

# Research on Repair Welding Method for Ground Rail of Stacker in Automated Cigarette Products Warehouse

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**Abstract.** As the most important equipment in the automated storage of cigarette product warehouses, the stacker is a machine used for automated operation of high-rise shelves in cigarette product automated warehouses. In order to ensure the safe operation of the stacker crane, it is necessary to promptly repair the ground rail when the local rail cracks. After completing general welding operations such as surfacing, the track cracks again after three days of operation, and the stacker crane makes a huge noise during operation. In order to quickly eliminate abnormal noise in the stacking function and prevent the track from cracking again in a short period of time, this article provides a repair welding method based on the ground rail of the cigarette finished product automated warehouse stacking machine. This method is a new method aimed at the rapid cracking of the track after general repair welding and the significant abnormal noise caused by the operation of the stacker crane.

**Keywords:** Repair Welding Method, Ground Rail of Stacker, Automated Cigarette Products Warehouse

## 1. Introduction

With the continuous development and improvement of information technology and automation in the tobacco industry, automated warehouses based on the concept of unmanned factories have been applied, innovatively realizing the entry and exit mode of fully automated finished cigarette warehousing. The cigarette finished product automated warehouse is a finished product automated warehouse used by some tobacco industry enterprises, and the most important equipment in the warehouse is the stacker.

The stacker crane is a safety device that can prevent damage to operators, cargo transportation, and machines. It has a fully automatic programmable logic controller that can be used to coordinate motion execution. The controller is connected to the advanced host system (WMS [Warehouse Management System]) and SCS [Stacker Crane Coordination System], responsible for managing and monitoring the current operating status of the machine and responding under assumed conditions. The working schematic diagram of the stacker is shown in Figure 1.

