Design and Implementation of a New Automatic Charging System for Metal Round Tubes

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Abstract: This paper took the automatic charging process of metal round tubes as the research object. A traditional manual charging method was researched and an automatic charging system was designed in this paper. The system improved the existing enterprise processing mode significantly and the overall production efficiency of metal round tubes. This article introduced the composition of the automatic charging system for metal round tubes, and further analyzed the structural design features and operation principles of each component; in order to realize the automatic production of the charging system, a complete set of automatic control system was designed in the paper, enabling the orderly connection between the round tube cutting and edge chamfering processing procedures. The automatic charging design was used to replace the original cut round tube manually transported to the chamfering process and then manually load to the chamfering slot, thereby reducing the cost of enterprise labor, improving productivity and ensuring production safety.

1. Introduction

In order to meet different production requirements, it is necessary to cut the long metal round tube into a shorter tube. After the metal round tube is cut, burrs will generally appear at the corresponding position, which affects the quality of the round tube. The processing of such products mainly relies on the traditional processing mode. Generally, workers operate the cutting machine to cut the long tube into short tubes, and then transport them to the next station for chamfering by a forklift, which is represented by a schematic diagram of the processed product. Pain points of the existing method lie in the efficiency of charging and chamfering, and the expensive labor cost, and the shape burrs after cutting, which easily threatens the safety of the operator. To improve production efficiency and reduce labor costs, enterprises are eager to develop an automatic charging system \textsuperscript{[1-4]}. A device with both deburring and loading and uploading functions was studied in this paper. It can receive cut round tubes, align the placement of those tubes, and remove the burrs generated after cutting, and complete the process of charging and baiting, thereby supplying materials for the chamfering. The device can operate and charge materials at a speed of 40-60 pieces per minute when chamfering. A single automatic loading and uploading system can save the labor of 4-5 people. The design can improve the operating efficiency of the metal round tube production line, reduce labor costs and labor intensity of workers, and provide a safer working environment.
2. The Composition of the Automatic Loading and Uploading System

The automatic charging system for metal round tubes designed in this paper includes the baiting device, material storage tank, deburring device and charging device arranged in sequence, and also includes a transition line between the storage tank and the charging device; The tank and the transition line are inclined downward along the conveying direction of the round tube, while the charging device is inclined upward along the tube; the line passes through the deburring device, connecting the end of the storage tank and the end of the charging device respectively. The overall assembly drawing of the device is shown in Figure 2.

The workflow: the cut round tube first falls on the conveyor belt of the uploading device. When it falls on the conveyor belt, the products are out of order and some products are even upright. Therefore, the uploading device ensures that the products are uniformly lying flat when conveying the products. Then products fall into the tank through the charging device, and enters the transition line in an upright state after falling; Since the line is designed with a certain inclination angle, products roll to the next procedure due to gravity; when a certain amount of products passes through the deburring device, the burrs are squeezed to the end of the inner circle by the cylinder positioning and squeezing burr mechanism; after the extrusion is completed, the cylinder and deburring device, then the products continues to roll to the next chamfering and charging station. The slots on the conveyor belt of the charging device can only hold each product. Finally, the products are sent to the charging platform of the end chamfering equipment. After this single process, the next process is followed.

3. The Working Principle of the Main Components

3.1. Operation analysis of automatic uploading device

The uploading device is mainly composed of driving mechanism, chain conveyor belt, motor, height limiting rod, conveying plate, shell and frame and other parts. among them

There are two outer shells, which are respectively fixed on both sides of the upper end of the bracket; the driving mechanism is fixed on one side of the bracket, and its output end is connected with the chain conveying mechanism; the chain conveying mechanism is arranged between the two shells, and the conveying direction is set along the length of the shell ; The two ends of the
height-limiting rod are respectively fixed on the upper part of the two shells and the upper part of the conveying mechanism. Figure 3 shows the assembly diagram of the automatic baiting device. The product falls on the front end of the conveyor belt, and the asynchronous motor drives the chain to convey the plate. After the product passes the height limit plate, the product is transformed uniformly from the upright posture to the flat state.

3.2. Operation Analysis of Transition Line and Deburring Device
After the product is output from the baiting device, it first falls into the storage tank, and the product is in an upright state; the storage tank and the transition line are installed on a bracket with a certain inclination angle, and then the product depends on its own weight along the inclined transition line rolling in the direction of the upward charging device; in the rolling process, the burr is removed through the squeezing and deburring device, and the burr is placed on the inner circle side to facilitate the removal of the burr in the chamfering process. As shown in Figure 4, a schematic diagram of the assembly of the transition line and the deburring device.

1. Drive mechanism 2. Transmission plate 3. Height limiting rod 4. Shell 5. Chain conveyor belt 6. Frame

Figure 3 Assembly drawing of automatic Baiting device

1. Frame; 2. Storage tank; 3. Flow plate; 4. Crank the cylinder; 5. Plate; 6. Tilt bracket;
Figure 4 Transition line
(1) The transition line mechanism is composed of storage tank, inclined bracket, frame, flow plate, air cylinder and push plate, as shown in Figure 4(a). The storage tank is installed on the end frame of the uploading device. In order to ensure that the products lying flat in the uploading device stand upright when entering the storage tank, it is bent at a certain angle on one side of the storage rack groove to realize the smooth sliding and upright status of the product, see Figure 4(a) an enlarged view of the deburring device. The flow plate that plays a guiding role is installed on the inclined bracket. In the area of deburring device, the flow plate allows products to pass, and the two aligning posts are symmetric. Since the posts guide and align the round tubes, so the cylinder cannot be too large.

