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Development of a New Device for Metallurgical Waste Treatment and Recycling

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Abstract

China has the largest amount of raw materials, such as steel, in production, consummation, and exportation. The total quantity of raw steel can be as huge as billion of tons every year, which account for up to more than half of the world. Metallurgical waste is solid waste produced in the process of raw materials, which has become one of the largest and most dangerous pollution in industry, as the material is extremely difficult to dispose of because of its diversity. These residues are discharged into the environment during the production process. In this study, a newly developed device for metallurgical waste treatment and recycling was proposed and designed. This has expanded our understanding towards the utilization of harmful solid industrial waste. The findings will have potential benefits in developing efficient and sustainable processes for industries to minimize chemical usage and environmental damage.

Keywords

Solid Waste; Environmental Protection; Waste Recycling.

1. Introduction

Metallurgical slag is a type of solid waste produced in the process of metallurgical industry [1-5], as shown in Fig. 1. It mainly refers to the blast furnace slag produced in the iron making furnace. The steel slag in the metallurgical process is the solid waste discharged in the process of steel-making, including converter slag, electric furnace slag, and so on. The slag discharge process in steel-making process not only affects the development of steel-making technology [6-10], but also closely related to the comprehensive utilization of steel slag. At present, there are four methods for slag removal processes in steel-making technology, which are presented as follow.

Figure 1. Accumulation of scrap steel (a) and metallurgical waste (b) from the production of raw materials in China

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a) Cold discarding method: steel slag is poured into slag tank and transported to slag yard to form slag hill after slow cooling;

b) Hot splashing crushed stone process: the liquid steel slag in slag tank is poured on slag bed (or slag pit) by crane in layers, and water is sprayed at the same time to make it cool and break, and then transported to slag yard;

c) Water quenching process of steel slag: the discharged high-temperature liquid slag is cut and broken by pressure water, and it is cracked due to rapid cooling and shrinkage when meeting water, and it is granulated in water curtain. The concrete methods include plate sprinkling water cooling method, water flushing method in front of furnace and tilting tank pool method;

d) Air quenching method: its main advantage is that it can recover 41% of the heat contained in the high temperature slag, about 2100-2200MJ/T, avoid the problem of slag explosion in water, and improve the operating environment.

Metallurgical waste can be wind hardened into a hard sphere less than 3mm, and can be used as fine aggregate of mortar directly. So far, many ways of comprehensive utilization of steel slag have been developed, including metallurgy, construction materials, agricultural utilization and back-filling. The tons of metallurgical waste have become a serious problem in China, and the comprehensive utilization [11-15] has great benefit considering environmental protection and economic development.

2. Design procedure

The metallurgical waste treatment and recovery equipment, including the following components, was developed, i.e., slag lifting part, slag screening part, slag conveying, steel slag adsorption, steel slag collection and slag collection.

The waste slag lifting part includes a lifting driving wheel, a lifting passive wheel and a lifting belt. And the lifting belt would cross the lifting driving wheel and the lifting passive wheel, and the lifting belt is arranged with multiple transverse baffles, and the lifting belt is arranged in an oblique direction.

The waste residue screening part comprises of a vibrating screen, a vibrating motor, a support spring and a support seat. The vibrating screen is obliquely arranged, and support seats are arranged under the four corners of the vibrating screen, and support springs are arranged on each support seat. One end of the support spring is fixedly pressed on the corresponding support seat, and the other end of the support spring is fixedly pressed on the corresponding position at the bottom of the vibrating screen.

The discharge port of the lifting belt is upward and is located above the middle part of the vibrating screen.

3. Results

In recent years, with the rapid development of steel industry in China, the demand of raw steel is increasing, and the issues of harmless disposal and resource utilization of these materials become important.

In view of the above existing shortcomings, the present work provides a metallurgical waste slag treatment and recovery device with high recovery rate of steel slag in the metallurgical waste slag in the slag yard and faster recovery speed. In order to solve the above technical problem, the development adopts the following technical scheme as below.

This work skillfully combines the slag lifting mechanism, slag screening mechanism, slag conveying mechanism and steel slag adsorption mechanism. The steel slag in the waste slag can be continuously transported by the conveyor belt, and the steel slag in the waste slag can be continuously adsorbed by the electromagnetic disk above the conveyor belt.

