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# An assembly scheme of elastic bag components in a rigid shell

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***Abstract:*** *In this paper, the development and current situation of China's aerospace manufacturing field are summarized, and the assembly of a kind of elastic bag assembly is analyzed, and the assembly scheme is proposed, which solves the defects of difficult assembly and easy to cut the sealing ring in the assembly of elastic bag assembly. Then, the assembly process of the assembly scheme was introduced in detail, and the reliability analysis of the auxiliary tooling was carried out by using finite element software, and the feasibility of the assembly scheme was verified by digital calculation. Finally, the assembly scheme of the elastic bag assembly is summarized and prospected.*

***Keywords:*** *Aerospace manufacturing; Tooling; Assembly scheme; Finite element simulation*

## 1. Introduction

In the 1970s, China's space industry began to develop vigorously. Especially in the 1980s and the 21st century, various space technology barriers were constantly broken through, and the space manufacturing industry reached a new level. [1] Nowadays, China's space technology has been among the international leaders, and the manufacturing technology in the space field has also undergone various innovations in line with the production needs. Spacecraft production process is divided into demonstration, design, analysis, manufacturing, assembly, testing 6 links, each of these 6 links are very important, assembly is no exception. Spacecraft assembly has complex assembly structure, small assembly space and high assembly requirements. In order to deal with these problems and ensure the progress of the final assembly of the product, the aerospace manufacturing staff analyzed the technical difficulties of various assembly, put forward the solutions and put them into practice, and formed the experience of spacecraft assembly.

Tooling is short for process equipment, that is, the general term for tools used in production and manufacturing, which is used to ensure the product manufacturing tools. [2-4] Tooling is widely used in the production and assembly of machinery, and can be used to ensure the processing technology and quality of products. It is an indispensable auxiliary equipment. Tooling is usually divided into class A tooling, Class B tooling and Class C tooling according to its complexity, vulnerability, maintenance difficulty and maintenance, which represent key tooling, main tooling and general tooling respectively. [5] According to the scope of use, it can be divided into general tooling and special tooling. In the field of aerospace production and manufacturing, due to the complex structure of spacecraft, as well as a variety of processing and assembly accuracy, quality requirements to ensure, tooling is an essential assembly. In general, when some processing and assembly purposes cannot be directly achieved, the first thing we will think of is to make tooling to achieve the goal.

## 2. Assembly of an elastic bag assembly of a spacecraft product in a rigid shell

### *2.1. Background Introduction*

The assembly position structure of the elastic bag assembly of a spacecraft is shown in Figure 1, where 1 is the rigid outer shell of the spacecraft. 2 is the outer shell end cover of the spacecraft; 4 is the elastic bag assembly, and flange 3 as one, collectively called the elastic bag assembly; The elastic bag assembly is connected with the outer shell end cover through 6 bolts of flange plate No. 3 in the figure. There are 2 sealing rings between 3 and 2 (No. 5 in the figure).

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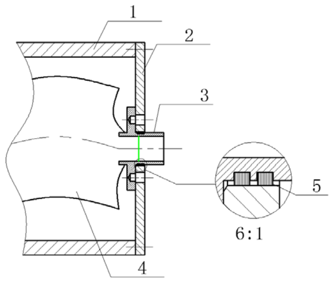


*Figure 1: Schematic diagram of elastic bag assembly assembly*

During the assembly process, due to the short length of the elastic bag assembly, it is not possible to connect the No. 3 flange in Figure 1 with the No. 2 end cover first, and then connect the end cover with the No. 1 rigid shell. Only after connecting No. 2 end cover with No. 1 shell, connect No. 3 flange with No. 2 end cover. Because the elastic bag is a flexible structure, there is no rigid support force in the assembly process, and there are two sealing rings on the flange, the installation needs a higher neutral (to prevent the deviation of the installation of the bad sealing ring), the axial installation force is larger (the two mounting surfaces are closely matched, the sealing ring needs to be compressed into the slot). In addition, the flange protrudes out of the end cover has no reliable force position, so it is difficult to assemble the flange and the end cover together after assembling the upper end cover.

