Optimization of Trademark Paper Conveyor Timing Belt Tooth of GDXC \ YB47 Packaging Machine

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***Abstract*—The third conveying roller of GDXC \ YB47 packaging machine is the trademark paper conveying device. In the course of its use, its timing belt tooth is often blocked and fractured, thus the timing belt requires frequent replacement, cumbersome dismounting and long maintenance time. For the above reasons, conveying principle and structure of the timing belt is analyzed to optimize belt tooth arrangement. The belt tooth thickness is increased, and the number of timing belt tooth is reduced from the original four to two, thus normal conveying requirement of trademark paper is satisfied, service life of timing belt tooth is prolonged. Meanwhile, the problem of tedious dismounting is solved, greatly reducing the maintenance costs and improving the maintenance efficiency.**

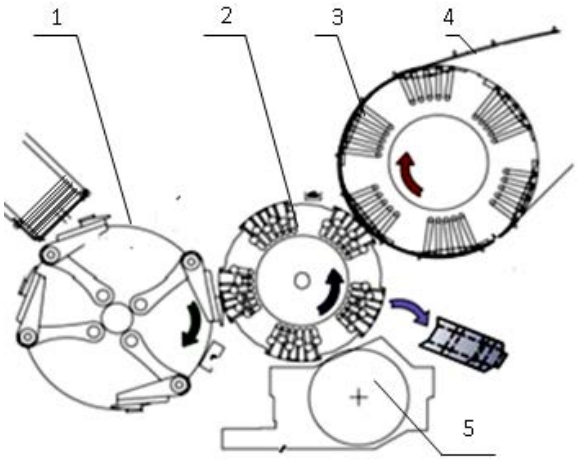
***Index Terms*—GDXC \ YB47 trademark paper conveying, timing belt tooth, fracture, arrangement mode**

I. Introduction

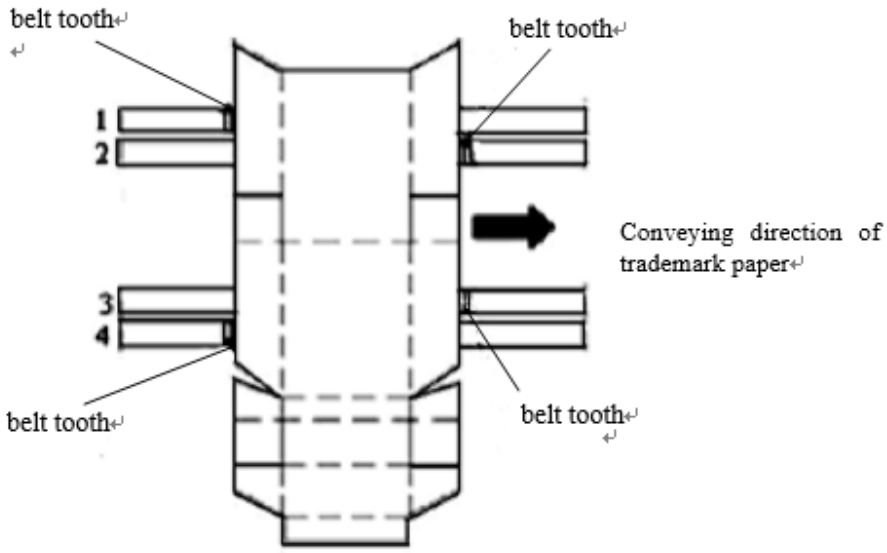
ZB47 packaging unit is a high-speed cigarette packaging unit designed and manufactured by Chinese tobacco machinery technology center after technology introduction and transformation. It has a maximum production capacity of 55 / min. It was found in its use that: for trademark paper conveyor timing belt tooth of the third conveying roller of GDXC \ YB47 packaging machine, belt tooth is often cracked or broken in the conveying after jammed by trademark paper [1]. Thus, it requires cumbersome and time-consuming dismounting and adjustment. The failure not only reduces equipment operation efficiency, but also adds maintenance intensity, and shortens service life of timing belt [2]. Therefore, this paper analyzes the structural device and optimizes technology, with service life of timing belt prolonged, replacement and maintenance times reduced, and the above issues solved [3].

