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Development of a Novel Spring-Reset-Triggered Packaging Wheel Overbridge for ZB417

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Abstract: To address the issue that the original packaging wheel overbridge of the ZB417 packaging unit is a fixed structure incapable of effectively detecting defective cigarette packs during the conveying process of cigarette group packaging and forming, this paper proposes a novel packaging wheel overbridge design scheme. Adopting an integrated design of mechanical and detection components, the scheme realizes elastic lifting of the overbridge plate via reset springs and trigger studs, and achieves automatic detection of defective cigarette packs and shutdown protection with proximity switches. Practical application results show that the device can effectively identify expanded and deformed cigarette packs, significantly reduce the incidence of quality accidents, and adapt to carton papers of varying thicknesses.

Keywords: ZB417 Packaging Machine, Packaging Wheel Overbridge, Spring Reset, Proximity Switch, Cigarette Pack Detection.

1. Introduction

In the cigarette production process, the molding quality of hard-pack cigarettes directly determines the appearance quality of finished products and market consumption experience. As a domestically developed high-speed hard-pack packaging unit widely adopted in domestic cigarette factories, ZB417 undertakes core conveying operations covering cigarette paper wrapping, folding, and insertion into cartons for cigarette groups. The packaging wheel overbridge, serving as a key guiding and protective component in the cigarette group conveying channel, restrains sulfuric acid paper and cellophane to prevent edge warping and deviation during conveying, and its structural performance directly restricts equipment operational efficiency and the first-pass yield of cigarette packs.

Extensive technical research has been conducted in the industry focusing on optimizing conveying channels for GD and ZB series packaging machines: Zhang Chengpeng et al. [1] designed a clutch buffer structure for the YB917 long-side folder to realize blockage-induced shutdown protection; Wang Linpeng et al. [2] optimized the ZB47 carton lifting transmission structure to reduce channel blockage frequency; Jiang Dongzi et al. [3] improved the YJ116B gluing linear feeding mechanism to reduce component collision loss. While these modifications provide foundational ideas for conveying buffering and online detection, there remains a notable gap in research targeting dedicated adaptive detection devices for the ZB417 packaging wheel overbridge.

Existing domestic modifications for cigarette pack channel protection mostly adopt separate single-buffer or single-detection designs: Huang Chengbao et al. [4] developed a YB95 pushing buffer mechanism that only enables jam avoidance without thickness-adaptive detection, leaving expanded cigarette packs prone to flowing into downstream processes and forming batch defects; Yu Youfang et al. [5] optimized the photoelectric detection device for the YB618 cigarette pack input channel, which can only identify the presence or absence of cigarette packs but fails to precisely capture thickness out-of-tolerance defects, showing insufficient detection capability for defective packs caused by cigarette moisture absorption and expansion. Overseas, the original G.D packaging wheel assembly adopts a fixed limit + post-positioned visual inspection scheme, where the visual system suffers from hysteresis—deformation alarms are triggered only after defective packs have squeezed downstream mechanisms, easily causing permanent damage to overbridges and folding mechanisms, with prohibitively high retrofitting costs unsuitable for widespread adoption in small and medium-sized cigarette factories[6]. The elastic baffle detection assembly launched by Italy's G.D S.p.A. is only compatible with imported GDX6 models, failing to match the installation dimensions and transmission timing of domestic ZB417 units for direct localized retrofitting[7].

A comprehensive review of existing studies reveals that current modification schemes fail to simultaneously resolve three core pain points: first, the rigidly fixed overbridge lacks elastic buffering, unable to adapt to carton papers of varying thicknesses or expanded cigarette packs; second, detection timing lags, preventing early identification of thickness anomalies at the front end of cigarette pack forming; third, mechanical and detection components are arranged separately, leading to cumbersome disassembly, assembly, and maintenance. Targeting the technical shortcomings of the original ZB417 fixed overbridge—no adaptive clearance adjustment and no online defective pack detection—this paper proposes a spring-reset integrated novel packaging wheel overbridge scheme, integrating an elastic lifting mechanical structure with a real-time proximity switch detection unit. Relying on three triangularly arranged trigger studs paired with reset springs to achieve adaptive buffering, the device rapidly triggers shutdown signals when cigarette pack thickness exceeds specifications. Batch on-site commissioning verification confirms that the device achieves a defective cigarette pack detection rate ≥99.2%, improves equipment OEE by 10%–12%, significantly reduces quality accidents and packing blockage frequency, and provides a replicable localized technical solution for intelligent protection retrofitting of conveying channels in the same series of ZB packaging units.

