Automatic feeding device for belt drum station of micro truck and light truck building machine

Chen Hongpeng

(Tianjin Saixiang Technology Co. LTD., Tianjin 300384, China)

Abstract: This article designs a kind of automatic feeding device for the belt drum station, featuring high automation and compact layout, which can simultaneously meet the feeding needs of the belt layer and tread for both micro truck and light truck tires. In response to the trend of the tire market shifting from mass production to diversified small batches, this device significantly enhances the production flexibility of the building machine, supports rapid model change and flexible response to market changes, and provides a practical solution for enterprises to enhance adaptability, reduce costs, and improve efficiency.

Key words: micro truck building machine; light truck building machine; belt material supply; tread material supply

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0 Preface

In tire manufacturing enterprises, equipment investment accounts for a relatively high proportion of the total investment; especially with the application of intelligent and digital technologies, the costs of equipment investment and technical support are even higher. Whether the equipment can be fully utilized directly affects investment benefits and production costs . Tire blank molding is a crucial step in the tire production process, which assembles and molds the semi-finished components of tires. The quality of the molding equipment greatly affects the final quality of the tires.

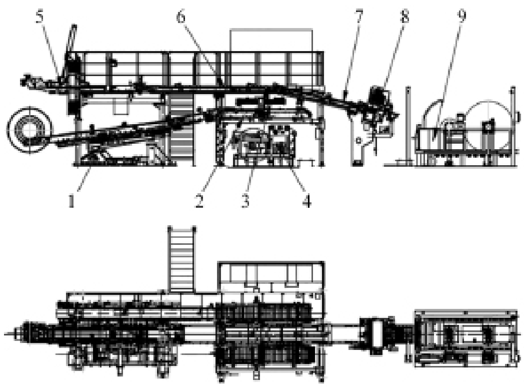
Currently, the mainstream production model in the tire manufacturing industry still relies on dedicated tire building machines, which are typically designed for producing a single type of tire (such as micro-truck or light truck tires) and can only achieve size changes within a limited range of specifications by replacing tooling. This rigid production model is difficult to adapt to new market trends. On the one hand, the market for traditional high-volume standardized tires has become increasingly saturated; on the other hand, consumers and the market are increasingly demanding personalized, low-volume differentiated tires, and the product life cycle is short, requiring enterprises to have rapid response capabilities.

In this context, the requirements for tire building equipment have surpassed basic automation, stability, and high efficiency, and have shifted towards pursuing higher production flexibility. This means that a single equipment is required to be capable of producing multiple types of tires, in order to quickly adapt to changing market demands and achieve the unity of cost-effectiveness and flexibility. The rubber compound applied at the belt drum station of the building machine includes the belt layer and tread, which are the main components of the tire structure and play a crucial role in the overall strength and wear resistance of the tire. Based on the above concept, this paper designs a new type of automatic feeding device for the belt layer and tread application at the belt drum station of the tire building machine. This device breaks through the limitations of traditional designs and aims to achieve compatibility and rapid switching of belt layer feeding for micro-truck and light truck tires, providing an effective solution for enhancing the overall flexible production capacity of the building machine.

Biography: Chen Hongpeng (1988-), Bachelor's degree holder, intermediate engineer, primarily engaged in rubber machinery design.

1 Traditional micro-card forming machine belt drum workstation feeding device

The traditional micro-calender belt drum feeding device mainly consists of a belt layer swing frame, a belt layer conveyor device, a belt layer cutting device, a belt layer spreading device, a tread swing frame, a tread intermediate conveyor device, a tread feeding conveyor device, a tread cutting device, and a tread spreading device, as shown in Figure 1.



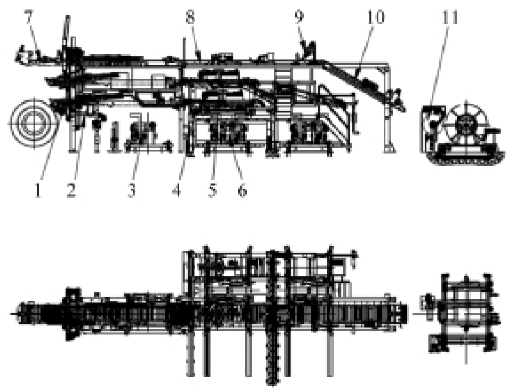
1-Belt sway frame; 2-Belt conveyor device; 3-Belt cutting device; 4-Belt spreading device; 5-Tread swing frame; 6-Tread middle conveyor device; 7-Tread feeding and conveying device; 8-Tread cutting device; 9-Tread spreading device

