Design of the AGV Trolley for Transporting the Drip Irrigation Belt Roll

Meng Fanzhao¹,²*, Wei Daifeng³

¹ School of Mechanical Engineering, Shandong Huayu University of Technology, Dezhou 253034, China
² Intelligent Manufacturing Equipment Design Engineering Technology Research and Development Center, Dezhou 253034, China
³ School of Safety and Ocean Engineering, China University of Petroleum (Beijing), Beijing 102249

*Corresponding author’s e-mail: mfzhthy@huayu.edu.cn

Abstract: Automatic Guided Vehicle (AGV) is a kind of driverless transport vehicle which can carry, store, and load and unload goods. It can follow the preset path, complete the task, and has the functions of obstacle avoidance and safety protection, which is widely used in automatic production system. This paper introduces the design and development of AGV trolley to realize the automatic production transformation of drip irrigation belt production line for agricultural irrigation. According to the design requirements of the drip irrigation belt rolling AGV trolley for the transformation of the production line, based on the previous design experience and technology of the automatic guided trolley, from the actual needs of engineering application, combined with the path guidance technology, embedded control system, sensor detection technology, module control and system control management technology, a tape guided AGV trolley with lifting module is designed, which realizes the functions of rolling, transporting and storing of drip irrigation belt, and the production efficiency of drip irrigation belt is improved.

1. Introduction

With the development of science and technology and the implementation of "industry 4.0" strategic plan, the level of intelligence and automation of manufacturing industry is constantly improving [1]. With the development of robot technology, AGV was produced and has been used in material handling and other automation fields for more than 50 years [2]. Its application fields are more and more extensive, including manufacturing industry, logistics industry, agriculture and other fields. It not only greatly improves the productivity, but also guarantees the production quality of enterprises to a great extent [3-4]. This paper introduces an automatic rewinding trolley used in drip irrigation belt production enterprises. During the investigation in Xinjiang Tianye Co., Ltd., the author found that the technology level of the production line of drip irrigation belt is high, but the labor intensity of the process of packing and transferring the drip irrigation belt to the production line is high. In this link, the drip irrigation tape with a weight of about 25kg needs to be manually transported to the ground for packing and labeling, and then transferred to the conveyor belt. Therefore, an AGV trolley with lifting module was designed. The site of winding, labeling and packing of drip irrigation tape is shown in Figure 1.
2. Design requirement
According to the site investigation, the following requirements are determined after communication with the technical personnel of the enterprise:

1) Positioning requirements
   a. AGV trolley adopts symmetrical structure; its center can be aligned with the vertical plane of the reel center;
   b. The distance between the front end of AGV trolley and the end face of reel is controllable.

2) It has the functions of anti-collision, obstacle avoidance parking, automatic tracking according to the magnetic stripe guidance, and automatic looking for charging pile charging and so on.

3) The lifting module has the capacity of lifting telescopic height not less than 0.5m, bearing capacity not less than 30kg, and turning the reel 90 degrees.

3. Structural design
According to the design requirements of AGV trolley for drip irrigation belt winding, its working process is determined as shown in Figure 2.

The main structure of AGV trolley for drip irrigation belt winding is shown in Figure 3. It is composed of chassis vehicle, magnetic stripe guidance system, scissor type lifting device, obstacle avoidance and positioning detection and control system. Chassis trolley is the bearing device of this product, equipped with drive system, sensors, control system, scissor type lifting device and other modules are installed on the chassis trolley. According to the command from the control system, the magnetic stripe guidance system can reach the designated position along the magnetic stripe laid on the ground. The scissor type lifting device is used to lift the drip irrigation belt. It is equipped with a manipulator, which can hold the drip irrigation belt and turn it 90° to the ground or the drive belt. The sensor is responsible for detecting the signal and transmitting it to the control system to realize the functions of motion positioning and obstacle avoidance.
Figure 2 Work flow of AGV trolley for drip irrigation belt winding

1. Magnetic sensor; 2. Obstacle avoidance sensor; 3. Driving wheel; 4. Scissor lift module; 5. Power supply; 6. Chassis; 7. Control module
(Remove the upper guide rail of lifting platform and scissor lifting mechanism)

Figure 3 Structure diagram of AGV trolley
3.1. Chassis design
Based on the consideration of light and easy processing, we use the traditional frame structure to design the chassis trolley, which can reduce the weight of the whole trolley and the difficulty of processing. The rectangular hollow section steel pipe is used to weld the whole frame, and the local welding steel plate is used to improve the connection strength. Using UG software to complete the three-dimensional model of the chassis trolley, the balanced layout of the battery, main control box, lifting module, and navigation and drive module is realized, which improves the stability of AGV trolley. In order to improve the safety of AGV, the front and rear of chassis vehicle are equipped with obstacle detection sensors.