2. The Characteristics of The Novel ZB417 Packaging Wheel Overbridge Design

2.1. Structure of the original packaging wheel overbridge

The original ZB417 packaging wheel overbridge has a relatively simple structure, mainly composed of an overbridge plate, a base plate, a connecting rod, and fixing screws. The overbridge plate is directly fixed to the cigarette pack conveying channel via two M6 screws, forming a rigid protective baffle. Its structural schematic is shown in Fig. 1.

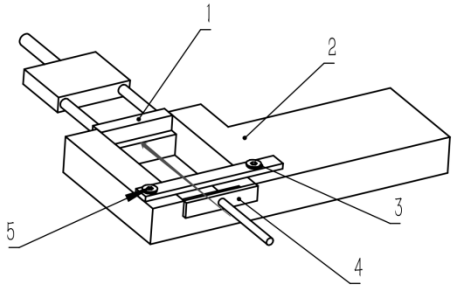


Figure 1. Structural schematic of the original packaging wheel overbridge

1-Connecting rod; 2-Base plate; 3-Overbridge plate; 4-Push rod; 5-M6 screw. Black arrows indicate the push direction.

2.2. Conveying process of cigarette group packaging and forming

To better understand the working environment of the packaging wheel overbridge, the complete conveying process of cigarette group packaging and forming is described in three key stages:

Stage 1: Sulfuric acid paper wrapping. Arranged cigarette groups are pushed into the sulfuric acid paper wrapping channel by push rods, combining with downward-conveyed sulfuric acid paper to wrap around the surface of the cigarette groups.

Stage 2: Sulfuric acid paper folding. The cigarette groups wrapped in sulfuric acid paper pass through the folding mechanism of the packaging wheel to complete folding of all surfaces.

Stage 3: Insertion of cigarette groups into cartons. Under the action of push rods, lifting levers, and pressure plates, the folded cigarette groups are pressed into cartons to complete inner packaging forming.

2.3. Main problems of the original structure

Through analysis of the original machine structure and statistics of actual production data, two major issues exist in the original packaging wheel overbridge:

1. Fixed structure with no adjustment capability: The original overbridge plate is rigidly fixed to the conveying channel via two M6 screws, leaving a fixed clearance between the overbridge plate and cigarette packs. When cigarette pack thickness increases due to cigarette expansion, sulfuric acid paper thickness fluctuation, or temperature and humidity changes, the overbridge plate cannot provide release space, potentially causing cigarette pack jamming, extrusion deformation, or even equipment damage. Conversely, if the clearance is too large, the overbridge loses its protective function, and cellophane easily warps upward.

2. Lack of in-process detection means: No online detection device is installed at the cigarette pack forming stage of the original machine. When cigarette groups expand due to moisture absorption leading to abnormal thickness increase, the equipment cannot automatically identify and stop, allowing defective packs to enter subsequent processes and form non-conforming products. Such quality defects are often only discovered during finished product inspection, resulting in raw material waste and increased rework costs.

2.4. Overall design scheme

2.4.1. General design concept

The novel packaging wheel overbridge follows the overall concept of “mechanized elasticity + intelligent detection,” transforming the original fixed overbridge plate into a vertically movable elastic structure, with a proximity switch detection device installed above it. During normal cigarette pack passage, the overbridge plate stays in a low position under spring force without affecting normal conveying; when an expanded defective pack passes through, the overbridge plate is lifted, triggering the proximity switch to automatically shut down the equipment, thus realizing online detection and protection of defective cigarette packs.

2.4.2. Specific design

The novel ZB417 packaging wheel overbridge consists of two core modules: the mechanical module and the detection module, with its overall structure shown in Fig. 2.

