Analysis of application status of spinning industry robot

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Abstract

To foster the application and research of robots in the spinning industry, this paper provides a summary and analysis of their current status of use. It reviews the application of Automated Guided Vehicles (AGVs) and cone yarn stacking robots within intelligent logistics systems. Furthermore, it discusses the use of automatic winding carts, fine yarn splicing robots, and sliver packaging robots in intelligent spinning single-machine equipment. The paper also contemplates the future development prospects of robots in the spinning sector and examines the challenges they face. It posits that the application of robots in the spinning industry is still in its nascent stage, with the primary goal of bridging the gaps in fully automated production processes and enhancing the continuity and intelligence of spinning production as the future direction for spinning robots.

Keywords Spinning Industry; Robots; AGVs; Winding Carts; Fine Yarn Splicing Robots; Stacking; Investment Value

1. Introduction

With the aggravation of population aging and the increase of labor costs, the "labor shortage" in the spinning industry has become more and more serious, forcing the spinning industry to carry out intelligent transformation and improve the level of automation of production equipment and process continuity [1-2]. The integration of robotics and big data, the Internet of Things, artificial intelligence, and other technologies has become an important part of the intelligent transformation of the spinning industry [3]. The intelligent upgrading of the spinning workshop includes three aspects: workshop intelligent control system, intelligent spinning stand-alone equipment, and an intelligent logistics system [4]. At present, robots in China's spinning industry are mainly used in intelligent logistics systems, and the application percentage and maturity of intelligent spinning stand-alone equipment are yet to be improved [5]. This paper summarizes the current situation of the application of robotics in the spinning industry, analyzes its application effects and challenges, and provides a reference for the research and application of robotics in the spinning industry.

2. The current situation of the application of robots in the spinning industry

2.1 Application in the intelligent logistics system

An intelligent logistics system is a link between the various processes of the single machine equipment, which in the intelligent control system scheduling, to achieve the automatic transportation of materials between the various processes and logistics information tracking records, including automatic cotton distribution package system, carding system, carding and tube conveying system, coarse and fine link rail system, fine link conveying system and automatic palletizing of the cylinder yarn packaged storage system. Among them, the cleaning carding, coarse and and fine winding through the pipeline or track to achieve a more mature automatic transportation. Robots play an important role in the automatic cotton distribution and packing system, automatic cylinder conveying system, and automatic palletizing and packing storage system.

2.1.1 AGV trolley

AGV trolley, i.e. automatic guided trolley, realizes intelligent handling by using magnetic stripe, ribbon, laser, and other navigation methods, using a rechargeable battery as a power source, which is an important branch of the mobile robot [6].AGV trolley has the functions of automatic operation, automatic obstacle avoidance, automatic navigation, automatic charging, active safety protection, etc. Before the operation of the AGV trolley, the workers use the terminal equipment to calibrate the working area.AGV trolley is equipped with the on-board control system. The AGV is equipped with an on-board control system, the upper computer system communicates with the on-board control system through a wireless network, to give the handling task, and the control system selects the effective path according to the current position to complete the transportation of the material, place it and return to the set station to wait. During this period, the AGV vehicle will regularly send the current speed, current position, and other relevant information to the host computer, and the AGV vehicle can be programmed and reconfigured according to the need to adjust the running path. Compared with the traditional conveyor, AGV has excellent flexible transportation ability and occupies less space, which can significantly reduce the demand for ordinary labor in production. In the spinning industry, the manual handling of cotton bales and strips is a large task, and the application of AGV trolleys creates an opportunity for the spinning industry to change from the mass production mode to the small batch and personalized production mode [7].

In the automatic cotton matching and gripping system, AGV trolleys equipped with soft bale clamps convey the cotton bales from the grading room to the designated position for gripping machines to grab. Cotton has different origins and batches, and it is necessary to make different kinds of cotton cross-arrange by matching and arranging the bales so that the cotton can be evenly mixed by the cotton gripper. Bale appearance is similar, the visual sensor is difficult to accurately identify, and usually need to manually take out different bales from the raw material warehouse after the regional arrangement in the workshop grading room, the AGV cart to obtain the corresponding region of the bale type information can realize the bale of directional transportation, this process undoubtedly increases the workload of workers. AGV carts and unmanned warehouse systems can be used in conjunction with the realization of complete automation [8].

