Research and optimization of automated processes for MDO simulation in BIW matching

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Abstract: This paper focuses on the research of BIW simulation analysis by a car company, introduces the content and method of BIW simulation, and proposes a new method of MDO simulation of BIW, while ensuring the continuity and perfection of key systems such as RPS and MBD in the whole process. Perfecting the process of virtual matching. The whole BIW matching analysis process is streamed through multi-disciplinary integration, and efficient automation is realized on the basis of programmatic, which greatly saves the time of the entire analysis process.

1. Introduction
For the traditional BIW matching process, the measurement range is limited, the information feedback is not timely, the cost is high, and the efficiency is low. It is difficult to obtain effective control of the vehicle quality. In the past, the measurement method was matching the actual body parts. In the matching process, the corresponding brackets are installed. This disrupts the original body positioning reference system, and the occurrence of virtual matching solves this problem in time[1]. However, in the virtual matching process, it is difficult to solve the complexity of the problem list. It is difficult to reasonably and effectively screen the deformation area with low risk. For the gravity simulation deformation process, it is difficult to effectively generate the reference positioning and provide PMI information. These have seriously affected the efficiency of vehicle production[2].

In order to improve the assembly efficiency and greatly reduce the time of analysis process of the body clamping matching and effectively control the excessive deformation of the BIW sheet metal parts in the assembly process, which affects the structural strength variation of the vehicle. From the front-end design to the medium-term production and even in the process of post-assembly, the accuracy of virtual matching and finite element analysis will depend greatly on the consistency and continuity of the RPS system, MBD system, which will be the top priority of the entire body design and production assembly process. Through the design of the front-end system, it is an inevitable problem to consider how to continue its complete reservation. Through UG secondary development technology, MBD technology, RFS technology, Hypermesh secondary development technology, Polyworks sec-
ondary development technology, MBD assembly information system, changing the engineers as important individuals in the vehicle manufacturing process in the past, avoiding human understanding. It avoids the unnecessary error caused by the difference of human understanding, and the whole process is automatically recognized and readed by the computer, and the complete information acquisition has been achieved.

2. Automation introduction

2.1. Process introduction

The overall process design is completely obtained from complete access to MBD information of the UG digital model, and the PMI coordinate recognition extraction will be used as the key information for the next deformation analysis. Disassemble the BIW in Hypermesh, automatically read the MBD information obtained in UG, determine the constraint points, establish constraints, loads and load conditions, submit analysis, and export analysis deformation cloud map. Finally, importing to polyworks and performing the joint analysis with the virtual matching results and screening. In this intermediate process, the MBD system and the RPS system can be reserved on maximum extent, staggered by traditional measurement methods and assembly analysis processes. The human interpretation difference in the process of handover of different module systems is avoided, and the complete automation process has improved the subsequent precision analysis and uncertainty determination. It can guarantee the accuracy of the BIW simulation results to the maximum, and is also closer to the real value. At the same time, the consistency between the analysis process and the actual process is fully considered. The flow chart is shown in Figure 1 below.

![Figure 1. BIW automation simulation process.](image)

2.2. The key to the UG part

The secondary development in the UG section focuses on how to effectively retain PMI information, which is the key to fully retain MBD model information and MBD assembly information throughout the automated process. Through the user CAD system, 3D assembly process information system, UG API function with the interface technology[4], the process information database, complete acquisition and export, the final result will be processed by hypermesh. The flow chart is shown in Figure 2 below.
2.3. The key to the polyworks part
In the existing research, obtaining the point cloud data, filtering the gross error point, lightening the triangulation model, setting the matching parameters, and performing the data matching to obtain the gap/interference analysis. On the basis of these, contrasting the strain cloud map obtained in hypermesh, screening, generating matching reports were added, and data processing based on polyworks can effectively expand the measurement range, timely feedback information, reduce costs, improve efficiency[3], and greatly reduce the virtual matching list, effectively relax the control of large and soft sheet metal parts. The automated flow chart is in Figure 3 as follows.

2.4. The key to the hypermesh part
Hyperemsh will carry out model finite element analysis, mesh division, and splitting assembly is a matter that consumes a lot of manpower and material resources and cannot be avoided. In the process of the disassembly assembly, the obstacle that is difficult to overcome is to deal with the solder joint which plays a decisive role in the time-consuming efficiency of the entire analytical simulation process. In the past, the processing of solder joints was performed by finding the solder joints, assigning the RBE2 unit, and then connecting the grid cell nodes on the midsurface of the sheet metal part, and using the RBE3 unit to simulate the force transfer occurring during simulation analysis. But the process of disassembly and looking for needs were generated twice. This type of repetitive work had not been well handled. Now, a new processing method is proposed, which is first disassembled and post-processed. Through certain means, the process of repeated processing can be avoided. At the same time, the automatic generation of solder joints is eliminated, and the API is used to search for neces-
sary solder joints and synchronize with the deletion of redundant solder joints. The automated flow chart is in Figure 4 as follows.

![Automated process](image)

**Figure 4. Automated process.**

### 3. Introduction to the new disassembly automation process

The key to the process of dismantling the BIW is how to deal with the solder joints. In the past, it was focused on the search of solder joint information, and parameterized the command file. As shown in figure 5. The data involved in this process is too large and the operation is also complicated.

The solder joints are created by the node and then the RBE2 unit is created, and the node that is closest to the soldered part is connected through the RBE3 unit to achieve the data transfer in the simulation analysis. By studying the disassembled small assembly parts, we found that if there is no processing, there will be the existence of redundant RBE2 units, As shown in figure 7. For the processing of the redundant welded solid element, choose to obtain the central coordinates of all RBE2 units, and then obtain the center coordinates of the RBE2 unit of the already developed connectors, and compare the two in a traversal manner. The realized solder joints’ default coordinate value difference is within 0.1 mm. the excess RBE2 unit is automatically marked and deleted, and the thing left is the RBE2 unit which analysis is required.

![Processing data in the background](image)

**Figure 5. Processing data in the background.**

Connectors form is as shown in Figure 6:

![Schematic diagram of connectors](image)

**Figure 6. Schematic diagram of connectors**
4. Optimization efficiency
In the past, in terms of individual parts, the time spent on solder joint processing in the entire small assembly simulation process, calculating the software running time, from the introduction of the BIW to the constraints, loads and conditions, at least 6mins. a BIW includes at least the left and right doors, the engine compartment cover, the trunk lid, the front and rear fenders, the roof, and the bottom of the vehicle. If do not calculate the time spent in the misoperation, it will take at least 36 minutes for the entire BIW to be imported into a single small assembly for constrained loading. It will take more than two hours to complete the complete process, which has been based on that the engineer is skillful enough and no errors.

After the original implementation of automation, this intermediate process saves 50% of the time. After the optimization of the automation process, the overall work efficiency has increased by 30% again. It achieved a significant increase in efficiency.

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