### *2.2 Solution*

Without changing the assembly sequence, that is, installing the end cover first and then the flange, the only way to apply axial force to the flange is to screw a threaded tie rod into the threaded hole of the flange, and then apply axial force. The auxiliary assembly tooling designed according to this scheme is shown in Figure 2

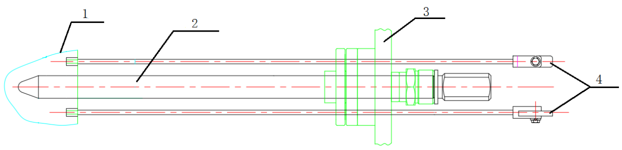


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*Figure 2: Schematic diagram of auxiliary assembly tooling for elastic bag components*

No. 1 in Figure 2 is the assembly structure of a spacecraft, that is, the combination of the end cover and the elastic bag assembly. No. 2, 3 and 4 together constitute the assembly tooling of the elastic bag assembly. The assembly scheme is divided into the following steps, and the assembly diagram is shown in Figure 3:

1) Place the elastic bag assembly in the rigid shell, adjust the flange of the elastic bag assembly to the general position where it is assembled with the outer shell end cover, and apply appropriate amount of grease to the sealing ring on the flange;

2) Pass the tie rod (No. 4) through the guide hole on the guide device (No. 3) as shown in Figure 2, then through the bolt hole on the end cover of the outer shell, connect with the threaded hole on the flange of the elastic bag assembly and tighten it;

3) Pass the mandrel (No. 2) through the guide and the outer shell end cover and insert it into the flange runner hole of the elastic bag assembly as the guide for flange installation. The top of the mandrel is conical structure to ensure that the mandrel and flange flow hole is neutral;

4) The assembly worker should hold the assembly tool by hand to prevent the mandrel from falling off from the flange hole of the elastic bag assembly, and install the outer shell end cover on the rigid shell;

5) Fix the bracket of the rigid shell, the assembly worker uses the guide mandrel to keep the flange flow hole of the end cover opening and the elastic bag assembly, slowly pull the pull rod, to ensure that the flange flow hole and the end cover opening in the case of the first seal ring is in the position to enter

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the hole, then slowly apply tension, the flange plate is pulled to the end cover opening;

6) Connect the outer shell end cover with the elastic bag assembly flange using mounting screws, and remove the assembly tooling to complete the assembly.

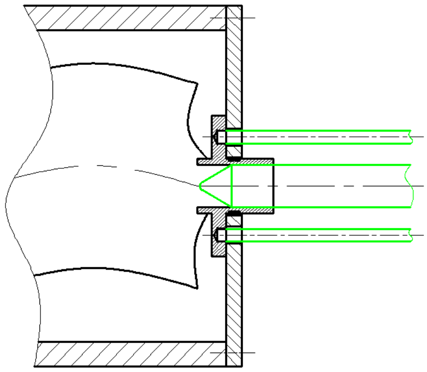

*Figure 3: Schematic diagram of elastic bag assembly assembly*

### *2.3 Analysis of assembly process of elastic bag assembly*

When the auxiliary tooling for the assembly of elastic bag assembly is working, the tension rod of the tooling is relatively thin (the thread of the rod is M5), which is prone to overload fracture. Therefore, it is necessary to analyze the tension process of the rod. In the process of exerting tension on the tie rod, the tension value required by the tie rod is divided into two stages, respectively before the sealing ring into the groove and after the sealing ring into the groove. The mandrel used in the pair has a smooth surface and produces negligible friction.

Before the sealing ring enters the groove, the pull of the pull rod is the axial projection of the pressure generated by the squeezing of the sealing ring, that is, Fpull =Faxis. The force diagram of each component in the assembly process is shown in Figure 4. After grooving, the pull of the tie rod is mainly to overcome the friction between the sealing ring and the inner hole surface of the outer end cover, that is, F pull =Ff. The force diagram of each component in the assembly process is shown in Figure 5.

