Design of a Bidirectional Belt Conveyor for Boxcar

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Keywords: boxcar, belt conveyor, loading and unloading.

Abstract. Boxcar is an important means of transport in railway transportation, but its unique structure brings a lot of trouble for goods loading and unloading. It mainly depends on manual handling, while there has been no efficient mechanized method. In this paper, a bidirectional belt conveyor for boxcar is presented. It has advantages of small size, simple operation and low cost to meet the loading and unloading of materials in the boxcar. It can greatly improve work efficiency.

1. Introduction

Boxcar is an important means of transport in railway transportation. Its structure is characterized by carriage is arranged on the upper part of the ceiling as well as the opening of both sides of the central compartment [1]. It is mainly used to transport various bags, boxes and other packaging of goods, avoid the sun, rain and snow. This conveyance has many advantages, such as wide range of goods, high universality, high utilization rate and low cost [2].

Boxcar has a good protective effect on goods, but the unique structure form brings a lot of trouble for goods loading and unloading [3]. Loading and unloading mainly depends on manual handling, while there has been no efficient mechanized method. In order to solve the problem of continuous delivery in boxcar, Xu Jiaolong proposed handling apparatus with a car chassis, which is complex and costly [4]. Wang Hao proposed a simultaneous delivery of supplies to the two ends of boxcar, but it does not solve the unloading problem [5]. Germany's Beumer boxcar loading machine can only solve the loading problem. It needs to take another set of unloading machine when transporting goods out of the boxcar [6]. Based on the above research problems, this paper presents a bidirectional belt conveyor for boxcar. It has advantages of small size, simple operation and low cost to meet the loading and unloading of materials in the boxcar. It can greatly improve work efficiency.

2. Design requirement

The bidirectional conveyor for boxcar is used for loading and unloading bags or boxes of materials in boxcars. It can form a continuous line with the telescopic conveyor and the horizontal conveyor. It can realize the forward and reverse transportation of materials in and out of the carriage, and can adjust the height and can adjust the height to adapt to the different height of the telescopic conveyor.

Single material quality: $\leqslant$50kg.

Single material size: $\leqslant$900 mm$\times$650 mm$\times$400mm.

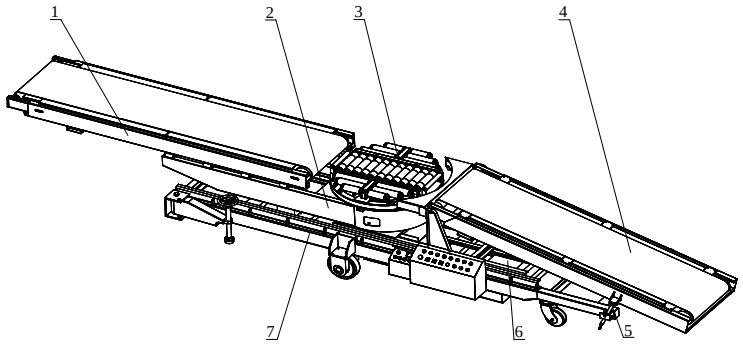
Conveying speed: 0m/s ~ 1m/s.

Maximum transverse transport distance: 5500mm.

3. Structure and function

In the material conveying fields, belt conveyor has been the most efficient way to transport bags and boxes of materials. Therefore, combining with the characteristics of belt conveyor The bidirectional conveyor for boxcar has been developed.

As shown in the fig. 1, the bidirectional conveyor for boxcar is composed of a walking chassis, a sliding frame, a conveying skew bridge, a rotary table, a cross turning machine, a telescopic conveyor, a height adjustment mechanism and an electrical system.



1-telescopic conveyor；2- rotary table；3- cross turning machine；4- conveying skew bridge；5- height adjustment mechanism；6- sliding frame；7- walking chassis

Fig. 1 Structure of the bidirectional conveyor for boxcar

(1) Walking chassis

The walking chassis assembly is composed of a fixed frame assembly, a supporting leg assembly, a rotary body component, two motor driving wheels and two universal wheels. Motor driving wheels provide the driving force to make the machine walk and turn.

(2) Sliding frame

The sliding frame is composed of a motor, a frame, a supporting wheel group, a chain and a fixed base. The motor is fixed on the walking chassis, which drives the chain wheel and the chain to make the sliding frame move forward or backward on the track of the walking chassis.

(3) Conveying skew bridge

The conveying skew bridge consists of telescopic and fixed sections. It is driven by an electric roller. The telescopic segment is hinged on the fixed seat of the sliding frame, and the fixed segment is supported on the walking chassis through the height adjustment mechanism. It expands with the movement of the sliding frame. It adjusts the height of the tail of the conveying skew bridge by the height adjustment mechanism to match with other transmission equipment.

(4) Rotary table

The rotary table is composed of rotary support and welding assembly. It is installed on the sliding frame through the rotary support. The rotary table is driven by a motor and a gear wheel mounted on the sliding frame to drive the rotary table and the telescopic arm to move to different conveying angles.