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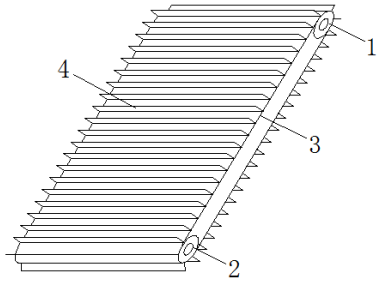

Figure 2. Structure diagram of the waste slag lifting part

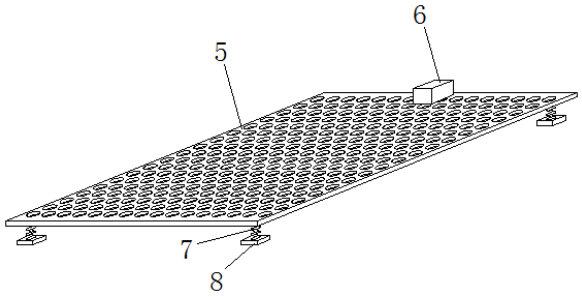

Figure 3. Structure diagram of the waste residue screening

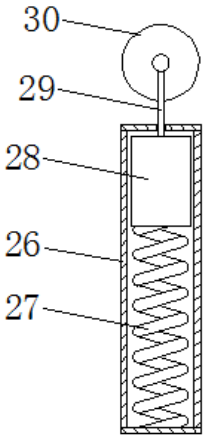

Figure 4. Structure diagram of the pressing guide part and supporting guide part

The recovery speed of the steel slag is faster, and the conveyor belt can be high and low. The waste slag can be turned over by itself due to the inclination in the conveying process. Once the steel slag at the bottom of the waste slag enters the upper part in the conveying process, it will be adsorbed by the electromagnetic disk, this greatly improves the recovery rate of steel slag.

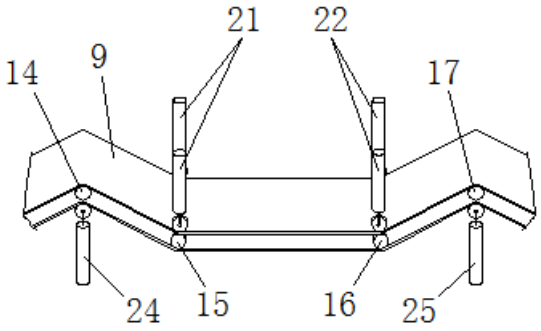

Figure 5. Structure diagram of the local structure of waste residue conveying mechanism

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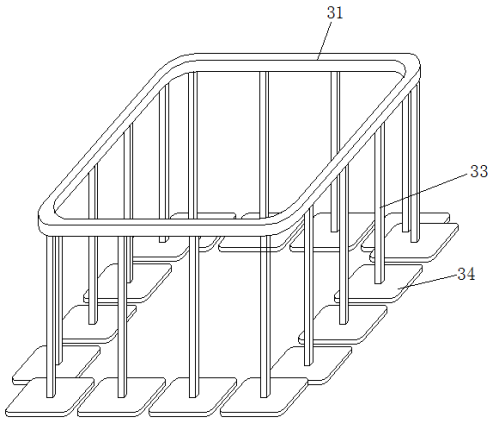

