Improved Design of Steel Pipe Transfer Device Turnover Mechanism

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Abstract. In the steel pipe manufacturing industry, the steel pipe manufacturing process is completed by multiple processes. And on the automatic production line, the transfer process between steel pipe working procedure is realized by the steel pipe transfer device. The unreasonable structural design of related parts in the steel pipe transfer device will result in the failure of the steel pipe transfer process to proceed smoothly, which will directly affect the normal operation of steel pipe production line, resulting in steel pipe productivity’s decrease and causing losses to steel pipe manufacturers. This article proposes an improved design method of the turnover mechanism of transfer device between steel pipe manufacturing processes.

1. Introduction
In modern society, the application of steel pipes has involved all walks of life. Steel pipes are widely used in public pipelines, industrial pipelines and machinery industries, such as water, gas, steam, oil, natural gas transmission pipelines, boiling water pipes of general boilers, superheated steam tubes, superheated tubes for locomotive boilers, aviation tubes and agricultural tubes, etc. They are all made of steel tubes. In the manufacturing process of steel pipes, steel pipe manufacturers have been pursuing the goal of reducing production costs, improving production quality and production efficiency [1-3].

The manufacturing process of steel pipes is relatively complicated, and the production types are generally mass production, and the manufacturing process often uses automated assembly line operations. In the automated production line, steel pipes are operated between different processes, and their transfer efficiency plays an important role in improving the production efficiency of steel pipes and reducing production costs.

2. Transfer method between steel pipe processes
Common transfer methods between steel pipe processes include longitudinal roller transfer, horizontal conveyor chain transfer and crane lifting transfer.

(1) Longitudinal roller transfer, as shown in Figure 1, is a transfer method along the direction of the steel pipe rotation centerline. Its working principle is to place the steel pipe on the conveying roller for conveying. At this time, the transfer mechanism is set at the middle position of the conveying roller [4]. When the steel pipe is transferred, the roller rotates under the action of power, and multiple rollers rotate synchronously. The transfer of the steel pipe is completed by the friction between the roller surface and the steel pipe outer circle. As the roller structure is V-shaped, the steel pipe has better alignment and high precision of the transfer position. This transfer method generally has long transport distance and low transport efficiency.
(2) Horizontal conveyor chain transfer, as shown in Figure 2, is the transfer method perpendicular to the centerline of the steel pipe axis. The principle is that after the upper process in the steel pipe manufacturing process is completed, the steel pipe is placed on the V-shaped block of the conveyor chain through turnover mechanism. Each steel pipe is carried by multiple rows of V-shaped blocks at the same time, and multiple rows of conveyor chains pass through a certain power driving for synchronous transmission. Each row of the transmission chain is equipped with multiple V-shaped blocks. Driven by the conveyor chain, the multiple rows of V-shaped blocks move synchronously to transfer the steel pipe to the next process. In this type of transfer method, multiple pieces can be placed on a conveyor chain, which has higher transfer efficiency. At the same time, the V-shaped block has good alignment. The V-shaped groove can prevent the steel pipe from rolling and guarantee the stability of the steel pipe and the position accuracy of the steel pipe transfer \[^{[5]}\], thereby ensuring that the steel pipe is accurately transferred to the appropriate station.

(3) Crane lifting transfer is shown in Figure 3. This transfer method generally uses the crane in the production workshop to lift the steel pipe in different ways, so that the steel pipe is transferred from one location to another along a special running track. This kind of transfer method is more efficient, but it has strict requirements on the transfer space, and it is easy to interfere with other agencies during the transfer process, so that the security is poor.
3. Working principle of steel pipe transfer device
In the longitudinal roller transfer and the horizontal conveyor chain transfer methods, after the completion of the previous process, the steel pipe is usually placed on the conveyor roller V-shaped groove or the conveyor chain V-shaped block through the turnover mechanism of the transfer device, and then, through the synchronous rotation of the conveying roller or the synchronous movement of the V-shaped block, the steel pipe is transferred to the next process. Among the many parts that make up the transfer device, the rationality of the structural design of the turntable of turnover mechanism has a direct impact on whether the steel pipe transfer can be carried out smoothly. In the manufacturing process of pipelines used to transport oil and natural gas, each steel pipe must be purged one by one. Before purging, the steel pipe needs to be transferred from the upper process to the station where the purge process is located. At this time, the transfer process of the steel pipe needs to be completed by a steel pipe transfer device.

As shown in Figure 4, after the steel pipe comes from the previous process, the rows of steel pipes roll on the inclined surface of the feeding rack. At the same time, the turntable of the turnover mechanism rotates clockwise around the shaft at a constant speed. Before each steel pipe enters the gap of turntable, friction occurs between the steel pipe outer circular surface and the turntables stop arc (the non-notched side of the turntable outer circle). When the steel pipe rolls into the gap of turntable, it is blocked by the stopper at appropriate position. The steel pipe is transferred to the catcher of the conveyor chain by turntable’s rotation. And then the steel pipe is transferred through the conveyor chain’s operation.
3.1. The turntable’s structural features and problems in production process before improved design

The turntable’s structure before improvement is that the center of three stop arcs is concentric with the rotating shaft (as shown in Figure 5). During the production process, it was discovered that when a steel pipe entered the turntable’s gap and was lifted by the turntable, the steel pipe in the back, which was in contact with stop arc, caused friction with the stop arc. As the stop arc is concentric with rotating shaft, the friction generated from the steel pipe outer circular surface during the rotation is relatively stable. When the friction is large enough to overcome the steel pipe’s gravity to lift it, the steel pipe behind will roll over due to gravity, so that the front and rear steel pipes occasionally intersect, which can easily cause the pipe row disordered, and the pipes cannot be transported normally. It reduces the transfer efficiency of steel pipes and even seriously hinders the entire steel pipe production line’s normal operation.

![Figure 5: Schematic diagram of the turntable of turning mechanism before improved design](image)

3.2. The turntable’s structural features and effect achieved after improved design

Through detailed analysis of the principle of steel pipe transfer device and the study of the turntable’s structure, an improved design plan for the turntable is proposed, which is to improve the stop arc’s structure. The three arc surfaces of turntable have their own circle centers, which means the three stop arcs are located on different circles. At the same time, the centers of the three stop arcs are not concentric with the turntable’s rotating shaft, as shown in Figure 6.

![Figure 6: Schematic diagram of the turntable of turning mechanism after improved design](image)

When the turntable rotates clockwise around the axis of the shaft, the rotation radius of stop arc gradually decreases. The contact line between stop arc and steel pipe outer circle surface shifts to the right, and the pressure between them is unstable and tends to shrink, so it cannot form relatively stable
friction. As a consequence, it is not easy to lift the steel pipe behind and will not cause disorder of the pipe row at the back, so that steel pipe transfer can proceed smoothly.

4. Conclusions
This paper proposes an improved method for the turnover mechanism’s turntable in the steel pipe transfer device. The turntable’s three stop arcs structure design is changed from being concentric with the rotating shaft to each having its own circle center and not concentric with the rotating shaft. Therefore, the friction between turntable stop arc and the steel pipe surface is in a state of gradual decrease, which avoids the problem of pipe row disorder during steel pipe transfer process and ensures smooth progress of steel pipe production. The improved design idea of turntable structure can be applied to not only steel pipes transfer device but also the production process of other products similar to steel pipes, and has certain practical value and market promotion value.

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