - 16% reduction in CO_2 emissions). Automakers have found that up to a 20% reduction in the vehicle mass is achievable in the 2015-2020 time frame with minimal additional manufacturing cost due to the needs for modifying current manufacturing routes [1, p.268].

A body panel for a mass transit bus was designed, analyzed and manufactured. Glass/PP woven tape was used as the face sheet material and PP honeycomb was used for the core. The Pro/E, Hypermesh and ANSYS codes were used for the design and analysis. The total weight calculated from the solid model was found to be 11.7kg, The weight of the manufactured parts after being assembled was found to be 13.1kg. A weight saving of 55% is achieved [2].

The replacing steel plates with composite materials, it is necessary to ensure the durability of the plate as well as the whole body. In order to solve this, analyzing the mixture of blended materials, with the structure core layers to make the plate to analysis. A research impact on composites function of many parameters influencing its analysis an composite laminates body of Glass Fibre Reinforced Polyester (GFRP) of varying thicknesses of 8mm, 12mm, 16mm, 20mm, 24mm, and 28mm. The impact resistance and subsequent load-bearing capacity of the composites depend on fibre and matrix properties, fibre-matrix lay-up, number of layers or ply, thickness and impact velocity. These GFRP composites were considerable strength of 145.83MPa before ballistic deformation and 97.3MPa after ballistic deformation [3].

A study is based on finding the best first natural frequency for the GFRP combinations which should be replaceable in place of steel plate. This study has experiment for the GFRP which is combination of all 3 layers 0 - 90 degree orientation and the FEA analysis results that first natural frequency observed as combinations which is around 10.6Hz to 11.063Hz [4]. The influence of stacking sequence of composite plates of the nine-node isoparametric rectangular element with 45 degrees of freedom for the generalized displacements and 2 electrical degrees of freedom is implemented for the static and dynamic analyses and position of piezoelectric layers and sensors/actuators patches on the response of the piezoelectric composite plates is evaluated [5].

2. METHODOLOGY OF RESEARCH

On the basis of a rectangular of bus body roof plate, the corner edges are bent in the shape of the vehicle with two different loading conditions including (1) uniformly distributed load throughout the sheet area, and (2) only middle at some point on the plate surface. There are two different materials compared to thin plate and composite material. These panels are modeled and statistically analyzed and dynamically analyzed in Ansys Workbench software version 18.2. Analysis results with different materials are compared using regression analysis.

3. ANALYSIS BODY STRUCURE

Body structure of bus are divided into 6 pieces joined together by welding links including front, rear, roof roofs, two side panels and floor. On plaques with metal frames and thin plates. Figure 1 shows the 29-seat body structure, Figure 1.

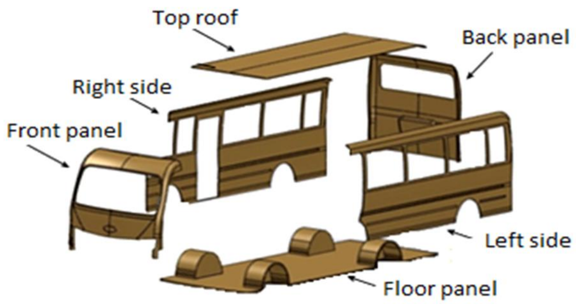

Fig. 1. The Hyundai County body structure

While the vehicle is in operation, the front plate is subjected to the main air resistance, the floor plate is fitted with the frame by damping rubber fixed by bolts, the side plates and the rear panels form a hard shape firm of cover. Out of covered with ED primer is 50 - 75 micrometers thick and sprayed with different coatings, the outermost is a decorative paint.

Thin plate will be to bending and cutting vibrations [7]. Natural oscillation frequency f_s of the plate when the displacement cut is calculated by the equation (1).

$$f_s = r_f \frac{1}{4H}\sqrt{\frac{KGS_W}{m}} \quad (1)$$

Natural oscillation frequency when bending f_u of sheet when bending displacement is calculated by equation (2)

$$f_u = r_f \frac{0.5595}{H^4}\sqrt{\frac{EI_W}{m}} \quad (2)$$

From that we determine the natural oscillation frequency of the plate determined by equation (3).

$$f_T \approx \sqrt{\frac{1}{f_s}+\frac{1}{f_u}} = \frac{2\pi}{\lambda_{sf}^2 r_f}\sqrt{\frac{m}{EI}} \quad (3)$$

Where r_f is coeffcient used by Zalka spreading lumped mass multiplied by the building's height, H is sheet thickness, K is shear constant, G is shear module, S_w is wall area, m is mass multiplied by height unit, G is shear modul, I_w is second moment of area- neutral axis ratio, λ_{sf} is characteristic coefficient of material given by manufacturer.

