The Principle and Control Method of Belt Support Industrial Laser Cutting Machine

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Abstract. The industrial-grade laser cutting machine studied by the author, it can cut metal sheets accurately and reliably without damaging the surface of the sheet. And experienced many years and multiple sets of cutting production verification. This kind of cutting machine adopts a belt to support the sheet metal belt, and the supporting belt forms a follow-up optical slit under the cutting head, and the air and dust are exhausted in the optical slit, so the surface of the blanking part is free from scratches and dust; the optical slit follows the movement of the cutting head, There is always no obstruction under the cutting head except for the material being cut, so no cutting dross will be formed, and reliable cutting can be ensured.

Keywords: Laser cutting · Belt support · Follow-up optical slit

1 Introduction

When the laser cutting machine cuts metal sheets such as steel and aluminum, the cutting head emits a laser beam to irradiate the sheet material to melt or even gasify the metal material. The movement of the cutting head forms a kerf and completes the cut.

1.1 Problems with Traditional Laser Cutting

Traditional laser cutting machines usually use multiple toothed nail plates to support sheet metal. When uncoiling and cutting steel coils or aluminum coils, usually multiple toothed nail plates are made into crawler-type structures, called rolling toothed plates, to support the material belt.

Slag jets are formed when molten metal is blown away from the sheet by compressed gas. When the slit is just above the stud, the slag jet is blocked by the stud, and the slag cannot be discharged in time. After the laser beam leaves, the slag cools and forms a slag bump on the sheet slit, as shown in Fig. 1.

The dross is attached to the scrap or material by welding, and the adhesion strength is high. Generally, grinding is required to remove it. What's more, slag lumps often weld scrap and blanks together, resulting in constant cutting. When the blank is used as a blanking part, the slag will damage the blank holder structure of the subsequent stamping die. The position of the cutting edge on the blank is not fixed.

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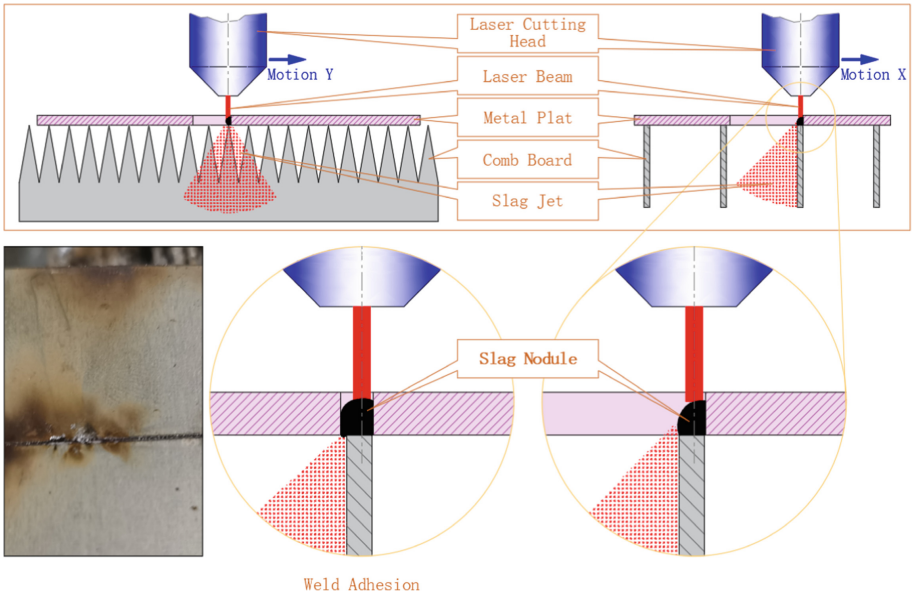

Fig. 1. Formation of slag nodules.

Pot manufacturers use laser cutting to make wafers. Before stretching, they need to be polished with an edger to remove slag. The disc edging machine has a simple structure and low price, so the edging process is easy to implement.

The blanking parts of automobile sheets have complex shapes and usually have inner holes. The slag on the inner and outer edges of the blanking parts can only be removed by manual grinding, and it cannot be cut off reliably, which does not meet the requirements of automatic production in the automotive industry, thus restricting the traditional the application scale of plane laser cutting equipment in the automotive industry.

