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Design of Curling Sports Service Robot

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Abstract. In order to implement handling and unmanned maintenance for curling in sports, a service robot is designed in this paper. It could save professional labor costs and improve work efficiency for the curling sports service with strong usability. Through analysis on the curling's feature, the mechanical model of the service robot is established by three-dimensional CAD software. The robot consists two functional sub robots. One is the curling handling robot and the other one is the curling maintenance robot. The design includes the robotic arm systems, maintenance systems, intelligent identification, industrial CT inspection systems and pneumatic control systems. Referred to the mechanical structure of the excavator, the mechanical arm movement is driven by the cylinder. The handling curling has strong stability. The maintenance system adopts a circular layout design. The simulated motion of the design is carried out with the rationality of mechanical structure analyzed. It can make reasonable serve sports and improve work efficiency significantly.

1. Introduction

The competition level of the curling sports in China has been progressed rapidly. It has made great achievements in the international competitions, which greatly gained wide recognition. The curling is expensive with its special material and high quality manufacturing [1]. As other sports equipment, the curling needs the regular maintenance in sports. The maintenance has several complicated steps with strictly rules. It is demanding with professional techniques [2]. It requires professional personnel to carry out the work. If users are lack of maintenance awareness, the service life of curling will be shortened. There are a few sport service machines for the curling, such as the decision robot, the innovation brush and others [3, 4, 5].

In this paper, a curling sports service robot is mainly designed for handling and maintenance of curling from professional manual operation to mechanical automation. It is a typical service robotics machine [6]. It could extend the service life of curling, reduces the cost of professional manual maintenance and could make the curling sports or games more popular [7]. The robot is suitable for the curling field with strong stability according with the wheel system design [8]. Its internal structure runs in an orderly flow. It could make rational use of space and improve work efficiency with saving a little cost. And it has positive significance in popularization of the curling sports.

2. Function of curling sports service robot

The robot makes handling and maintenance of curling from manual operation to mechanical automation. It consists two functional sub robots. One is the curling handling robot and the other one is the curling maintenance robot. The functional structure diagram with the main parts and system is shown in Fig.1. Firstly, the handling robot collects the curling from field. It picks up the curling and transfers it to the maintenance robot. The curling is pushed by the door conveyor and tested through an industrial CT inspector. Then, by cooperation of the lifting conveyor and the arms, the bottom is exposed. The maintenance process in carried out soon and the curling position is switched under the rotation of the table. The bottom of the curling is



sequentially followed by the scrubbing arm, the waxing arm, the baking arm, the gas nitrogen cooling arm and the polishing arm. Finally, the professional maintenance work of the curling is finished.

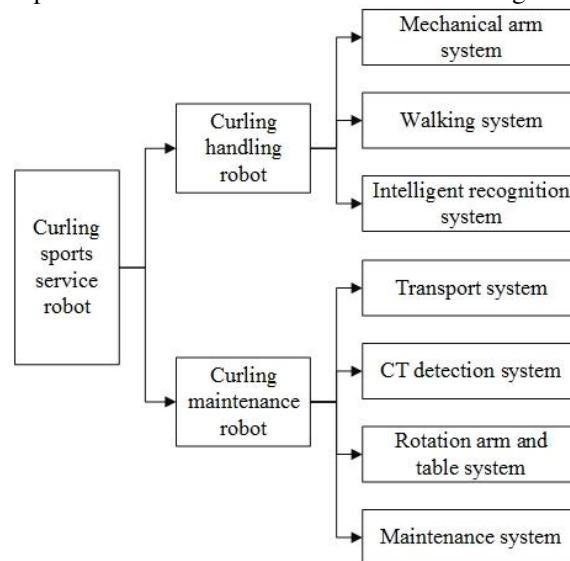


Figure.1. Functional structure diagram.

