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Design and Analysis of Spring Plates on Electronic Connector

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Abstract:
This paper is mainly to improve the existing spring plate used in the connector. To solve the problem that the spring plate breaks when the service life is less than the expected target due to the large gap (deformation). In this study, the analysis model of the spring plate is established by finite element ANSYS software and the appropriate elements are cut.At the same time, the relevant loading conditions and boundary conditions are established based on the actually used and the analysis of the gap is performed. Next, in this study, the design of the spring plate structure is divided into three parts, push rib, fixed rib and intermediate rib, and changed the design. By considering the proper gap of the spring plate, the finite element ANSYS is used to find the best design model of the spring plate. Finally, this study produces the best spring plate and installs it in the actual electronic connector. At the same time, thegap measurement test of the spring plate is performed under the condition of biting the cable tightly and then releasing the cable. The test result is compared with the analysis result of the best design of the spring plateto confirm the accuracy of thebest spring plate design model.

Keywords — **Electronic connector, spring plate, finite element ANSYS analysis, gap of the spring plate.**

I. INTRODUCTION

The connector refers to all the connecting components and accessories used in the electronic signal and the power supply. The generalized connector includes the socket, plug and cable assembly. From the point of view of the electronic assembly, the connector is a component that can be separated or replaced by the interconnected part. In other words, the bridge between all the signals, so the quality and stability of the performance will affect the service life of the product. In particular, the connector is the most frequently contacted and frequently inserted and fixed for a long time, so the manufacturing process of the connector requires very strict quality testing and control. Its products can include adapters, wire-to-board, board connectors, PC board connectors, D-SUB connectors, I/O connectors, short-circuit cap connectors, etc.

The wide range of electronic connector products are used in computers, communications, transportation, medical, aerospace and other fields, and are closely related to our daily lives. In electronic connector products, the contact spring plate has an important function of transmitting signals and power. The manufacturing method is to use the metal processing steps such as punching, drawing, bending, etc. to obtain the required geometric shape. And the good or bad design will affect the quality of the entire connector.

II. ELETRONIC CONNECTORS

A. Function of Electronic Connectors

The electronic connector consists of a plastic body, a contact elastic element (generally referred to as a terminal element and a spring plate), and a hardware designed to provide protection or a fixed connector function depending on the product requirements. The function of the contact spring plate is responsible for the transmission of signals or electricity. The selection of materials, the material of plating and the thickness of the coating and the design of the structure all affect the quality of the transmission. It is the heart of the connector. Generally, the copper alloy is used [1], and the positive force of the contact spring plate directly affects the resistance of the contact itself, thereby affecting the transmission of electricity or signals, so the relationship between the contact spring and the positive force is an important parameter in the connector. In the design process, the electronic connector must pay great attention to its stability and reliability, and do a series of testing work to determine the quality of the product.

B. Effect of Spring Plate on the Performance of Electronic Connectors

This study only conducts related research on the spring plate of the electronic connector produced by Sin Sheng Terminal & Machine Corp. [2], and the electronic connector number is MSA24070P30. Fig. 1 is a photo of the electronic connectorused in this study, and Fig. 2 is anexploded view of the electronic connector. The terminal that contacts the spring plate has the following function on the connector: a path for guiding the communication number is provided between the components. When the connectors are combined, due to the flexibility of the contact terminals of the spring plates, sufficient positive contact force is generated at the contact interface, which is sufficient to maintain the stability of the contact interface and allow the signal or power to be transmitted smoothly without anymechanical interference.

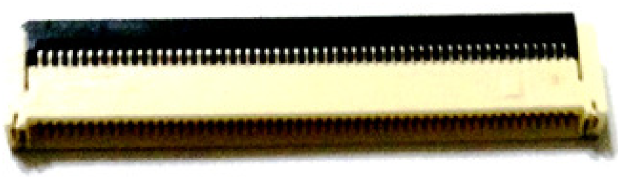


Fig. 1 Photo of the electronic connector in this study (MSA24070P30)