1.2 Belt Support Laser Cutting Principle

The industrial-grade laser cutting machine developed by the author can realize reliable cutting and non-destructive cutting, and has experienced three years and multiple sets of cutting production verification. This kind of cutting machine adopts a belt to support the sheet metal belt, and the supporting belt forms a follow-up optical slit under the cutting head, and the air and dust are exhausted in the optical slit, so the surface of the blanking part is free from scratches and dust; the optical slit follows the movement of the cutting head, There is always no obstruction under the cutting head except for the material being cut, so no cutting dross will be formed, and reliable cutting can be ensured, as shown in Fig. 2.

The key structure of the belt-supported laser cutting machine is the follow-up optical slit. The follow-up light slot is a closed beam frame that can move autonomously, on which 4 follow-up rollers are installed to keep the belt away from the laser beam and the slag jet; a long slot is opened on the top of the closed frame to keep the laser beam

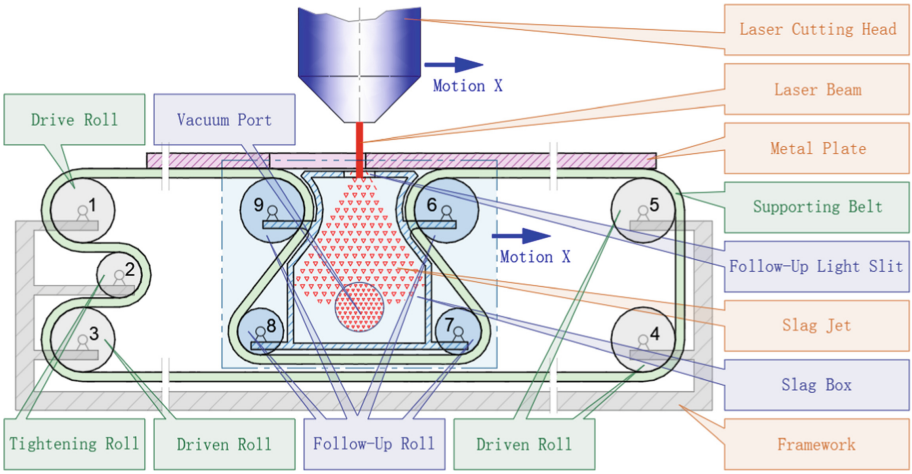

Fig. 2. Principle of belt support laser cutting.

and the molten slag jet away. The slag jet enters the interior; a waste slag box is formed inside the closed frame; the air exhaust port is arranged in the follow-up light slit, which is connected with the dust removal fan to ensure that the slag completely enters the waste slag box and is drawn out with the airflow.

Under the action of the driving roller, the linear movement of the top of the supporting belt forms the feeding function. The feeding motion and the motion of the follow-up optical slit are independent of each other.

1.3 Coordinate System Definition

The coordinate system of the belt-supported laser cutting machine consists of 5 axes including x, y, z, a and b. The y-axis is in the width direction of the device, and details are not described in this article.

As shown in Fig. 3, the cutting head and the follow-up optical slit move horizontally along the x-axis, the cutting head moves up and down along the z-axis, and the belt moves along the a-axis. The origin of the coordinates is O, which is located on the upper surface of the belt above the center of the belt drive roller 1.

The displacement caused by rollers 1 to 5 is on the a-axis, and the displacement caused by the follower rollers 6 to 9 is on the b-axis. As shown in Fig. 4, the b-axis coincides with the x-axis and the a-axis, and the origin O_b of the b-axis is always on the upper surface of the belt above the center of the follower roller 9, and O_b is follow-up. Since the upper surface of the support belt is used for feeding, when calculating the relationship between the angular displacement of the belt roller and the linear displacement of the a-axis and b-axis, the effective radius of the roller is the shortest distance from the center of the roller to the belt surface where the upper surface of the belt is located. Refer to Fig. 3 The effective radius of each roll R_1–R_9.