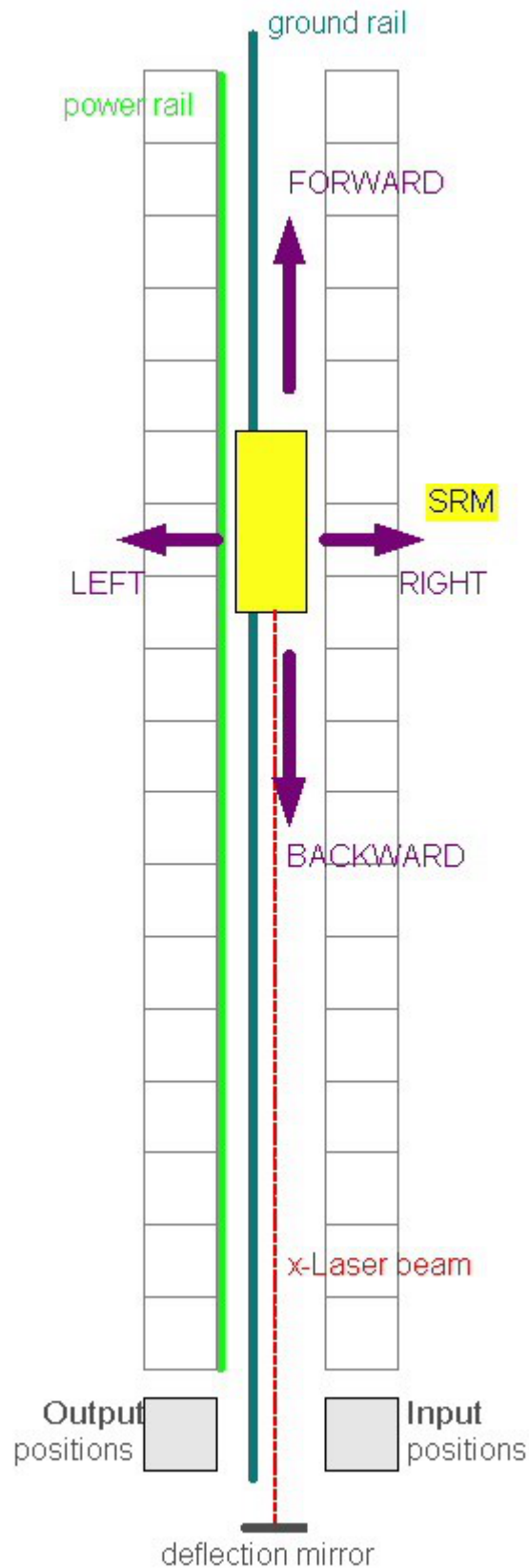


Fig 1. Schematic diagram of stacker crane operation

The stacker crane in this article is a mechanical device that moves along the X (longitudinal) and Y (vertical) axes. It is a telescopic fork used to pick up and transport cigarette trays, also known as the Z-axis. The schematic diagram of the stacker and shelf is shown in Figure 2.

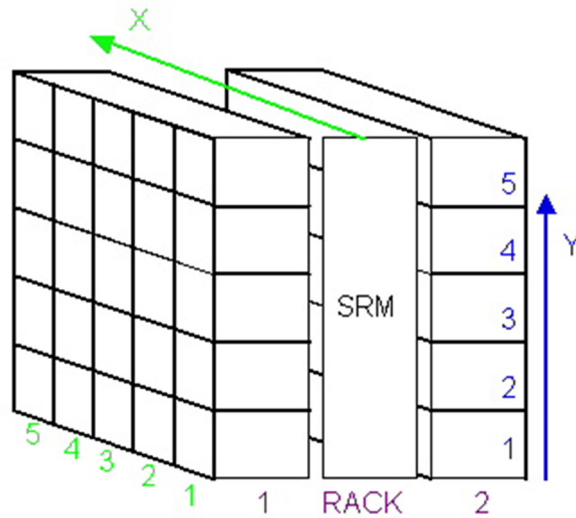


Fig 2. Stacker (SRM) and rack Schematic Diagram

The track on which the stacker operates is used to carry the weight of the stacker and its load ( $\leq 20$  tons), and this track is the ground track. The ground rail is a 15 meters long and 139 mm high I-shaped steel rail made of Q235 carbon structural steel, welded from four sections of steel rails.

After a few years of operation of the stacker crane, there may be cracks at the welding points of each section of the ground rail. Some welding points do not have cracks visually, but after DPT-5 flaw detection, internal injuries are shown. As shown in Figure 3.

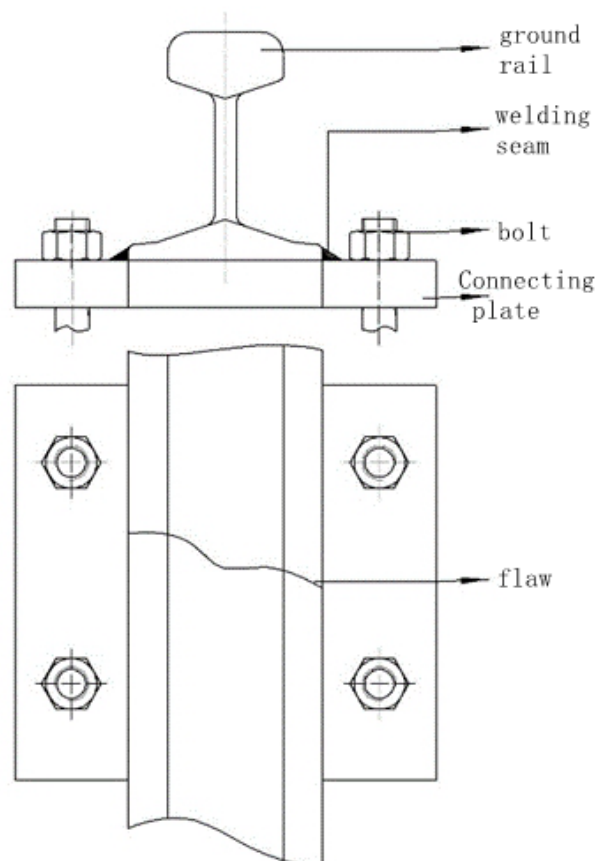


Fig 3. Schematic diagram of ground rail and ground rail cracks

In order to ensure the safe operation of the stacker crane, it is necessary to repair the ground rails in a timely manner. After completing general welding operations such as surfacing, the track cracks again after three days of operation, and the stacker crane makes a huge noise during operation.