The unmanned warehouse system can automatically select the type of bale required for outgoing storage, eliminating the manual classification process, but this is a higher requirement for equipment interconnection. In the carding and sliver conveyor system, AGV carts are equipped with holders, from the card will be with a raw sliver of the sliver is carried to the card, retrieved from an empty cylinder to the card entrance position, in an orderly manner to achieve the merging machine and card between the full cylinder, empty cylinder convenient transportation, more widely used in spinning enterprises.

Configuration of multiple AGV trolleys needs to pay attention to scheduling problems, such as task allocation, path planning, and task sequencing of AGV trolleys [9]. The spinning workshop production process is long, with many production processes, and processing equipment distributed across the region, there are multiple processes in parallel machines, increasing the complexity of the AGV cart scheduling problems. If the number of AGV trolley configurations is too much, it will lead to a low utilization rate and bring higher purchase, maintenance, and other costs to the enterprise; while the configuration is too little, it will lead to semi-finished products staying too long, and the latter process can not be processed in time. Therefore, it is necessary to reasonably formulate the AGV trolley scheduling plan, to achieve the optimal number of configurations, and shorten the unloaded trips, to maximize the effectiveness of the AGV trolley. AGV trolley is a more mature product, and there have been several

applications in spinning enterprises. 2020, Jingwei Textile Machinery Co., Ltd. and Wuhan Yudahua Textile and Garment Group Co. Ltd. and Wuhan Yudahua Textile and Garment Group Co., Ltd. to build a "100,000 spindle full-process intelligent spinning" project, through the 11 AGV trolleys to complete the automation and continuous automation of the carding to the merging, merging to the roving, packaging pallets to the finished product warehouse and other processes.

2.1.2 Cylinder yarn palletizing robot

Cylinder yarns need to be packed in single yarns to prevent dust, moisture, water, and friction between the cylinder yarns from damaging each other. After the cylinder yarn attitude detection and turning, the cylinder yarn will be arranged according to certain specifications for the whole package packaging, so that it is strong and tight for storage and transportation. After online weighing and automatic labeling, the production information is affixed to the whole package of cylinder yarn. The cylinder yarn palletizing system consists of three main parts: a central scheduling unit, a palletizing robot, and a cylinder yarn lifting mechanism, and the robot realizes automatic gripping and palletizing of cylinder yarn. The central scheduling unit adopts intelligent scheduling algorithms to schedule robots for yarn gripping and palletizing according to the real-time output of the winder and coordinates the robot palletizing and winder production. The robot recognizes large head-up and small head-up yarns and grabs them with different gripping mechanisms. The stacking shape can be set according to the process parameters to realize the stacking of various shapes. The dispatching unit monitors the working situation in real-time and displays it on the HMI.

(hereinafter referred to as SAT Global) and Qingdao Shuangqing Intelligent Technology Co., Ltd (hereinafter referred to as Qingdao Shuangqing) are the representative enterprises of cylinder yarn palletizing robots. SAT Global has mastered the core technology of intelligent packaging and logistics systems for cylinder yarn. The multi-station rail palletizing system can complete online automatic palletizing of multiple varieties, compatible with carton and woven bag packaging, and can be set to palletize in the form of zigzag, parallel, tic-tac-toe, etc., to realize intelligent and flexible production. In 2020, Qingdao Shuangqing introduced a fully intelligent cylinder yarn conveying and packaging system, with an original palletizing system that solves the risk of inverted and crooked palletizing in the traditional method, and has smooth and compact palletizing, and can choose from 2 to 6 packages per layer according to the storage and transportation needs. According to the storage and transportation requirements, it can choose the form of 2 packages~6 packages per layer, with a standard layer height of 11 layers and a maximum of 15 layers.

2.2 Application in single machine equipment

2.2.1 Automatic winding trolley

In the traditional winding process, when the single spindle sends out the signal of full cylinder, it is necessary for the workers to remove the full cylinder yarn from the arm, and put the prepared empty paper tube back into the arm; at the same time, do a good job of winding and leaving the end according to the requirements, and then restart the equipment to complete the process of a single spindle falling cylinder. The whole production efficiency and product quality are dependent on the ability level of the blocker, the product parameters make it difficult to form a standardized scale. The emergence of automatic cylinder drop trolleys improves the automation level of automatic winders and is of great significance to realize the intelligentization of the whole production process. The automatic winding trolley can accurately locate the movement track, and interact with the full single spindle and the upper computer to realize the work of dropping, changing, clearing, and the second head of the full spindle,

etc. It has the features of a high degree of automation, complex structure, and high precision.

