

## Research on the Status Quo of Steel Strip Rust Removal Technology

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**Abstract:** Steel is an indispensable metal material for modern industrial development. It has a huge amount of use and it involves a wide range of industries. However, the easily oxidized and easily acid-base corrosion chemical properties of steel lead to rust and corrosion during its production and storage. Therefore, rust removal is a key link in the steel industry. This article studies the process of strip oxidation and rust removal, introduces the composition of oxide layers, summarizes several mature rust removal processes, introduces a new type of rust removal process, and compares the advantages, disadvantages, and applicability of different processes and their development status. Summarize the law of development of steel rust removal and rust, and look into the future.

**Keyword-** Corrosion; Rust removal process; Oxide Layer; Law of rust removal

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Date of Submission: 24-05-2018

Date of acceptance: 08-06-2018

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### I. Introduction

Steel is widely used in ships, automobiles, bridges, buildings, and pressure vessels. Currently, major equipment manufacturers often need long-term stacking of steel after they are put into storage. At present, there are no strict rust prevention measures, resulting in the appearance of different steel surfaces. To a certain degree of corrosion, if it is to be used again, it must be de-rusted [1], as shown in Figure 1.

Iron and steel as the most common in the engineering, the most widely used, the largest amount of metal material is known to people. However, the chemical properties of iron and steel are easy to be oxidized and easily corroded by acid and alkali. The economic loss caused by metal corrosion and corrosion in the developed countries of the world is about 2% ~ 4% of its gross national product. By metal corrosion and corrosion every year, the annual steel 20% ~ 10% output is wasted and the loss value is more than \$70 billion by metal corrosion and corrosion in the world. Hot rolling steel strip has good toughness, easy processing and good welding and so on. It is widely used in ships, automobiles, bridges, buildings and pressure vessels and so on.



Fig1. Rusty steel

### II. Corrosion process and Oxide Layer

The main cause of steel corrosion at present:

- (1) Hot rolled steel in the rolling, drawing and other processing processes, the surface of the formation of a prone to corrosion scale oxide, resulting in the steel in the transportation and storage process of corrosion;
- (2) The naked hand touches the surface of the steel during the production process, resulting in corrosion due to the salt in the hand sweat;
- (3) In the atmospheric environment, moisture, smoke dust, and harmful gases in the atmosphere come into contact with the steel surface, causing corrosion[2].

Different structures were used to form scales with different structures on the surface of SS400 hot-rolled strip. Observations using electron microscopy revealed that although the oxide scales formed were different, they all contained  $\text{Fe}_3\text{O}_4$ ,  $\text{Fe}_2\text{O}_3$ , and Fe. The oxide scales of the hot strip produced by different cooling methods are mainly composed of  $\text{Fe}_3\text{O}_4$  and  $\text{Fe}_2\text{O}_3$  and Fe. As the cooling rate decreases, the content of  $\text{Fe}_3\text{O}_4$  in the scale increases, but no FeO is found; when the cooling rate is fast enough, part of FeO will be decomposed into  $\text{Fe}_3\text{O}_4+\text{Fe}$ , and part of FeO will be stored within a few microns of the mother's body, which will have rust-proof effect. Therefore, the scale of the hot strip produced by the furnace cooling is relatively thick and uniform, and there is a delamination phenomenon. The thin outer layer a is  $\text{Fe}_2\text{O}_3$ , and the thicker inner layer b is  $\text{Fe}_3\text{O}_4+\text{Fe}$ . The purpose of descaling is not only to remove the outer layer of  $\text{Fe}_2\text{O}_3$ , but also to remove the inner layer of  $\text{Fe}_3\text{O}_4$  [3], as shown in Figure 2.