AGV trolley drive module is the most important part of the vehicle, which directly determines the performance of the trolley in operation. At present, the common gear train structure of AGV trolley is mainly divided into independent steering and differential steering. The former separates the steering wheel and the driving wheel, and designs an independent steering mechanism; the latter uses the rear wheel differential drive, and makes the trolley turn with a certain radius by using the speed difference of the rear driving wheel, so there is no need to design an independent steering mechanism.

AGV wheel layout mainly includes three wheel structures, four wheel structures and six wheel structures. Different number of wheel structures has different steering modes, and the same number of wheels also has different layout modes, which will lead to different trolley body stability. This design adopts six wheel chassis structure, two differential wheels in the middle, two universal wheels in front and two universal wheels in the back. This structure has large bearing capacity, good landing effect and good stability.

3.2. Lifting mechanism design
In order to realize the lifting function of drip irrigation coil, the scissor type lifting mechanism is selected in this paper, which has the characteristics of simple structure, convenient operation, strong bearing capacity, good system stability and saving installation space [5-6]. According to the number of scissors, the scissors lifting structure can be divided into single-layer and multi-layer scissors lifting mechanism. In this design, the lifting height is 500mm, and the single-layer scissor structure can meet the requirements. As shown in Figure 4, it is composed of fork arm, carriage, screw nut pair, etc.

The power layout of scissors type lifting mechanism mainly includes horizontal layout, vertical layout and double hinged layout. This design selects a relatively simple horizontal layout, the push rod adopts the screw nut pair, and the motor drives the screw to rotate to realize the lifting of scissors mechanism.

![Figure 4 lifting mechanism](image)
4. Conclusion
This paper analyzes the design requirements of AGV trolley for the transformation of drip irrigation belt production line, and on this basis, completes the structure design of AGV trolley for drip irrigation belt winding. The whole AGV trolley adopts left-right symmetrical structure, and uses tape guidance, laser positioning and other means to achieve alignment and positioning with the vertical plane where the reel center is located, so as to solve the problem of automatic handling of drip irrigation reel. The AGV trolley is equipped with an automatic obstacle avoidance system, with anti-collision, obstacle avoidance and parking functions. The lifting module adopts scissors lifting structure with horizontal arrangement of push rod, and the push rod is driven by screw nut pair, which has simple structure and high lifting height controllability. The design has the advantages of simple working principle, stable structure and low manufacturing cost, which is conducive to the liberation of labor force and high application value.

Acknowledgment
This work was supported by the project of the scientific research project of Shandong Huayu Institute of Technology “Design of AGV forklift based on laser navigation” (No. 2020KJ06).

References
[1] Miao X Q. (2015) Industry 4.0 promotes Mechatronics to intelligent technology system. Process Automation Instrumentation, 37(01):1-5+8.
[2] Ji W W, Zhang Y Z. (2014) Troubleshooting of common faults of AGV. Technology and enterprise, 13:374.
[3] Pu B S, Chen Y K, Wang T, Huang Y Y. (2020) Development status of automated guided vehicle technology and its application and prospect in agriculture. Jiangsu Agricultural Sciences, 48(01):61-65.
[4] Huang X L, Tan X. (2015) AGV Car Applied in Body Shop. Equipment Manufacturing Technology, 04:201-203.
[5] Xu J. (2013) Analysis and optimization for lifting mechanism of scissor-fork lifter. Mechanical Science and Technology for Aerospace Engineering, 32 (6):919-922.
[6] Liu J Y. (2014) Force analysis of scissor lift mechanisms. Journal of PLA University of Science and Technology Natural Science Edition, 15 (2):133-138.