Research on moving door by screw drive of laser projector

L. Lu[1], B. Ruan[1], G. Li[1], J. Wu[2] & W. Zhao[2]
[1] *Shanghai Key Laboratory of Intelligent Manufacturing and Robotics, Shanghai University, China*
[2] *Shanghai INESA Electron, China*

Abstract

The structure of the moving door of laser projector is designed to open and close the door automatically at start-up and shutdown. The moving door is actuated to move by screw drive between the screw rod and the nut. And the moving path is limited by guide rail. The device is analyzed through motion simulation and the problem of interference is settled to ensure the feasibility of application.
Keywords: laser projector, moving door, screw drive.

1 Introduction

Laser is a light source with the highest spectrum purity and high saturation in nature, and its color reducibility is even better than LED light source, which makes the audiences experience ultimate color [1–3]. As a result, the laser projector has risen in importance. With mature solid-state laser light source technology, the life of the light source is up to 20,000 hours and the use cost is almost zero. With high-tech ultra-short focal lens and 0.19 projection ratio, laser projector can project 100-inch-large images in 42 cm [4–8]. After the integration, the laser needs to be projected onto the screen when running, at which time the door of the laser projector should be open. And at shutdown, the moving door must be closed. In the past, these processes were accomplished manually, which was very inconvenient [9, 10].

In this paper, the movement of the door of laser projector is mainly by screw drive. The travel mechanism is connected with the drive mechanism and combined with the corresponding guide rail to limit the door's movement, thus realizing the automatic opening and closing of the door finally.

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2 Structural design

Figures 1 and 2 are the overall design structure of the moving door of laser projector, which mainly consists of upper cover, moving door, drive mechanism, travel mechanism, and guide rail.

As can be seen from Fig. 2, the device is symmetrically distributed on both sides of the door; the movement process is carried out on both sides simultaneously to drive the door, realizing simultaneous opening and closing of the door.

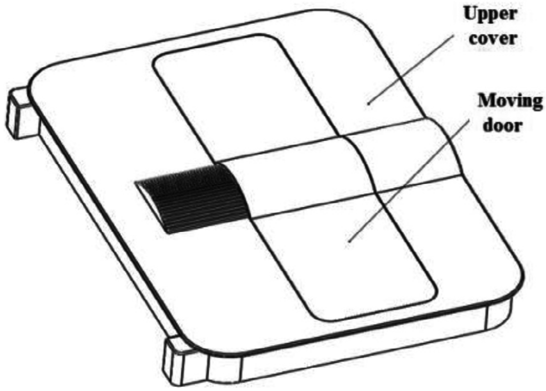

Figure 1: The overall design structure (outside).

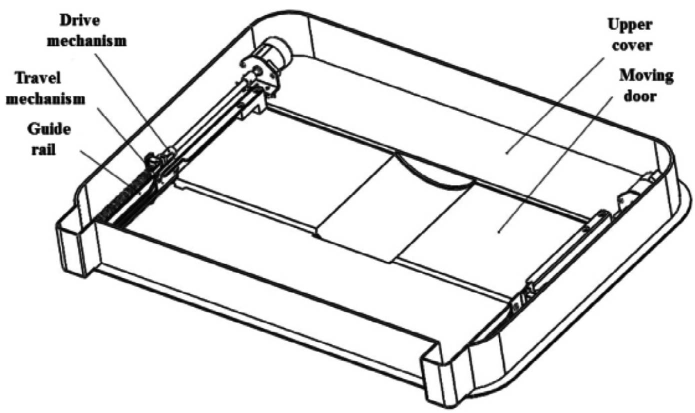

Figure 2: The overall design structure (inside).