Qingdao Hongda Textile Machinery Co., Ltd. is the only manufacturer of automatic winder series in China, with more than 10,000 sets of winder production experience, and VCRO series automatic winder is equipped with a trolley that can move at a speed of up to 60m/min, with a cycle time of 13.5s, and a trolley that can satisfy the demand of 72 spindles, with a success rate of more than 95% in dropping the cylinder and retaining the tail yarns. The newly developed third-generation cylinder-dropping trolley is more intelligent, the cylinder-dropping trolley can automatically drop the original batch number of the cylinder yarn, automatically borrow and replace the cylinder tube, complete the task of replacing the yarn batch number, and can also born many times.

2.2.2 Yarn joint robot

Yarn head breakage is a problem that restricts the production efficiency and output of spinning machines. At present, enterprises generally use manual jointing. The rapid development of image processing and robotics technology has created conditions for the splicing robot. The Jointing robot needs to complete the braking spindle, pulling yarn, look for the head, set of steel wire rings, around the guide hook, release the braking device, joints, and other 7 actions, the accuracy of the action and the strength of the control of the fine degree of requirements, the research, and development of more difficult. At present, there are Swiss Rieter and Rizhao Pinte Yuhua Textile Technology Co., Ltd. launched a splicing robot. Splicing robots rely on a single spindle monitoring system to detect and obtain the location of the broken head information and move to the spindle where the broken head occurs, in the shortest possible time for the joints, to create conditions for the speed of spinning. Rizhao Pinter Yuhua Textile Technology Co., Ltd. of a new generation of jointing robot jointing success rate of more than 98%, jointing time can be controlled within 35s. In the long run, the splicing robot is a development direction, but also the industry's hot spot. However, the spaghetti joint robot is expensive, hanging on the outside of the spaghetti machine, and usually can only look after a single side of a spaghetti machine. Management level of advanced enterprises, spinning machine thousands of spindles when the head breakage is less than 5, that is, a 1000 spindles of spinning machine 1h head breakage is not more than 5 times, the use of spaghetti joints robot utilization rate is very low. As for ordinary enterprises with high head breakage rates, the purchase intention is affected by expensive equipment [10].

2.2.3 Sliver wrapping head robot

In the combing, merging, roving, and other processes, the replacement of sliver canisters or broken slivers to connect the two sliver heads and tail to continue production. The sliver wrapping header is divided into 11 actions, such as putting sliver, splitting sliver, clamping, pulling "fishtail shape", taking joint sliver, sending sliver, pulling "nib shape", sending "nib shape", hitching header, wrapping 1, wrapping 2, and so on. 11 movements. Among them, "pulling the fishtail" requires loose fibers, straight and uniform; "pulling the nib" requires loose fibers, straight and non-flowering; "hitching" requires the right length; wrapping requires the same thickness as the original cotton sliver and the same thickness as the original cotton sliver. The thickness of the sliver is the same as the original sliver. Because the sliver is not twisted, the holding force is very small, more looser, the action needs to be particularly gentle, and the operation is difficult. In addition, the location of the joint is not fixed, there may be various obstacles that need to be avoided. Poor sliver wrapping head will cause sliver joints too thick or too thin, as well as wrapping rolls too tight, which has a great impact on the quality. A sliver head can occur more frequently than a spun yarn joint, with a roving machine requiring at least 120 joints a day. If a sliver header robot can replace

manual labor, it will bring considerable economic benefits. It is a challenging task for the robot to find the joints in the sliver cylinder, gently lap as many fibers as possible between the two slivers, and increase the twist. Determination of structural form, workspace analysis, structural lightweight design, and force control technology will be the focus of the research. Now no robot on the market can complete the sliver wrapping head, which is also the reason why the parallel and coarse connection is not yet mature.

3. Challenges facing the application of robots in the spinning industry

3.1 Applicability

The spinning workshop's high temperature, high humidity, flying flowers, and dusty working environment are not friendly to the robot; at the same time, cotton individual differences and high flexibility, are not conducive to robot operation. To promote the application of robots in the spinning industry, it is necessary to deeply understand the characteristics of the industry, targeted design, and development. Spinning in the field of robotics research and development of less talent, and robotics professionals are not familiar with the spinning industry. Therefore, it is necessary to strengthen cross-field cooperation and talent training to promote the application and development of robotics in the spinning industry.

3.2 Innovative R&D

Profit margins in the spinning industry are relatively low, and many companies lack sufficient funds to carry out R&D and application of specialized robots. Therefore, the spinning industry needs to find a balance to improve production efficiency and product quality while reducing production costs through innovative technologies and business models. The government and society should also give more support and attention to encourage enterprises to increase R&D investment, promote the automation and intelligent development of the spinning industry, solve the plight of the spinning industry recruitment difficulties, and achieve sustainable development.