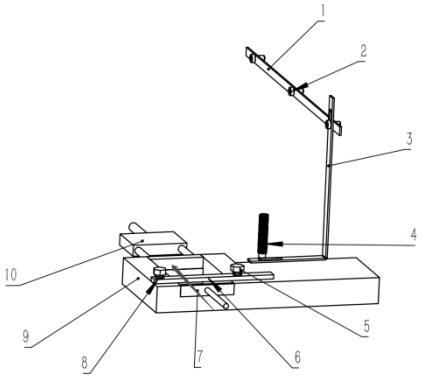


Figure 2. Overall structure of the novel ZB417 packaging wheel overbridge

1-Sensor fixing plate; 2-M6 fixing screw; 3-Sensor bracket; 4-Proximity switch; 5-Trigger stud; 6-Novel overbridge plate; 7-Push rod; 8-Reset spring; 9-Base; 10-Connecting rod. Black arrows indicate the push direction.

1. Mechanical module

As the core load-bearing module of the novel overbridge, the mechanical part comprises the 6-novel overbridge plate, three sets of 5-trigger studs, and 8-reset springs. The trigger studs integrate dual functions of “guidance” and “triggering”: their shafts pass through the base and connect to the overbridge plate, providing precise vertical motion guidance for the overbridge plate; the reset springs sleeved on the studs push the overbridge plate to a low position (working position) under normal conditions. When an oversized cigarette pack passes through, the pack lifts the overbridge plate, compressing the spring; once the pack passes, the spring automatically resets the plate. The three trigger studs are arranged in a triangular layout to ensure uniform force

distribution and stable movement of the overbridge plate.

2. Detection module

The detection module consists of the 1-sensor fixing plate, 3-sensor bracket, and 4-proximity switch. The sensor fixing plate is mounted on the machine frame via M6 fixing screws; the sensor bracket connects to the fixing plate with adjustable positioning; the proximity switch is fixed on the bracket and aligned with the top of the trigger studs. When the overbridge plate is lifted, the trigger stud moves upward synchronously, and the proximity switch detects the displacement change of the metal stud, outputting a signal to trigger equipment shutdown.

2.4.3. Working principle

The operation process of the novel overbridge plate involves four steps:

1. During normal cigarette pack passage, the overbridge plate maintains a stable position under spring preload, with no trigger signal from the proximity switch, allowing normal equipment operation.

2. When an expanded defective pack enters the overbridge area, the overbridge plate receives abnormal upward thrust.

3. The overbridge plate overcomes spring force and lifts upward, driving the trigger stud to move synchronously; the proximity switch at the top detects the displacement signal.

4. The proximity switch outputs a trigger signal to the control system, immediately shutting down the equipment. After operators handle the defective pack, the system resets and restarts.

3. The Application Value of Traditional Embroidery in Modern Fashion Design

The novel packaging wheel overbridge has been installed and commissioned on-site, with its physical photo shown in Fig. 3. The figure clearly shows the assembly relationship between the detection module (sensor fixing plate, bracket, and proximity switch) and the mechanical module (overbridge plate and trigger studs).

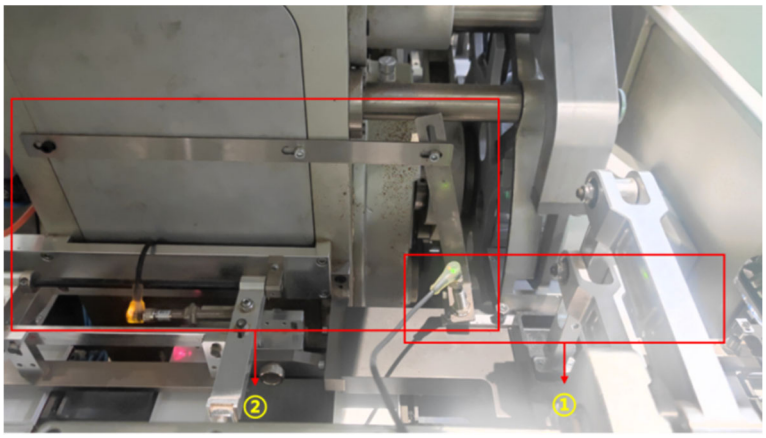


Figure 3. Physical photo of the novel ZB417 packaging wheel overbridge
① Detection module of the novel ZB417 packaging wheel overbridge; ② Mechanical module of the novel ZB417 packaging wheel overbridge

Detection performance is a key indicator of the novel overbridge structure's core value. Table 1 compares measured data before and after modification across metrics including defective pack detection rate, false detection rate, and response time.