The scale is composed of  $\text{Fe}_2\text{O}_3$  exposed on a relatively thin surface,  $\text{Fe}_3\text{O}_4+\text{Fe}$  on the inner layer, and adheres to the substrate. Cracks and partially fractured oxide scales have little protective effect on the substrate, which also makes the hot strip steel susceptible to corrosion. Therefore, when the hot-rolled strip is used as a material, it is necessary to remove the oxide scale and the rusted part of the surface. The thickness of the scale is different depending on the method and time of storage. The thickness of the oxide layer formed on the surface of the hot rolled strip is  $7.5\ \mu\text{m}$  to  $15\ \mu\text{m}$ . Ferrous oxide FeO within a few micrometers of the mother's body can be retained as a rust preventive.

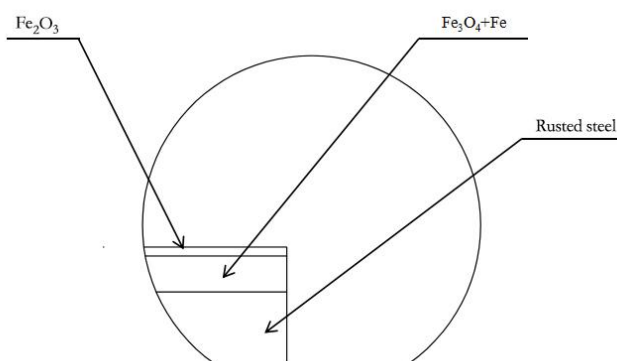


Fig2.Schematic diagram of oxide scale

### III. Several kinds of steel band rust removal processes

The traditional rust removal methods are divided into chemical rust removal and mechanical rust removal. Among them, chemical rust removal is mainly based on pickling and rust removal. Under the premise of increasingly important environmental protection, pickling and rust removal will be gradually eliminated; Pellet, shot blasting, and laser are the main factors. Since shot peening and shot blasting cannot be performed on a continuous production line, lasers are expensive and expensive.

At present, a new rust removal method, which is environmentally friendly, low cost and able to work continuously on the assembly line, has been proposed, which is called curved loose shell rust removal method.

#### 3.1 Pickling Rust removal

The principle of pickling and removing rust is to use the chemical properties of oxide layer and substrate. The  $\text{Fe}_2\text{O}_3$  in the thinner outer layer and  $\text{Fe}_3\text{O}_4$  in the inner layer are more difficult to dissolve in acid solution. But the Fe and substrate contained in the inner layer react with the acid itself, producing iron salts and hydrogen dissolved in acid solutions. There are cracks and pores on the surface of the oxide layer. These cracks and pores become the earliest reaction sites, meaning that the pickling process begins with the inner layer and the substrate. Hydrogen is produced during pickling and rust removal, and hydrogen here has two effects. The first effect is to enlarge the cracks and pores, because hydrogen atoms combine to form hydrogen molecules. The second effect is to reduce high iron salts and their oxides, producing low - and low-price oxides that dissolve in acid solutions. Gradually, the junction between the substrate and the oxide layer begins to loosen until the oxide layer is finally separated from the substrate surface, as shown in Figure 3.

Due to the huge environmental pollution caused by pickling and rust removal, it was gradually eliminated[4].



**Fig3.Pickling Rust removal**

### **3.2 Shot peeningRust removal**

Shot blasting is the use of compressed air to expel quartz sand to clean parts surface. Through the medium of against rust substrate surface, using the impact of the media and the matrix of friction remove the matrix of the oxide layer and other impurities. Obtaining a certain degree of roughness, the matrix has a metallic color[5], as shown in Fig. 4.



**Fig4.Shot peeningRust removal**

Hardened steel particles is the selection of injection medium of Shot peening , which the hardness is about HRC49.The shapes of the particles are columnar, pill and block, in which the diameter of the pellet is 0.6mm ~ 3.5mm, and the size of the other shapes is similar to that of the size of the pellet.For the general steel parts, compressed air pressure of 0.4 ~ 0.8MPa is appropriate. For alloy and light metal alloy 0.1 ~ 0.3MPa is appropriate.