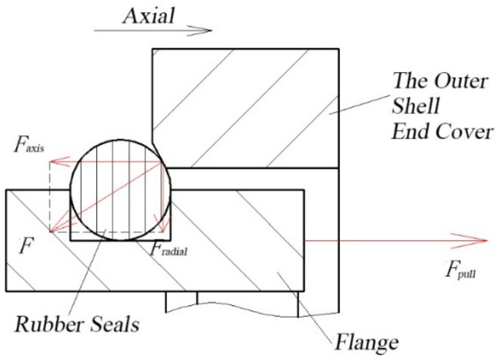


*Figure 4: Force diagram of each component during assembly before slotting*

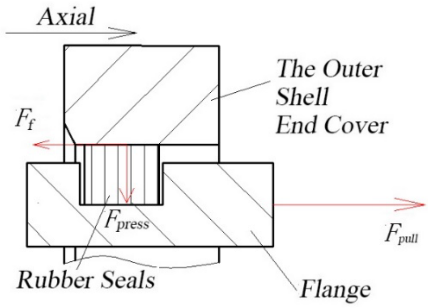


*Figure 5: The force diagram of each component during the assembly process after entering the slot*

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An electronic tension device is used to measure the tension required during the assembly of the elastic bag assembly. The tension curve during assembly is shown in Figure 6.

According to the curve, OA section is the assembly process before the sealing ring enters the groove. At this time, the effect of external load is mainly to make the sealing ring deform and compress. With the increase of displacement, the tension exerted on the flange becomes larger and larger. Section AB is the moment when the sealing ring enters the groove, and the tension decreases instantaneously. The CD section is the tension data of the sealing ring in the groove. At this time, the external load mainly overcomes the friction between the sealing ring and the sealing groove. Due to the small deviation of the surface finish of the whole sealing groove and the uneven application of grease, the sealing ring slips in the groove and there is a phenomenon of stuck. When it reaches point D, the flange of the elastic bag assembly is assembled in place, and the flange is in rigid contact with the outer shell end cover. With the increase of tension, the displacement does not increase.

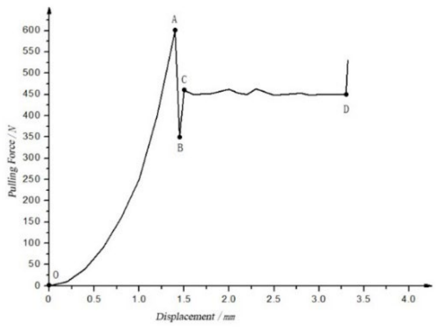


*Figure 6: Auxiliary tooling assembly displacement-pull force diagram*

In the overall assembly process, the position where the maximum tension occurs is point A, that is, the state before the sealing ring enters the sealing groove, and the external load applied at this time is 593N.

### *2.4 Reliability analysis of elastic bag assembly auxiliary assembly tool*

Considering the ergonomics, when assembling the elastic bag assembly, the way of symmetrical screw connecting two tie rods on the flange of the elastic bag can make the operator exert more force.

According to Figure 6 in Section 2.3, during the assembly of the elastic bag assembly, the maximum tension exerted by the pull rod on the flange of the elastic bag is 593N, and the maximum tension uniformly distributed on each pull rod is 296.5N. In this paper, the finite element software ABAQUS is used to analyze the process of stretching the elastic bag flange of the tie rod. It can be seen directly whether the mechanical properties of the tie rod meet the assembly requirements.

#### *2.4.1 Model drawing*

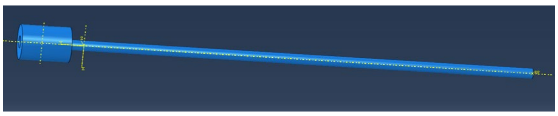

*Figure 7: Schematic diagram of tie rod assembly*

As shown in the figure7, the thread of the tie rod M5 is simplified into a cylindrical entity with a diameter of 5mm. The diameter of the tie rod is Φ4.08mm, which is the same as the inner diameter of the thread. The screw connecting part of flange and tie rod is simplified as a solid cylinder, ignoring the shape of thread.

#### *2.4.2 Setting Material Properties*

The tie rod is made of stainless steel, and the material properties are shown in Table 1.

*Table 1: Stainless steel material performance table*

| Density $\rho$/g/cm3 | Elastic Modulus E/GPa | Poisson ratio $\mu$ | Tensile strength $\sigma_b$/MPa | Elongation $\delta$/% |
|---|---|---|---|---|
| 7.93 | 203 | 0.29 | 530 | 40 |

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#### *2.4.3 Set the interaction properties*

Set the contact property between the threaded end of the tie rod and the threaded hole of the flange as surface to surface contact, select small slip for the slip formula, and change the amount of interference to the specified single grain bolt. Half line Angle 30°, pitch 0.8mm, bolt diameter 5mm. The setting of the interaction attribute can accurately simulate the force condition after threaded connection.

