Design And Analysis Of Linear Drive Mechanism For CNC Axes Of Laser Cutting Machine

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Abstract:

Recent trend of advanced manufacturing processes like Laser Cutting Machine. In Fabrication industries require more production by using automation so that required CNC machine which is more popular for mass production. Laser Cutting Machine having different critical components are them so in that mechanical side to develop CNC axes as per technology concern. In CNC axes required different parts like Runner Block, Rails, and Linear Drive Motor etc. In past there were ball screw used for making CNC axis now a day linear drive mechanism used more because it is more powerful system to positioning, efficiency. By using CAD tools like Solid Work, to make 3 D Modelling for required part and practical analysis for cost.

Keywords: Design, Analysis, Linear Drive Mechanism, CNC Axes, FEA.

1. Introduction

Laser cutting has become one of the most reliable advanced manufacturing technologies for industrial productions and has undergone many improvements since its beginning in the 1970s. The cost-effectiveness of the laser cutting process is evident in its wide scope of application. The cutting process is CNC programmable and so can be flexible. Lasers have undertaken those tasks that are carried out by CNC flame cutting. It can be also an alternative to mechanical cutters and is used in a wide variety of industries. Almost all materials can be cut by laser. Metal plates, hollow section metal and polymers can be cut by laser. The maximum metal sheet thickness is limited depending on the type of laser, material, assist gas and other cutting parameters. It is believed that the laser cutting process has the potential to be optimized to a greater extent of efficiency than at present.

Laser cutting is a non-contact process so there is no force mechanically applied to the workpiece except for that from the pressure of the assistant gas. Therefore, strong clamping fixtures are not necessary and hence, thin or delicate sheets can be cut without any mechanical damage.

Nowadays, two types of lasers are most commonly used in laser cutting: CO_2, and disk/rod/fibre Nd: YAG lasers. Both generate high-intensity beams of infrared light. CO_2 laser with a wavelength of 10.6μm and disk/fibre laser with a wavelength of 1.06μm has its own applications. The general principles of cutting are similar for both types of laser. Most organic materials cannot be cut properly by disk/fibre lasers. In general cutting applications, CO_2 lasers are most effective. However, it has been reported that the disk/fibre laser has some advantages over the CO_2 laser. The performance of the fibre laser, when laser cutting mild steel sheet, is the subject of this research.

1.1 Fibre Lasers

Industrial users of laser technology have demanded laser systems with higher powers. Applications such as cutting, welding, piercing and drilling could be enhanced by the development of more powerful lasers with high beam quality, efficiency and stability. Several solid-state laser structures have been developed such as rod, disc and fibre as shown in Figure 2. Fibre/disk lasers are designed to minimize thermal distortion and provide light brightness beam. Both fibre/disk lasers have a 1.06μm wavelength. Likewise, several kinds of fibre laser systems in terms of laser sources have been developed: single emitter, modular and high-power fibre lasers. Regarding optical fibers, single-clad and double-clad fibres have been used.