3. Design and configurations

3.1. Curling handling robot.

The curling handling robot is designed as shown in Fig.2. In the figure, Label 1 is the balance linkage which is used to maintain horizontal levels during curling to ensure stability during handling. Label 2 is the small cylinder numbered 1. It is used to drive the balance link. Label 3 is the robotic arm. Label 4 is the manipulator drive cylinder, which powers the movement of the arm. Label 5 is the robotic arm support. It is used to fixed and supported robotic arm system. Label 6 is the Mecanum wheel. It is a kind of universal wheel and enables the robot to move in all directions. Label 7 is the chassis. Label 8 is high definition camera with aims to position curling. Label 9 is the small cylinder numbered 2. It provides the grab power. And Label 10 is the suck for the claw. It is used to grab the curling.

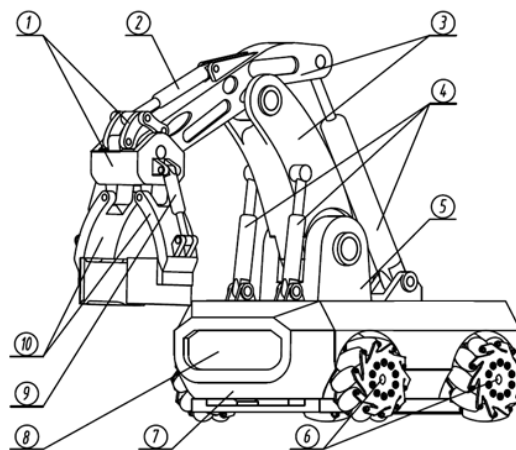


Figure.2. Curling handling robot.

The extension and contraction of the robot arm of the curling handling robot is mainly driven by the linear cylinder motion. Its mechanical structure mainly refers to the structure of the construction machinery, such as the excavator. The balance linkage mechanism ensures the stability of the transportation, which is flexible and ingenious. It adopts the cylinder as the economical power supply. The curling claws is designed according to the size of the curling. The assembly suction cup assists in the grasping, which could flexibly grab the curling without damage to the curling on the field. The machine is configured with four Mecanum wheels, with four

secondary gearboxes and with four independent motors controlled by control and power supply system. Based on the omnidirectional motion characteristics of the Mecanum wheel, free and quickly motion can be realized with a high maneuverability of the robot.

3.2. Curling maintenance robot.

The design of the curling maintenance robot is shown in Fig.3. Its appearance resembles looks like a large curling and it is successfully integrated into the curling venue. Since the weight of curling is heavy, the curling maintenance robot is fixed on the field corner during work. The curling handling robot will carry the curling to the curling maintenance robot, and put the curling into the interior of the maintenance robot through the door conveyor. As shown in Fig.3, Label 1 is the enclosure containment of the robot. The containment is designed as similar as the curling, which makes the robot successfully integrated into the curling field. Label 2 is the industrial CT inspection system, which is used to detect the quality overall of the curling. Label 3 is the cabin landing gear. Label 4 is the door cylinder. It powers the switch of the door conveyor.

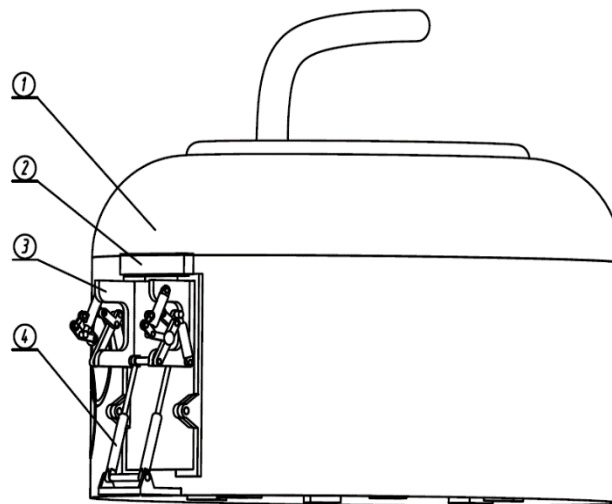


Figure.3. Curling maintenance robot.