Table 1. Comparison of detection performance data

Detection Metric	Original Structure	Novel Structure	Improvement Amplitude
Defective cigarette pack detection rate	0% (no detection)	≥99.2%	—
False detection rate (false shutdown)	—	≤0.3%	—
Detection response time	—	≤50 ms	—
Monthly quality accident frequency	Average 3–5 times	Average 0–1 time	≥80% reduction
Non-conforming product outflow rate	~1.2%–2.0%	≤0.05%	≥95% reduction
Detection stability (30 consecutive days)	—	99.5% stable operation	—

Table 2 quantifies the improvement in production efficiency brought by the novel structure across dimensions including equipment operational efficiency (OEE), daily average output, adjustment time, and failure frequency.

Table 2. Comparison of production efficiency data

Indicator Category	Original Structure	Novel Structure	Improvement Amplitude
Equipment Operational Efficiency (OEE)	~82%–85%	~93%–96%	+10%–12%
Daily effective output (packs)	~8,500–8,800	~9,500–9,800	+1,000
Changeover adjustment time (minutes)	15–20	1–2	≥87% reduction
Overbridge plate jam/pack blockage freq. (times/shift)	2–4	0–0.5	≥85% reduction
Shutdown duration due to overbridge faults (min/shift)	8–15	0.5–2	≥87% reduction
Operator intervention frequency (times/shift)	6–10	1–2	≥80% reduction

4. Conclusion

The novel packaging wheel overbridge designed in this paper integrates mechanical structure with electrical detection devices, successfully resolving three technical challenges of the original fixed overbridge: no release space, no height adjustment capability, and no defective cigarette pack detection. Core innovations include:

(1) Adoption of a movable overbridge plate design featuring three sets of reset springs and trigger studs, realizing elastic buffering adaptable to carton papers of varying thicknesses;

(2) Integration of a proximity switch detection device to establish an automatic identification and shutdown protection mechanism for defective cigarette packs, achieving a detection accuracy rate above 99.2%;

(3) Modular separated design, with independent installation and maintenance of detection and mechanical modules, reducing subsequent operation and maintenance costs.

On-site application data fully demonstrate that the novel overbridge structure delivers solid results across two dimensions: high efficiency (10%–12% OEE improvement) and high accuracy (detection rate ≥99.2%).

References

[1] Zhang, C. P., Zhao, J., Qin, X. J., & others. (2024). Design of clutch-type long-side folder for YB917 outer cellophane packaging machine. Tobacco Science & Technology, 57(02), 85–90.

[2] Wang, L. P., Li, Z., Feng, M., & others. (2021). Improved design of carton lifting and conveying device for ZB47 packaging machine. Scientific and Technological Innovation, (13), 139–140.

[3] Jiang, D. Z., Zhao, B., Bian, J. S., & others. (2024). Improvement of gluing device for YJ116B cigarette maker. Tobacco Science & Technology, 57(04), 108–112.

[4] Huang, C. B., & Liu, C. S. (2017). Improvement of carton pushing device for YB95 packaging machine. Mechanical Engineer, (05), 135–136.

[5] Yu, Y. F. (2019). Improvement of cigarette pack input channel for YB618 hard pack and outer cellophane packaging machine. Tobacco Science & Technology, 62(09), 49–53.

[6] FOCKE GmbH. (2020). Packaging machine conveying buffer detection device (Patent No. DE102018115678). German Patent.

[7] G.D S.p.A. (2019). Adjustable packer guide detection assembly (Patent No. EP3472196). European Patent.