Analysis of the local position of electric vehicle frame connection by steel and aluminum hybrid material

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Keywords: Frame connection; Steel and aluminum hybrid material; Optimization

Abstract. With the advantages of low energy consumption and zero emissions, pure electric vehicles are tent to be the substitution of the traditional vehicles. However, there are a lot of electric frames still made of welded square steel and angle iron, it can increase the intensity of the frame by this way, and the total weight of the vehicle will be increased and then waste the limited energy of the vehicle batteries. So in this research, the lightweight material aluminum alloy is used to be combined with square steel as the new vehicle frame. And such two different kinds of materials were combined using riveting way. Two types of structure, $40 \times 40 \times 3$ and $30 \times 30 \times 3$, were used in this research. In order to validate the results, the analyze function of the Ansys Workbench 14.5 can be used to analyze the overall frame to determine the optimal stress distribution and deformation conditions.

Riveting design

There are two kinds of riveting way for the combining of the square steel and the angle iron. For the first one, as shown in the figure 1(a), the size $40 \times 40 \times 3$ material was used as the frame and another material was inserted it. Another one is the $30 \times 30 \times 3$ as the former, and then it was riveted on another material, as shown in figure 1(b).

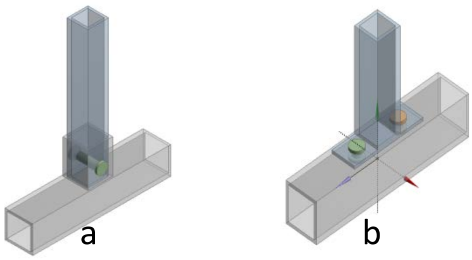
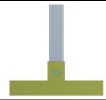
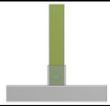
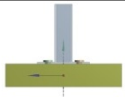
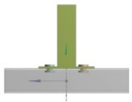


Figure1.Riveting design

When interchange the different size and materials, we can get such compositions as shown in Table 1.

Table 1 Riveting method

No.	Riveting design	Riveting method		Schematic diagram
a	Frame riveting	(1)	Structural steel interest into Aluminum alloy welding	
		(2)	Aluminum alloy interest into structural steel welding	
b	Spoke riveting	(3)	Structural steel former and Aluminum alloy welding	
		(4)	Aluminum alloy former and structural steel welding	

Simulation analysis

In this paper, the Geometry module of the ANSYS Workbench is used to create the 3D model, and then analysis the static loading by the Static Structural module. And the parts of the mount support in the front suspension is the analysis model which bear the weight of batteries (135kg) and the driver (65kg), as shown in the Figure 2.

Specific programs loaded as shown in Figure 3. Optimal design consideration is pulled 2000N in the case, for other loading can also be treated in the same way, this article does not repeat all.

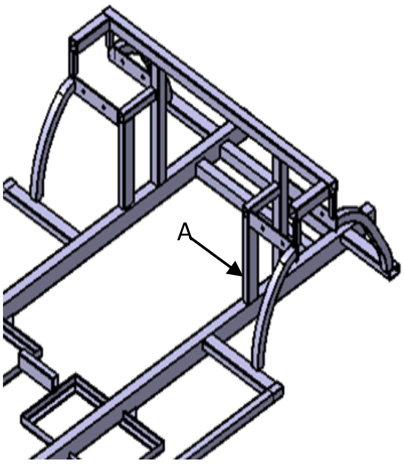
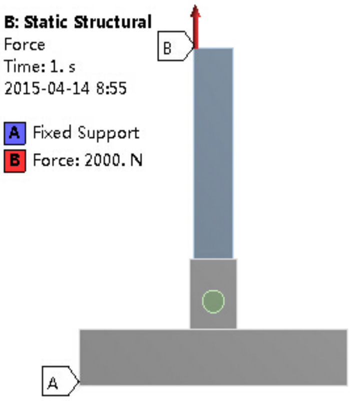
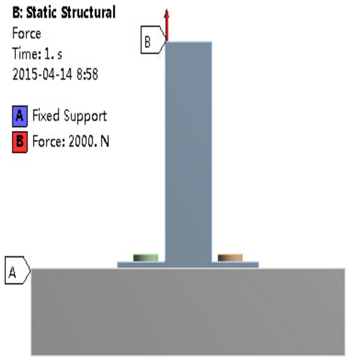


Figure2.Diagram of Analysis



Load of Riveting design a



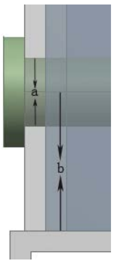
Load of Riveting design b

Figure3.Load program

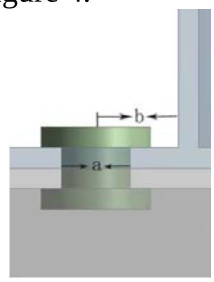
Parameters and Optimization

Optimal parameters

Parameterization modeling is used to select the diameter of the rivet hole and the distance between the center of the rivet hole and the edge, as shown in the figure 4.



Optimal parameter of Riveting design a



Optimal parameters of Riveting design b

Figure 4. Optimal parameters

Target parameters

The target parameters are the maximum distortion value and the maximum stress value.