II. Trademark Paper Conveying Principle

As shown in “Fig. 1”, the single capsule trademark paper is rotated clockwise and conveyed to the air suction plate of the second conveying roller 2 from the suction cup of the first conveying roller 1 after suction by the paper storehouse. The air suction plate of the second conveying roller sucks the trademark so that it is rotated and conveyed counterclockwise, to be transferred to the third suction drum 3 on the upper right of the conveying roller. Then, the trademark paper is conveyed forward, and air suction is stopped when the trademark paper is conveyed to the third conveying roller 3. Afterwards, the trademark paper is conveyed forward by the toothed frame of the timing belt tooth 4.



1. the first conveying roller 2. the second conveying roller 3. the third conveying roller
4. timing belt tooth 5. trademark paper rubber cylinder
Figure 1. Schematic diagram of the conveying principle of trademark paper



(1.2.3.4 first timing belt tooth)

Figure 2. schematic diagram of the combination of timing belt tooth

As shown in "Fig. 2", the first timing belt has a total of four teeth. Wherein, the first and the fourth timing belt teeth constitute pushing block of the model frame, while the second and third timing belt teeth constitute stop dog of the model frame. In this way, the four timing belt teeth make up a trademark paper conveying model frame. When the timing belt is in continuous rotation and the nine model frames continuously forward single sheet of trademark paper to the bottom entrance of the fifth wheel, a pair of trademark paper pushing blocks quickly push the trademark paper to the packaging position, thus completing conveying of trademark paper.

III. EXISTING PROBLEMS AND REASON ANALYSIS

A Existing problems

In the actual production process, for the trademark paper conveyor timing belt tooth of the third conveying roller, trademark paper jamming occurs frequently, which can easily cause timing belt tooth to be broken and replaced due to loss of usability.

After the timing belt is broken, in each replacement, the four timing belts need to be loosened, and parts like front rails, left rail brackets and trademark paper top folders need to be dismounted. Repositioning & adjustment of each timing belt is needed in its installation. The cumbersome process increases maintenance time and reduces effective operating rate of the equipment.

B Reason analysis:

First, observation reveals that: groove wear will appear on the belt tooth working face after a few months of normal use of timing belt. Such wear will cause instable conveying jitter during trademark paper conveying, so that trademark paper is skewed on the timing belt tooth, leading to frequent jamming of trademark paper.

Second, as the timing belt has a belt tooth thickness of only 4mm and the bonding strength with the belt surface is small, trademark paper jamming can easily cause the timing belt tooth to be broken, thereby equipment downtime. In this way, the only solution is to replace it with a new timing belt. Plus other reasons of the equipment, like quality problems of trademark paper accessories, inappropriate conveying passage adjustment, trademark paper jamming which breaks belt tooth occurs frequently. As a result, timing belt requires highly frequent replacement.

Finally, the conveyor device consists of four timing belts. Once one timing belt tooth is fractured, all the four belt teeth need to be loosened in replacement. Moreover, the four timing belts need positioning and tensioning one by one in installation, so the maintenance adjustment is cumbersome and time-consuming.

IV. DETERMINATION OF IMPROVEMENT PLAN

According to the trademark paper conveying principle and failure analysis, to increase the service life of timing belt, reduce consumption of parts, shorten the maintenance time and improve equipment efficiency, the key is to improve bonding strength of timing belt tooth surface and belt tooth abrasion performance, improve combination structure of timing belt tooth and belt tooth arrangement mode to solve its problem of cumbersome installation and adjustment.

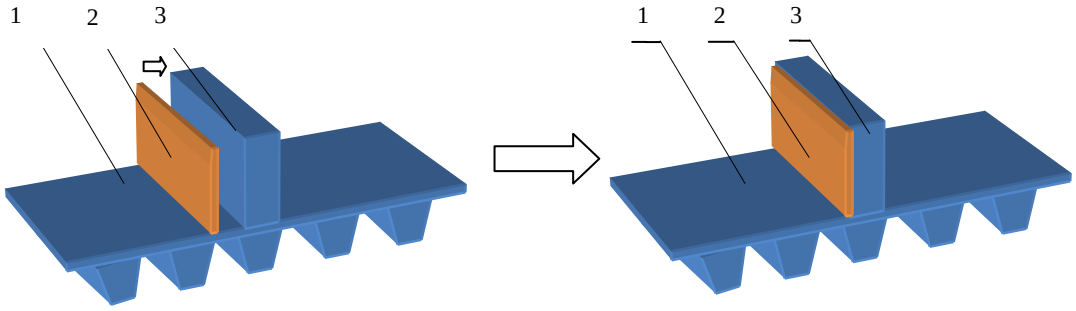
A Solution for easy belt tooth fracture

The original timing belt has a design belt tooth thickness of only 4mm and the bonding strength with the belt surface is small, causing easy squeeze and fracture as well as frequent replacement. For this phenomenon, three solutions are proposed according to structure and material characteristics of timing belt.

a Attach metal plate to the belt tooth

The solution is to attach the belt tooth working face with metal sheet in good abrasion performance, to enhance its wear resistance.