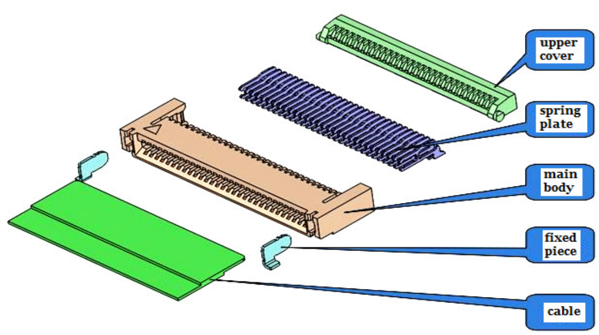
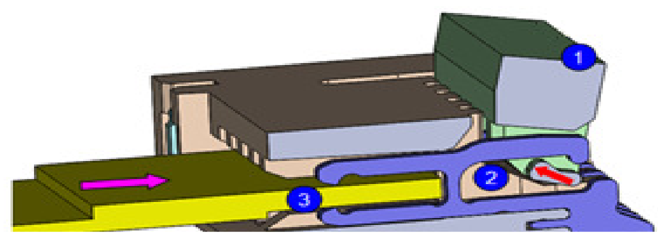
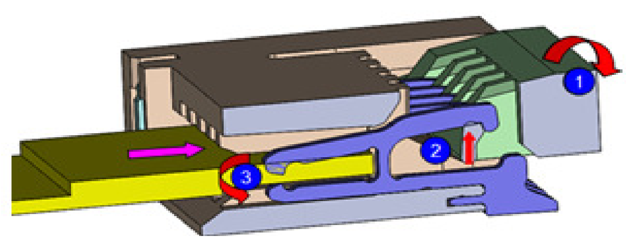


Fig. 2 Exploded view of the connector

The contact resistance value of the connector interface is also related to the magnitude of the positive contact force, and is designed in this study to focus on the form of the contact spring plate. However, in addition to the consideration of the positive contact force, in the connectors used in today's integrated circuits and printed circuit boards, there is a problem of high insertion force during assembly, and excessive insertion force may cause assembly difficulties. It can also cause the mechanical damage in electronic assembly. Since the positive contact force of the contact spring plate is closely related to the insertion force, if the spring plate type contact terminal geometry is to be redesigned to reduce the insertion force, the positive contact force is simultaneously lowered. Because of the connector type of this study, in the case of the connector, there is no insertion force, only the forward thrust, so the different styles of the spring plate design will definitely affect the size of the spring plate gap. In this study, we will find out the design that affects the size of the gap. Fig. 3 shows a joint diagram of the cable and the connector, wherein (a) shows that the cable is inserted into the connector from the position of the left side③, and (b) shows that the upper cover ①is turned clockwise downward to cover. The buckle ② of the red arrow pushes the spring plate up, and the front end ③ of the spring plate can bite the wire.



(a)



(b)

Fig. 3 Connection diagram of cable and connector

III. ANSYS ANALYSIS OF ELTRONIC CONNECTORS

A. Model of the Electronic Connector

In the connector design, the spring plate is the key to the entire communication, and it is the product's service life, playing an important role. Due to the structural design of the spring plate, it changes with the connector products of each family, so there is no certain design specification, as long as the self-connector product can be used to complete the conduction design. This study was designed by the spring plateof the products produced by Sin Sheng Terminal & Machine Corp. [2]. As shown in Fig. 4, the main structure is divided into three parts. A is called a push rib, B is called a fixed rib, and C is called the middle. rib. The overall dimensions of the spring plate are shown in Fig. 5, which is 3.8 mm in length, and 1.6 mm in width, while the widths of A, B and C are 0.3, 0.25 and 0.15 mm, respectively. In addition, the force applied is 2.0 ± 0.2 kgf.

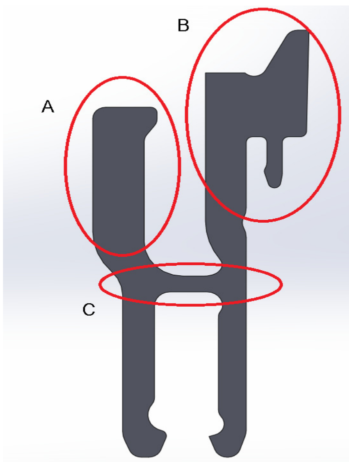


Fig. 4Schematic drawing of the spring plate

B. Material Selection, Boundary Setting and Mesh Cutting

The spring plate material of the electronic connector used now is a copper alloy, and the mechanical properties of the alloy are: specific gravity = 8.86 g/cm^3, elastic modulus = 110 GPa, Poisson's ratio = 0.34, yield strength = 580 MPa and ultimate tensile strength = 750 MPa.