The effective improvement of mechanical properties of the workpiece is a significant additional advantage of the anti-rust effect. Shot blasting can produce a lot of plastic deformation on the surface of the workpiece, and high density dislocation and slip zone are introduced without changing the overall mechanical properties of the matrix and anti-intercrystalline corrosion sensitivity.

The disadvantages of shot blasting are low efficiency, low recovery rate, open working environment, high noise and dust, which are harmful to workers' health.

### **3.3 Shot blasting Rust removal**

Shot blasting is a surface cleaning method [6], as shown in Figure5, using a high-speed rotating impeller to cast small steel pellets or small iron pellets to high-speed impact on the surface of the part to deform the surface of the part.



**Fig5. Shot blasting Rust removal**

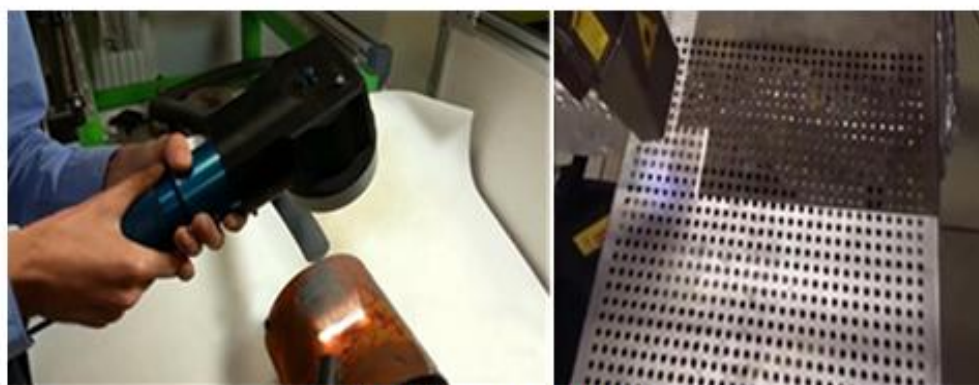
Blasting technology is the use of more advanced derusting technology in industry at present, by which machine parts can be surface cleaning, removal of burr, polishing and strengthening. The principle of blasting derusting process and shot peening cleaning process are the same. Through shot blasting equipment in high-speed rotation of the impeller, the shot is the abrasive to a certain speed and a certain angle along the curved track of workpiece of collision and impact to make the oxide layer occurred off.

Shot blasting has the following advantages, shot blasting rust has a complete production line supporting the use of a high degree of automation, closed studio to reduce dust on the worker's body damage. The abrasive loss of pelleting is small and the abrasive can be recycled. In terms of energy consumption, the process of shot blasting and rust removal is smaller than that of shot blasting. Uniform surface roughness can be obtained. The most important thing is that the efficiency of shot blasting is higher than that of shot blasting.

The disadvantage is that the blasting, spray nozzle in the angle of 70 degrees to 90 degrees, in some surface rust will be dead. Unlike the shot blasting process will be more thorough removal of the oxide layer. Like shot peening process, shot blasting process need to paint in steel, or steel will expose in the air. Blasting process, influenced by many factors, it is not convenient to adjust.

### 3.4 Laser rust removal

Laser cleaning is a new type of technology that uses short-pulse lasers to quickly clean the surface of materials. It has the advantages of no mechanical contact, no substrate damage, selective cleaning, and environmental protection [7], as shown in Figure 6. However, lasers are expensive and are not suitable for large-scale serial processing on the assembly line.



**Fig6. Laser rust removal**

The characteristics of comprehensive modern rust removal methods are compared and the results are shown in Table 1.