Figure 1 Feed device for the belt drum station of traditional micro-card forming machine

This belt drum station feeding device can achieve the feeding of 2 layers of belt and 1 layer of tread, with the belt being fed from below and the tread being fed from above. The 2-layer belt feeding devices are arranged side by side below the tread feeding device, each with a separate set of swing frames, conveyor devices, cutting devices, and spreading devices. The tread feeding device is arranged above the belt feeding device. This belt station feeding device has only two belt feeding stations, and the limited space for belt feeding from below can only meet the production requirements of small-sized tires with two layers of belt, such as micro-trucks.

2 Traditional light truck forming machine belt drum workstation feeding device

The traditional light truck tire building machine's belt drum feeding device mainly consists of a belt layer oscillating frame, a zero-degree oscillating frame, a zero-degree spreading device, a belt layer conveyor device, a belt layer cutting device, a belt layer spreading device, a tread oscillating frame, a tread intermediate conveyor device, a tread cutting device, a tread feeding conveyor device, and a tread spreading device, as shown in Figure 2.



1-Belt layer swing frame; 2-Zero-degree swing frame; 3-Zero-degree guide device;4-Belt conveyor device; 5-Belt cutting device; 6-Belt spreading device; 7-Tread oscillating frame; 8-Tread middle conveyor device; 9-Tread cutting device;10-Tread feeding and conveying device; 11-Tread spreading device

Figure 2 Feed device for belt drum workstation of traditional light truck forming machine

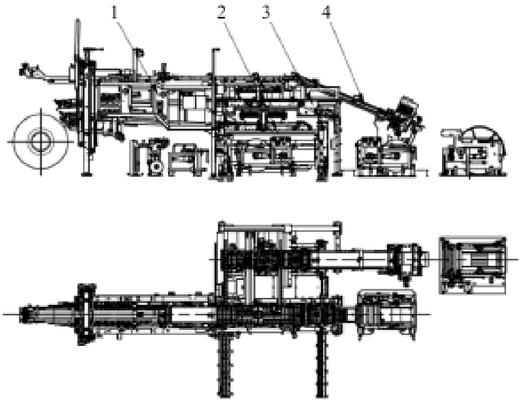
This belt drum station feeding device can achieve the feeding of 4 layers of angled belt layers, 1 layer of zero-degree belt layer, and 1 layer of tread. Both the belt layers and the tread are fed from above. The zero-degree belt layer is located near the first row of the front guide rail in a single station, while the 1st and 3rd belt layers are arranged in parallel near the second row of the front guide rail. The stations can be switched horizontally according to the feeding requirements, sharing the lower belt layer swing frame. The 2nd and 4th belt layers are arranged in parallel near the third row of the front guide rail, and can be switched horizontally together with the 1st and 3rd belt layers according to the feeding requirements, sharing the upper belt layer swing frame. The tread feeding device is arranged above the belt layer feeding device, with the guide opening arranged at the last station. Although this belt drum station feeding device has a large number of stations, the overall roller bed structure used for tread conveyance cannot meet the conveyance accuracy requirements for micro-sized and small-sized treads. At the same time, the overall movement of the belt layers during conveyance requires the tread feeding device to be arranged across the entire conveyance path, resulting in a long overall conveyance distance and a large footprint.

3 Automatic feeding device for belt drum station of micro-card and light-card forming machine

Based on the problems existing in the above-mentioned belt drum feeding device, and fully considering the needs of producing different types of tires, a new type of automatic belt drum feeding device compatible with both micro-truck tires and light truck tires is designed.

3.1 Mechanical structure composition

The belt drum feeding device for the micro- and light-truck tire building machine mainly consists of the front feeding and bonding section, the zero-degree belt layer feeding section, the horizontal switching and rear feeding section for belt layers 1 and 3, the rear feeding section for belt layer 2, and the tread rear feeding section, as shown in Figure 3.

