

Research on simulation fixture for seat anchorage strength test

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Abstract. The fixture is often used to the test of automotive component parts. This paper states the research ideas of a new type simulation fixture for the seat anchorage strength test. The effectiveness of the simulation fixture is verified by FEA (Finite Element Analysis) and experiments. The new simulation fixture has higher strength and better applicability, which can simulate preferably the position of the belt anchorage in the actual vehicle.

1. Background

Automotive is a highly integrated industrial product. An ordinary car usually contains more than 10,000 component parts. So many parts make up a machine that can run at high speed, and it often needs to work in harsh working condition [1]. It is necessary to strictly control the quality during the design and production process of the automotive. Therefore, there are numerous test projects in the automotive industry, and automotive component parts are the main object of these test projects [2]. For example, car seats, seat belts, air bags, etc. The whole vehicle or the body in white is usually not available during the component test. It is necessary to make some fixtures that simulate the state in which the components are installed in the whole vehicle [3,4]. It is generally necessary to make a simulation fixture to realize the installation of the seat belt on the vehicle body during the seat anchorage strength test.

The seat anchorage strength test is described in detail in GB 14167-2013, GB 15083-2006 and ECE R17. The test conditions for the seats with three-point belt installed on the M1 and N1 models are as follows: the upper and lower body modules are fixed to the seats by seat belts. A test load of 13500 ± 200 N is applied to the upper and lower body modules respectively, and a load equivalent to 20 times the mass of the seat assembly is applied to the seat [5]. It is not difficult to find that the load of the seat test is large. Therefore, the fixture for the test should have a certain strength. The original simulation fixture of the laboratory has been damaged during the high-frequency test, and local areas may be deformed or even broken. In addition, the original fixture cannot adjust the position of its belt anchorage, and it is difficult to meet increasingly stringent test conditions. Therefore, we summarize the experience gained in the test, design and manufacture the new type simulation fixture for the seat anchorage strength test. This paper will elaborate the structural design, simulation and verification of fixture.

2. The design of simulation fixture

2.1. The thinking of simulation fixture

At the beginning of the design, the goal is to increase strength and enhance applicability. Based on the



advantages of CATARC (China Automotive Technology and Research Center), the survey and statistics of the position of belt anchorage commonly used in the market were carried out, and the statistics results were applied to the design. In addition, the laboratory undertakes the seat tests of more than 100 companies every year, and produces fixtures according to different test items to assist the test. It has accumulated valuable experience in this work. Combining extensive research and rich experience, engineers repeatedly research and demonstrate in the design stage of the project, so that the new fixture has the advantages of high strength and adjustable belt anchorage position. The design process is shown in Figure 1.

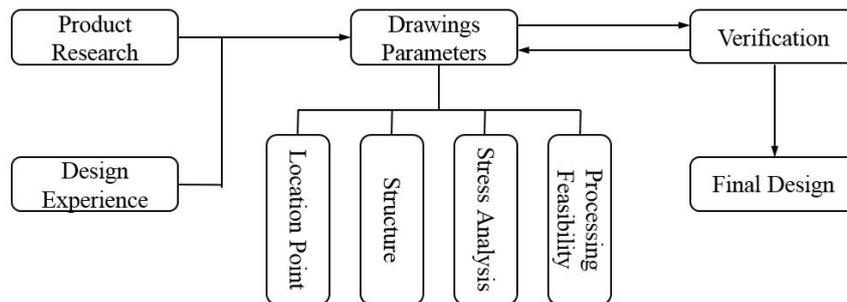


Figure 1. Design process of simulation fixture.

2.2. The design scheme of simulation fixture

2.2.1. Introduction. The simulation fixture is divided into upper and lower parts. Each of the upper and lower parts includes structural module, backing plate and convex plate. Structural modules have support and connection functions. There are a lot of through holes on the back plate to fix the convex plate which is connected to the lock ring to simulate the belt anchorage.