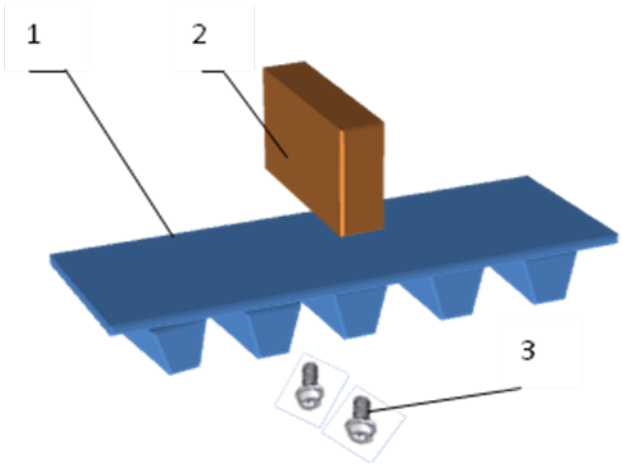
To analyze and investigate the solution of attaching the belt tooth working face with metal sheet in good abrasion performance, the trademark paper conveyor timing belt is studied in use. It is found that the attached metal sheet in "Fig. 3" often falls off, and the use effect is not idea. Moreover, for GDXC \ YB47 trademark paper conveyor timing belt tooth, attachment of metal sheet virtually reduces belt tooth thickness, reduces the bonding area between the belt tooth and timing belt, so the bonding strength will be reduced. In case of trademark paper jamming, belt tooth is more likely to be squeezed out, so this solution is not chosen.



1. timing belt 2. metal sheet 3. belt tooth

Figure 3. Schematic diagram of attaching belt tooth working face with metal sheet

b Use metal belt tooth



1. timing belt 2. belt 3. screw

Figure 4. Schematic diagram of fixing metal belt tooth with screw

As shown in "Fig. 4", produce belt tooth with metal materials, and fix it to the timing belt for increased wear resistance and strength. But the way to fix the metal belt tooth with the timing belt needs to be considered.

If bonding method is adopted, it is not easy to guarantee bonding strength due to great differences in characteristics of the two materials and belt tooth can easily fall off. The fixture with screw or bolt clamping is subject to limitation of the conveying device structure. The timing belt has a width of 10mm, but two holes need to be punched on the timing belt surface for passage of screw if double screw fixture is adopted, thus the tensile layer of the timing belt will be destroyed, leading to less service life of timing belt. Hence, this method is not applicable. Moreover, in case that the metal parts fall into the equipment, adverse consequences like equipment damage will be caused!

c Increase belt tooth thickness

The method is to appropriately increase belt tooth thickness, increase the bonding area while increasing its strength, to prevent belt tooth breakage in trademark paper jamming and prolong its service life.

Polyurethane material with good wear resistance and elasticity is still used. Only by appropriately increasing belt tooth thickness, increasing bonding area while

increasing the bonding strength, belt tooth breakage can be prevented in trademark paper jamming, so that its service life is prolonged. Therefore, this optimization solution is chosen.

B Solution for cumbersome replacement and adjustment

For the cumbersome replacement and adjustment of timing belt, the proposed optimization solution is to: change the arrangement mode of trademark conveyor timing belt tooth, and reduce the number of used timing belt.

In the original conveying device, a timing belt with evenly distributed four teeth constitutes a trademark paper conveying model frame for trademark paper conveying. Wherein, the innermost and outermost two timing belt teeth push the trademark paper, while the second and third timing belt only stop the paper. The design purpose is mainly to adapt to trademark paper in different specifications, so that model frame size can be easily adjusted when the trademark paper width varies.

As shown in "Fig. 5", after the product type of the equipment is determined, the model frame size adjustability loses its original meaning. Therefore, it is decided to add a tooth to the innermost and outermost timing belt to block the trademark paper so that normal conveying of trademark paper is realized. Also, the second and third timing belts are removed, to simplify the disassembly and adjustment steps, reduce maintenance time and maintenance intensity, while saving spare parts costs.