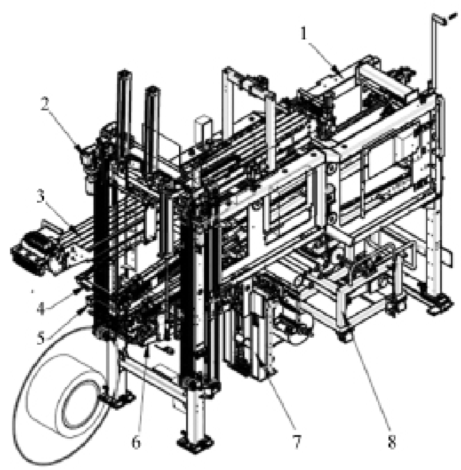


1-Front feed lamination and zero-degree belt layer feeding section;
2-Feed section after lateral switching of belt layers 1 and 3;
3-Rear feeding section of belt layer 2; 4-Rear feeding section of tread

Figure 3 Feed device for the belt drum station of the micro-card and light-card forming machine

The front feeding and bonding section, as well as the zero-degree belt feeding section, primarily comprises: the front fixed frame, the lifting mechanism, the tread swing frame, the upper layer No. 2 belt swing frame, the lower layer No. 1 and No. 3 belt swing frames, the zero-degree belt swing frame, the zero-degree belt tensioning device, and the zero-degree belt spreading device, as illustrated in Figure 4. Among these components, the tread swing frame, the upper layer No. 2 belt swing frame, and the lower layer No. 1 and No. 3 belt swing frames are hinged to the front fixed frame via bearings at the rear, and are connected to three sets of power sources of the lifting mechanism at the front, allowing them to swing around the hinge points under the drive of the lifting mechanism. The zero-degree belt swing frame is connected below the lower layer No. 1 and No. 3 belt swing frames, allowing it to swing together and share the lifting power. The tread swing frame is used for receiving and bonding the tread.

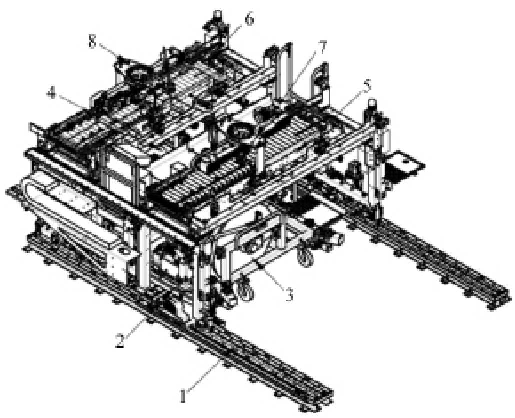
The upper No. 2 belt layer swing frame is used for the pickup and bonding of the No. 2 belt layer. The lower No. 1 and No. 3 belt layer swing frames are used for the pickup and bonding of the No. 1 and No. 3 belt layers. The zero-degree belt layer swing frame is used to convey the zero-degree belt layer, swing downwards and extend to bond the zero-degree belt layer onto the belt drum, featuring a mechanical centering function. The zero-degree belt layer unwinding device is used to unwind the zero-degree belt layer roll, while the zero-degree belt layer tensioning device is used to tension the material pocket between the zero-degree belt layer unwinding device and the zero-degree belt layer swing frame, featuring a material tail clamping function.



1-Front fixed frame; 2-Lifting mechanism; 3-Tread swing frame;
4-Upper belt sway frame No. 2; 5-Lower belt sway frames No. 1 and No. 3;
6-Zero-degree belt layer swing frame;
7-Zero-degree belt layer tensioning device;
8-Zero-degree belt layer unwinding device

Figure 4 Front feed lamination and zero-degree belt feed section

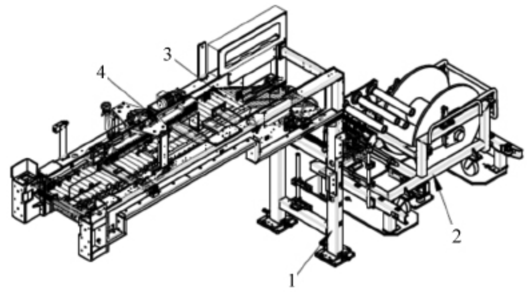
The feeding section after the lateral switching of the 1# and 3# belt layers mainly comprises: a lateral guiding mechanism, a moving frame, a 1# belt layer guiding device, a 3# belt layer guiding device, a 1# belt layer conveying device, a 3# belt layer conveying device, a 1# belt layer cutting device, and a 3# belt layer cutting device, as shown in Figure 5. The 1# and 3# belt layer guiding devices are used to guide the belt layer rolls. The 1# and 3# belt layer conveying devices are used for centering and conveying the belt layers after guiding. The 1# and 3# belt layer cutting devices are used for cutting the belt layers after determining their length. The cutting angle can be adjusted according to the angle of the belt layer steel wires. All the 1# and 3# belt layer guiding devices, conveying devices, and cutting devices are installed on the moving frame. The moving frame is equipped with a servo motor that drives the moving frame and the related devices mounted on it to move along the lateral guiding mechanism through chain transmission. After switching to the 1# or 3# belt layer, the feeding section aligns with the lower 1# and 3# belt layer swing frames.