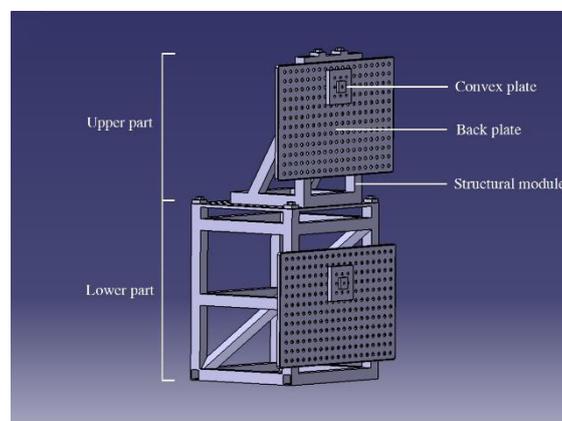


Figure 2. The stereogram of simulation fixture.

2.2.2. Characteristics

(1) High strength. The load of the seat test is large. Therefore, the fixture for the test should have a certain strength and needs to have no effect on the seat test. In view of the precedent of the original fixture deformation, the strength of the new one is optimized by the structure and material selection. The original one adopts angle steel welding design, and the new one has firmly frame structure. No.45 steels which is widely used in industry is selected as materials [6].

(2) Independent design of upper and lower structure. The simulation fixture adopts an independent design of the upper and lower parts, and they are connected through the positioning holes at the bottom of the upper module and the top of the lower module, so that the position can be adjusted.

Modern automotive design is streamlined, and there are a lot of surface shapes in the vehicle. This type of melding not only exists in the sheet metal structure but also in the body in white structural parts. The B-pillar and C-pillar of the vehicle are usually not a vertical cylinder, so the upper and lower anchorage of the seat belt are not in a vertical section. The up and down independent design of the fixture can simulate this situation and makes the test conditions closer to the vehicle situation.

(3) Matrix design of convex plate mounting holes. There are a lot of holes on the back plate of the upper and lower parts, and thus form a matrix for mounting the convex plate modules. Therefore, the position of belt anchorage can be adjusted up and down, left and right in the cross section of the back plate. Combined with the up and down independent adjustment function of the fixture, the belt anchorage can be adjusted on the x, y, z axis. Simulation fixture can simulate the belt anchorage position of most vehicle in the market. The applicability enhanced, the efficiency is improved.

3. Finite element analysis of simulation fixture

Finite element analysis simulates real physical systems (geometry and load cases) by mathematical approximations [7]. With simple and interacting elements (units), a finite number of unknowns can be used to approximate an infinitely unknown real system. FEA not only has high calculation accuracy, but also can adapt to various complex shapes. It has become an effective engineering analysis method.

3.1. Stress analysis

In the seat test, the upper and lower body modules are respectively subjected to a pulling force that is perpendicular to the plane of the seat. The pulling force are loaded on the anchorage of the simulation fixture and the seat by the transmission of the seat belt. The convex plates on the fixture are subject to tensile and shear forces. The strength and stiffness of the fixture are analysed by FEA.

3.2. Establishment and analysis of finite element model

When the finite element model is built to simulate the actual problem, it is necessary to restore the force of the actual problem as much as possible, and the calculation accuracy and calculation efficiency should also be taken into consideration. The type of unit is selected by test object and calculation accuracy. The fixture is a typical solid structure, and the convex plates of the upper and lower modules are subjected to tensile and shear forces. The solid No.95 cell grid is selected to divide the model in the simulation process. The influence of some small structures on the force situation is neglected in the division process [8]. The model is divided into 121500 nodes and 512657 grids. The meshing and constraints of the model are shown in Figure 3.