(5) Cross turning machine [7]

The cross turning machine is composed of two semicircle roller machines and a middle roller machine. A semicircle roller machine consists of multiple rollers of various lengths, and all the rollers are driven by a motor to rotate in the same direction. The middle roller machine consists of multiple rollers of the same length, and all rollers are driven by a motor to rotate in the same direction too. It can connect two transmission lines to transport supplies, reduce or eliminate the probability of falling in the process of conveying.

(6) Telescopic conveyor

The telescopic conveyor is fixed on the rotary body welding assembly and rotates with the rotary table. The telescopic conveyor is driven by a motor through a chain wheel, and the conveyor belt is driven by an electric roller.

(7) Height adjustment mechanism

The height adjustment mechanism is composed of a supporting seat welded on the fixed segment of the conveying skew bridge, a supporting seat welded on the walking chassis, a screw, a nut, a rotating shaft and so on. By rotating the rocker, the relative motion between the screw and the nut is made, which changes the height of the end of the conveyor.

(8) Electrical system

The electrical system of the bidirectional conveyor is composed of two parts, which are the control of the transmission mode and the control of the driving wheels. The equipment is in the transmission mode for a long time, so it uses alternating current in this mode. The control of the driving wheels uses battery power in order to transfer more convenient.

4. Operation process

(1) Operation process

The bidirectional conveyor has four walking action，which are forward, backward, turning left and turning right. The states of the motor wheels corresponding to them are shown in the table1.

Table 1 States of the motor wheels

Numble	Left motor wheel	Right motor wheel	The bidirectional conveyor
1	forward	forward	forward
2	backward	backward	backward
3	forward	backward	turning right
4	backward	forward	turning left

(2) Unfolding and folding

Fig. 2 shows the schematic diagram of the unfolding process.

a. The bidirectional conveyor walks to the proper position, and then open and stable support legs.

b. The sliding frame moves forward, and the rotary table turns to one side of the carriage at the same time.

c. After arriving at the proper position, adjust the cross turning machine to the appropriate angle and then extend the telescopic conveyor.

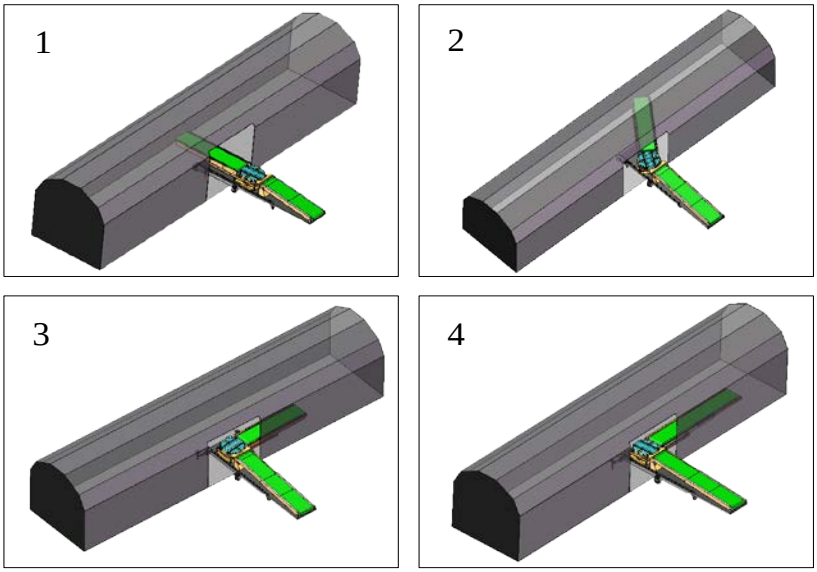


Fig. 2 The schematic diagram of the unfolding process

(3) Transport operation

After the equipment is unfolded, the loading operation can be carried out.

In the loading process, the middle roller machine and the telescopic conveyor have the conveying directions. Two semicircle roller machines run toward the middle in order to ensure the material does not cross out of the turning table. The operator can adjust the length of the telescopic conveyor according to the actual transmission distance demand.

In the unloading process, the middle roller machine and the conveying skew bridge have the conveying directions.

5 Conclusion

According to the above structure, the shape and size of the bidirectional belt conveyor for boxcar is 6900mm×1185mm×1140mm（Length × width × height, folded state），and it has a quality of 2100kg.

The bidirectional belt conveyor has the following advantages:

(1)It adopts the form of the sliding frame and the wheels need not to enter the carriage, so the height difference between the floor of the carriage and the platform is easily to adapt.

(2)Boxcar unilateral distance is generally less than 8m, while its transverse conveying distance reaches 5.5m, covering most of the space of the carriage;

(3)The form of the cross turning machine can reduce or eliminate the probability of falling in the process of conveying.

(4)It has a simple structure and is easy to operate by using two motor wheels to achieve its forward and backward and steering.

In the loading test of bags of quilts（580mm×460mm×370mm,40kg）with a group of 4 persons, it took them 38minutes to fill a carriage with the bidirectional belt conveyor for boxcar. One of them operate the machine and remove the goods， and the others put the bags piles into a six layer stack up to 2200mm . In another test, it took 4 people 75minutes to fill a carriage without the bidirectional belt conveyor for boxcar. According to the calculation, operation efficiency is improved by 49.3% when the bidirectional belt conveyor for boxcar is used. It not only greatly improves the level of mechanization and work efficiency, but reduces the labor intensity.

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