## 2. Research contents

In response to the aforementioned problems in existing welding technologies, this article specifically relates to a repair welding method based on the ground rail of the cigarette product automated warehouse stacker. This method is a new method aimed at the rapid cracking of the track after general repair welding and the significant abnormal noise caused by the operation of the stacker crane.

The new method in this article mainly consists of ten key steps:

The ten steps form a whole, and the order cannot be reversed. The relevant temperature control standards have been obtained through extensive experiments, and the temperature control cannot be changed.

Step 1: Use penetration testing method to comprehensively detect the location and quantity of cracks. The items used in the penetration testing method are DPT-5 cleaning agent, penetrant, and developer.

The specific usage method of penetration testing method is:

- Clean the dirt (floating rust, grease, etc.) on the surface of the stacker track with a cleaning agent and open the penetration channel.

- After evenly spraying the cleaned surface of the stacker crane track with a penetrant, penetrate for 9-12 minutes.

- Wipe the penetrant on the surface of the stacker track with a cleaning agent.

- After thoroughly shaking the imaging agent, spray evenly at a distance of 200mm-250mm from the ground rail of the stacker crane.

- After spraying imaging agent on the ground rail of the stacker, defects can be observed after 3 minutes.

- After inspection, wipe and remove the developer with a cleaning agent.

Step 2: Use an open polishing method to remove all cracks. And use penetration testing until complete removal.

Step 3: Use the "heating stress reduction zone method" to uniformly heat the stress reduction zone.

The heating stress reduction zone method described is a process method that selects one or several parts on the track, except for the welding repair area, for appropriate heating before, during, or after welding, so that this part and the welding repair area undergo the same elongation and contraction during welding, in order to reduce the welding stress of the joint. The selected heating area is called the heating stress reduction zone. The essence of the heating stress reduction zone method is to reduce the compressive plastic deformation caused by the obstruction of heating expansion in the weld seam and its vicinity by utilizing the properties of metal thermal expansion and contraction based on the law of stress generation in welding, thereby achieving the goal of reducing welding tensile stress and preventing cracks.

The principle for selecting the heating stress reduction zone should follow the following principles:

- (1) The heating stress reduction zone must be selected to prevent the expansion and contraction of the welding repair area. When the area is heated or cooled, there is a possibility of expansion and contraction in the weld seam. Heating the area before welding can expand the weld seam, while heating the area after welding can cause it to contract together with the weld seam.

- (2) The main deformation direction of the heating stress reduction zone must be consistent with the opening and closing direction of the welding seam, and the optimal position of the stress reduction

zone is to enable the welding seam to achieve appropriate lateral opening displacement. In track repair welding, if heated at a certain location, the crack can expand to a certain gap, indicating that heating this area can make the weld freely expand and contract.

(3) The heating stress reduction zone should be selected in areas with low restraint, high strength, and limited connection with other parts. In track welding, stress reduction zones should be selected as much as possible: the edges of the I-shaped ground rail (such as edges, corners, and edges) are less restrained and prone to deformation, while the strengthening ribs, bosses, and other parts have higher strength and are not easy to crack.

(4) The deformation of the heating stress reducing zone has a relatively small impact on other parts, and will not crack other parts due to the expansion and contraction of the stress reducing zone.

(5) The heating stress reduction zone generally selects the area that hinders weld shrinkage along or parallel to the crack direction.

Select J427 welding rod. Dry and keep warm to 200-250 °C using a drying and insulation box, and use it as needed.

According to the material of the ground rail of the stacker crane, the minimum tensile strength value of the welded seam fusion metal should not be less than  $42 (\times 10)$  That is 420N/square millimeter, and low hydrogen sodium type (coated) low-carbon structural steel welding rod is selected, which belongs to alkaline welding rod. Therefore, J427 welding rod is selected and DC reverse polarity welding is used.