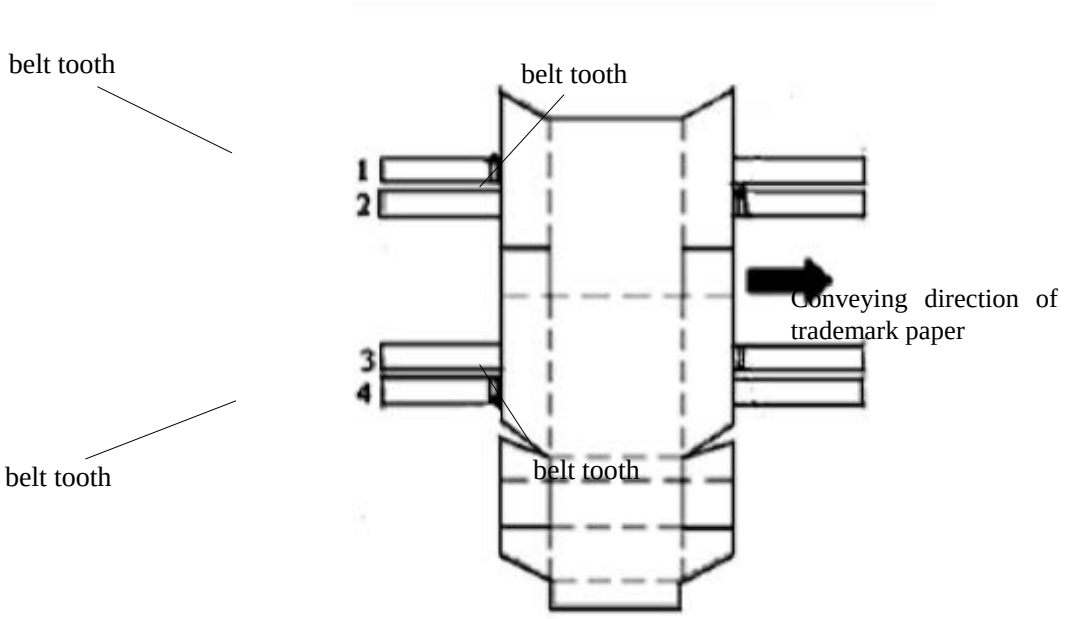


Figure 5. Schematic diagram of optimization solution for timing belt tooth

C Final establishment of the solution

The final optimization solution is determined based on analysis of various solutions:

First, choose similar materials with good comprehensive performance for tooth material, increase the belt tooth thickness;

Second, reduce the number of timing belt from the original four to two, install belt tooth to the belt so that model frame is formed for conveying of trademark paper.

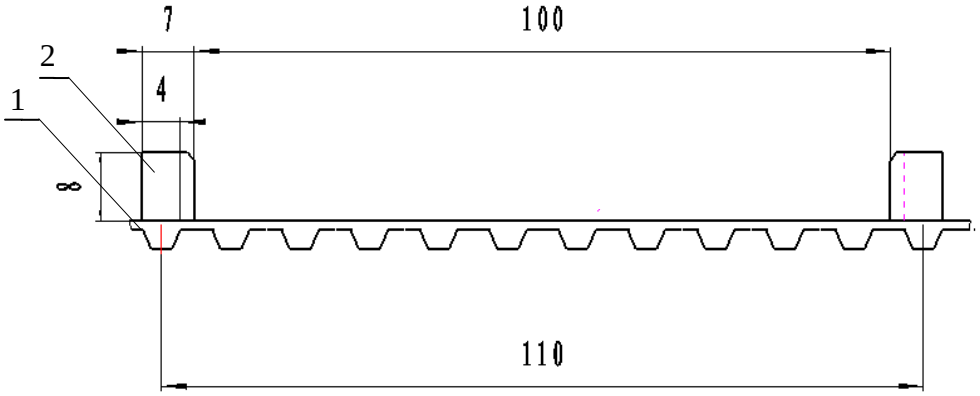
V. SOLUTION IMPLEMENTATION

A Determination of belt tooth thickness

According to the determined optimization solution, to increase the belt tooth service life, belt tooth thickness and size should be appropriately increased to increase the bonding strength between the belt tooth and the timing belt surface. As the device structure and timing belt size are not changed, specification and dimension of timing belt remains the same as T10 / 1530 × 10mm. According to the model frame size and the corresponding relationship between belt tooth and timing belt tooth, in datum point selection of timing belt position, one side of the original timing belt tooth is taken as the starting point which is just in the corresponding position of the root of the timing belt tooth.