2.1 Design of drive mechanism

The drive mechanism of the device in this paper mainly adopts screw drive between the screw rod and the nut. The concrete structure is shown in Fig. 3. In order to ensure enough torsional strength, the length of the screw rod should not be too long; so a drive shaft is added which is connected with the motor shaft. Thus, screw rotation is driven by the motor shaft, and then the nut is made to do the corresponding translation along the screw rod. At this moment, by connecting the nut with the travel mechanism in a certain way, other moving parts can be driven. The drive mechanism is fixedly connected with the upper cover mainly through the motor stand, front seat, and back seat of the screw rod [11, 12].

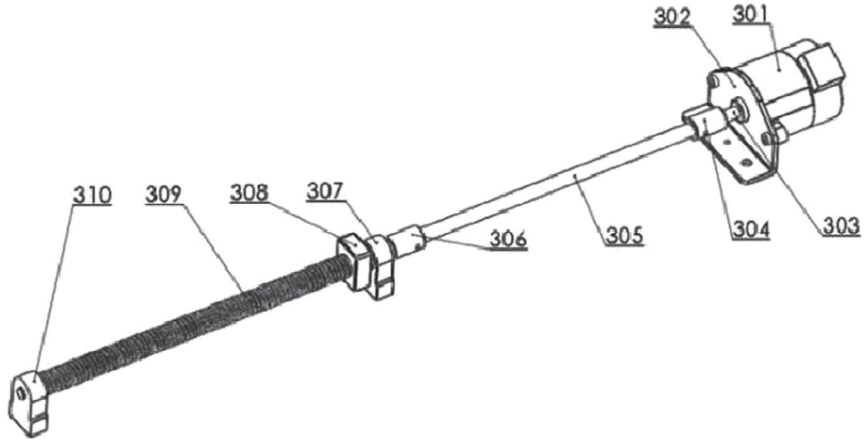

Figure 3: The structure of drive mechanism. 301: motor; 302: motor stand; 303: motor shaft; 304: coupling; 305: drive shaft; 306: coupling; 307: screw rod front seat; 308: driving nut; 309: screw rod; 310: screw rod back seat.

2.2 Design of travel mechanism

Figure 4 is the concrete structure of the travel mechanism connected with the moving door to move together along the guide rail. The connection plate is an important part connecting the travel mechanism with the moving door, and there is higher requirement for its strength. The structure in the figure ensures flexural strength and saves materials and space as well. The spacer and sliding sleeve are used to reduce friction and wear between the mechanism and guide rail. The connection piece is connected with the driving nut in drive mechanism. From the figure, the upper and lower parts of the connection piece are through, so in the horizontal direction they are relatively fixed, but can move in the vertical direction. So the horizontal and vertical movements can be realized at the same time.

2.3 Design of guide rail

Guide rail is used to determine the mobile track of moving door, and its specific structure is shown in Fig. 5. As we know, two points cannot steadily support a plane. So there are two slide rails arranged in tandem to support the door with four points. According to the track of slide rail, from the external view, the door is uplifted to a certain height and then it moves along the horizontal direction.

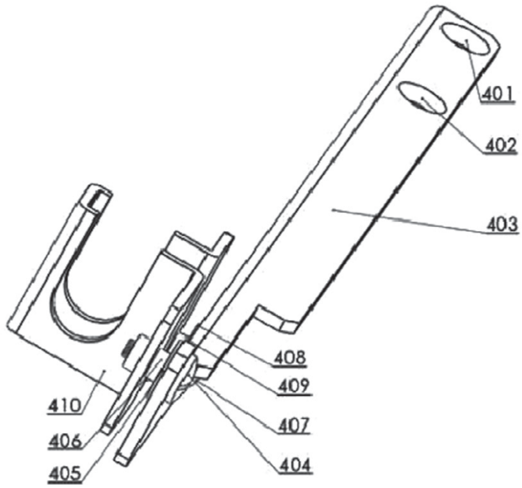

Figure 4: The structure of travel mechanism. 401: fixing hole; 402: fixing hole; 403: connection plate; 404: bolt; 405: spacer; 406: sliding sleeve; 407: connection piece.