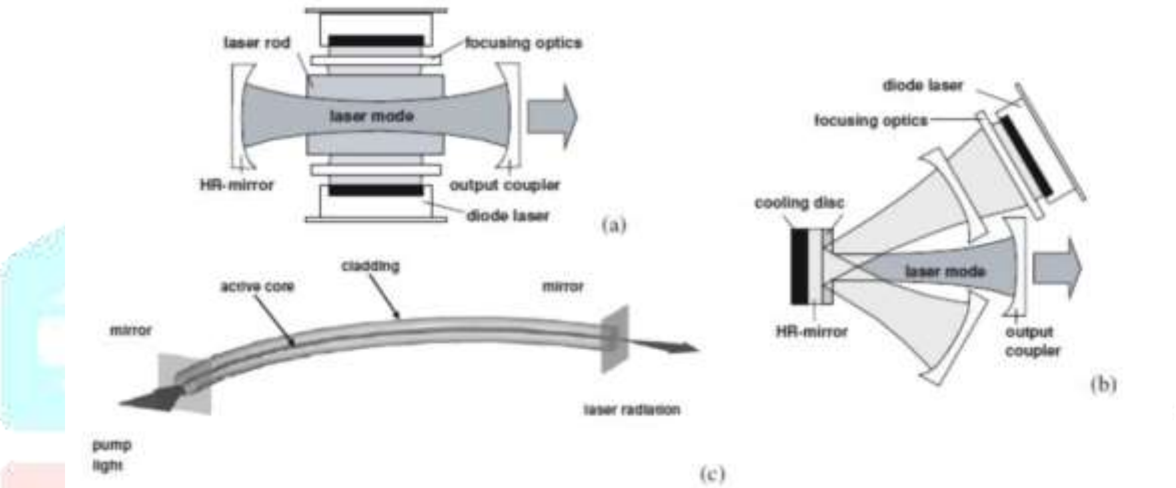

Fig. 1 Schematic showing the solid-state laser designs. (a) Side pumped rod laser, (b) thin disc laser and (c) fibre laser

1.2 Fibre Laser Systems

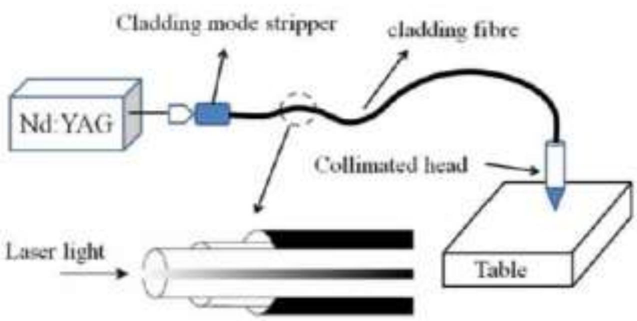

Fig. 2 Schematic showing a single emitter fibre laser machine

A single emitter fibre laser is established using a Ytterbium fibre laser system and has a wavelength from 1.06 μm to 1.08 μm, with power output up to 3 kW available by IPG laser company. Single-Mode fibre has been reported to deliver a laser beam from a typical flash pumped Nd: YAG system for precision machining at a peak power of 225 W.

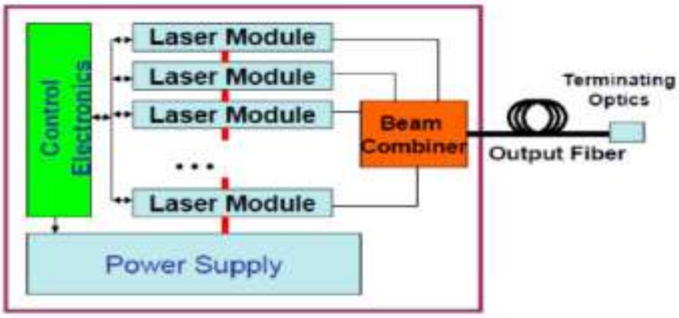

Fig. 3 Multimode (modular) fibre laser structure

In modular fibre lasers, fibre lasers deliver their energy through an integrated flexible optical fibre that can be up to 200 meters long. Each module yields some part of the total power, and a beam combiner combines the outputs of the modules (Figure 3). In contrast with single emitter lasers, the output fires from the modular can be single or multiple. IPG Photonics has developed a modular system up to 10 kW output power. For example, the fibre laser cutting machine, which is used in this research, had five modules of 500 W and the maximum output power is 2000 W, with one module reserved as a backup.

