Research on Energy-saving and Environmentally Friendly Optimization of Building Sand and Gravel Screening Devices

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Abstract: Sand and gravel are the largest and irreplaceable materials in China's infrastructure construction. Sand and gravel aggregates are the main components of concrete. To ensure the quality of concrete, a large amount of sand and gravel needs to be screened on-site using screening devices. However, existing screening devices cannot change different screening modes according to the quantities of materials, leading to high energy consumption. Additionally, a significant amount of smoke and dust is generated at the feed inlet during screening, which affects the construction environment. This paper aims to design an environmentally friendly and energy-saving sand and gravel screening device to address these issues.

Keywords: Building Sand and Gravel; Screening Device; Energy-Saving; Environmental Protection

1. Introduction

Sand, gravel, and crushed rock, collectively referred to as construction aggregates, are the most extracted solid materials in the world, surpassing fossil fuels and biomass [1]. Sand and gravel are essential and irreplaceable raw materials in China's infrastructure construction. According to statistics, China's annual consumption of sand and gravel is about 20 billion tons, equivalent to an average of 13.9 tons per person per year. the demand and consumption of sand and gravel resources rank second only to water resources, making them the largest mineral raw material and bulk commodity globally [2]. Sand and gravel aggregates are the main components of concrete, playing a crucial role in filling and providing a framework for the production and application of concrete. the quality of sand and gravel aggregates directly influences the performance of concrete, including strength, deformation, permeability, frost resistance, and durability [3].

Upon delivery to construction sites, a large amount of sand and gravel needs to be screened to ensure concrete quality. However, existing screening devices cannot adapt different screening modes according to the quantity of materials, resulting in high energy consumption. Moreover, the screening process generates a significant amount of smoke and dust at the feed inlet, which negatively impacts the construction environment. Therefore, it is necessary to design an environmentally friendly and energy-saving sand and gravel screening device to address these issues.

2. Literature Review

Li et al. [4] designed a sand and gravel aggregate screening system for the Jinhe Power Station project. They proposed the process flow, main equipment, quality control, and environmental protection measures for the sand and gravel screening system. Lei [5] conducted an analysis and research on improving the efficiency of multi-stage screening for construction sand and gravel. They proposed two efficient multi-stage screening device designs, which increased screening efficiency and included a circulation purification system to avoid dust generation. Qu [6] designed an environmentally friendly and intelligent three-dimensional sand and gravel storage system for concrete mixing station equipment. They put forward new ideas and approaches for large-scale environmentally friendly storage of sand and gravel aggregates, suggesting a supporting dust reduction system to meet the low-carbon demand for "low energy consumption, low pollution, and low emissions, " which is of significant importance for low-carbon environmental protection. Wang [7] designed a water source protection sand and gravel processing system and proposed environmental protection measures. They optimized the design of the production process and equipment selection, detailed the wastewater treatment process, dust sealing measures, dust collector measures, and spray dust reduction measures, as well as solid waste treatment measures, to meet environmental protection requirements. Ye [8] analyzed the operation management and cost control of sand and gravel processing systems. They discussed management strategies from the perspectives of operation management and cost control, promoting targeted improvements in processing and transportation capacities to better meet the sand and gravel demand in construction projects. Zhu [9] conducted a finite element analysis of the dynamic response of the screening building in the sand and gravel processing system. They used the commercial software ANSYS to perform a dynamic time history analysis of the screening building in a certain hydropower station's sand and gravel processing system. the results showed that the vibrating screen did not resonate with the screening building at low frequencies during normal operation, and the horizontal and vertical displacements of the screening building remained within the control standard under the long-term action of the vibrating screen, indicating that the design of the screening building was safe.