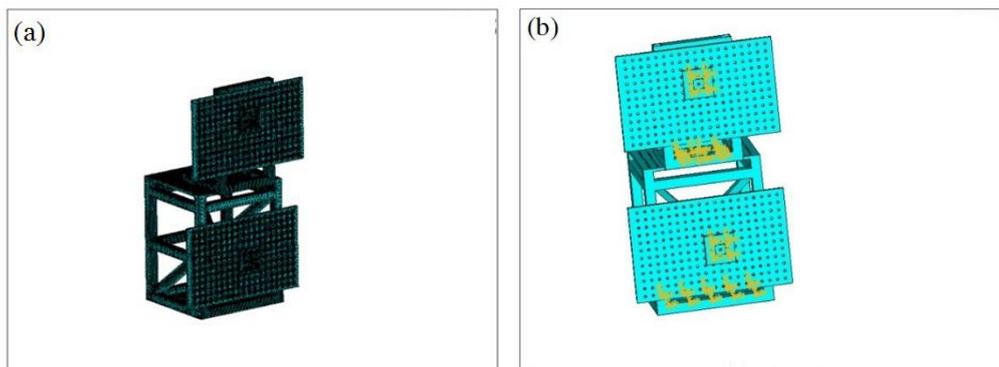


Figure 3. Meshing (a) and constraint (b).

The upper and lower parts are separately simulated, and the force and displacement of are calculated. The analysis of the force is to ensure that the fixture has sufficient strength. The analysis of the displacement is to ensure that the fixture should not has significant displacement due to the test load. The force of the upper and lower modules is shown in Figure 4. (a) and (b), respectively. The maximum stress is 49.6 Mpa and 15.7 Mpa respectively. This is far less than the yield strength of the

material. The displacement of the upper and lower modules is shown in Figure 4. (c) and (d), respectively. The maximum displacement is 1.19×10^{-3} mm and 1.08×10^{-3} mm respectively.

