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Research Article

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Optimal design for brake shell of passenger car

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ABSTRACT

In this article, taking the design for brake shell of passenger car of a company for example, combining structural optimization technology, integrating the factors of optimizing design requirements, space requirements of the system, molding process and cost analysis. Integrate topography optimizing, then stamp process technology and the layout requirements of the brake shell. Formed a technology road-map of the structural optimization of the brake shell and carried out an optimal-design method. Solved problems of the previous design for the brake shell (repeated cycle between design and simulation analysis) whose cycle is long and the results are not ideal.

Key words: optimal design; brakes; shell; topography optimizing; space layout.

INTRODUCTION

Brake is a very important safety part of a car, which enables to slow down or stop a moving car, to let the speed of the downhill motor vehicles remained stable and to make the suspended car (including on the slopes) reside fixed. Hence, during the design of a car, the design and optimization of the brake are extremely important to the safety and performance of a car. However, the traditional design process of the brake shell is miscellaneous, so a lot of scholars have done some research in this regard.

In the study, Shao-feng Kang [1] put forward that the first-order modal of the brake shell of passenger car is required more than 60HZ in the plan, or it will produce the resonance phenomenon with the system and external motivation. For this, he improved the first-order frequency of the brake shell by discussing topology optimization and topography optimization.

Cheng Wang [2] put forward the topography optimization of the support parts in the OptiStruct software, and then got a new method to arrange the stiffener. Yun-hui Duan [3] put forward that the brake shell of the passenger car is a structure of sheet metal, and the constrained mode of the brake shell is required to be more than a certain value, or it will produce the resonance phenomenon with the external motivation and then it will affect the fatigue life of the product structure.

Nowadays, in pace with the development of computer technology and structure optimization, the topography optimizing of sheet metal achieved a certain development [4-6]. But literature of the optimal design for brake shell of the car is so few. In this essay, taking the design for brake shell of passenger car of a company for example and combining structural optimization technology, we find a practical method for the optimization design of the brake shell.

EXPERIMENTAL SECTION

Optimal design for brake shell

The traditional design-course of the shell is that the product designers determine the three-dimensional mathematical model and forward it to the simulation staff to do the CAE analysis. If the first-order constrained mode is less than

60HZ, the engineers only can improve by relying on the results and design experience. That is to say, the whole design process is generally a reciprocating cycle which is design--analysis--improve--reanalysis. Thus, the time of the design is longer and the efficiency is too low, furthermore, due to the limit of the project's cycle, the final plan is often not optimal. The technique of topography optimizing of the Altair-company comprehensively considered the factors of the design process and optimization methods and solved the problem perfectly. In the following, we elaborate on the method and route of the optimization design of the brake shell from optimizing mathematical model and the process and confirming the results.

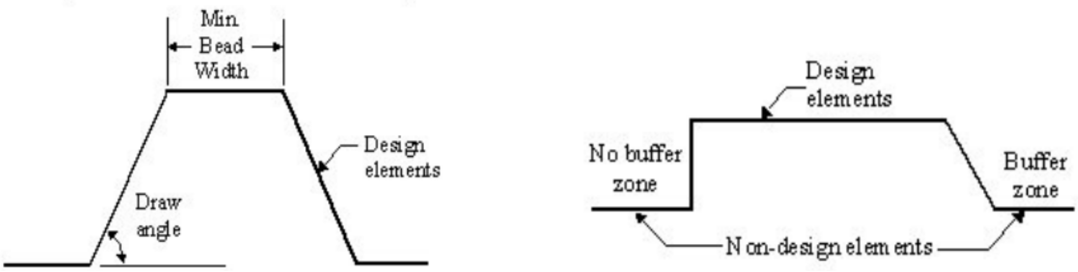
Optimizing mathematical model

1) The optimizing mathematical model can be described as:

Maximize: $f(x) = f(x_i)$

s. t.: $lb_i \leq x_i \leq ub_i$ i=1, 2, … , n

$x=x_i$ is the design variable, and here it is the design variable of the stiffener size (Figure 1 shows a schematic of partial stiffener parameters); f(x) is the design goal, here it is the frequency of the first-order constrained mode; lb_i is the lower threshold of the design variable; ub_i is the upper threshold of the design variable.



Note: The buffer zone is the transitional forms of the optimization element.

Figure.1 Schematic of partial stiffener parameters

Optimizing the design process

1) Processing the digital analogy: This process is a very important part and it determines the basic configuration of the analysis. If we can't get the ideal results after the optimization, then we need to modify the basic configuration of the digital analogy. The product model and its stamping draw-bead set we get in the optimization analysis are often undesirable, then we should modify the draw-bead, like removing or modifying some holes or flanges, and do the further work of optimization analysis.

2)Establishing and analyzing the finite element model: Establishing the standard constraint modal finite element analysis model of the brake shell, and doing the simulation analysis. The results of the simulation analysis are shown in Table 1.

Table.1 The frequencies of constraint modal of the brake shell

Front brake shell					
1	Mode	1:	Value = 1.79318E+05	Freq = 67.396	(cycles/time)
2	Mode	2:	Value = 2.43076E+05	Freq = 78.468	(cycles/time)
3	Mode	3:	Value = 5.39695E+05	Freq = 116.92	(cycles/time)
4	Mode	4:	Value = 8.59687E+05	Freq = 147.57	(cycles/time)
5	Mode	5:	Value = 1.51884E+06	Freq = 196.14	(cycles/time)

3) Establishing the Optimal Model: The structure optimization model of the shell is based on the above finite element equation. The morphology change of a shell unit which is considered as a design variable.That is to say, set the parameters of draw-bead which conform to the actual demand (size parameters are shown in figure 1). The parameters setting contain the parameters such as the layout direction, size, concave and convex direction of rebar, whether to include a buffer area or not and other factors.