In this study, a building environmentally friendly and energy-saving sand and gravel screening device and its usage method were designed. the device includes a base, a screening cylinder, a coarse filter frame, and a cover plate. the screening cylinder is positioned above the base, the coarse filter frame is placed inside the screening cylinder, and the cover plate is located on the left side of the screening cylinder. the building's environmentally friendly and energy-saving sand and gravel screening device and its usage method involve inserting the coarse filter frame into the screening cylinder and securing it with a square sleeve and a rotating rod. A sealing pad is used to block the second movable mouth, achieving the effect of preventing dust. Furthermore, by starting the motor, the rotating rod is driven to rotate, which, in turn, rotates the cam disc. the cam disc's movement, through contact with the arc top block, causes the screening cylinder to move up and down in a reciprocating motion. Simultaneously, the motor-driven rotating rod rotates the coarse filter frame, which, in turn, rotates the screening cylinder, achieving the effect of grading screening.

3. Energy-Saving and Environmentally Friendly Design

3.1 Introduction

The designed building's energy-saving and environmentally-friendly sand and gravel screening device, as shown in Figures 1 and Figures 2, comprises a base 1, screening cylinder 2, coarse filter frame 13, and cover plate 16. Screening cylinder 2 is located above base 1, while the coarse filter frame 13 is positioned inside screening cylinder 2. the inner wall of screening cylinder 2 is fixedly connected to a conical filter cylinder 3. the cover plate 16 is located on the left side of screening cylinder 2. the surface of screening cylinder 2 is rotationally connected to a rotating cylinder 27 via bearing components. An annular slide groove 4 is provided on the left side of the surface of the rotating cylinder 27, and a sliding block 5 is slidingly connected beneath the annular slide groove 4. the top of base 1 is fixedly connected to the first telescopic rod 6, and the top end of the first telescopic rod 6 is fixedly connected to the bottom of the sliding block 5. the right side of the surface of the rotating cylinder 27 is fixedly connected to a convex block disk 7. An arc-shaped top block 8, which cooperates with the convex block disk 7, is fixedly connected to the top right side of base 1. the top of base 1 is also fixedly connected to a second telescopic rod 9, and an electric motor 10 is fixedly installed at the top end of the second telescopic rod 9. the electric motor 10 is a servo motor, and its output shaft is fixedly connected to a rotating rod 11 via a coupling. the surface of the rotating rod 11 is fixedly connected to a U-shaped traction rod 12, and one end of the U-shaped traction rod 12 is fixedly connected to the front of the rotating cylinder 27.

3.2 Optimization Design Proposal

To achieve effective energy-saving and environmental benefits based on the quantities of materials, the right side of the cover plate 16 is fixedly connected to sealing pad 21, which closely adheres to the inner wall of the second movable port 30. the left side of the screening cylinder 2 is provided with the second movable port 30, which cooperates with the sealing pad 21. Cover plate 16 is fixedly connected to square feeding pipe 22 via an opening, and the left side of the coarse filter frame 13 is fixedly connected to a square sleeve 23, which cooperates with square feeding pipe 22. the right end of the square feeding pipe 22 extends into the interior of the square sleeve 23. the right side of the coarse filter frame 13 is fixedly connected to a square insert rod 14. the left end of the rotating rod 11 passes through screening cylinder 2 and extends into its interior. the left end of the rotating rod 11 is provided with a square groove 15, into which the right end of the square insert rod 14 extends.