2 CAD Modelling of Ball Screw Mechanism

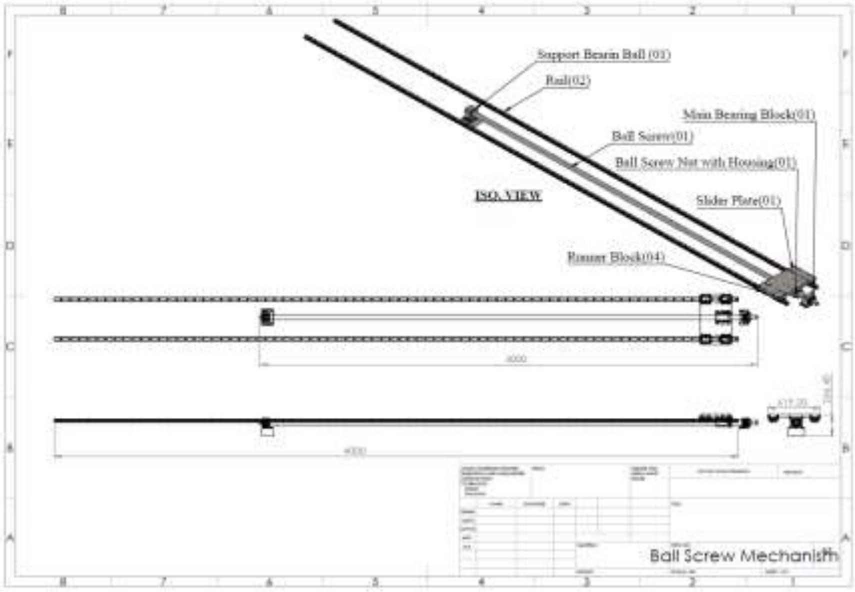

Fig. 4 Existing Design of XYZ axes of Fibre Laser Cutting Machine

(Ball Screw Mechanism)

The ball screw assembly consists of a screw and a nut, each with matching helical grooves, and balls which roll between these grooves providing the only contact between the nut and the screw. As the screw or nut rotates, the balls are deflected by the deflector into the ball return system of the nut, and they travel through the return system to the opposite end of the ball nut in a continuous path. The balls then exit from the ball return system into the ball screw and nut thread raceways continuously to recirculate in a closed circuit.

The ball nut determines the load and life of the ball screw assembly. The ratio of the number of threads in the ball nut circuit to the number of threads on the ball screw determines how much sooner the ball nut will reach fatigue failure (wear out) than the ball screw will.

The External Ball Return System. In this type of return system, the ball is returned to the opposite end of the circuit through a ball return tube which protrudes above the outside diameter of the ball nut.

The Internal Ball Return System (There are several variations of this type of return system) the ball is returned through or along the nut wall, but below the outside diameter.

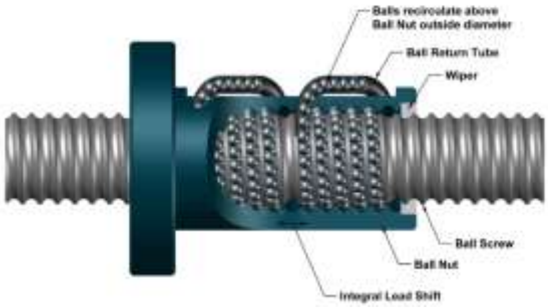

Fig. 5 External Ball Return System

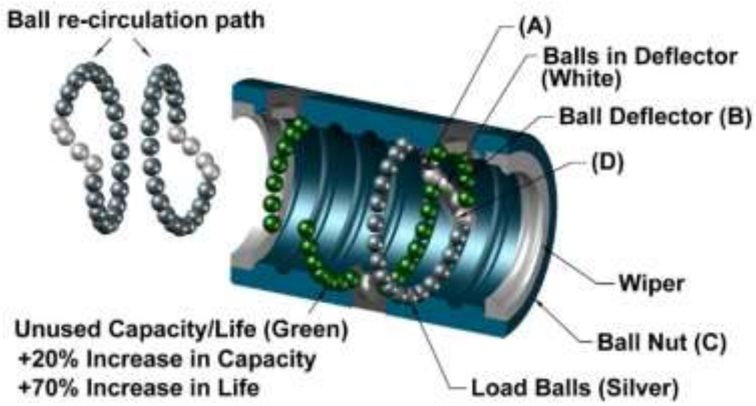

Fig. 6 Internal Ball Deflector Type Return System

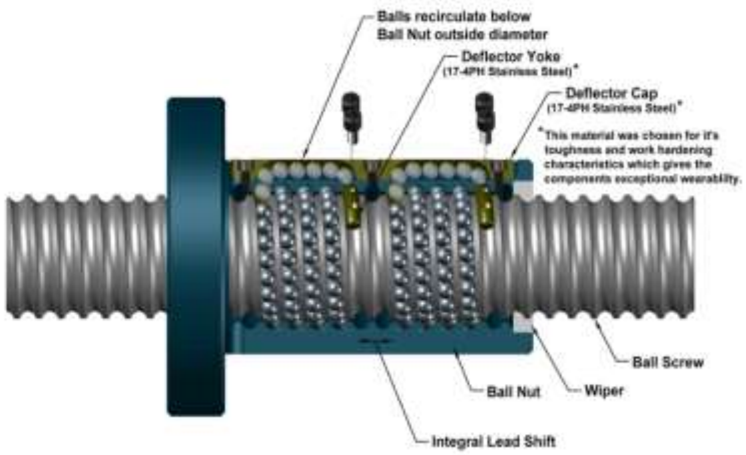

Fig. 7 Internal Ball Return System

As shown in Figure 4 to 7 where different type of sub mechanism available for ball screw mechanism as per application design. There was an internal ball return system used in existing fibre laser cutting machine axes design.

