A kind of tread weighing device for tire building machine

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Abstract: This article addresses the issue of the lack of effective weighing methods in the tread feeding section of tire building machines, which leads to missing weight data and affects tire quality traceability. A sinking weighing device integrated into the conveyor roller bed is designed. This device detects the arrival of the tread through a photoelectric sensor, and the weighing tray and L-shaped support rod are driven up and down by a guiding cylinder. The net weight of the tread is accurately measured using a differential weighing method. This structure is compact and highly compatible, suitable for both new model design and retrofitting of old equipment, providing an effective solution for improving tire product quality control.

Key words: tire building machine; tread feeding; weighing device; quality traceability; submerged design

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0 Foreword

With the development of technology and economy, the competition in the tire industry is becoming increasingly fierce, and the market demands for tire quality are becoming higher and higher. Tire blank molding is a crucial step in the tire production process, which assembles and molds the semi-finished components of the tire. The quality of the molding equipment greatly affects the final quality of the tire. The tread is in direct contact with the road surface, generating horizontal forces in the contact area and providing the vehicle with driving, braking, steering, and other control functions [4]. The weight deviation of the tread is one of the key factors affecting the dynamic balance and uniformity of the tire. In the field of high-end tire manufacturing, precise weighing of each tread and achieving data traceability throughout its entire lifecycle have become important aspects of the quality control system.

Currently, most tire building machines both domestically and internationally have not yet achieved integrated online weighing functionality at the tread feeding station. In the existing production methods, some enterprises adopt offline static scales or manual regular spot checks for tread weight detection. This approach is not only inefficient and increases labor costs, but more importantly, the obtained data cannot be tied to the specific tire's identity information, resulting in poor traceability of quality data during production and making it difficult to achieve full lifecycle management. The few solutions that have attempted to implement online weighing typically simply install the weighing sensor in the supporting structure beneath the conveyor belt or roller mechanism. This structure causes the sensor to bear the static weight of a large number of non-tread components such as the conveyor belt, drive rollers, and brackets during the weighing process, and is highly susceptible to dynamic interference from vibrations generated during conveyor operation, motor drive fluctuations, and friction between the belt and rollers. These factors significantly reduce the measurement accuracy of the system, leading to large errors, poor long-term stability, and failure to meet the requirements of high-precision production processes.

To address the aforementioned issues, this paper designs and develops a high-precision tread online weighing device based on a sunken independent lifting structure. The core

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innovation of this device lies in the complete decoupling of the weighing unit and the material conveying unit through mechanical structural innovation. Specifically, the system utilizes a high-precision cylinder to drive a liftable weighing platform, which only lifts the tread from bottom to top when weighing is required, separating it from the conveyor belt. After weighing, the platform descends and resets, placing the tread back on the conveyor line. This design maximally eliminates external interference factors such as the weight of the conveying mechanism itself and vibration and friction during operation, allowing the sensor to only perceive the net weight of the tread itself, thereby significantly improving the accuracy, repeatability, and long-term operational reliability of weighing measurements.

1 Overall layout and design idea

This weighing system adopts a highly integrated design concept and is directly embedded into the middle position of the tread feeding section conveyor roller bed of the tire building machine. Without changing the original equipment layout, it achieves a truly online dynamic weighing function. The overall layout of the system fully considers the strict requirements of the tire production process for continuity and production pace. By optimizing the coordination between the mechanical and control systems, it minimizes the interference with the original material conveying process, ensuring smooth and efficient production processes.

In the non-working state, all components of the entire weighing mechanism are completely hidden beneath the conveying plane, avoiding the normal conveying path of the tread, thus ensuring that the tread can pass through the station smoothly without obstruction or interference, effectively guaranteeing the continuity and overall efficiency of production. The main body of the system consists of a liftable weighing platform, a high-precision weighing sensor, a guiding cylinder, a photoelectric detection unit, and a PLC control system, which realizes real-time communication with the main control system of the production line through an industrial bus. Once the PLC receives a weighing command from the host computer or a trigger signal indicating that the tread has been conveyed to the weighing station detected by the photoelectric sensor, the guiding cylinder responds immediately, driving the weighing platform to rise vertically and steadily, lifting the tread on the roller entirely, so that it is completely separated from the conveying roller. In this state, the tread is in an independent and stable suspended weighing position, completely isolated from all external mechanical interference. The system provides a static and undisturbed weighing environment for this stage, enabling the high-precision platform scale to accurately and reliably collect tread net weight data, greatly improving the accuracy and repeatability of measurement.

This design not only effectively addresses the long-standing challenge of lacking reliable online weighing methods in the tread section of the tire building process, but also significantly reduces the demand for longitudinal installation space with its unique "submerged" structure, reflecting highly intensive and modular design characteristics. Furthermore, this system provides a complete and scalable solution for the intelligent upgrade of standard tire building machines, laying a solid foundation for the subsequent implementation of advanced functions such as fully automated quality traceability and adaptive adjustment of process parameters.

