Finite element analysis and optimization design for automobile interior door-handle

Enguang Zhang \textsuperscript{1,\textastemoji} and Li Wang\textsuperscript{1,\textdagger},
\textsuperscript{1}Zhuhai College of Jilin University, Zhuhai, 519041, China.
\textsuperscript{a}teamcenter@163.com \textsuperscript{b}wangli00019@163.com

Abstract. This paper used NX8.0 to perform parametrization design, motion simulation, finite element analysis, fatigue life analysis and optimization design on the automobile interior door-handle. Load Transfer Method and Single Body Method were used to analyze the Maximum stress of door-handle. The mechanical properties before and after optimization were compared. Results showed that the maximum stress was reduced by 12.65\%, the fatigue life is 3.62E+007 Duty Cycles, and fatigue life met design requirements. All processes were completed under the same software, which ensured the data consistency and improved design efficiency.

1.Introduction
According to incomplete statistics, in 2018, China's domestic passenger vehicle sales reached over 24 million, with a broad market in automobile manufacturing related fields. For manufacturing enterprises eager to improve the added value of products in the Pearl River Delta, it is easier to apply for design, manufacturing and independent intellectual property rights in the field of auto interior parts. Especially in the new energy vehicles without the traditional engine, gearbox and other important parts, the car body and interior and exterior parts are more important.

Many automobile interior parts are wearing parts. The car door handle is the most touched interior parts except the steering wheel. The multi-phase characteristics of the materials, the randomness of the load and etc, all bring random uncertainty factors to the reliability of the car door handle, which often cause situations such as breaking, deformation and so on. Therefore, the research on the reliability of automobile door handle is very important. At present, a lot of optimization design of automobile interior is about Humanization, aesthetics and assembly\[1-3].

The door handle assembly is composed of base, door handle and fastener. There are about 8 sets of inner and outer door handle assemblies for each car. For a car with a market share of about 500000, there are about 4 million sets of door handle assemblies, so the best layout of its materials is particularly important in cost control.

In this project, through the top-down design method, the door handle assembly of a certain type of automobile is designed parametrically, and kinematic and dynamic analysis is done. Capture mechanical loads at joint locations for use in a finite element analysis in the Advanced Simulation application. According to the results of finite element analysis, combined with many years of practical design and production experience and user feedback of vulnerable parts, the structure was optimized to complete the detailed design of automobile door handle assembly, improve its reliability and reduce product cost. The limit position of the interior door handle assembly is shown in Figure 1.
2. About NX8.0

NX8.0 is a powerful software that integrates CAD, CAE and cam solutions. Its advanced simulation module has gradually absorbed and integrated many functions and advantages of the world's excellent finite element software in the development of many years. The advanced simulation module is seamlessly connected with many mainstream solvers, such as NX Nastran, MSC Nastran, ANSYS and ABAQUS. You can transfer mechanical loads at Motion Simulation joint locations for use as time-dependent loads in a finite element model in the Advanced Simulation application.

3. Motion Simulation and Capture mechanical loads

In Motion Simulation, for a selected link, the Load Transfer command captures the reaction forces, torques, gravity, and accelerations at each timestep in the simulation for each motion object (such as a joint) connected to the link. The captured forces and torques are saved in the motion simulation file and are also written to a spreadsheet for your reference. XY graphing records are also generated for each connected motion object at each timestep. You can plot these graphs as needed[4]. Then select the transfer load at the limit position of the last step as the load in advanced simulation.

In Advanced Simulation, you can use the load before Import Motion Loads command loading. A single load transfer node is generated at the center of the motion object's motion pair. The rigid elements or a 1D Connection mesh must be used to connect the load transfer node to the surrounding mesh there. As shown in Fig.2.

4. Finite Element Analysis of Interior Door Handle form “Load Transfer” Method

The finite element analysis of the Interior Door Handle base was performed in the NX8.0 advanced simulation module using a 4-node 3D tetrahedral mesh. The finite element model contains 148551
elements and 237787 nodes. The load under this working condition is the ultimate tensile force of 360N loaded in the dynamic simulation, and the material is PC/ABS alloy, whose Young's model is 2410N/mm², poisson's ratio is 0.39. Because of the difference in composition, the tensile strength is basically between 45 and 69 MPa[5]. As shown in Figure 3, the maximum Von Mises is 33.54Mpa.

5. Finite Element Analysis of Interior Door Handle form “Single Body” Method
According to the working condition, add load to the interior door handle separately to ensure that the maximum force or reaction force is the ultimate load of 360N. The material is still PC/ABS alloy, using a 4-node 3D tetrahedral mesh, element size is 0.5mm. The finite element model contains 1693017 elements and 339299 nodes. As shown in Figure 4, the maximum Von Mises is 44.02Mpa. This is close to the tensile strength of some PC/ABS alloys. Compared with the Load Transfer Method, the maximum stress is basically in the same position and is consistent with the actual product. But the Load Transfer Method can be used to get more accurate results in more complex institutions.

6. Optimization Design and Finite Element Analysis
Because maximum von Mises does not exceed tensile strength, only unreasonable detail features are optimized, some constant radius edge blend before is deleted, and weak parts are optimized by using edge blend, variable radius blend and other commands combined with enterprise experience, as shown in Figure 5. The variable radius blend command is used to optimize the design of the model. Because the whole design process is parametric and relevant, the latest results can be calculated and analyzed by updating the final element model directly after the optimization design. The maximum Von Mises
is 38.45MPa, which is decreased by 12.65%. as shown in Figure 6. According to the normal tension of 8N, the reaction force at the limit position is 19N, and the fatigue life is 3.62E+007 Duty Cycles. as shown in Figure 7.

Fig. 5 The variable radius blend command is used to optimize the design of a model

Fig. 6 The maximum Von Mises

Fig. 7 The fatigue life
7. Conclusion
This article takes an automobile interior door-handle as the research object, using Nx8.0 to carry out dynamic simulation, finite element analysis and optimization design. All processes are completed in NX8.0, which ensured the data consistency. The method used in this paper has a certain engineering value, which can help related enterprises reduce design cost and shorten design cycle. The research in this paper can be referred in further research of auto parts.

Acknowledgement
This paper is supported by the project "Design and reliability analysis of key parts in automobile interior"(2018KTSCX310), which is a key scientific research platforms and research projects of Guangdong universities in 2018 approved by Guangdong Provincial Department of education.

References
[1] Zeng Qi,Wang Kang,Liu Xuelei,Liu,Hua-guan. Design optimization of automotive door interior panel based on switch assembly requirements [J]. Auto Time,2019(16):98-100.
[2] Zhao Zhi-gang,Liu Li-tao,Liu Hong-xuan. Lightweight design of car interior [J]. Auto Time,2019(10):57-58.
[3] Xu Cheng-kun. Some thoughts on the optimization design of automobile interior [J]. Science & Technology Information,2018,16(25):74+78.
[4] Siemens PLM Software, NX8.0 Help Library, 2011.
[5] Sheng Hai-feng,Cheng Yang-chao,Guo Rui-feng,. Application of Waste ABS in PC/ABS Alloys Used in the Car Interior [J]. China Plastics Industry,2019,47(05):94-97+1