Fig. 8 Real Image of Internal Ball Return System for CNC axes

Fig. 9 3 D Model of Ball Screw Mechanism for XYZ axes of Fibre Laser Cutting Machine

2.1 CAD Modelling of Liner Drive Mechanism

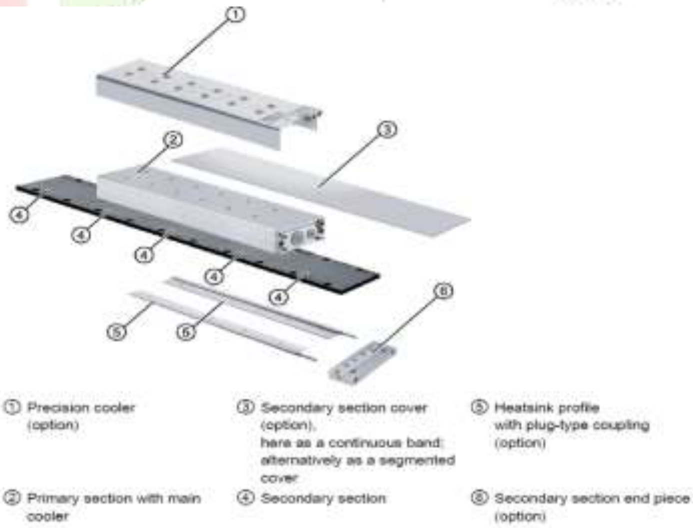

Fig. 10 Components and options of a 1FN3 linear motor

2.2.1 Motor assembly with divided secondary section track

One prerequisite for this type of assembly is that the entire second section track can be divided into two sections. In this case, the two sections must at least be as long as the slide.

Procedure

1. Mount the slide together with the linear guide and the primary section.

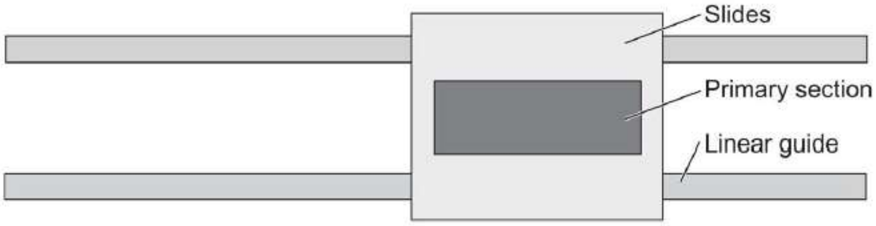

Fig. 11 Step-1

2. Push the slide to one side. Mount the secondary section on the other side. Align the secondary section track. Tighten the mounting screws according to the specifications.

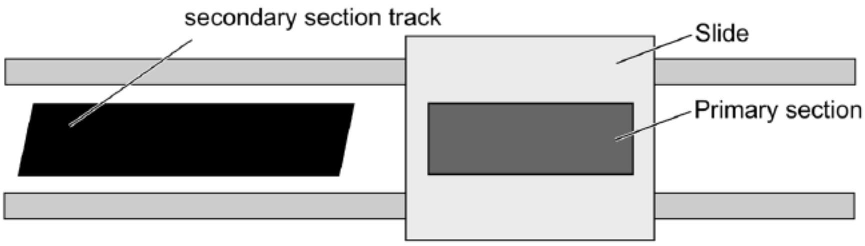

Fig. 12 Step-2

3. Push the slide over the mounted secondary section track. The attraction forces are taken up by the linear guides.

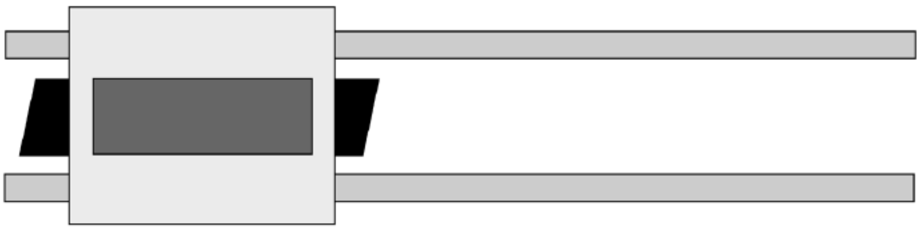

Fig. 13 Step-3

4. Mount the remaining secondary section track. Align the track as well. Tighten the mounting screws according to the specifications.