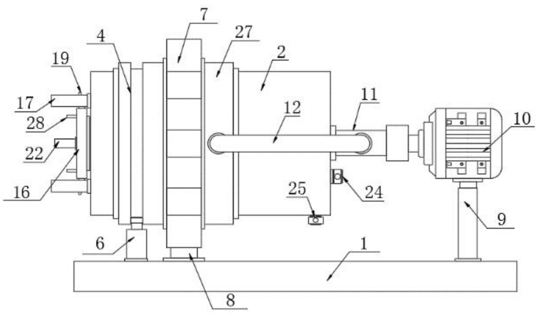

Figure 1. Front view of the screening device

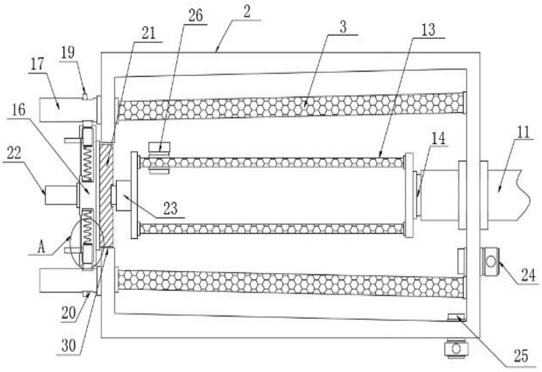

Figure 2. Top view of the screening device

To facilitate the disassembly of screening cylinder 2, both the upper and lower parts of the left side of screening cylinder 2 are fixedly connected to limit plate 17. Both the top and bottom of cover plate 16 are provided with slot 31. One side of the interior of slot 31 is fixedly connected to a spring 18, which is replaceable for convenience. One end of the spring 18 is fixedly connected to a trapezoidal rod 19. the left side of the trapezoidal rod 19 has a slope, and one end of the trapezoidal rod 19 passes through slot 31 and the limit plate 17, extending to the exterior of the limit plate 17. the top of the limit plate 17 is provided with a limiting port 20, which cooperates with the trapezoidal rod 19. the left side of the trapezoidal rod 19 is fixedly connected to rod 28, which passes through slot 31 on the left side of the cover plate 16 and extends to the exterior of the cover plate 16. Both the top and bottom of the left side of the cover plate 16 are provided with a first movable port 29, which cooperates with the rod 28.

To facilitate the discharge, the top of the filter cylinder 3 is connected to an inlet pipe 26 through an opening, the right side of the screening cylinder 2 is connected to a first discharge pipe 24 through an opening, and the bottom right side of the screening cylinder 2 is connected to a second discharge pipe 25 through an opening.

3.3 Optimization Effects

By pulling the coarse filter frame 13 outwards to the exterior of screening cylinder 2 and moving cover plate 16 to the right, cover plate 16 drives sealing pad 21 to close the second movable port 30. At this point, sand and gravel can be conveyed to the interior of screening cylinder 2 through square feeding pipe 22. After the conveyance, by starting motor 10, it drives U-shaped traction rod 12 to rotate, causing the reciprocating motion of screening cylinder 2 through the movement of convex block disk 7, thereby achieving effective energy-saving when screening a small amount of sand and gravel. Meanwhile, by simultaneously pulling both rod 28 to the center, rod 28 moves, driving trapezoidal rod 19 to move, moving trapezoidal rod 19 outside limit plate 17, and then pulling square feeding pipe 22 to the left. Consequently, square feeding pipe 22 moves, causing cover plate 16 to move to the left, and cover plate 16 drives sealing pad 21 to move to the exterior of screening cylinder 2, thus facilitating the removal of larger sand and gravel.

3.4 Process Principle

Sand and gravel are placed into coarse filter frame 13 through feeding pipe 26. Then, coarse filter frame 13 is inserted into screening cylinder 2 through the second movable port 30. Square insert rod 14 is connected to rotating rod 11 through square groove 15. Subsequently, cover plate 16 is pushed to the right, causing two trapezoidal rod 19 to move. Trapezoidal rod 19 contacts limit plate 17, retracting them into slots 31. When trapezoidal rod 19 reaches limiting port 20, they spring out due to the force of spring 18, fixing cover plate 16 in place. At the same time, cover plate 16 moves, driving sealing pad 21 to close the second movable port 30, preventing dust from spreading.

Motor 10 is activated, driving rotating rod 11 to rotate, and in turn, U-shaped traction rod 12, which rotates rotating cylinder 27. This rotation of rotating cylinder 27 drives convex block disk 7, causing screening cylinder 2 to move up and down in a reciprocating motion through the interaction with arc-shaped top block 8. As a result, the first telescopic rod 6 and the second telescopic rod 9 undergo reciprocating contraction, thus achieving the up and down screening motion of screening cylinder 2.