1-Lateral movement guide mechanism; 2-Mobile frame;
3-No. 1 belt layer spreading device; 4-No. 3 belt layer spreading device;
5-No. 1 belt layer conveyor; 6-No. 3 belt layer conveyor;
7-No. 1 belt layer cutting device; 8-No. 3 belt layer cutting device

Figure 5 Feed section after lateral switching of belt layers 1 and 3

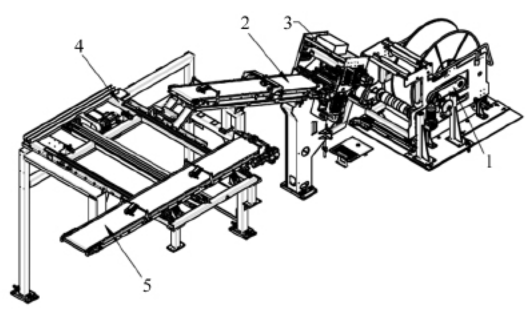
The rear feeding part of the No. 2 belt layer mainly includes: the rear fixed frame, the No. 2 belt layer unrolling device, the No. 2 belt layer conveying device, and the No. 2 belt layer cutting device, as shown in Figure 6. The No. 2 belt layer unrolling device is used for unrolling the belt layer material roll. The No. 2 belt layer conveying device is used for feeding, centering, and conveying the belt layer after it is unrolled. The No. 2 belt layer cutting device is used for cutting the belt layer after it is cut to a fixed length. The cutting angle can be adjusted according to the angle of the steel wire in the belt layer.



1-Rear fixed frame; 2-No. 2 belt layer unwinding device;
3-No. 2 belt layer conveying device; 4-No. 2 belt layer cutting device

Figure 6 Rear feeding part of belt layer 2

The rear feeding part of the tread mainly includes: tread unrolling device, tread feeding conveyor device, tread cutting device, tread lateral conveyor base, and tread lateral conveyor device, as shown in Figure 7. The tread unrolling device is used for unrolling the tread material roll. The tread feeding conveyor device is used for feeding, centering, and conveying the tread after unrolling. The tread cutting device is used for cutting the tread after it is fixed length. The tread lateral conveyor base drives the tread lateral conveyor device to switch between the material receiving position and the feeding position through a motor synchronous belt transmission structure. The material receiving position is aligned with the tread feeding conveyor device, and the feeding position is aligned with the tread swing frame. The tread lateral conveyor device is used to receive the rubber compound from the tread feeding conveyor device and transfer it to the tread swing frame.



1-Tread spreading device; 2-Tread feeding and conveying device;
3-Tread cutting device; 4-Tread transverse conveying base;
5-Tread transverse conveying device

Figure 7 Rear tread feeding section

3.2 Operating Principle and Process

The automatic feeding device for the belt drum station of the micro-truck and light-truck molding machine mainly includes the following steps in the feeding sequence during operation, and the specific steps can be selected according to the process requirements of the corresponding tire specifications.

1# belt layer feeding: After the lateral switching of 1# and 3# belt layers, the initial position of the feeding part is at the feeding position of 1# belt layer. The 1# belt layer is guided by the 1# belt layer guide device and then placed onto the 1# belt layer conveyor device. At the feeding inlet, there is a mechanical edge-retaining device for centering. Then, it is conveyed forward. When it reaches the gap between the 1# belt layer conveyor device and the lower 1# and 3# belt layer swing frames, a deviation detection device detects the deviation of the 1# belt layer and controls the electric cylinder to drive the 1# belt layer conveyor device to move laterally for correction based on the detection results. The lower 1# and 3# belt layer swing frames have a fixed length detection device, which can be combined with servo motor conveyor control to achieve fixed length for the belt layers. After being fixed in length, the 1# belt layer cutting device cuts the 1# belt layer. After cutting, the 1# belt layer is conveyed to the front end of the lower 1# and 3# belt layer swing frames. During the forward conveyance process, the fixed length detection device can calculate the length of the 1# belt layer based on the position of the material tail detected when it passes through. The lower 1# and 3# belt layer swing frames swing downwards and extend for conveyance, while the belt drum rotates. The conveying speed and rotation speed are matched based on the comparison between the actual length and theoretical length of the 1# belt layer detected, ultimately ensuring that the 1# belt layer is properly connected end to end after bonding, ensuring the bonding effect on the belt drum.