3.2.1. Internal of the curling maintenance robot.

The internal of the curling maintenance robot is shown in Fig.4. As show in Fig.4, Label 1 is the pillar, which is used to support the suction cup rotating arm. Label 2 is the scrub arm. It wipes small portion of the ice powder remaining on the bottom. Label 3 is the polishing arm. It polishes the bottom of the curling pot. The bottom is exposed to the luster of the stone. Label 4 is the gas nitrogen cooling manipulator. It performs the cooling process in the maintenance. Label 5 is the baking arm and performs the baking wax process. Label 6 is the rotary table. The gear rotates to switch the position of the curling. Label 7 is the suction cup swivel arm. It could hold the curling, lifted by the screw drive, and can be rotated by 90 degrees. Label 8 is the waxing arm and performs the waxing process. Label 9 is the transfer lift to be used for transporting curling. Label 10 is the door conveyor. It is a part of the shell and could protect the internal structure.

The curling maintenance robot has many internal components and complicated structure. Its working process is ordered by the control system. Firstly, the hatch door is open and the cabin door conveyor receives the curling and transports it into the internal. The top of the hatch is equipped with an industrial CT detector to check the overall of the curling. Then the lifting conveyor is pneumatically close to the door conveyor and receives the curling. The curling is transferred to a suitable position with proper maintenance process. If the lifting conveyor received the curling, the rotary table will be controlled by the stepper motor to rotate 72 degrees. After that the conveyor lift will receive the next curling. If the internal has received five as full filled the positions, the lifting conveyor and the rotating arm would work corporately with each other for the maintenance. And the two parts are operated by the screw drive to lift and transfer the curling.

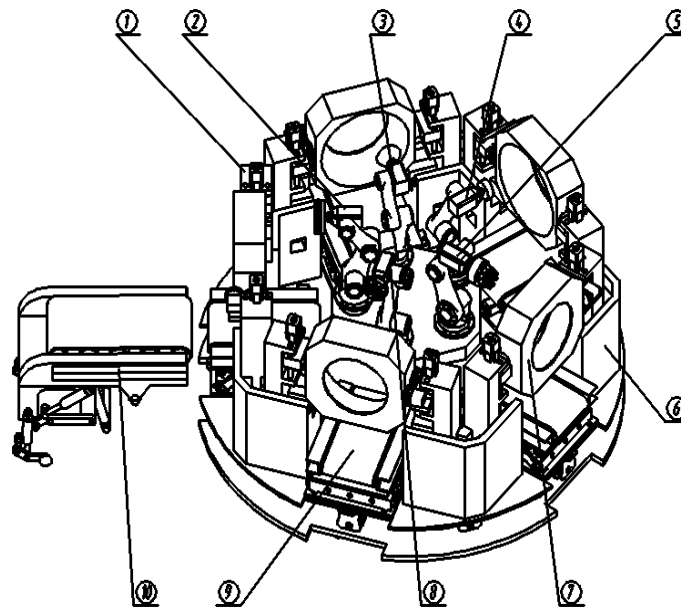


Figure.4. Curling maintenance robot internal structure.

In the later the suction disc revolving arm sucks the pot and moves upward, while the lifting machine drops two to the appropriate positions. The suction disc arm controlled by the stepper motor rotates 90 degrees and exposes the bottom of the curling to the manipulator. At the same time the lifting platform rises and holds the sucker rotating arm. Then the maintenance process on the surface of the curling is started here. The five manipulators will carry out the maintenance according to the accurate procedure. It strictly follows five steps in proper sequence, such as the scrubbing, wax, baking, cooling and polishing. It is shown in Fig.5. It is controlled by the rotary table, which is stepped rotated with 72 degrees to change the curling position.

3.2.2. Maintenance manipulators.

The maintenance manipulators system is one of the most important parts. It involves the maintenance process of the curling and conducts the professional work. As shown in Fig.5, the system consists of five five-axis manipulators. As shown from left to right, they are the scrubbing manipulator, the waxing manipulator, the baking manipulator, the gas nitrogen cooling manipulator and the polishing manipulator. The five manipulators control systems are independent and flexible scrubbed separately. The control strategy of the required professional maintenance processes is fixed and programed with operation command code written into the control program.