Determine the range of parameters cautiously by taking the manufacturability of the actual product under consideration and communicating with the process engineer. The other important point is that these parameters are related to the specific-actual work space of the brake shell. Or it probably can't be applied in different work space for rapid improvements of the model and can only point out a certain-direction of improvements. We even need to try to change the model and reanalysis and even can't get the optimization of the model. There is no need to set the constraint response (what the most important is constraint of variables). Set the maximize first-order constraint modal frequency of the optimal objective. From figure 2, the optimal analysis model is easy to the produce processing. It can be achieved by removing three holes on the original model of the shell, and modifying the modulus according to the optimized size of the stamped rib.

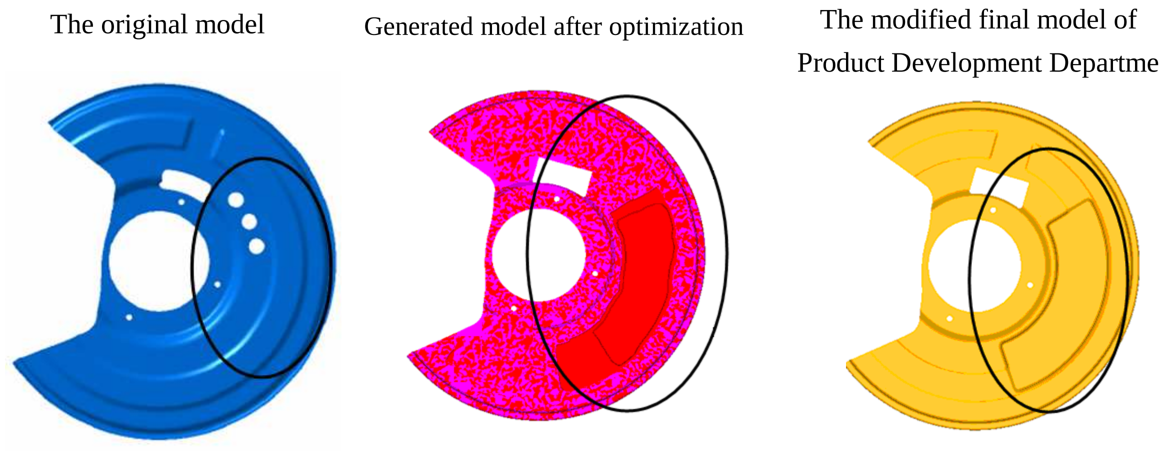


Figure.2 The optimal design results of the brake shell

RESULTS AND DISCUSSION

Verification of optimization

The simulation analysis of the standard modal analysis was carried out on the final model validation. The result is shown in figure 3. The first-order frequency (67.396 Hz) increases by 26.4% compared to the original model. Applying the shell program to the braking system, as shown in figure 4, the minimum clearance between the shell and the steering knuckle is 5.447mm, which can meet the demand.

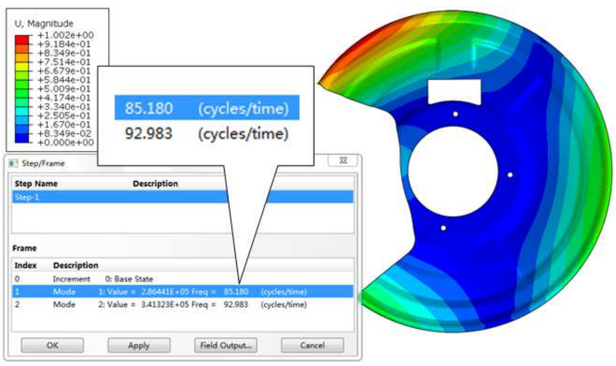


Figure.3 The optimal design results of the brake shell

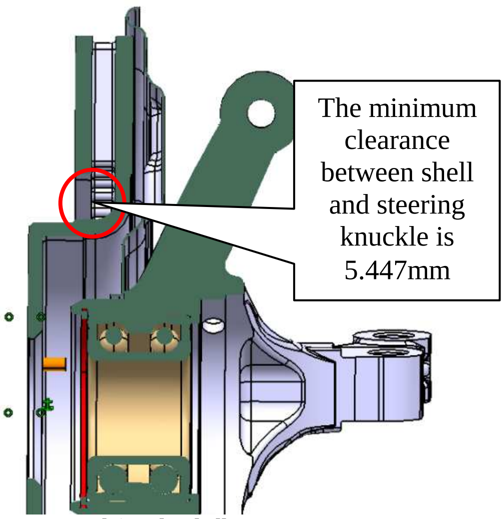


Figure.4 Applying the shell to the braking system

CONCLUSION

The effect of product optimization in this case is very good in that its digital model characteristic is clear and its molding process is excellent and it is convenient for product-designers to build the digital mode. The verification of the analysis result shows these models can be directly used for research and develop in next phase such as engineering drawing just after a little bit of modification.

The cover-shell structure can be stiffened and strengthened by the added draw-bead in its metal plate. Generally, how to reasonably design the layout of draw-bead and look for optimal product structure are the difficult points in the design of the cover shell. In this essay, integrated the factors of optimization design requirements, space requirements of the system, molding process and cost analysis, used the morphology optimization technology which can improve the performance of the product by a large margin, and extracted an optimization design line which can be used into the company for developing similar products.

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