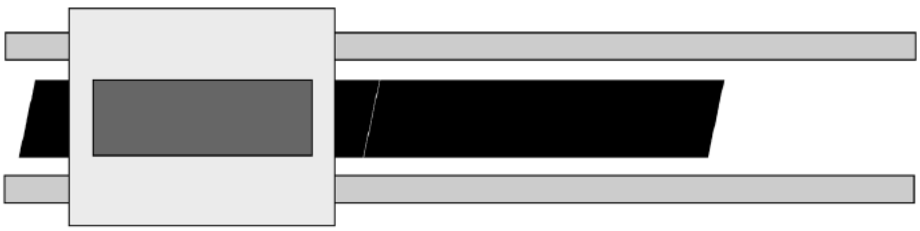

Fig. 14 Step-4

2.2.2 Motor assembly through the mounting of the motor components

1. Mount the secondary section track according to Chapter "Assembling individual motor components".

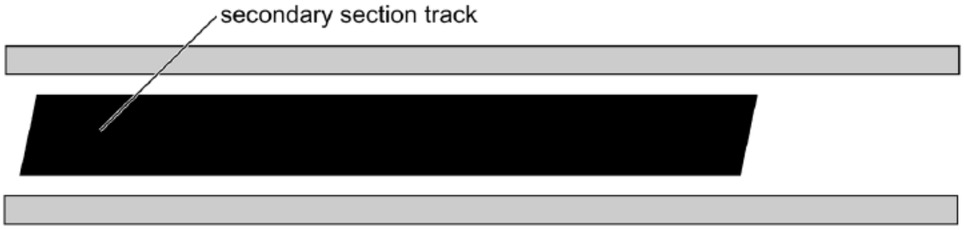

Fig. 15 Detail of Secondary Section Track

2. Place the primary section with a forcing assembly on the secondary section track as follows.

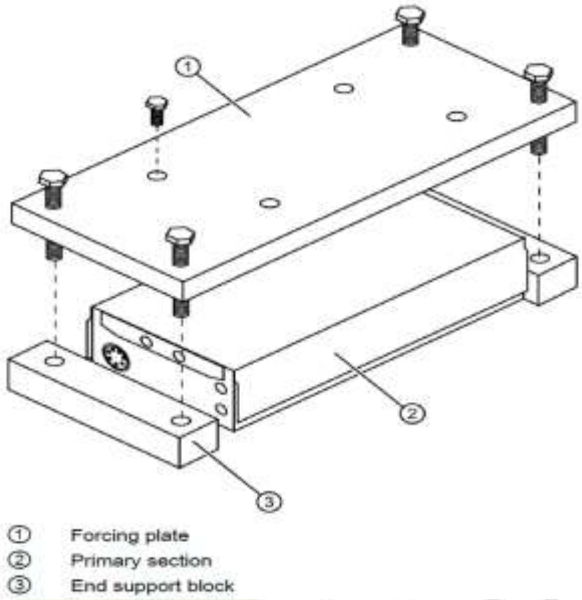

Fig. 16 Forcing Assembly

- Mount the primary section on the forcing plate of a forcing assembly. You can use the factory-made mounting holes for this purpose.
- Screw the jack screws into the forcing plate. Ensure that the jack screws protrude evenly from the forcing plate. There must be a minimum distance of 50 mm between the nonmagnetic counter-bearing blocks and the forcing plate.
- Place a spacer foil between the primary section and the secondary section track. This spacer foil must be thinner than the required air gap. This is necessary to ensure that the spacer foil can be removed at the end of the assembly without any effort. The forcing assembly must ensure that the primary section can be lowered onto the secondary section track (covered with the spacer foil) in a controlled fashion. Further, it must be lowered in parallel with the secondary section track and centred.
- Screw back the jack screws in steps to lower the primary section onto the secondary section track, in parallel and centred with it.
- Then completely remove the forcing assembly from the primary section.