No. 2 belt layer feeding: After being guided by the No. 2 belt layer guiding device, the No. 2 belt layer is loaded onto the No. 2 belt layer conveyor. A mechanical edge retaining device is positioned at the feeding inlet to center the material, and then it is conveyed forward onto the No. 2 belt layer swing frame. The entire process of conveying, cutting, and bonding is similar to that of the No. 1 belt layer, and ultimately, the No. 2 belt layer is bonded onto the belt drum.

3# belt layer feeding: After the horizontal switching of 1# and 3# belt layers, the initial position of the feeding part is at the feeding position of 1# belt layer. The servo motor on the moving frame drives the moving frame and the related devices mounted on it to move along the lateral guide mechanism through chain transmission. After switching to 3# belt layer, the feeding part aligns with the lower 1# and 3# belt layer swing frames. After being guided by the 3# belt layer guide device, the 3# belt layer moves up to the 3# belt layer conveyor device. There is a mechanical edge retaining device at the feeding inlet for centering, and then it is conveyed forward to the 1# and 3# belt layer swing frames. The entire conveying, cutting, and bonding process is similar to that of 1# and 2# belt layers, and finally the 3# belt layer is bonded to the belt drum.

Zero-degree belt layer feeding: After the zero-degree belt layer is guided by the zero-degree belt layer guiding device and tensioned by the zero-degree belt layer tensioning device, it is placed on the zero-degree belt layer swing frame. There is a mechanical edge retaining device at the feeding entrance for positioning. When the zero-degree belt layer is attached, the zero-degree belt layer swing frame extends, and the manual traction of the zero-degree belt layer material head is positioned on the belt drum according to the light mark line. Then, the belt drum rotates for attachment, while the zero-degree belt layer tensioning device continuously tension the zero-degree belt layer to ensure the attachment tension. After the attachment is completed, the electric scissors are manually used for cutting, and the material tail is attached to the belt drum. When a roll of zero-degree belt layer is used up, the sensor on the zero-degree belt layer guiding device detects the material tail and controls the pneumatic clip on the zero-degree belt layer tensioning device to clamp the zero-degree belt layer, thus avoiding the zero-degree belt layer from being completely conveyed out of the zero-degree belt layer tensioning device and causing re-threading during material change.

Tread feeding: After being guided by the tread guiding device, the tread is loaded onto the tread feeding conveyor. An automatic correction device at the feeding inlet corrects the deviation of the tread, which is then conveyed forward. The tread feeding conveyor is equipped with a fixed length detection device, which, in conjunction with servo motor conveyor control, ensures the tread is fed in a fixed length. The tread is then cut by the tread cutting device. After cutting, the tread is fully conveyed onto the tread lateral conveyor. The motor on the tread lateral conveyor base drives the conveyor to move laterally to the position aligned with the tread swing frame through a timing belt. The tread lateral conveyor and the tread swing frame synchronously convey forward, gradually transferring the tread from the conveyor to the swing frame. A 3D camera is mounted behind the tread swing frame to scan and record the tread deviation and length data during the forward conveyance of the tread. As the tread swing frame swings downwards and forwards, the belt drum rotates. The conveying speed and rotational speed are matched based on the comparison between the detected actual length and theoretical length of the tread, ultimately ensuring that the tread is properly aligned end to end after bonding, thus guaranteeing the bonding effect on the belt drum. Simultaneously, during the bonding process, the motor driving the tread swing frame is controlled based on the tread deviation detected by the 3D camera, ensuring the tread is fully aligned with the belt drum after bonding.

4 Conclusion

This automatic feeding device for the belt drum station of the micro-truck and light truck tire building machine not only accommodates the production of micro-truck and light truck tires, but also combines the advantages of high automation and small footprint, effectively reducing the equipment's footprint and providing strong support for flexible production scheduling in tire factories.