Next, the contact relationship is set in ANSYS [3], and the wire is tightly bitten for the spring plate, so the contact surface set by the spring plate is a red portion, and the fixed object is set as a target surface, that is, a blue portion, as shown in Fig. 6. Because the spring plate is actually used in the plastic box, so the spring plate has several parts that are fixed and will not move, as shown in Fig. 7. After setting the solid boundary and the contact condition, the force application surface is set, and the force application amount is based on the force surface of the spring plate according to the reaction force actually reversed by the plastic body, and the force application surface is as shown in Fig. 8.

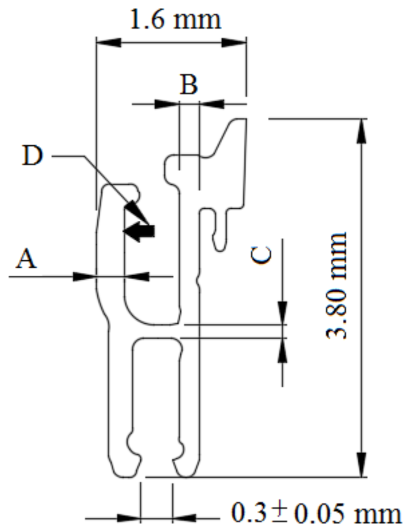


Fig. 5Overall dimensionsof the spring plate

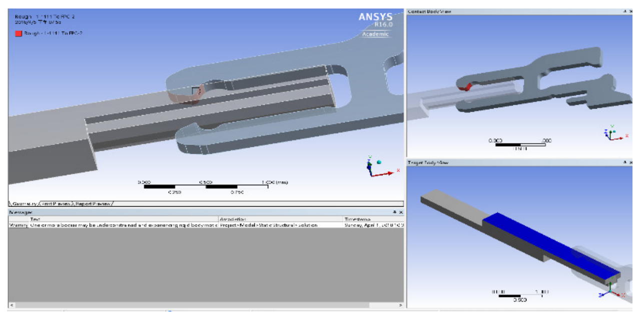


Fig. 6Setting of contact conditions in ANSYS

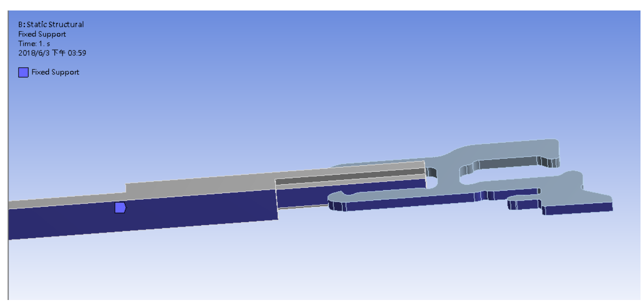


Fig. 7Setting of fixed surfaces in ANSYS

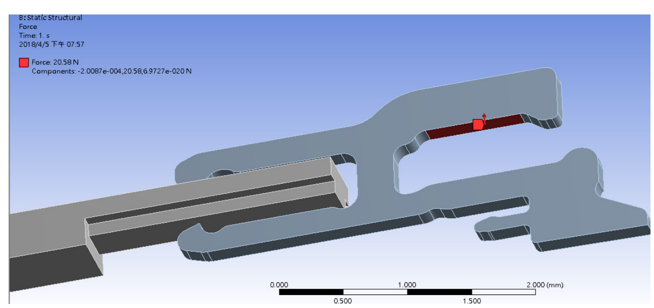


Fig. 8Setting of loading surfaces in ANSYS

After confirming that all the boundary and the force application conditions are completed, the mesh cutting is performed, and Fig. 9 is a mesh cutting diagram of the spring plate. As the grid size is set by the user, the finer the grid will make the analysis more accurate, but it will make the analysis time too long. For the mesh convergence analysis part, in order to improve the analysis accuracy and numerical convergence, the mesh is refined andconverged. The main purpose is to watch the grid, and the analysis data will start to converge and no longer diverge. For this analysis, the mesh size considered in this paper is from 0.07 mm to 0.03 mm. From Fig. 10, it is shown that when the mesh is less than 0.05 mm, the gap of the spring plate is calculated to be close to a stable value, so the grid size is selected to be 0.05 mm.