3.3 Operation, maintenance difficulty, and reliability

Robots are equipped with sensors, PLCs, and other components, which need to be regularly maintained and serviced by professionals. Spinning enterprise equipment use and maintenance personnel's professionalism is generally not high, lack professional knowledge and skills to deal with complex robotic systems, so the robot used in the spinning industry should be as simple and easy to use as possible. Taking into account the high demand for reliability in continuous production, it should reduce the frequency of failure or facilitate manual intervention when failure occurs, to reduce maintenance costs and improve production efficiency.

3.4 Stock market transformation

The spinning process is long, with many processes and a large footprint, and the addition of robots will further increase the space requirements. Robots usually need to be used in conjunction with other equipment to form a complete system. For example, the spinner joint robot is externally mounted on the spinning machine, and the spacing between the spinning machines has to be increased, resulting in stock market transformation facing certain difficulties.

3.5 Safety

At this stage, robots cannot completely replace labor. The use of robots for automatic conveyance may require overhead or floor tracks, while silver wrapping, replacement of rolls, packaging film, packing tape, etc. need to be manually operated, and people and robots are prone to interfere with each other, resulting in the potential safety hazards of machine injuries. If robotics can be used to achieve unmanned operation of the production line or minimize the direct involvement of manpower, production accidents can be effectively avoided.

4. Application effect and prospect of robot in spinning industry

4.1 Application effect of robot in spinning industry

Robot action is accurate and high precision, which is conducive to maintaining stable quality. The use of robots can also avoid contact between people and sliver and yarn, thus avoiding pollution of the yarn. The value of the robot is mainly reflected in the quality traceability. Taking AGV as an example, it is usually used with an MES system, which can define different process flow and material configurations according to the production requirements of different products, and MES system records the sender and receiver of materials, time, material name, quantity and so on, and carries out the whole process of controlling the material's warehousing, stocking, receiving and dispatching, etc. The AGV feeds back to the MES system on the situation of the handling task and the result, and the raw material warehouse and the transportation department know at any time how much material is used in the production. The combination of the AGV trolley and MES system not only saves manpower but also realizes the functional scheduling and management of the production process, and real-time monitoring of the production status, which can greatly improve the traceability of production.

Most of the spinning enterprises are still in the stage of manual inspection, that is, relying on the blocker to inspect the spinning head breakage [11]. Due to factors such as negligence and repetitive labor, a large number of breaks are not dealt with in a timely and effective manner. Spinning automatic jointing system equipped with a broken head detection device can make up for the lack of manual inspection.

4.2 Application prospect of robots in the spinning industry

Take a spinning enterprise with 30,000 spindles as an example, it needs to be equipped with 3 AGV trolleys, 2 tube yarn palletizing robots, and 8 automatic drop tube trolleys, and the three shifts together replace 10.5 manual labor. Assuming that each worker's annual salary of 80,000 yuan, the use of the above equipment, the annual labor cost savings of 840,000 yuan. In the long run, the progress of science and technology so that the price of industrial robots is a downward trend and gradually popularized, while the cost of labor rises year by year, the robot for the economy will become more and more obvious. For spinning enterprises, the same benefits, the robot payback period will be gradually shortened.

5. Conclusion

Robot replacement is the inevitable trend of modern industrial development, but also an important symbol of modernization of the spinning production chain. Through the introduction of industrial robots, the spinning industry in the automation of the automatic drop tube, in the continuous aspect of the realization of the cotton bale and strip tube automatic transport, automatic palletizing, and packing of the cylinder yarn. The application of robots in the spinning industry is still in its infancy, and there is still a large gap between the proportion of applications in the actual production of enterprises and automobile manufacturing, aerospace, logistics, and warehousing. Filling the whole process of automated production breakpoints as the basis for improving the continuous and intelligent level of spinning production is the future direction of the development of spinning robots. Automatic jointing robots help to reduce the labor intensity of workers in spinning mills and reduce labor, but the jointing efficiency and equipment costs are still unable to meet the requirements of spinning enterprises. The realization of automatic sliver head wrapping is crucial for the automation of parallel and coarse connection, but the complexity of the head wrapping action, low strength of sliver, narrow operating space, and other issues to the robot research and development have brought greater challenges. China's spinning enterprises should strengthen the independent innovation and research and development of spinning robot technology so that the production process is further continuous, and intelligent, helping China's spinning industry competitiveness, to ensure the healthy and stable development of the industry.

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