

Design and Simulation of a Large - scale Two - dimensional Mechanical Translation Mechanism

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Abstract. In many large simulation laboratories, in order to simulate the characteristics of moving objects, often need to use mechanical devices to drive the experimental equipment in a specific space movement. The accuracy of the mechanical device is very high because the motion parameters of the object greatly affect the experimental results. Especially large-scale mechanical devices often do not achieve the desired accuracy of the work by the basic industry, assembly technology and testing methods. The impact of the whole simulation experiment. In this paper, according to the actual needs of the project, designed a large mechanical translation mechanism. Through simulation to optimize, to achieve a higher motion accuracy. This design has a high reference value in many areas.

The Overall Layout of the Mechanical Translation Mechanism

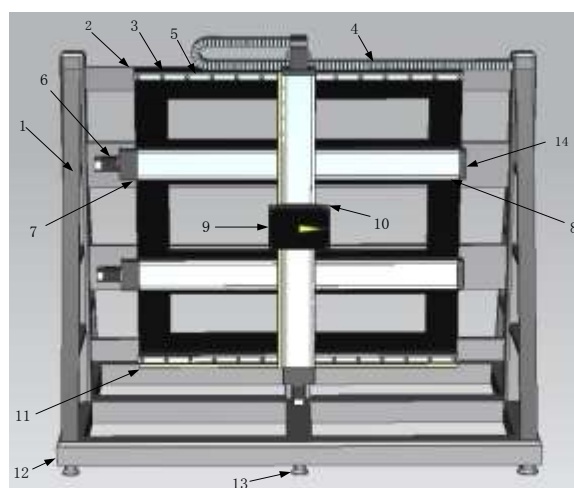


Figure 1. Finite Mechanical translation structure

1—Channel steel frame; 2—Base frame; 3—Plate; 4—Wire towline;
5—Auxiliary rails; 6—motor; 7—Coupling; 8—Y-axis; 9—target;
10—Z axis; 11—Positioning grating; 12—Base; 13—pillar; 14—Block iron.

The overall layout of the mechanical translation mechanism is shown in Fig .1.

According to the movement characteristics of the target, two linear motion systems (composed of rolling guide and lead screw) and two auxiliary rails are used in the axial direction, which are fixed on the frame through the plate. As the rigidity of the guide rail itself is not high, so the installation of the rail base frame to have a high stiffness, to prevent the movement in the process of bending deformation. The four sliders in the axial direction are connected by a linear motion system in the axial direction to achieve axial direction (horizontal) movement with an effective stroke of 4000 mm. There is a linear motion system in the axial direction, and the target is mounted on its slider to achieve axial (vertical) movement with an effective stroke of 4000 mm.

Y axial and Z axial use of servo motor and coupling drive linear motion system screw drive load movement, motion positioning is completed by reading the raster in the two directions. The whole frame is made of 100mm × 100mm × 10mm channel welded steel, the frame is installed on the floor, the floor is equipped with lifting pillars, you can level the entire frame.

To prevent axial movement to the end may occur when the collision, the use of two anti-collision measures to design. The first type of non-contact switch. When the axis movement direction to the end of 40mm, the contactless switch to detect the signal and sent to the controller, forced to stop the motor running. The second set of a set of iron, in the axial travel to the end of 20mm, directly blocking the target movement. Axial direction travel The non-contact switch is mounted on the upper side of the upper rail. Axial direction travel The contactless switch is mounted on the left side of the linear motion system. In order to prevent direct collision, the block attached to the thick rubber to play the role of buffer.

Finite Element Analysis of Mechanical Mechanism

Establishment of Finite Element Model. For a geometrical shape to a certain degree of similar mechanical structure, the construction of the different can change the state of force. The overall frame consists of four beams, three vertical beams and stiffened ribs, two auxiliary rails and three linear motion units. These parts have a lot of craft holes and edges. In addition, the vertical and horizontal steel beam and the linear motion unit are installed with many accessory parts. We have simplified the factors that have little impact on the overall structural analysis of these ancillary components, process holes and chamfers.

Different types of units have different levels of analysis, different structural forms, different types of analysis, the clear structure of the general form of conventional beams, rods, plate shell and block unit, the overall frame welded for the channel, with beams Unit, block unit and the mixing unit are able to meet the technical requirements of engineering results. Here is the block unit for finite element analysis.

Determining and dealing with boundary constraints is as important as modeling the framework structure, and the nature of the boundary and the main factors determining the nature of the boundary constraint are analyzed. The entire mechanical frame allows the movement and the structural parts of the structure to be connected to the foundation. The channel frame can transmit the load of the structural part to the foundation, so the base of the frame can be regarded as a fixed constraint on the basis of the auxiliary rail and The movement of the linear motion unit to the beam acts on the entire frame, which is the major part of the force of the entire channel, and the mechanical deformation of the frame itself.