**Table no1:** Comparison of several methods of derusting.

Rust removal method	advantage	Shortcomings	Processing degree	Note
Chemical rust removal	Fast speed	Environmental pollution, rough surface, general effect, not suitable for local operations	good	Phase out
Shot peening	Oxidation can be completely removed, complex shapes can also be processed, can change the mechanical properties of the workpiece	Large dust, large noise, unable to clear the film of the substrate	excellent	Used for complex shapes, suitable for manual rust removal
Shot blasting	Oxidation can be completely removed, complex shapes can also be processed, high efficiency, abrasive recycling, high surface cleanliness. Closed operation, small dust pollution	Thin plate or complex shaped product is not suitable; limited by site	excellent	Used for casting surface cleaning or surface hardening
Laser rust removal	No mechanical contact, no substrate damage, green	Costly and technically demanding	excellent	

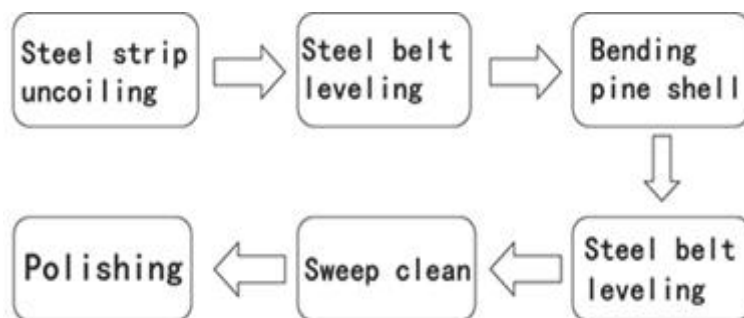
### 3.5 Curved pine shell rust removal

Curved pine shell rust removal process is a purely mechanical rust removal method. The principle is to apply pressure on the steel strip to bend and deform it without affecting the quality of the base metal, thereby weakening the bond strength between the oxide layer and the base metal. After several times of bending and deformation, the oxide layer is separated from the base metal, and the purpose of rust removal is finally achieved. The steel strip is then flattened by a leveling machine, and finally the surface impurities of the treated steel strip are removed by stucco grinding.

The advantages of this process are low cost, environmental protection, and continuous processing in the assembly line. The difficulty lies in how to control the pressure, that is, the amount of bending deformation, so that the oxide layer and the substrate can be completely loosened and separated.

The derusting process of curved loose shell will not cause pollution to the environment. At present, there is a lack of theoretical research in this field at home and abroad, which requires a lot of effective theoretical support. At present, the research on the rust removal process of curved loose shell is still in its infancy. This paper thinks that this process has a great development prospect.

This process can be based on different degrees of steel plate and its degree of corrosion to varying degrees of bending deformation, to achieve the purpose of rust removal, the work process and equipment schematic are shown in Figure 7 and Figure 8 below, the steel belt sucked by the inhalation device leveling, followed by A plurality of curved pine shell devices undergo multiple bending deformations to loosen the oxide layer, and then enter the leveling machine again for leveling. Finally, the rust layer is removed by brushing and polishing on the grinding machine, and cleaning is performed to remove impurities.



**Fig7.**Workflow diagram

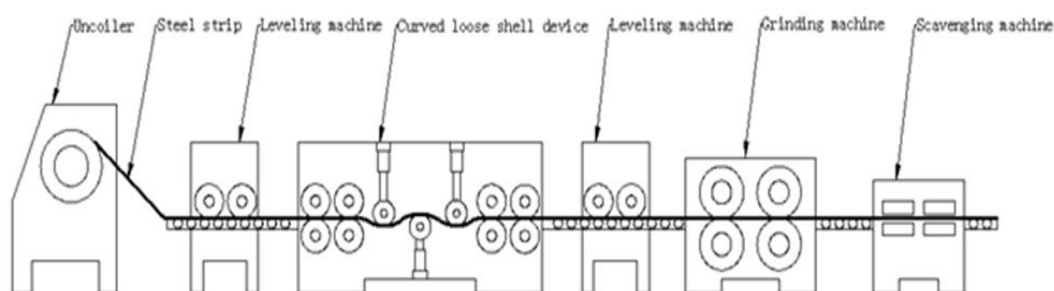


Fig8.Process and equipment schematic

First.Uncoil. The rolled hot rolled strip is opened through a standard uncoiler. As an auxiliary machine, the function of the uncoiling machine is to open, level and correct the steel coil. The hot rolled strip steel plate and uneven plate of the leveling line can be formed into the production line of uncoiling, leveling, cutting and other strip steel products according to the relevant configuration.