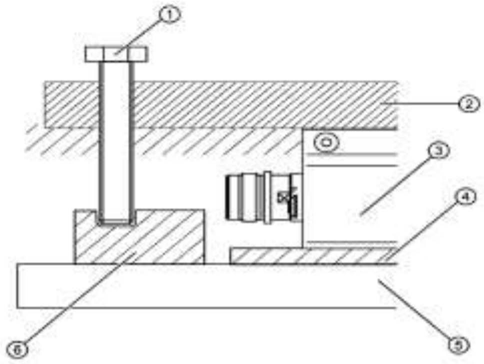

Fig. 17 Fastener Detail for Assembly

3. Mount the primary section on the slide.

- Secure the slide on the guides.
- Push the slide over the primary section. When doing this, the mounting holes of the primary section and slide must be fully aligned.
- The mounting screws are initially screwed through the slide into the primary section and tightened by hand. By uniform and alternating tightening of the mounting screws, the primary section is lifted from the secondary section track.
- Then remove the spacer foil from the air gap without applying any force.

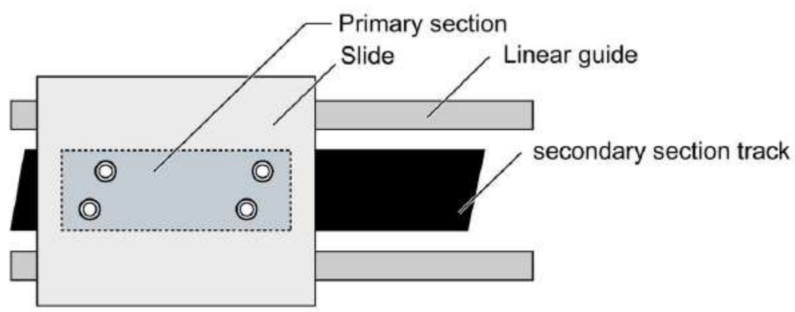

Fig. 18 Detail of Air Gap

3.1.3 Assembling individual motor components

The letter "N" is to be found in each secondary section. Ensure that the letter "N" on each of the secondary sections is pointing in the same direction, as shown in the following figure 19.

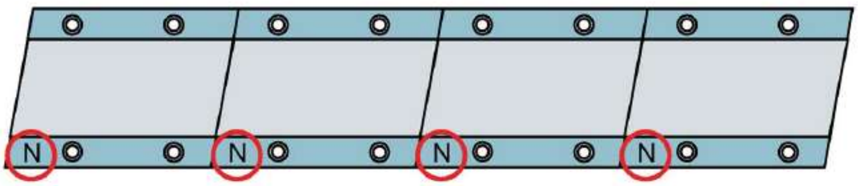

Fig. 19 Position of the "N" mark on secondary sections of the 1FN3 product family

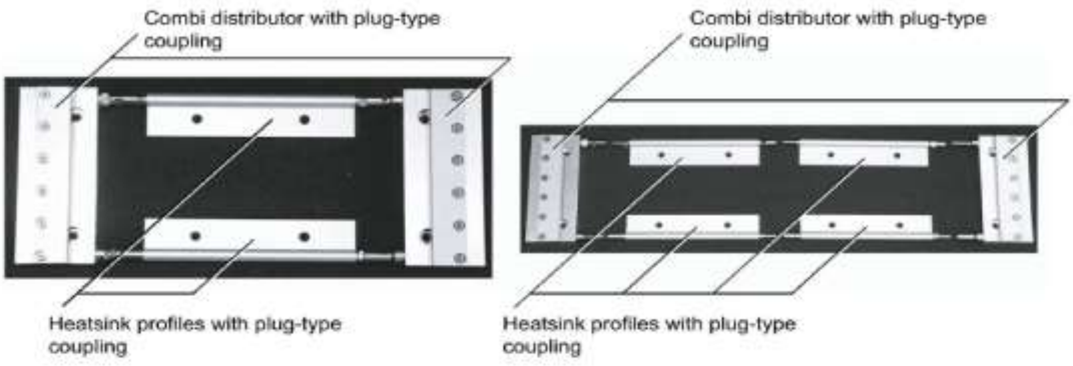

Fig. 20 Position of the heatsink profiles and combi distributors (illustration without fastening screws)