In original trademark paper conveying, the two conveying belts stagger to form the working model frame with a cavity size of 100mm. For the newly designed timing belt, the two working belt teeth also have a spacing of 100mm, so that the two adjacent working teeth

are just at the location of 11 belt teeth: the 11 belt teeth have a spacing of 110mm. With the corresponding position of the 1st and 11th belt tooth root as the starting point, then the maximum extension to both sides is only 7mm and spacing of 100m between the two belt teeth is achieved, so the belt tooth extension is determined to be 7mm.



1. belt tooth 2. lug

Figure 6. Schematic diagram of belt tooth thickness design

As shown in "Fig. 6", under the premise that thickness does not affect the role of bending groove between the two timing belt teeth, the timing belt tooth thickness can be increased from the original 4mm to 7mm, to maximize its bonding area, without affecting normal use of the timing belt, thereby increasing service life of the belt tooth.

B Belt tooth layout

The original timing belt is provided with nine 4 × 8 × 10mm belt teeth evenly distributed on the toothed belt. The four timing belt teeth are staggered and installed on the belt pulley of the third suction drum. Wherein, the belt teeth on the first and fourth timing belt constitute the pushing block of the model frame, while that on the second and third timing belt constitute the stop dog of the belt tooth model frame. The conveying model frame has a cavity size of 100mm. The cavity size of the newly designed timing belt tooth model frame is still unchanged. The size of the belt tooth frame is determined and analyzed as follows:

Total length of timing belt: 1530mm, belt tooth thickness: 7mm, model frame cavity: 100mm

The length of the timing belt with length of 18 belt teeth removed: 1530- (18 x 7) = 1404 mm

The length of the timing belt with length of 9 conveying model frames removed: 1404- (9 x 100) = 504 mm

The model frame spacing is determined as: 504 ÷ 9 = 56 mm,

As shown in "Fig. 7", eighteen belt teeth are machined along the length direction of the timing belt with the standard belt tooth as the starting point, to form nine trademark paper conveying frames with a cavity size of 100 mm. Each frame, with a spacing of 56 mm, is evenly distributed on the timing belt. With belt tooth corresponding to each other as in the original cog belt, it can meet the conveying requirements of trademark paper. "Fig. 7" shows schematic diagram of belt tooth distribution in the newly designed timing belt.

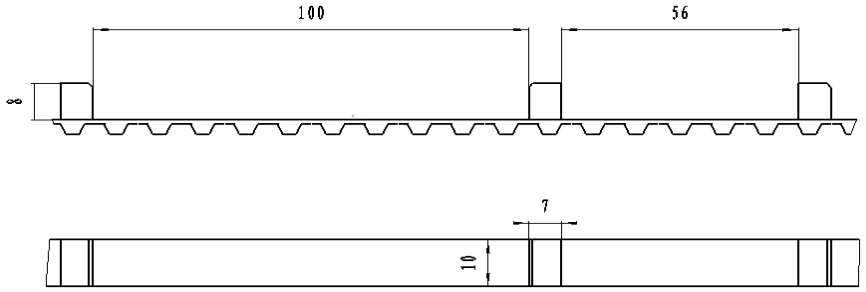
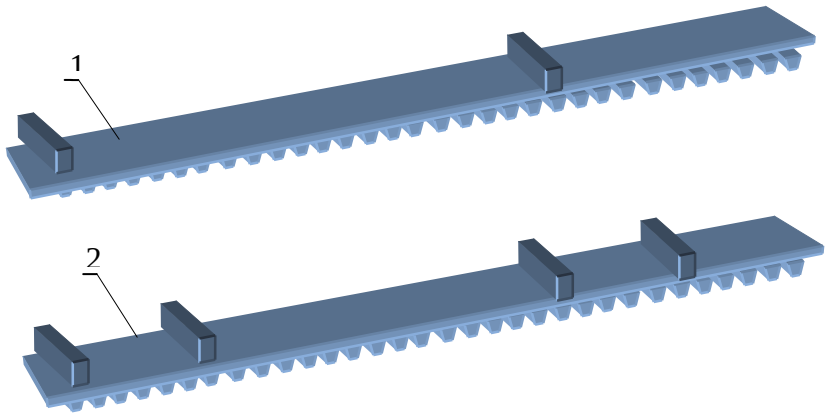