In addition, when motor 10 is activated, it drives rotating rod 11 to rotate, in turn driving square insert rod 14 to rotate. This rotation of square insert rod 14 drives coarse filter frame 13 to rotate. Coarse filter frame 13, in turn, drives square sleeve 23 to rotate. Square sleeve 23 drives square feeding pipe 22 to rotate, and square feeding pipe 22 drives cover plate 16 to rotate. Cover plate 16, in turn, drives trapezoidal rod 19 to rotate, causing limit plate 17 to rotate. Limit plate 17, in turn, drives screening cylinder 2 to rotate, allowing materials to rotate within coarse filter frame 13 and filtering cylinder 3.

To facilitate discharge, the first discharge pipe 24 and the second discharge pipe 25 surface-mounted electromagnetic valves are opened. This allows the sand and gravel between filtering cylinder 3 and coarse filter frame 13 to be discharged through the first discharge pipe 24, and the sand and gravel between the inner wall of screening cylinder 2 and filtering cylinder 3 to be discharged through the second discharge pipe 25.

Finally, by pulling both rod 28 towards the center simultaneously, rod 28 moves, driving trapezoidal rod 19 to move. Trapezoidal rod 19 moves to the outside of limit plate 17 and then pulls square feeding pipe 22 to the left. Consequently, square feeding pipe 22 moves, bringing cover plate 16 to the left, and cover plate 16 moves sealing pad 21 to the exterior of screening cylinder 2. Coarse filter frame 13 is then pulled outwards to the exterior of screening cylinder 2, and sand and gravel inside coarse filter frame 13 are poured out through feeding pipe 26, facilitating the removal of waste materials.

4. Improvement Effect

The designed building's energy-saving and environmentally-friendly sand and gravel screening device, along with its usage method, achieves the effect of dust prevention by inserting the coarse filter frame into the screening cylinder and fixing it with the square sleeve and rotating rod while sealing the second movable port with a sealing pad. Additionally, by starting the electric motor, the rotating rod is set in motion, which, in turn, drives the convex block disk to move. the contact of the convex block disk with the arc-shaped top block results in the reciprocating motion of the screening cylinder. Simultaneously, the electric motor also drives the rotating rod, causing the coarse filter frame to rotate, which, in turn, drives the screening cylinder to rotate, achieving the effect of graded screening. This not only significantly increases the screening efficiency but also fulfills the objective of environmental protection.

The designed building's energy-saving and environmentally-friendly sand and gravel screening device, along with its usage method, optimizes energy consumption effectively when screening a small quantity of sand and gravel by pulling out the coarse filter frame to the exterior of the screening cylinder and shifting the cover plate to the right to seal the second movable port using the sealing pad. Furthermore, after the sand and gravel are conveyed into the screening cylinder through the square feeding pipe, the electric motor is started to rotate the U-shaped traction rod, which drives the convex block disk to perform the up-and-down reciprocating motion of the screening cylinder, achieving energy-saving efficiency.

The designed building's energy-saving and environmentally-friendly sand and gravel screening device, along with its usage method, facilitates the clearing of larger-sized sand and gravel by simultaneously pulling both rods to the center, which moves the rods and drives the trapezoidal rod to move. Once the trapezoidal rod is moved outside the limit plate, it pulls the square feeding pipe to the left, causing the feeding pipe to move the cover plate to the left, which, in turn, moves the sealing pad to the exterior of the screening cylinder, facilitating the removal of larger-sized sand and gravel. We hope you find the information in this template useful in the preparation of your submission.

5. Conclusion

This paper optimizes the design scheme of the sand and gravel screening device, changing different screening modes based on the number of materials, in order to save energy consumption and prevent dust by using sealing pads. HOWEVER, this sand and gravel screening device did not fully consider factors such as cost and safety, so its scope of use is limited to some extent.

Acknowledgement

Chongqing University of Arts and Sciences General item “Research on energy saving optimization of building sand and gravel materials under the background of New Infrastructure” (Y2022TM11).

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