Fig. 21 Mounting of the first segment of the segmented secondary section cover

Fig. 22 Mounting of a further segment of the segmented secondary section cover

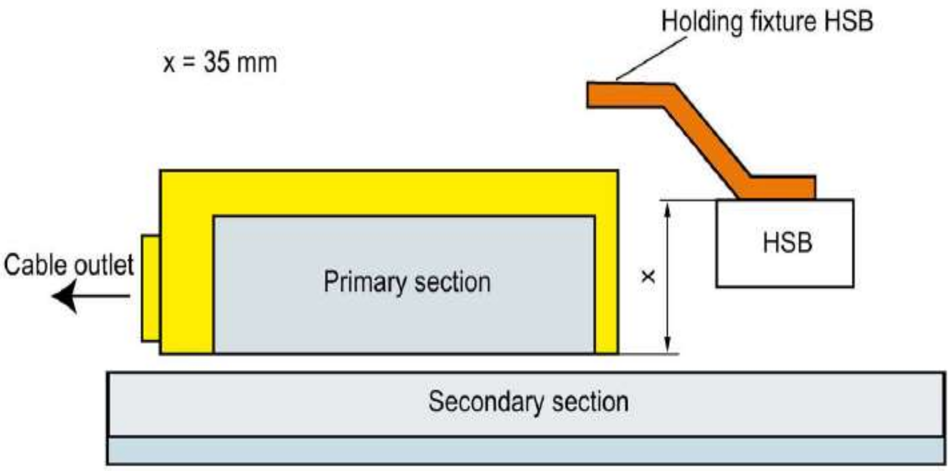

Fig. 23 Specified dimension for mounting the Hall sensor box (HSB)