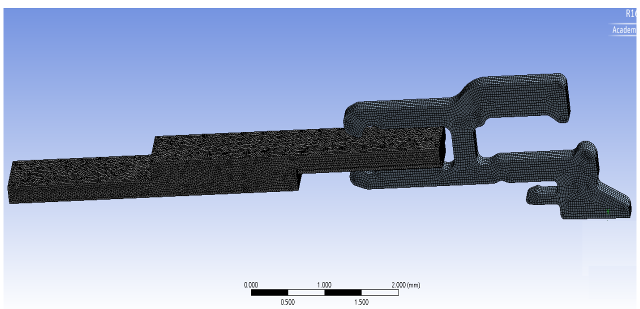


Fig. 9Setting of grid cutting in ANSYS

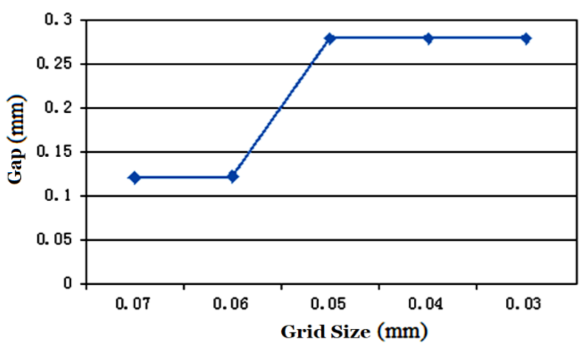


Fig. 10Convergent analysis

IV. DESIGN MODELS OF THE SPRING PLATE

A. Change Design of the Spring Plate Model

The modified structural design for this product is divided into three parts, including the push rib design of the spring plate, the fixed rib design and the intermediate rib design, each of which is changed in design except for the original dimensions (A2, B2 and C2). Push ribs, fixed ribs and intermediate ribs are shown in Figs. 11, 12 and 13, respectively. Figs. 11 and 12 respectively show that the push rib and the fixed rib are both thickened (A1 and B1) and thinned (A3 and B3), and the intermediate rib in Fig. 13 is thickened (C1). The upper edge of the intermediate rib is designed in an arc shape (C3), wherein the radius r of the arc is equal to 0.2 mm.

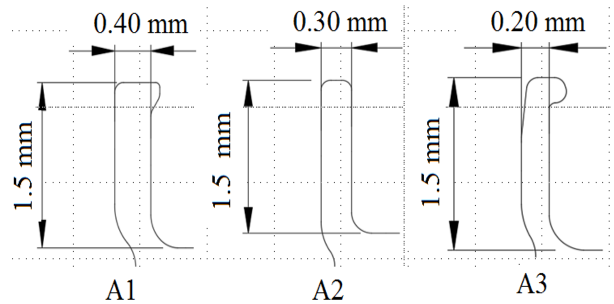


Fig. 11Push ribs in three different sizes

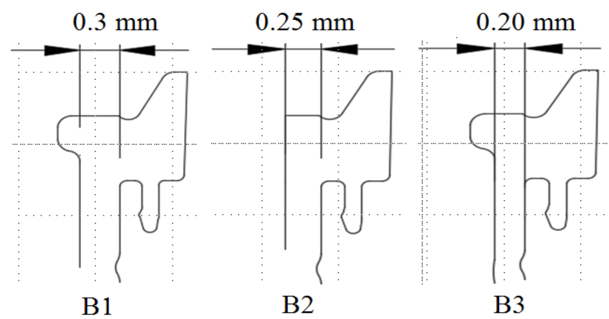


Fig. 12Fixed ribs in three different sizes

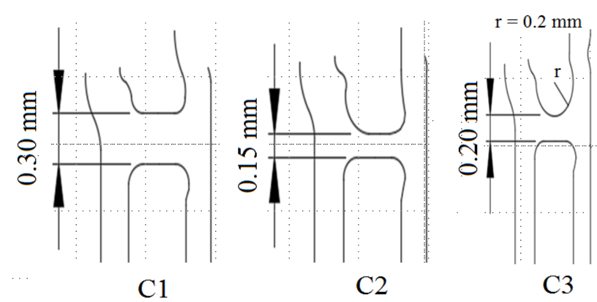


Fig. 13Intermediate ribs in three different sizes

Then, the spring plate design of various combinations is analysed by finite element ANSYS. There are 27 kinds of spring plate designs with different combinations, A1B1C1, A1B1C2, A1B1C3, A1B2C1, ..., etc. Figs. 14, 15 and 16 respectively show the spring displacementsobtained by ANSYS analysis for the spring plate designof A1B2C2, A2B3C1 and A3B1C3, and the analysed gap amounts are 2.32, 0.32 and 1.04 mm. As for the other different combinations of spring plate design, the finite element ANSYS analysis of the amount of gap is very similar to Figs. 14, 15 and 16, so this study does not show the ANSYS analysis of other designs. Next, according to the ANSYS analysis results of 27 kinds of spring plate design and the gap of 0.3±0.05 mm required by Sin Sheng Terminal & Machine Corp., the ANSYS analysis result of the spring plate design A2B3C1 is 0.32 mm, which is closest to the gap required by Sin Sheng Terminal & Machine Corp.