J427 welding rod is mainly used for welding pressure loads or low carbon steel thick plate structures and low alloy steel structures, such as machinery, shipbuilding, bridges, pressure vessels, etc. It is suitable for carrying required ground rail welding.

Step 4: Heat the ground rail to be welded and measure the temperature of the ground rail in a timely manner, maintaining the temperature between 200 and 250 °C.

Step 5: Welding. When welding, the sequence should be symmetrical to minimize the adverse effects of restraint stress.

After each layer of welding is completed, it must be cleaned before proceeding to the next layer of welding.

After covering the surface, the excess height must be 1-3mm higher than the base material and there must be no obvious defects.

If necessary, reinforcement treatment can be carried out. The reinforcement treatment mentioned refers to the method of increasing the effective area of the weld seam by repairing the weld seam in welding engineering, so that the weld seam with insufficient strength can achieve equivalent strength to the base material.

Step 6: Use a special tool such as a polishing machine to polish the excess height until it is flush with the base material.

Step 7: After welding, slow cooling and stress relief treatment should be carried out, and the temperature should be kept at 200-250 °C for 1-2 hours.

Step 8: After completely cooling for 3-4 hours, perform another penetration test to check for cracks.

Step 9: Test run the equipment, and then use the penetration method again after the equipment has been running for a period of time.

Step 10: Use a rail grinder to further level the track and eliminate any abnormal noise caused by the stacker running on the track.

The rail grinding machine described in this article is a rail grinding machine, with specific parameters as follows:

1. Motor: power 1.5kw, speed 3000r/min
2. Overall size: 1000 × five hundred and thirty-five × 500 (mm)
3. Grinding wheel size:  $\Phi$  two hundred ×  $\Phi$  thirty-two × 25 (mm)
4. Vertical stroke: 0-150mm, lateral stroke: 0-50mm
5. Overall weight:  $\leq$  42kg

The rail grinding machine described in this article is powered by an electric motor and uses an A-type triangular belt (with an inner circumference of 889mm) to drive the grinding wheel through the transmission system for rail grinding operations. The machine is mainly composed of main components such as a frame, transmission system, grinding wheel, arc grinding roller, and running device. The frame is welded with thin steel plate angle steel. The grinding wheel relies on screw and nut spiral feed, and the running device is connected to the frame with bolts. The rim of the running wheel is high, and it can also be pushed on the ground after getting off the track. The appearance is shown in the figure.



Fig 4. Schematic diagram of rail grinding machine operation

Insulated wheels (or rollers) can be used for grinding the top and side of the steel rail; The roller used for grinding the top arc of the rail can be used to repair the rounded corners of the rail.

### 3. Conclusion

The new method first comprehensively detects the location and quantity of cracks through penetration testing. Then, an open polishing method is used to remove all cracks and penetrant testing is performed until complete removal. Next, use the "heating stress reduction zone method" to uniformly heat the stress reduction zone. Simultaneously heat the ground rail that needs to be welded and measure the temperature of the ground rail in a timely manner, maintaining the temperature between 200 and 250 °C. The next step is welding. After welding, special tools such as a polishing machine are used to polish the excess height until it is flush with the base metal. After welding, slow cooling and stress relief treatment should also be carried out, and the temperature should be kept at 200-250 °C for 1-2 hours. After complete cooling for 3-4 hours, perform another penetration test to check for cracks.

Finally, there is a trial operation of the equipment. After the equipment has been running for a period of time, the penetration method is used again for inspection, and then the track is further leveled with a rail grinder to eliminate any abnormal noise caused by the stacker running on the track.

After these ten steps, the ground rail repair welding operation of the stacker crane met the technical requirements, and the abnormal noise of the stacker crane disappeared. After three months of operation, all operating indicators were normal and there was no abnormal noise from the stacker crane. The new method of repair welding proposed in this article effectively solves the problems of rapid cracking and huge abnormal noise during the operation of the stacker crane after rail repair welding.

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