Second. Leveling.The most common flatness defects in coils are vertical roll area and horizontal warping. Longitudinal curls are caused by plastic deformation during winding. Transverse warping is caused by uneven cooling or longitudinal cutting of rolled material within the entire width of the rolled material (residual stress).After the hot rolled strip rolled, the surface of the product is still uneven and there is residual stress. The leveling process is needed to provide the basis for subsequent processing.

Third.Bending pine shell, the most important step.According to the theory of bending loose shell, the process of bending loose shell with two sides is carried out by using the difference of bending performance between the base material of steel strip and the oxide layer. The process USES a self - designed bending loose shell device to completely remove or relax the oxide layer on the outside of the bend.as shown in Figure 9.

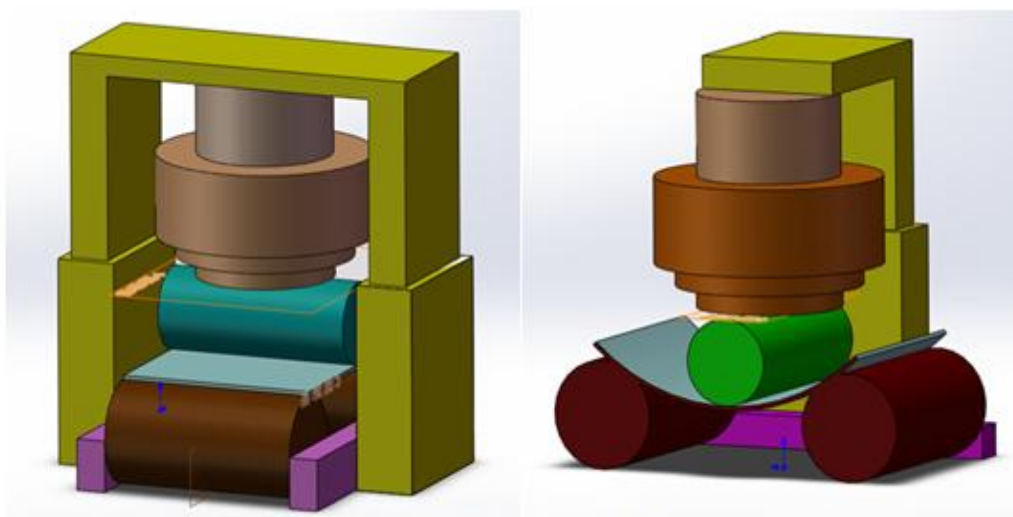


Fig9.bending loose shell device

Fourth.Leveling.Straighten bent steel bands. Fifth. Sweep clean. The effect of the cleaning device is to clean the impurities on the surface of the steel belt and the powders on the rust oxidation layer, so as to enhance the quality of components and enhance the value of products. Sixth, Polishing.Reduce the surface roughness of workpiece by mechanical, chemical or electrochemical action.

#### IV. Conclusion

The future rust removal process should be based on continuous renewal and development of mechanical rust removal. Research on this new type of curved pine rust removal process is still in its infancy, and its practicality has great development prospects. There are many other things that we need to study, such as the microscopic binding force between the oxide layer and the substrate, and the mathematical relationship between the degree of bending deformation and the breaking bond strength, the structural design of the device,

and so on. It is believed that in the course of in-depth research, mechanical rust removal technology will continue to be powerful.

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Xu Jianxin "Research on the Status Quo of Steel Strip Rust Removal Technology." IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) , vol. 15, no. 3, 2018, pp. 35-41