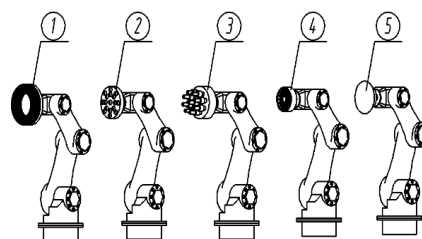


Figure. 5. Maintenance manipulators.

As shown in Fig.5, Label 1 is the scrubbing. It is a soft brush made of special soft cortical material. It is used to wipe the rubbing ring on the bottom of the curling. The aim is to wipe off the snow or impurities stuck on the ring. Label 2 is the wax manipulator, which is used to heat the wax to the proper thick shape with the internal heating tube. Through the spiral transmission, the wax is evenly spread at the bottom, so that it can be attached to the surface of the stone body. It has to be waited for its natural cooling and solidification. Label 3 is used to carry out the baking with alcohol as fuel. The torch emits uniform flames and bakes the bottom. Label 4 is used with gas-nitrogen cooling to cool the curling heated in the previous step. The curling temperature should be kept at a specify temperature that is similar to the ice surface temperature. Label 5 is the polishing. It uses a

professional polishing wheel to polish the curling on a smooth sliding surface for revealing the smoothness and luster of the original.

3.3. Control system.

According to the configuration and operation management, the robot machine is applying the PLC control system to realize system control and automatic operation. The control unit of pneumatic actuator, stepper motor driver is controlled with the special operation part.

3.4. Power supply system.

The maintenance robot is static and powered by the power supply from the field main output. The handling robot is mobile and powered by the rechargeable battery supply, which is set on the robot itself. The power charge interface is set on the maintenance robot and the handling robot with the battery could be charged by the maintenance robot during the off working time.

4. Summary

The curling sports service robot uses mechanical automation instead of professional manual operation to realize the handling and maintenance of curling. The machine replaces the human labor, which could reduce the cost and improve the efficiency. It aims to serve the curling sports automatic with automation robot movement. The robot has the simple mechanical structure, comprehensive function, comprehensive operation and PLC intelligent control system by the reliable operation control of various mechanisms. Each mechanism of the robot is closely coordinated, which is safe and stable with running orderly. At present, there has been few public machine products that serve the curling sports. The curling robot in this paper can effectively serve the curling sports and so on. It could significantly improve the popularity of the curling sports.

5. References

- [1] J.L. Bradley 2009 The Sports Science of Curling: A Practical Review *J. SPORT. SCI. MED.* **8** 495-500
- [2] T. Kawamura, Y. Takegawa and M. Yamamoto 2017 Scientific Approach and Challenges of Curling Study *IEEJ TRANS. ELECTRIC. INF. SYS.* **137** 1137-1140
- [3] T. Kawamura, R. Kamimura, S. Suzuki and K. Iizuka 2015 A Study on the Curling Robot will match with Human Result of One End Game with One Human *IEEE CIG.* **1** 489-495
- [4] B.A. Marmo and J.R. Blackford 2004 Friction in the Sport of Curling *ENG. SPORTS.* **1** 379-385
- [5] M.P. Buckingham, B.A. Marmo and J.R. Blackford 2006 Design and Use of an Instrumented Curling Brush *PROC. INST. MECH. ENG. L-J MATER.* **220** 199-205
- [6] S. Verlag 2006 *Field and Service Robotics* (Berlin: Springer) p 126
- [7] Y.P. Kondratenko 2015 *Robotics Automation and Information Systems: Future Perspectives and Correlation with Culture, Sport and Life Science* (Berlin: Springer) pp 136-138
- [8] C. Tian, G. Min, Q. Wen, J. Zhang and Y. Zhang 2018 P.R.C. Patent 207640084U

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