Static Analysis. The conventional analysis of the mechanical two-dimensional translation mechanism is static analysis. When the frame structure is subjected to a small alternating dynamic load, it can be regarded as a static effect, directly to the static analysis, the initial judgment of the frame by the maximum static effect Is the weight of the pad, the auxiliary rail, the linear motion unit, the motor, the air-cooled system, the target and the attachment, respectively, equally on the four beams. Through the finite element analysis, the results of the static analysis are obtained: the maximum deformation occurs in the middle of the beam, and the deformation is mm, as shown in Fig. 2.

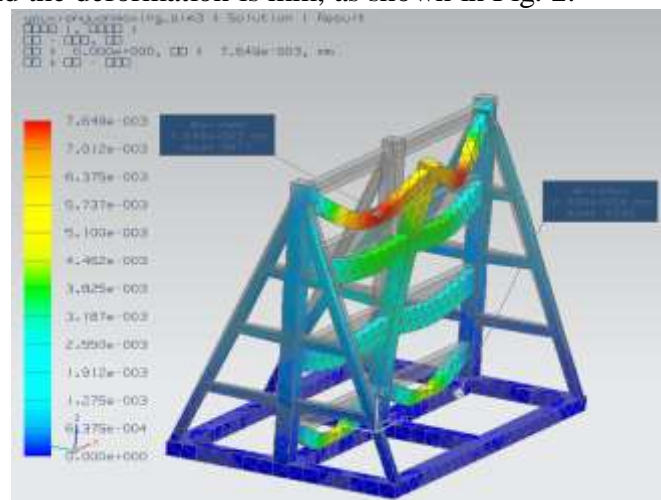


Figure 2. Finite Frame static analysis of strain cloud

The maximum stress occurs at the junction of the top beam and the bracket, the maximum stress is 26.86MPa, and the minimum stress occurs at the junction of the middle pillar and the base of the channel. The minimum stress is MPa, as shown in Fig. 3.

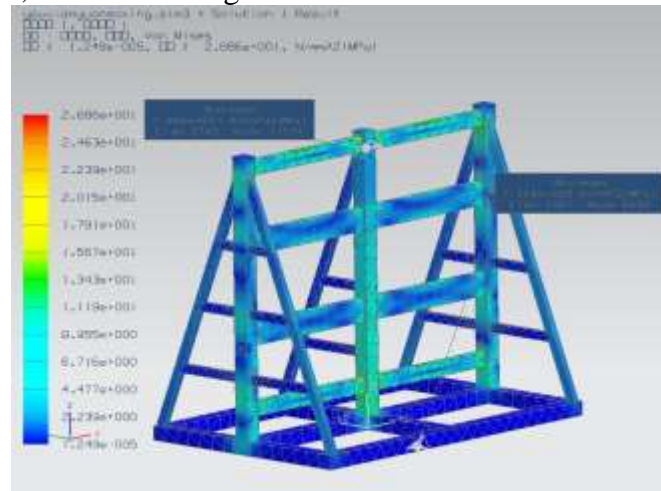


Figure 3. Finite Stress analysis of frame static analysis

Modal Analysis. In order to further evaluate whether the design of the overall system can meet the requirements, the following is a special modal analysis and calculation of the dynamic stiffness of the channel structure. Which can be obtained in the channel structure of the ninth-order natural frequency value of Hz, the maximum vibration deformation of 13.72mm.

As can be seen from Table .1, when the natural frequency of the channel structure of the channel steel reaches Hz, the entire structure of the rib fastening parts swing, which is mainly the channel structure of the steel frame without ribs solid frame, resulting in Axial rigidity is small, swing becomes larger. It can be seen that the first seven modes have a great influence on the frame, especially the deviation of the beam, which can increase the overall error in the transmission process and have some influence on the whole system simulation test. After the third-order mode is only the deflection of the ribs, the impact of transmission accuracy is small, can not be considered.

Table 1 Description of the frequency and mode of the first ten steps of the channel steel frame

order	frequency (Hz)	Shape description
1	1.07×10^3	The frame erected part is slightly shifted to the right
2	1.368×10^3	The frame erected part is slightly offset backward
3	1.816×10^3	The frame erected part is twisted in a clockwise direction
4	2.105×10^3	The frame erected part moves forward slightly.
5	2.225×10^3	The frame erect portion is twisted in a counterclockwise direction.
6	2.418×10^3	The upper and lower beams are polarized forward, the middle two beams are laterally polarized, the rear part of the ribs are polarized outward, and the front part of the ribs inward is polarized.
7	2.614×10^3	The upper beam is polarized forward, and the lower three beams are deflected backward, the rear part of the rib is polarized inward, and the front part of the rib is polarized outward.
8	2.620×10^3	All ribs are slightly offset to the right.
9	2.689×10^3	Both sides of the ribs to the left of a small shift.
10	2.747×10^3	Both sides of the ribs on both sides of the small offset.

Conclusion

Through simulation, it can be concluded that the static error of 4000×4000 is only mm when the target weight is less than 30KG, the dynamic maximum vibration mode is 13.72mm, the final Y axis plane error is less than mm, and the Z plane error is less than mm. Which meets the requirements of the large number of large mechanical motion mechanisms.

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