Application of finite element method we can calculate f_T frequency in Ansys Workbench software.

4. SIMULATION OF BODY VIBRATIONS

The process of simulating the thin plate vibration is done to increase the local stiffness by increasing the thickness of the extra plates or beams, or fabricated with wavy shape, or treated with complex structures. Other impurities such as welding additional small plates on the surface or corner of the plate also affect the plate vibration behavior.

The characteristics of the oscillation frequencies of the plate are considered to be the parameters to be investigated and obtained by the finite element method (FEM) or the actual test on vehicles with sensors, measuring devices and software. The frequency of oscillation will depend on the parameters of the material and the weight of the plate. When changing these parameters, the oscillation frequency of the plate will change accordingly, from which the appropriate material can be chosen in the direction.

Solve the equation to calculate the natural oscillation frequency of the plate, we use the finite element equation. Element stiffness matrix parameters [K], load matrix [R] and displacement matrices [r] of elements. with general equations solve by the displacement method analyzing the structure of the tires mentioned in equation (4), [8, p75].

$$[R] = [K].[r] \quad (4)$$

Using Ansys Workbench software to simulates thin roof panels. Criteria for selecting materials for body panels are mechanical strength, low weight, energy absorption, cost and ease of production. Thin-plate carbon steel material is the original material of the vehicle, and the composite material selected to compare the simulation results of CFRP-Epoxy type with tensile strength and better bending properties than steel [3]. The material properties used for analysis are given in Table 1.

Make drawings of 2D and 3D design of thin plates of bus body, update 3D modeling software with material parameters as shown in Table 1. Next select element type and conduct meshing of elements. After controlling the quality of fine meshing according to the time and

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configuration of the computer. Figure 2 introduces 3D models of top roof is thin plates that have been updated into software and meshed. To ensure smooth and error-free mesh, the appropriate number of nodes will be 2413 and 2310 elements.

Table 1. Material properties in the investigation of thin plates

Materials	Density (kg/m^3)	Young's Modulus (GPa)	Tensile Yield strength (MPa)	Poisson ratio	Thickness (mm)
Steel plate	7890	210	210	0.3	0.8 - 1.5
CFRP-Epoxy	1600	150	1100	0.22	3.0

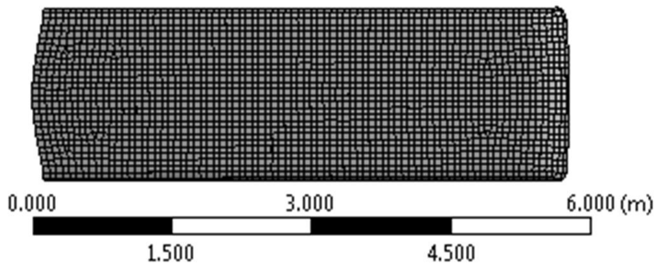

Fig. 2. Model of top roof and meshing

The next step determines the boundary conditions and load mode. The boundary condition defined at the boundary around the roof plate is the position of tight assembly with the panels around the body of the vehicle. Load mode is the air pressure acting on the plate surface when the vehicle moving. Choose Static module in structural analysis, Modal module analyze oscillation forms, Harnomic module analyzes harmonic fluctuations of the plate. For each different thickness of thin sheet metal or with Composite material will give different simulation results, from which we can reasonably analyze the parameters of thickness of thin metal sheet or material type Composite matching. The simulation results in the form of colored areas that distinguish stresses, maximum displacements on the surface of the sheet, Figure 3.