Figure 6. Structure diagram of the steel slag adsorption part

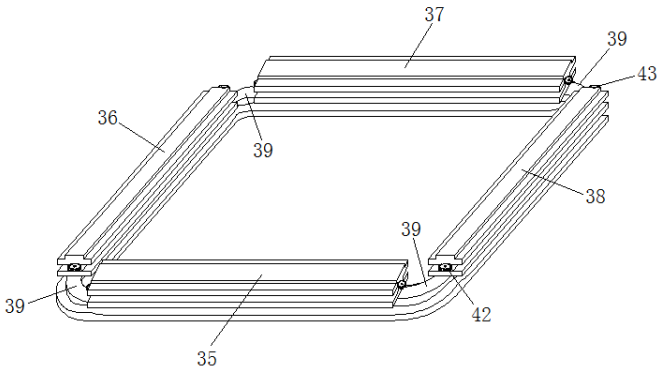

Figure 7. Structure diagram of the circular track

In the existing technology, the metallurgical slag in the slag field is often screened, the useful steel slag in the metallurgical slag is screened out, and the steel slag and slag are separated. The usual method is to use electromagnetic disk to absorb the steel slag, and then drive the electromagnetic disk to gradually absorb the steel slag in the slag field below by the electromagnetic bridge crane, and then transfer the adsorbed steel slag to the vehicle. The electromagnetic disk adsorption method of this type of electromagnetic bridge crane has low efficiency, and can only absorb the steel slag on the surface of the slag. The slag adsorbed in the slag field is less than 70%, which greatly reduces the recovery rate of the steel slag.

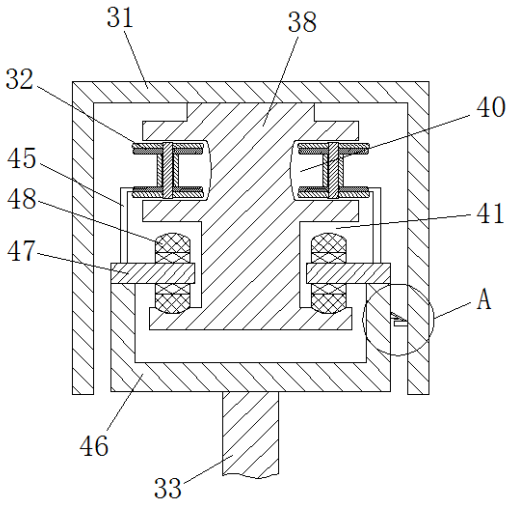

Figure 8. Structure diagram of the cross section of n-shell, right rail and boom fit on right rail

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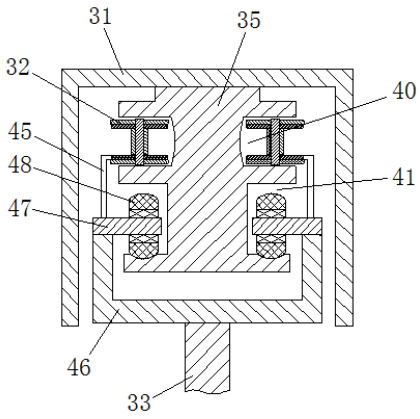

Figure 9. Structure diagram of the Cross section of n-shell, front rail and boom fit on front rail

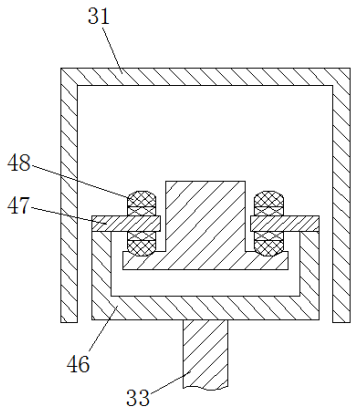

Figure 10. Structure diagram of the cross section of transition track and suspender

When the metallurgical waste residue treatment and recovery equipment is used, the waste residue in the slag yard is lifted to the top of the waste residue screening mechanism through the waste residue lifting mechanism, and the especially large solid substance rolls down to the solid matter collection hopper 58 along the inclined vibrating screen 5, and the remaining waste residue falls into the conveyor belt 9 through the sieve holes on the vibrating screen 5, and the remaining waste residue moves with the conveyor belt 9.

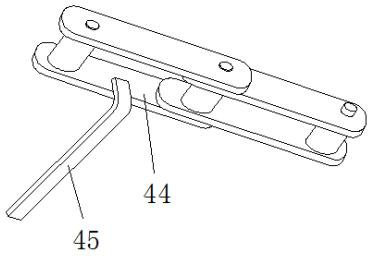

Figure 11. Structure diagram of the push plate arranged on the outer chain plate

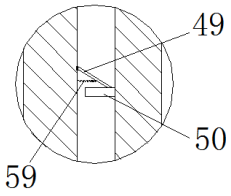

Figure 12. The enlarged structure for figure 8

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The electromagnetic disk 34 on the left track 36 on the first adsorption mechanism continuously adsorbs the steel slag in the waste slag in rotation. When the steel slag passes through the conveyor belt between the guide pulley Ⅲ 13 and the guide pulley Ⅳ 14, and between the guide pulley Ⅳ 14 and the guide pulley Ⅴ 15, it can turn over by itself due to the inclination. Once the steel slag at the bottom of the waste slag enters the upper part during the conveying process, the steel slag will be transported to the upper part.