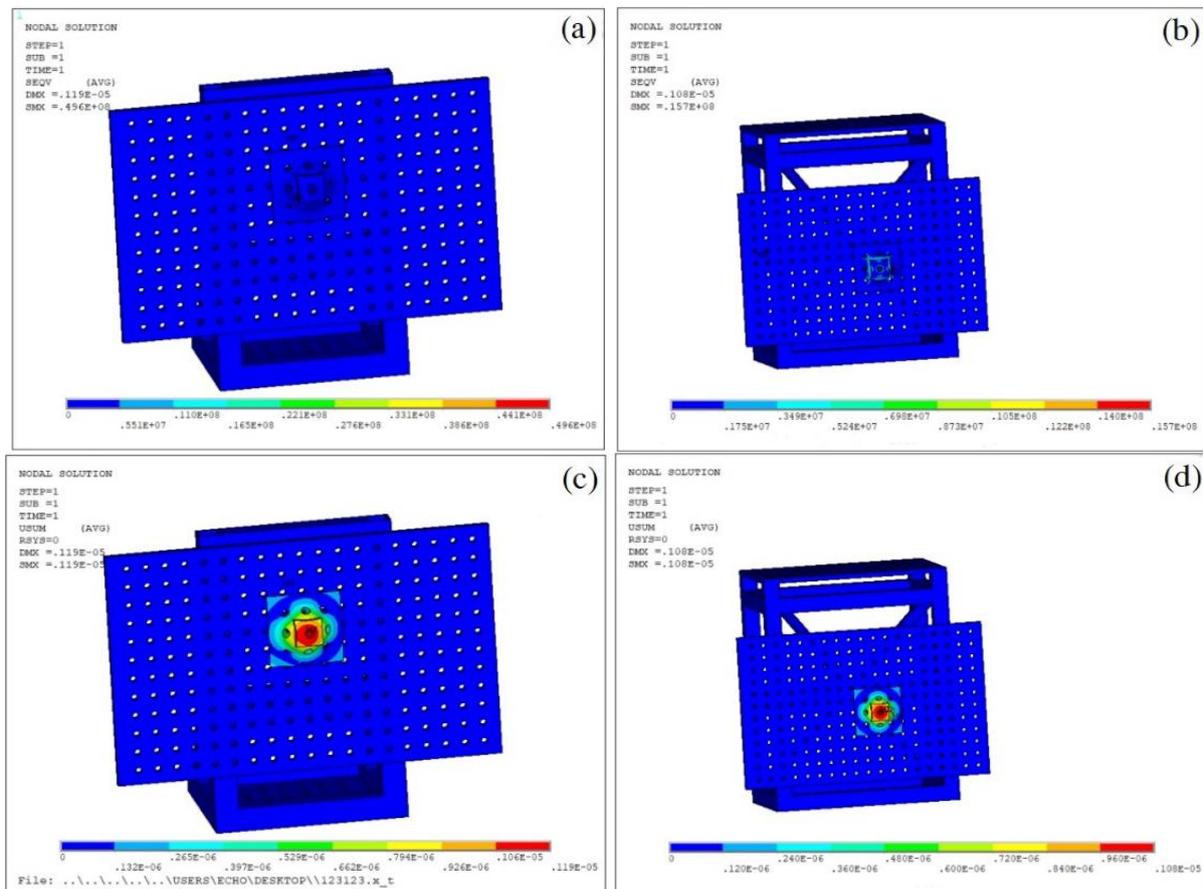


Figure 4. Simulation of force and displacement.

4. Processing and verification

4.1. Production requirements

- (1) There should be no scratches, scratches, etc. on the surface of the part.
- (2) The machining of machined parts must comply with the product drawings, technical procedures and the provisions of this standard.
- (3) The defects must be completely removed before welding, and the groove surface should be smooth, and no sharp corners should exist.
- (4) The sand, oil, water, rust and other dirt within 20mm around the weld zone and the groove must be cleaned.
- (5) The oxide layer on the part should be removed.
- (6) Not specified square steel size is 5mm.
- (7) The surface of the part should be painted.

4.2 Test verification

Simulation fixture was applied to the seat test. A load was applied to the seat according to GB 15083-2006. The displacement of the fixture in the vertical position of the test was measured by a dial gauge. The test load settings are shown in Table 1, the test picture is shown in Figure 5, and the actual load is shown in Table 2.

Table 1. The load setting of seat test.

Items Channels	Initial load	Test load	Loading time	Hold time
Chest module	500N	13500N/16200N	30s/10s	10s/1s
Hip module	500N	13500N/16200N	30s/10s	10s/1s
Centroid	500N	4161N/4993N	30s/10s	10s/1s

**Figure 5.** The picture of seat anchorage strength test.**Table 2.** The actual load of seat test.

Items Channels	Maximum displacement	Maximum load	Loading time	Hold time
Chest module	160.6mm/175.8mm	13835N/16347N	29.75s/9.81s	10.04s/1.00s
Hip module	129.0mm/142.0mm	13714N/16324N	29.79s/9.40s	10.00s/1.41s
Centroid	61.1mm/66.6mm	3605N/4241N	29.54s/9.46s	10.25s/1.35s

During the verification test, the displacement of the fixture in the vertical direction was measured by a dial gauge. In the case where the chest module, the buttocks module, and the seat centroid position are simultaneously loaded, the vertical displacements of the upper and lower modules of the simulated tooling are 0.13mm and 0.09mm, respectively. Although the measured conditions are somewhat different from those obtained by FEA, such displacement does not have a significant impact on the seat test. It shows that the new fixture has a significant improvement in strength and rigidity compared to the old one. At present, the new one has been used in the test for half a year, and no abnormal situation has occurred during the period.

5. Conclusion

CATARC (China Automotive Technology and Research Center) is committed to becoming the No.1 think tank in the automotive industry and continuously improving its capabilities. In order to better serve the test, the new simulation fixture with higher strength and wider applicability is designed and manufactured. The new fixture overthrew the old design and adopted the innovative split design of the upper and lower parts. The back plate which has the hole matrix is respectively welded on the upper and lower parts, thereby realizing the adjustment function of the upper and lower fixed points in six directions in space. The upper and lower anchorages can be adjusted in x, y, z axes in space. New fixture can more accurately simulate the actual situation of seat belt installation. The feasibility and effectiveness has been proved by FEA and test.

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