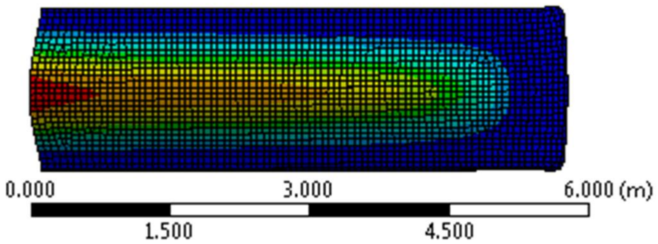

Fig. 3. Simulation results of top roof

5. RESULTS ANALYSIS

Simulation results include vibration frequency of 14 modes shape, Figure 4, show ingthat for thin plate steel materials, the specific vibration frequency gradually increases with the plate thickness, with thin plates 0.8 (mm), frequency values lowest dynamic; 1.5 (mm) thickness, the individual vibration frequency value is the largest. This suggests that thinner thickness sheets will vibrate lighter than large sheets. When using CFRP of 3.0 (mm) synthetic materials, it is shown that the specific vibration frequency is much greater than that of steel thin plates. Obviously, when using a composite materials, the body structure will be subjected to more vibration, so it is needed to find a more suitable thickness to reduce vibration.

The loads mainly as air pressure acting on the plate surface out, the results obtained for the value of the plate displacements are shown in Table 2. Steel plate thickness of 1.0mm have 0.38698 (m) displacement is greater for the remaining case, the CFRP transposition is 0.17926 (m) equivalent to other thin steel plates. This result affects the durability of the plates.

Table 2. Displacements of top roof

Thichnees of thin plates (mm)	Minimum (m)	Maximum (m)
0.8	2.6066e-003	0.27456
1.0	1.2959e-004	0.38698
1.2	1.8899e-003	0.18516
1.3	2.3876e-002	0.13106
1.4	1.9883e-002	0.15462
1.5	1.6826e-004	0.19324
CFRP	9.185e-002	0.17926

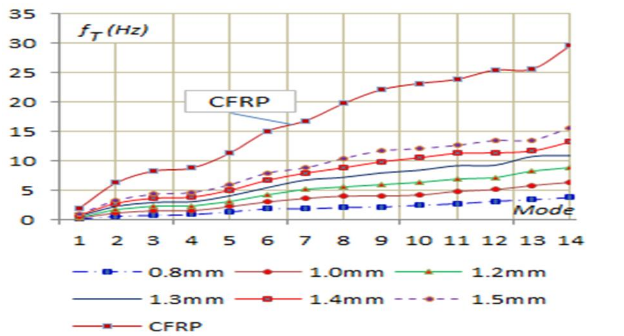

Fig. 4. The Modes shape of top roof

Calculating the strength of the roof sheet when assembling the thin plate on the body of the vehicle, we get the stress and deformation values of the plate, from which the optimal size in the design can be determined. The values of durability of the sheet are shown in Table 3. The plate using CFRP synthetic materials will be the largest deformed, to overcome the need to strengthen the glass fiber composition of the material.

Table 3. The displacement value, stress and equivalent stress of top roof

Thickness of plate (mm)	Total Deformation (m)	Equivalent Elastic Strain (m/m)	Equivalent (von-Mises) Stress (Pa)
0.8	2.4051e-003	5.9243e-005	1.1823e+007
1.0	2.7934e-003	2.9697e-004	5.9327e+007
1.2	3.2698e-003	3.6364e-004	7.2694e+007
1.3	1.8179e-003	1.6824e-004	3.3635e+007
1.4	2.6637e-003	3.1289e-004	6.2543e+007
1.5	3.6178e-003	4.851e-004	9.7005e+007
CFRP	4.6202e-003	2.9091e-004	4.3631e+007

6. CONCLUSIONS

The research results contribute to the process of designing automobile body. By careful selection of thickness and materials, on this basis, it is possible to actively manufacture thin plate technology for body buses. Using the iterative design and finite element method, simulation in Ansys Workbench software for top roof analysis is a case study and developing the analysis of other panels of the whole vehicle body also (base on the analysis of the top roof, further similar analyses for different parts of the bus body...).

Using CFRP synthetic materials will help to reduce vehicle weight while maintaining durability and reducing noise to the passenger compartment. This weight reduction will meet future fuel consumption and emissions requirements, both for the present and the future.

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