It will be continuously adsorbed by the electromagnetic disk 34 on the right track 38 of the first adsorption mechanism in turn, and the remaining waste slag will fall into the conveyor belt 9 on the second stage waste slag conveying mechanism from the output end of the conveyor belt 9 on the driven wheel 18, and move on the conveyor belt 9 on the second stage waste slag conveying mechanism.

And the waste slag on the second stage waste slag conveying mechanism will also turn over due to the inclination. The electromagnetic disk 34 on the left track 36 and the right track 38 of the second adsorption mechanism continuously adsorbs by turns. The recovery speed of steel slag is not only faster, but could also greatly improve the recovery rate of steel slag, and the recovery rate of steel slag can reach more than 90%. The over-view of the developed device is shown in Fig. 13.

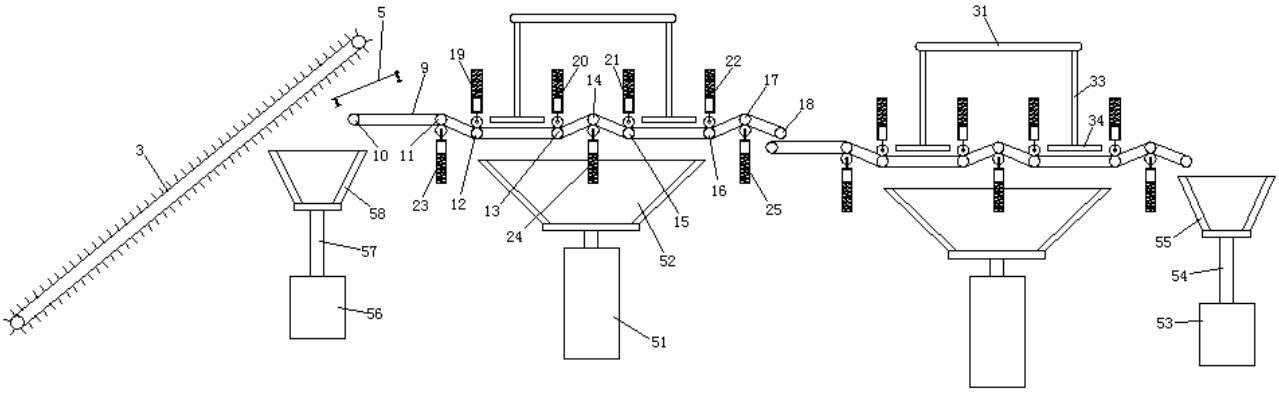

Figure 13. Structure diagram of the developed metallurgical waste residue treatment and recovery equipment

4. Conclusions

A metallurgical waste residue treatment and recovery equipment was developed, which include a waste residue lifting mechanism, a waste residue screening mechanism, a waste residue conveying mechanism, a steel slag adsorption mechanism, a steel slag collection mechanism and a waste residue collection mechanism.

The discharge port of the lifting belt is upward and located above the middle part of the vibrating screen. The first stage waste residue conveying mechanism and the second stage waste residue conveying mechanism are composed of conveying belt, driving wheel, guide wheel, driven wheel, pressing guide mechanism and supporting guide mechanism. The adsorption mechanism is composed of *n*-type shell, annular track, chain, suspender and electromagnetic disk; The circular track is surrounded by front track, left track, rear track and right track. The invention continuously transports the waste slag through the conveyor belt, and alternately adsorbs the steel slag in the waste slag through the upper electromagnetic disk. The recovery speed of the steel slag is faster, and the waste slag can be turned automatically in the conveying process. Once the steel slag at the bottom of the waste slag enters the upper part in the conveying process, it will be adsorbed by the electromagnetic disk, thus greatly improving the recovery rate of the steel slag.

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Acknowledgments

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