Analyze process and results

The analyze process is operated in ANSYS Workbench. The four connections are applied to optimize the analysis, the response surfaces are shown in Table 2, and each connection and the minimum amount of deformation data are selected. System minimum stress values for optimal results are shown in Table 3.

Table 2 Response Surface

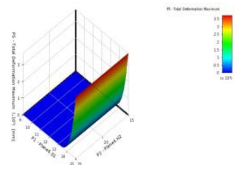
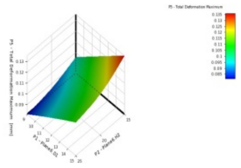
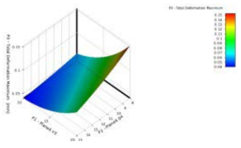
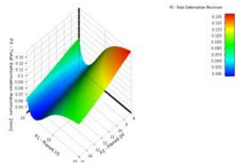
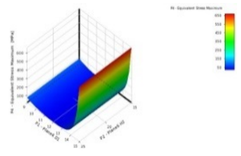
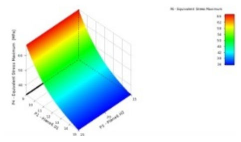
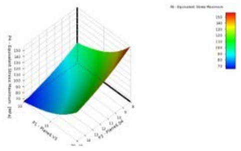
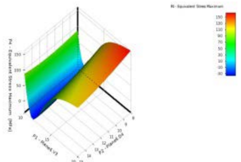
Response surface type	Riveting method	response surface
Numerical optimization parameters on the deformation response surface	Structural steel interest into Aluminum alloy welding	
	Aluminum alloy interest into structural steel welding	
	Structural steel former and Aluminum alloy welding	
	Aluminum alloy former and structural steel welding	
Numerical optimization parameters on the stress response surface	Structural steel interest into Aluminum alloy welding	
	Aluminum alloy interest into structural steel welding	
	Structural steel former and Aluminum alloy welding	
	Aluminum alloy former and structural steel welding	

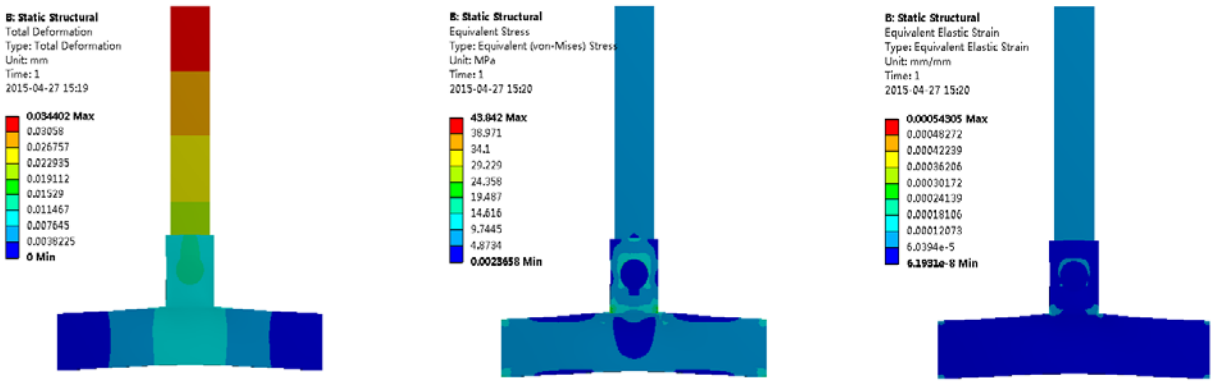
Table3 Total Deformation Maximum Minimum and Equivalent Stress Maximum Minimum

Riveting method	Design Point	Total Deformation /mm	Equivalent Stress /Mpa	Rivet hole diameter /mm	Distance from hole center to the edge /mm
Structural steel interest into Aluminum alloy riveting	Total Deformation Maximum Minimum Design Point	0．043561	46.781	15	15
	Equivalent Stress Maximum Minimum Design Point	0．043777	46.649	15	22.784
Aluminum alloy interest into structural steel riveting	Total Deformation Maximum Minimum Design Point	0．034654	44.231	15	22.784
	Equivalent Stress Maximum Minimum Design Point	0．034393	44.231	15	25
Structural steel former and Aluminum alloy riveting	Total Deformation Maximum Minimum Design Point	0.038439	67.609	15	11.374
	Equivalent Stress Maximum Minimum Design Point	0.042252	167.37	13.773	11.486
Aluminum alloy former and structural steel riveting	Total Deformation Maximum Minimum Design Point	0.03916	65.312	15	10
	Equivalent Stress Maximum Minimum Design Point	0.03916	65.312	15	10

In summary, the optimal plan is that Aluminum alloy interest into structural steel welding plan when the diameter of the rivet hole is 15mm, and the distance between the center of the rivet hole and the edge is 25mm.

Conclusion

According to the analyzing, the deformation deprogram、stress deprogram、strain deprogram are show in the Figure 5.



The deformation nephogram Stress nephogram Strain nephogram

Figure 5. Analysis result

At last, the system distortion of the selected optimal plan is about 0.034mm which satisfy the requires of stiffness of the electric vehicles frame; and the maximum stress of the system is 43.842Mpa which is much less than the admissible stress of the structure steel (250Mpa) and the admissible stress of the Aluminum alloy (280Mpa), so it can satisfy the requirements well for the electric vehicles.

References

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