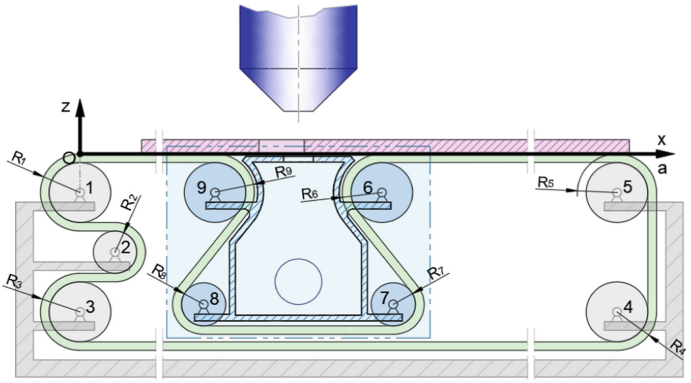

Fig. 3. The coordinate system of the transmission conveyor flat belt.

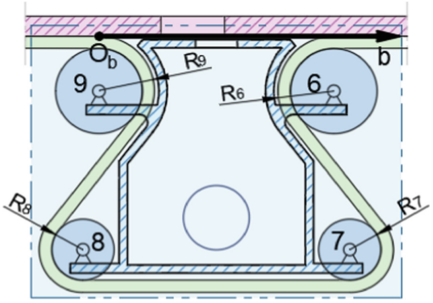

Fig. 4. The b-axis on the follow-up optical slit.

2 The Relationship Between the Drive Shafts

There is a linear displacement relationship between the x-axis, a-axis, and b-axis in the drive train.

$$\Delta b = \Delta a - \Delta x \tag{1}$$

Its instantaneous velocity relationship is:

$$V_b = V_a - V_x \tag{2}$$

Its instantaneous acceleration is

$$a_b = a_a - a_x \tag{3}$$

The linear displacement caused by the angular displacement ω_i of the belt roller i is

$$\Delta a = \varpi_i R_i \quad (\text{where i } = 1, 2, 3, 4, 5) \tag{4}$$

or

$$\Delta b = \varpi_i R_i \quad (\text{where i } = 6, 7, 8, 9) \tag{5}$$

3 Control Method

The x-axis, y-axis and z-axis control methods are traditional and will not be described in this paper. When the contour accuracy of the cutting sheet is not high, it is only necessary to control the feeding motion of the driving roller 1 according to the Eq. (4), and then the goal of the cutting operation can be completed.

The inertia and frictional resistance of the passive rollers will cause the elastic deformation of the belt and bring about feeding errors. Therefore, when the cutting accuracy is high and dynamic cutting is used, all belt rollers must be servo-driven, and controlled servo motor according to Eq. (1) to Eq. (5). The cutting accuracy can be improved from ± 2 mm to ± 0.1 mm.

4 Summary

When the laser cutting machine is cutting, the laser head usually moves, which requires that there should be a gap under the corresponding position of the workpiece to be cut, that is, a light slit, so that the laser head will not cut the worktable when cutting the workpiece. And other components. The traditional light slot is usually fixed, which is very inconvenient when maintenance is required, which brings great difficulties to the maintenance work. This research realizes a multi-segment belt-supported conveying device and a laser cutting system; the multi-segment belt-supported conveying device can not only meet the position matching needs of the laser head when cutting and move, but also can enlarge and reduce the width of the working space, which is convenient for maintenance. And maintenance; the laser cutting system includes the aforementioned multi-segment belt support conveying device, which is more convenient for maintenance.

References

1. J. Y. Wang, J. H. Zhong, G. C. Wang and L. Wang, Automatic generation of laser blanking toolpath for multiple cutting heads on one beam, in *Advanced High Strength Steel and Press Hardening Proceedings of the 5th International Conference*, (Shanghai, China, 2020).
2. Y. Lu, X. Y. Zhao, R. Y. Fu and J. Y. Wang, A cloud computing architecture for laser blanking, in *Advanced High Strength Steel and Press Hardening Proceedings of the 5th International Conference*s, (Shanghai, China, 2020).
3. J. H. Zhong and J. Y. Wang, Sheet Metal Preparation Production Optimization Management System, *Forging Technology* **12**, (2002).
4. J. Y. Wang and J. Liu, Laser blanking of tailor-welded blanks for automobiles, *Sheet Metal and Fabrication* **4**, (2021).
5. J. Y. Wang, Y. P. Yang, P. Zhang, J. W. Xie and G. C. Wang, Fully digital laser blanking line, *Sheet Metal and Fabrication* **9**, (2020).