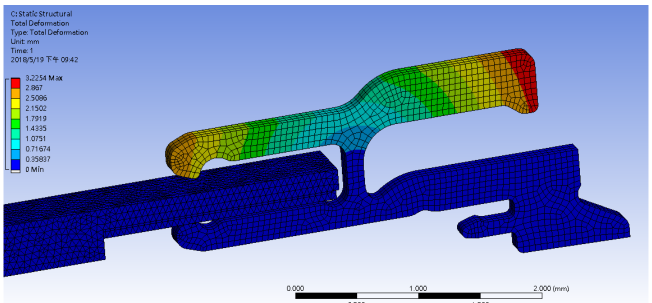


Fig. 14 Spring displacement calculated byANSYS analysis for the spring plate design A1B2C2

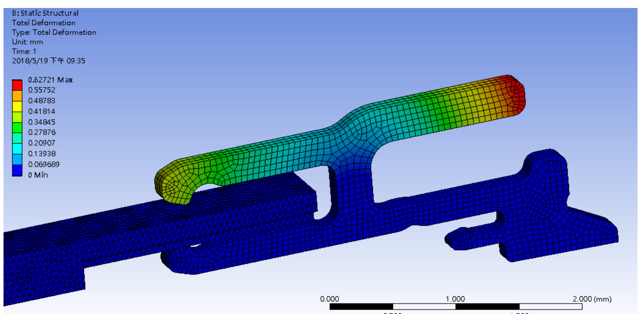


Fig. 15 Spring displacement calculated byANSYS analysis for the spring plate design A2B3C1

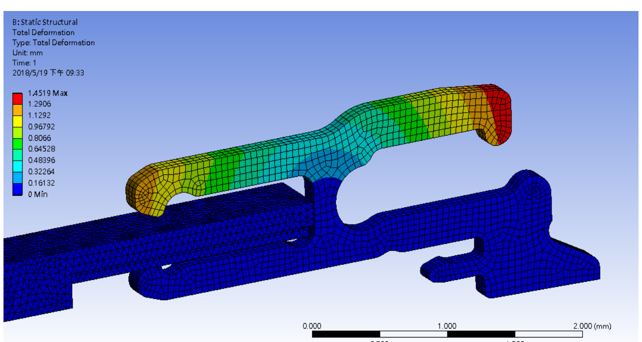


Fig. 16 Spring displacement calculated byANSYS analysis for the spring plate design A3B1C3

V. COMPARISON OF EXPERIMENTAL AND THEORETICAL RESULTS

After determining the best model for the spring plate design (A2B3C1), we then made the actual spring plate and used it on the electronic connector to test the gap value of the cover after the cover was bitten and then the cover was released. According to the application range of the buckle force is 1.8~2.2 kgf, and the clearance value of the spring plate is 0.3±0.05 mm (provided bySin Sheng Terminal & Machine Corp.). In this study, the buckle force was divided into 1.8, 1.9, 2.0, 2.1 and 2.2 kgf, and a total of five groups were loaded. Next, the ANSYS simulation analysis was performed according to the five buckle forces, and the analysed gap values were: 0.28, 0.30, 0.32, 0.34 and 0.35 mm.

This study then carried out five sets of the buckle force test on the products. The purpose of the inspection is mainly to determine the gap of the spring plate after the cable is bitten and then the cable is released. This experiment used a 2.5-dimensional projector as shown in Fig. 17 to measure the gap. The spring plate is placed on the measure device under the 2.5-dimensional projector as shown in Fig. 18. By using the triangular prism, the projections of the spring platewere displayed on the screen, and then the gap of the spring was measured shown in Fig. 19. According to the measured values displayed on the screen, Table 1 shows the spring plate gap values for the five setsof the buckle force test.