2 Mechanical structure composition

The tread weighing device is primarily composed of the following core components: a fixed bracket, a guiding cylinder, a tray, a platform scale, a lifting bracket, an L-shaped support rod, and a photoelectric sensor, as illustrated in Figure 1. Each component serves a distinct function and is tightly integrated, collectively ensuring the precision and reliability of the weighing process.

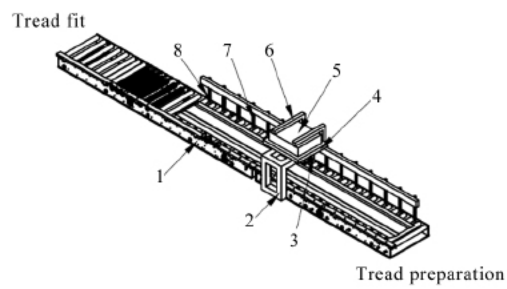
The fixed bracket serves as the installation base for the entire device. It is rigidly connected to the side of the conveyor roller bed frame through high-strength bolts, ensuring the structural stability of the entire weighing system in a dynamic production environment. A guide cylinder is installed on each side above the fixed bracket. The cylinder adopts a structure with a built-in guide rod, which not only provides sufficient lifting force but also effectively resists eccentric load moments, ensuring a smooth lifting and lowering process without shaking and avoiding the impact of lateral impacts on the scale body.

The piston rod end of the guide cylinder is connected to the tray via a flange. As a crucial component that serves as a link between the upper and lower parts, the tray not only bears all the weight of the upper part but also provides a stable installation platform for the weighing element. The platform scale is placed on top of the tray, with its legs firmly connected to the tray via bolts. The weighing platform is fixedly connected to the base of the lifting bracket, ensuring that all forces applied to the tread during weighing are accurately transmitted to the platform scale sensor.

Multiple L-shaped support rods are evenly installed along the conveying direction on the top beam of the lifting bracket. The surfaces of these support rods have undergone wear-resistant and anti-adhesive treatment, which not only ensures a sufficient contact area with the tread to reduce pressure and avoid tread deformation, but also facilitates smooth separation from the tread during the descent and resetting process. The upper surfaces of all L-shaped support rods must be coplanar to ensure even distribution of force when lifting the tread.

Near the weighing station of the conveyor roller bed, a photoelectric sensor is installed to detect the positioning of the tread conveyor.

In the entire system, the pallet, platform scale, lifting bracket, and L-shaped support rod jointly constitute a complete lifting and weighing unit, which is synchronously driven by two guide cylinders to achieve integrated lifting. When the guide cylinders are retracted, the upper surfaces of all L-shaped support rods are slightly lower than the upper surface of the conveyor roller bed. However, when the cylinders extend to the end of their stroke, the L-shaped support rods will be lifted to a height slightly above the surface of the roller, thereby completely lifting the tread off the roller and creating conditions for effective weighing.



1-Conveyor roller bed; 2-Fixed bracket; 3-Guide cylinder; 4-Tray; 5-Platform scale; 6-Lifting bracket; 7-L-shaped support rod; 8-Photoelectric sensor

Figure 1 Overall layout of tread weighing device

3 Working principle and process

The working process of this system is an orderly and automated cycle, which can be divided into four consecutive stages and is centrally controlled by a PLC program.

Standby and Conveying Stage: After system initialization, the guide cylinder is in a retracted state, as shown in Figure 2. At this time, the upper surfaces of all L-shaped support rods are slightly lower than the upper surface of the conveyor roller bed, forming an unobstructed conveying channel. The tread is driven by the drive motor and conveyed forward at a constant speed on the roller bed, smoothly passing through the weighing station without any impact on the entire process. During this stage, the control system reads and records the readings of the platform scale in real time. This weight value W1 is automatically calibrated by the system as "tare weight", which is the total weight of all lifting components such as the tray, lifting bracket, and L-shaped support rod. This is to facilitate automatic zeroing and compensation for the subsequent implementation of the "difference weighing method", and is a basic prerequisite for ensuring measurement accuracy.

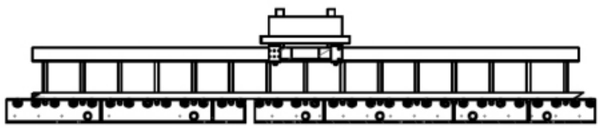


Figure 2 Tread weighing device guide cylinder in retracted state

Triggering and lifting stage: When the tread runs along the conveying direction and its front end reaches the detection area of the photoelectric sensor, the sensor immediately detects the object and generates a switch signal, which is collected by the PLC. Upon receiving this signal, the PLC first issues a command to control the drive motor of the conveyor roller bed to stop rotating, ensuring that the tread stops accurately at the predetermined weighing position. Subsequently, the PLC controls two guiding cylinders to act synchronously, pushing the entire weighing unit (tray, platform scale, lifting bracket, L-shaped lifting rod) to rise vertically as a whole. The L-shaped lifting rod first contacts the bottom of the tread steadily, and then, under the continuous pushing of the cylinder, overcomes the weight of the tread and steadily lifts it from the roller. The guiding cylinders are fully extended, as shown in Figure 3.