Figure 7. Tooth belt arrangement and size in the newly designed timing belt



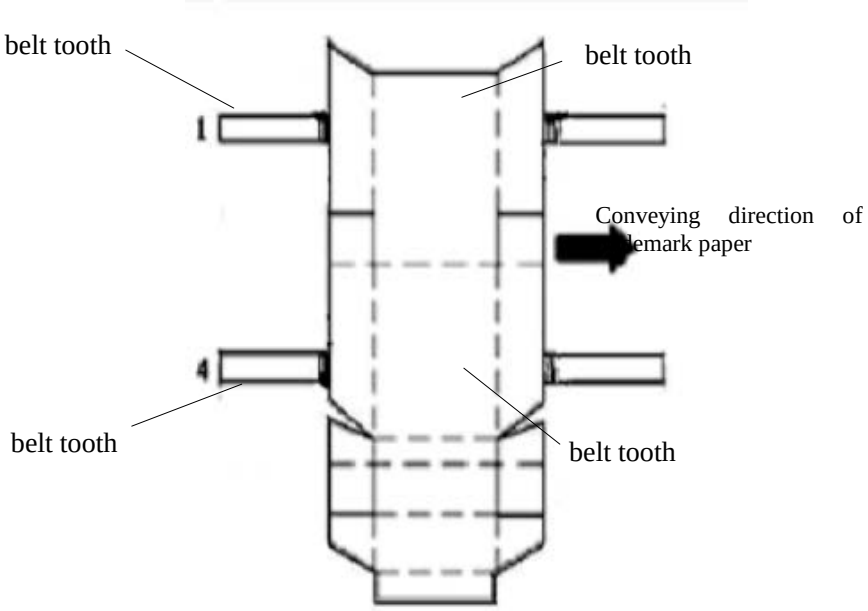
1. The original timing belt tooth 2. the newly designed timing belt tooth

Figure 8. Schematic diagram of belt tooth arrangement in the newly designed timing belt

C Improvement of assembly structure

To ensure stability in trademark paper conveying, the first and fourth timing belt teeth are designed as pushing block in the original design. Therefore, in the improved version, the first and fourth timing belts are maintained, while the second and third timing belts are removed.

After installation of the conveying belt, the role of the original four timing belts can be fulfilled with just two timing belts, as shown in "Fig. 9". Moreover, disassembly and installation are convenient and fast, greatly reducing the time for timing belt replacement and effectively enhancing effective operating rate of the equipment.



1. the first timing belt tooth 2. the fourth timing belt tooth

Figure 9. combination diagram of the newly designed timing belt tooth

VI. Verification of Improvement Effect

Before the transformation, the trademark paper conveyor timing belt tooth has a normal service life of a few months or so. Belt tooth breakage due to trademark paper jamming frequently occurs, which increases labor intensity of maintenance personnel, increases timing belt replacement frequency, causes large spare parts costs, reduces effective operating rate of equipment, and increases production costs.

After the transformation, the trademark paper conveyor timing belt has a normal service life of about six months, and belt tooth failure rarely happens. As two timing belts are reduced, timing belt replacement requires shorter maintenance time. Meanwhile, effective operating rate of equipment is improved, labor intensity of maintenance personnel is lowered and spare parts costs are reduced. The project has been applied in 4 sets of equipment in the workshop, with annual savings in spare parts costs as follows:

The number of timing belts that can be saved per

group of devices per year is 16-4 = 12 (piece)

The price of each timing belt; 4239.60 (yuan),

Annual savings per group of equipment 4239.6 × 12 = 50875.2 (yuan)

Annual savings of four groups of equipment 50875.2 × 4 = 203500.8 (yuan)

VII. Conclusion

Through the transformation of the trademark paper conveyor timing belt, tooth thickness is increased, new belt tooth arrangement is adopted, number of conveyor timing belt is reduced, and problems in equipment operation are solved. The improvement effect is significant, as the trademark paper conveying is more stable, effective operating rate of equipment is improved and maintenance costs are reduced. Practice has proved that transformation of this device can meet high-speed operation requirements of equipment, with device structure more concise and maintenance operations simpler.

References

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