Table 1Gap valuesfor five sets of the buckle force test

	Gap (mm)	Buckle Force (kgf)
Sample 1	0.29	1.8
Sample 2	0.29	1.8
Sample 3	0.30	1.9
Sample 4	0.30	1.9
Sample 5	0.31	2.0
Sample 6	0.31	2.0
Sample 7	0.31	2.1
Sample 8	0.32	2.1
Sample 9	0.32	2.2
Sample 10	0.33	2.2

According to Table 1, the experimental gap value range is 0.29~0.33 mm, and the gap value obtained by the ANSYS simulation analysis is 0.28~0.35 mm. The error between simulation and actual experiment is 3.5%~6%. The error is acceptable rangeby Sin Sheng Terminal & Machine Corp.

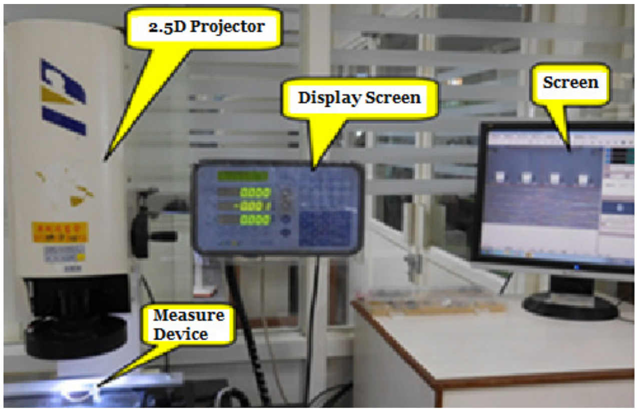


Fig. 17Experimental Device

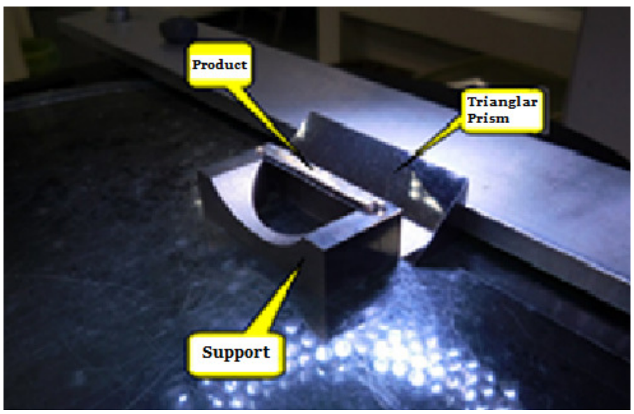


Fig. 18Measure Device

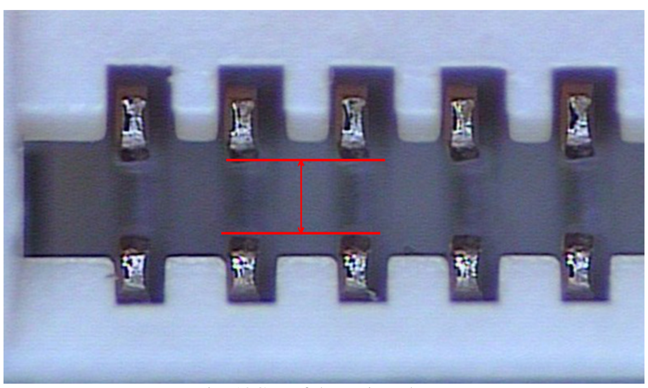


Fig. 19Gap of the spring plate

VI. CONCLUSIONS

This research is based on the improvement of the spring plate in the existing connector. Through the finite element ANSYS analysis, the best spring plate design model is found. Based on the results of the analysis, the following conclusions can be drawn:

1. For this analysis, the mesh size considered in this paper is from 0.07 mm to 0.03 mm. From Fig. 10, it is shown that when the mesh is less than 0.05 mm, the gap of the spring plate is calculated to be close to a stable value, so the grid size is selected to be 0.05 mm.
2. The structural design for the spring plate is divided into three parts, including the push rib, fixed rib and intermediate rib design. According to the ANSYS analysis results of 27 spring plate designs and the gap required by Sin Sheng Terminal & Machine Corp., 0.3 ± 0.05 mm, the ANSYS analysis result of the spring plate design A2B3C1 has a gap of 0.32 mm which is closest to the gap required by Sin Sheng Terminal & Machine Corp.
3. Five sets of the buckle force test on the products are compared with the ANSYS analysis. It can be seen form Table 1 that the ANSYS gap value is 0.28~0.35 mm and the actual test gap value is 0.29~0.33 mm. The simulated and actual error is about 3.5%-6%, and this error range can be accepted by Sin Sheng Terminal & Machine Corp.

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