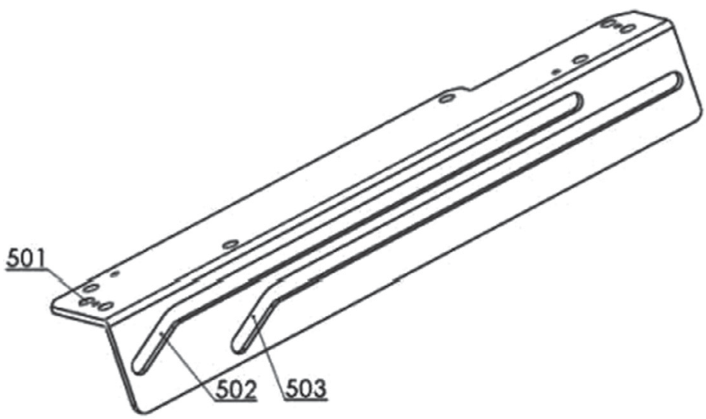

Figure 5: The structure of guide rail. 501: fixing hole; 502: first sliding rail; 503: second sliding rail.

3 Motion analysis

3.1 Motion simulation

To verify the feasibility of the device, a 3D modeling structure based on the actual size and motion simulation based on the design principle were carried out by Unigraphics NX, and the result is shown in Fig. 6. A and B, respectively, represent

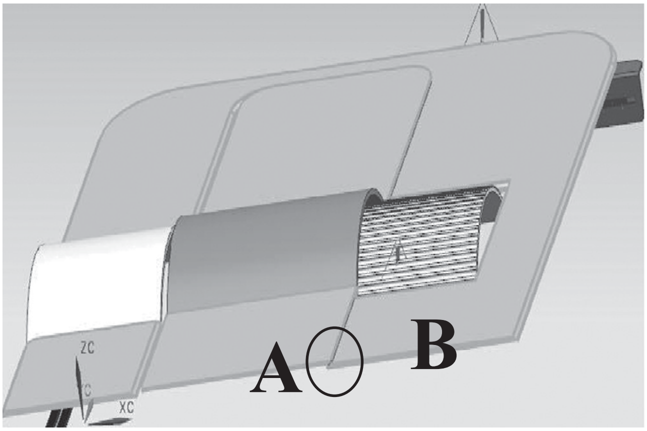

Figure 6: The result of motion simulation.

the moving door and upper cover. From the figure, it can be seen that in the process of uplift, because of the displacement in the horizontal direction, interference between the contact surfaces of A and B occurs. Therefore, it is necessary to solve the problem of interference.

3.2 Solution for interference

The fundamental reason of interference is a slope at the beginning of the sliding rail. But it is necessary for alleviating the burden of motor. Therefore, cutting the chamfer on the contact surfaces of A and B is the only way to solve the problem. However, for the overall appearance of the products, they cannot be cut too much. In this paper, through theoretical analysis and calculation, the specific size of the chamfer can be obtained. Three kinds of situations are discussed.

(1) Only B to cut chamfer

Figure 7 is the schematic diagram of cutting. $\triangle t$ is the gap size of A and B in the horizontal direction, $\triangle h1$ is the vertical dimension between the lower surfaces of A and B, γ is the angle of the slope, and H is the vertical dimension between the lower surface of A and the upper surface of B.

Through analysis and calculation, when $\gamma \geq \tan^{-1}\left(\frac{\Delta h1}{\Delta t}\right)$, the problem can be solved by cutting the chamfer on B alone. At this point, the chamfer size should satisfy $\Delta x \geq \frac{H}{\tan\gamma} - \Delta t$, $\Delta y \geq H - \Delta t \times \tan\gamma$.

(2) Only A to cut chamfer

Figure 8 is the schematic diagram of cutting. $\Delta h2$ is the vertical dimension between the upper surfaces of A and B.