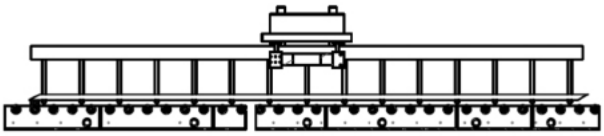


Figure 3 Tread weighing device - guide cylinder extended state

Weighing and recording stage: When the guide cylinder is fully extended and remains stable, the tread is completely suspended in the air, completely disconnected from the conveyor system, and is in a static and stable state. After the platform scale reading stabilizes completely, the weight reading W2 at this time is collected. W2 is the sum of "tare weight" (W1) and "net weight of tread". The algorithm built into the control system automatically performs the calculation: net weight of tread = W2 - W1, thus obtaining the true weight of the tread after deducting the tare weight. This data, along with information such as time and production batch, is saved to the local database and uploaded to the upper-level Manufacturing Execution System (MES), where it is bound to the tire information that this tread will be used to construct, laying a solid data foundation for quality traceability throughout the entire process.

Lowering and Resetting Phase: After the weight data is recorded, the PLC issues a command to control the guide cylinder to retract, driving the entire weighing and lifting system to lower smoothly. The L-shaped support rod subsequently descends, gradually separating from the bottom of the tread, and finally placing the tread back onto the conveyor roller bed that has stopped rotating. Once the system detects that the weighing unit has fully lowered to its initial hidden position, the PLC starts the drive motor of the conveyor roller bed again, conveying the weighed tread to the next station for subsequent bonding operations. The system then resets and automatically enters the next standby and conveying phase, waiting for the arrival of the next tread, repeating this cycle.

4 Analysis of advantages

Compared to traditional offline spot checks or other online weighing solutions, this sinking tread weighing system possesses the following notable advantages:

High-precision measurement: Due to the complete isolation of the tread from the conveyor system during weighing, the platform scale only bears the "tare weight" and the tread weight, effectively avoiding factors such as friction, vibration, and motor interference. Combined with the automatic compensation of the tare weight using the "difference weighing method", the system can obtain stable and reliable tread net weight data, fully meeting the strict data requirements for process parameter control in high-quality tire manufacturing.

Data traceability: This system achieves 100% full inspection of every tread on the production line, completely changing the outdated model of relying solely on manual offline and spot checks. The weight data obtained is no longer isolated information, but is automatically associated and integrated into the Manufacturing Execution System (MES) through the network, becoming a key component in the quality archive of every tire throughout its entire lifecycle. This not only greatly facilitates rapid and accurate cause tracing in case of subsequent quality issues, but also provides effective data support for the process department to analyze weight fluctuations, optimize material formulations, and improve product uniformity.

Good compatibility: The "sinking" design of the device requires minimal installation space. It can be seamlessly integrated into newly designed tire building machines as a standard functional module, and can also be quickly retrofitted onto existing old equipment with minimal modifications. This "plug and play" feature enables tire manufacturers to cost-effectively upgrade and modernize old production lines with automation and intelligence, without significantly affecting existing production, and with a significant return on investment.

High reliability: The mechanical structure utilizes mature and reliable standardized components such as guide cylinders and rigid supports. It is simple, sturdy, and durable, inherently adaptable to harsh industrial environments common in tire production workshops, such as dust, oil contamination, and temperature differences. Additionally, the modular design greatly simplifies routine inspections and maintenance tasks. Even if a component (such as a sensor or cylinder) malfunctions, it can be quickly replaced, minimizing system downtime and ensuring stable production rhythms.

5 Conclusion

This article designs and elaborates on a kind of automatic tread weighing device based on a sinking lifting structure, which successfully solves the problem of the lack of efficient and precise online weighing methods at the tread feeding station of the tire building machine. Through ingenious mechanical structure design, the device achieves efficient functional coordination and effective physical isolation between the weighing unit and the material conveying unit under space-constrained conditions, fundamentally ensuring weighing accuracy.

Its highly automated and integrated design enables automatic collection, calculation, storage, and uploading of tread weight data, and completes information integration with the production management system. It provides indispensable key data support for the whole process quality traceability, process optimization, and lean management of tire production, and is an important part of building a smart tire factory. The system has stable performance, high measurement accuracy, good compatibility with new and old equipment, low manufacturing and maintenance costs, high promotion value, and broad application prospects. It provides a practical and feasible solution for the intelligent upgrade of the tire manufacturing industry.