(2) The deburring device includes a second support, a first stopper cylinder, a second stopper cylinder, and a squeezing push cylinder arranged on the second support; the second support is installed from top to bottom; the first stopper The air cylinder and the second stopper cylinder are respectively arranged on opposite sides of the first mounting part of the second bracket along the conveying direction of the circular tube, the squeeze push cylinder is arranged between the first stopper cylinder and the second stopper cylinder, and on the top of the second bracket, with its working end downward.

For the squeezing and pushing cylinder in the deburring device, it includes a connector, a cylinder body, a guide post, a spring guide post, a scraper, and a pressure plate; the lower end of the cylinder body is connected with the connector through the guide post; the guide post and the spring guide post pass through There are two connecting pieces, spring guide posts, which are arranged symmetrically on both sides of the guide posts along the length direction of the connecting piece, and their lower
ends are respectively connected to the pressure plate; the upper ends of the two scrapers are respectively connected to the connecting piece along the tube on both sides of the conveying direction. The length of the scraper along the conveying direction of the circular tube is shorter than the distance between the two stopper cylinders; the length of the pressure plate along the conveying direction of the circular tube is no longer than the length of the scraper along the conveying direction of the circular tube.

3.3. Operation analysis of chamfering charging device

How to transport products to the chamfering process in an orderly and stable manner is a key technical indicator reflecting the feasibility of the equipment, which is also the core content of the research and development device in this article. In this paper, innovative design is carried out in accordance with the existing charging methods of the products to be chamfered. As shown in Figure 5.

![Figure 5: Assembly drawing of chamfering charging device](image)

1. Frame; 2. Drive mechanism; 3. Shell; 4. Transport plate slot; 5. Slot body; 6. Baffle plate; 7. Protection net

The designed chamfering charging device includes a frame, a drive mechanism fixed on the frame, a shell and a transport plate slot set between the two shells. One end of the drive mechanism rotating shaft is connected with the transport plate slot, and the conveying direction is along the side of the shell. It is set in the length direction; the power source of the transport plate groove is provided by the drive mechanism to drive the gear chain transmission to ensure the stable charging of the transport plate groove. The shells located on both sides can protect the round tubes in the transport plate slot and prevent the round tubes from falling from the side.

The transport plate trough in the charging device is composed of several troughs. The troughs and the round tubes are of the same specifications. Each trough can only transport one round tube to prevent the round tubes from squeezing each other and falling due to the influence of gravity during the ascent. If the specification of the tank is adapted to the round tube, the round tube will not shake in the tank, avoiding the round tube falling during the ascending process. The charging device also includes a baffle plate and a protection net. The baffle plate is arranged at the end of the charging device close to the conveying transition line, and is fixed between the two shells so that the round tubes entering the transport plate slot fall into different slots; the protection net is arranged on the shell to prevent the round tube in the tank from falling from the side.

4. Equipment Operation Control System Design

In order to ensure that each mechanism of the equipment can perform as expected, it is necessary to design and produce a complete set of automated control systems: the core control unit module of the control system of the whole set of equipment chooses Siemens CPU314C-2PN/DP as the controller.
The PLC control module can meet the need of the IO points required for the operation of a single or multiple sets of equipment. It supports Ethernet communication or PROFIBUS DP communication protocol; the inverter module uses Siemens MM440 to achieve the purpose of speed adjustment of the chain conveyor; Siemens TP177B series touch screen is used to detect the operating status of the equipment, display the production process data, and display alarms, data information management and equipment debugging and operation, etc. [5-7].

The equipment studied in this paper has been successfully adopted in the production of metal round tubes and innovatively designed for the existing production mode. The operation status of the original single process sheet equipment has been integrated into an automated production line mode. It can complete receiving and cutting round tubes and pairings according to requirements. The burrs on the edge of the round tube are removed into the inner edge and the material is charged to the chamfering process. Practice has proved that the automatic charging system of the designed metal round tube can meet the expected functional requirements. With stable overall operation, the automation and efficiency of the entire production line are improved, the labor cost is reduced, and the operational safety of workers is guaranteed. This also solves the problems of slow charging of metal round tubes and a large number of labors.

5. Conclusion
The automatic charging system of metal round tube designed in this paper is an integration and innovative design of the existing traditional production equipment, and can achieve the technical index of charging at a speed of 40-60 pieces/min for the chamfering process. At the same time, it can meet the automatic charging of products of the same specification and different sizes, and has certain technical promotion value among similar products.

The designed system can not only complete the above technical indicators, but also has the following characteristics:

1) Change the previous manual loading, manual transportation and manual charging modes. All the actions of the entire charging system are controlled by PLC, which saves the labor cost of the enterprise while monitoring and commanding the operating status and data of the system, etc.;

2) The modular design is easy to ensure the continuous and stable operation of the equipment, and the maintenance is simple and convenient, thereby reducing the cost of the enterprise;

3) Advocate low-carbon and environmentally friendly operation. Most of the system adopts air cylinder and mechanical transmission technology, which has high operational reliability. It can make the equipment stay in the best operating condition and realize zero-emission production.

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