#### *2.4.4 Division of grid*

As shown in the figure8, the mesh of each component was divided, and the C3D6 mesh was drawn by sweeping wedge mesh, and the overall mesh size was adjusted to 0.5mm.

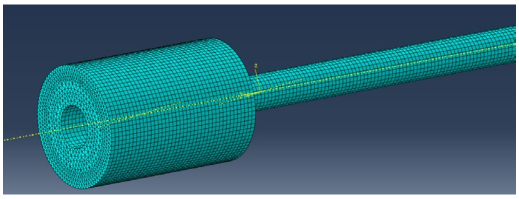

*Figure 8: Meshing*

#### *2.4.5 Apply a load*

Constrain the position marked in red in Figure 9 with 6 degrees of freedom, and apply a surface load of 296.5N to the part marked in red in Figure 10.

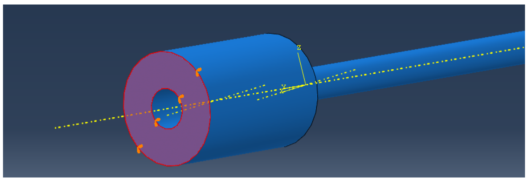

*Figure 9: Constraints*

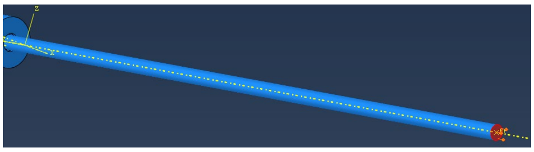

*Figure 10: Load application site*

#### *2.4.6 Post simulation processing*

After simulation calculation, the stress distribution of the auxiliary tooling is shown in Figure 11. According to the figure, it can be analyzed that when assembling the elastic bag components, the part where the pull rod bears the maximum stress is the part where the root of the thread connects with the cylindrical rod of the pull rod. The stress at this position is 339.5MPa, which is far less than the tensile strength of 530MPa. The performance parameters of the material can cover the application in actual production.

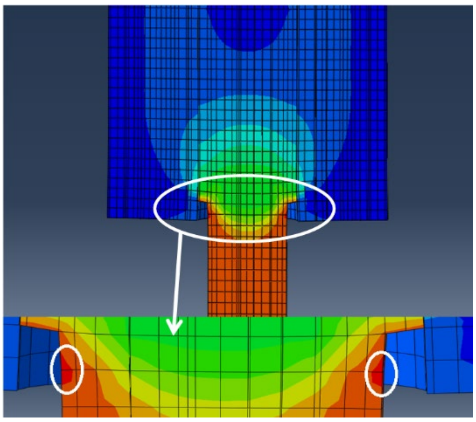

*Figure 11: Tie rod stress distribution diagram*

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## 3. Conclusion and prospect

By using ABAQUS finite element software to carry out mechanical analysis on the pull rod of auxiliary tooling under working condition, it can be obtained that the maximum stress of the pull rod during working is 339.5MPa, which is far less than the tensile strength of stainless steel 530MPa. The material performance of the pull rod can cover the mechanical conditions during assembly. The mechanical performance of the lower pull rod in this assembly scheme meets the requirements and is feasible.

In the aerospace field, this type of structure is not only suitable for the installation of elastic bag components, but also suitable for other similar blind and difficult to operate locations. It is widely used, and the manufacturing cost of auxiliary tooling is very low, so it can be generalized and popularized.

Spacecraft manufacturing has a variety of complex structures. The use of low-cost and simple special auxiliary assembly tooling will be a major trend to ensure assembly quality and efficiency in subsequent spacecraft assembly and manufacturing.

## References

*[1] Genyu Chen, "Application of laser welding technology in automobile manufacturing and design of laser assembly and welding unit,". Electric Welding Machine, Paper 32-38, 2010.*
*[2] Yanchao Wang, "Discussion on daily management of enterprise tooling," Die & Mould Manufacture, Paper 6-8, 2014.*
*[3] Weibo Zheng, "Research on Tooling Life Cycle Management," Automobile Applied Technology, Paper 256-257+267, 2018.*
*[4] Wei Hou, Research and Implementation of Key Technologies of Tooling Life Cycle Management, Xian, China: Northwestern Polytechnical University, 2006.*
*[5] Zhe Mao, "Discussion on standardized management of chrome plating tooling," Sci-tech Innovation and Productivity. Paper 12-13+16, 2014.*