Through analysis and calculation, when $\gamma \geq \tan^{-1}\left(\frac{\Delta h2}{\Delta t}\right)$, the problem can be solved by cutting the chamfer on A alone. At this point, the chamfer size should satisfy $\Delta x \geq \frac{H}{\tan\gamma} - \Delta t$, $\Delta y \geq H - \Delta t \times \tan\gamma$.

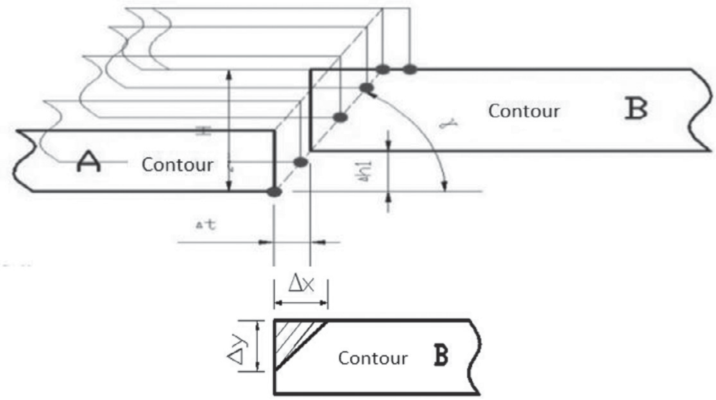

Figure 7: The schematic diagram of cutting (only B to cut chamfer).

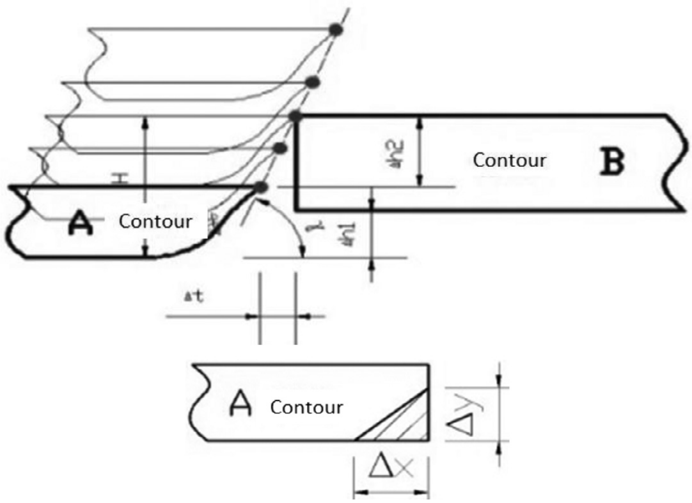

Figure 8: The schematic diagram of cutting (only A to cut chamfer).

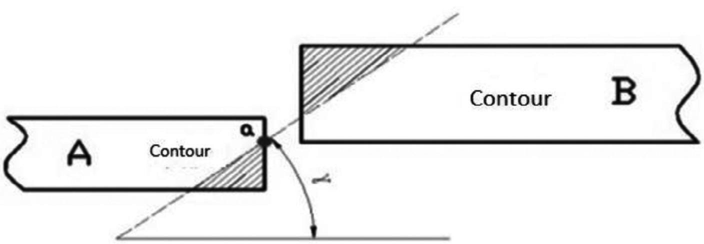

Figure 9: The schematic diagram of cutting (A and B to cut chamfer).

(3) A and B to cut chamfer

When γ is lesser, the previous two cases cannot be satisfied, and the chamfers on A and B must be cut. As shown in Fig. 9, the shaded part must be completely cut. The respective cutting quantity is distributed by the position of point a.

4 Conclusion

According to the structural design of drive mechanism, travel mechanism, and guide rail and simulation analysis, the following conclusions are obtained: (1) travel mechanism is driven to move along the guide rail by drive mechanism, which are interrelated and work together to complete opening and closing of the door; (2) the angle of slope that determines the chamfer size is related to motor power; and (3) the appropriate method of cutting is determined by the angle of slope, which can settle the interference and avoid the problem of the appearance and external pollution caused by larger chamfer.

Acknowledgment

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