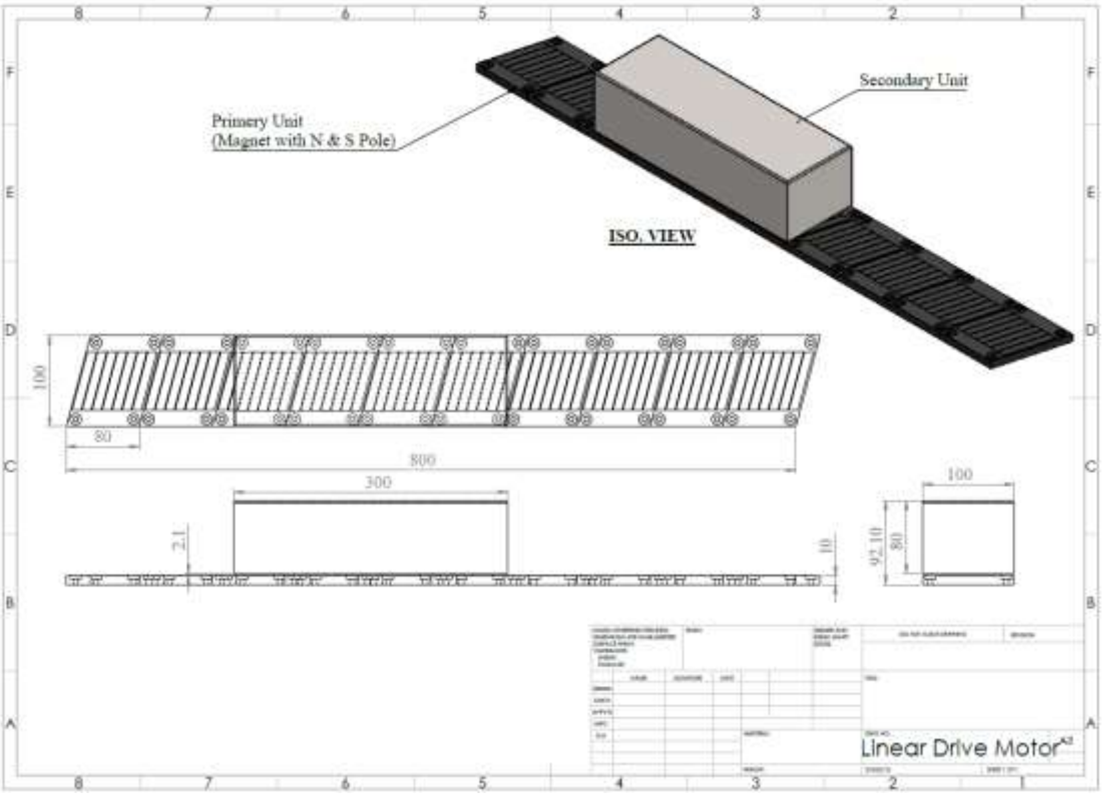

Fig. 24 2 D Drawing of Linear Drive Mechanism for XY Axes

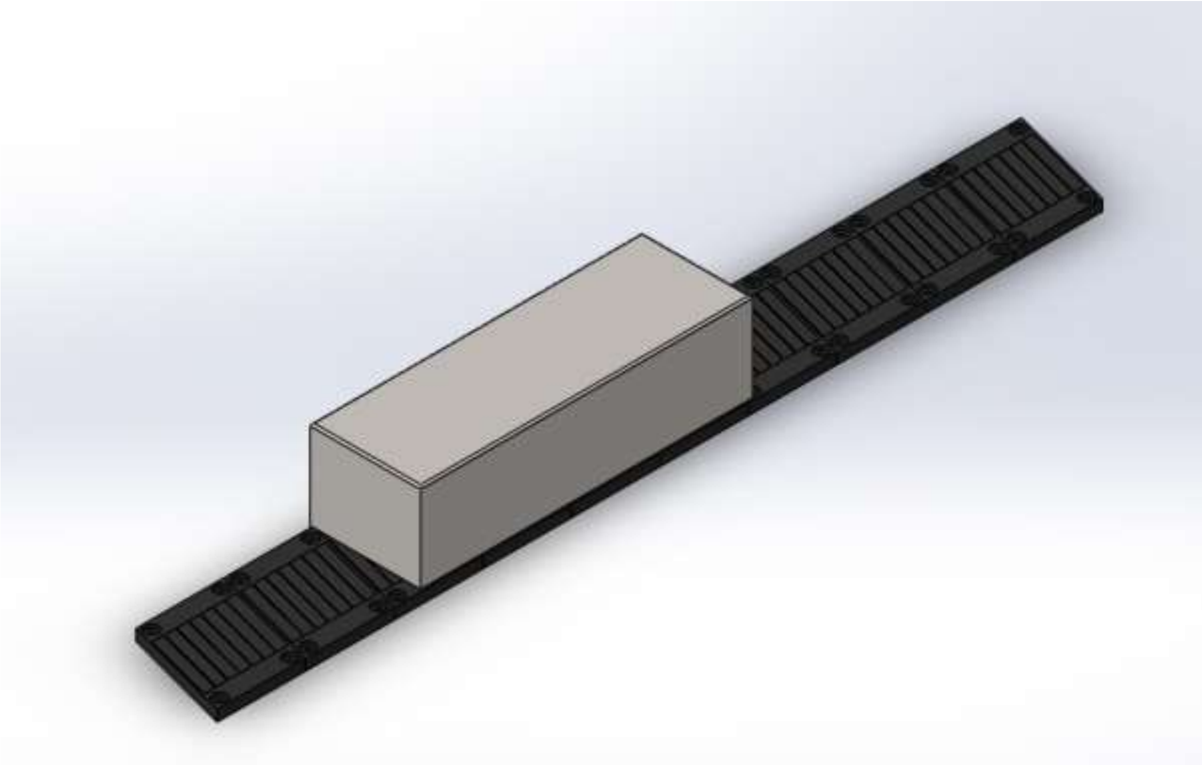

Fig. 25 3 D Model of Linear Drive Mechanism for XY Axes

4. Conclusion

It was reflected in the different application of fibre laser cutting machine likes laser scanning, open-cell formation process. Some research paper indicated about drive mechanism for axes design which are a bionic linear rolling guide, NC drive and linear drive. There is a possibility of work in direction different main components of fibre laser cutting machine which depend on operation and area of cutting the workpiece. Detail of fibre laser cutting machine was taken Form Company and considering the ideal case of loading for calculating existing linear drive system.

By taking practical data of existing mechanism like ball screw which having more time during assembly it was very complex assembly during maintenance in machine required more time and it was total mechanical assembly.

To overcome such problem taking as a project by supporting design engineer of the company to replace existing mechanism by using linear drive motor which are more component and easily assembled, also life is more compared to exist so understand the technical aspect of a linear motor and set this mechanism in the same design of the base structure.

5. References

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