Application of a kind of micro-angle seamless fan-shaped block in all-steel light truck radial tires

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Abstract: This article introduces a kind of structure for the bottom of the fan-shaped block of the tire blank in a two-drum light truck tire building machine, featuring a slight angle. This structure is applied to the 16" all-steel radial tire product. The purpose of this structure is to improve a series of defects in the bead area of the original fan-shaped block, such as bead bubbles, bead under-fill, and bead edge protrusion (bead width). The results show that after changing the fan-shaped block from a seamless to a seamless design, by deepening the depth of the fan-shaped block and increasing the angle at its bottom, the angle of the fan-shaped block is brought closer to the bead angle, thus achieving better compatibility with the steel bead. This improves the squeezing force of the fan-shaped block on the inner side of the tire blank after lifting, solving the problem of edge warping on the inner side of the tire blank, while ensuring the consistency of the tire bead shape with the contour of the bead mold.

Key words: fan-shaped block bottom curve; all-steel light truck tire; bead chip; bead bulge (bead width)

Classification number: TQ330.46 **Article number:** 1009-797X(2026)10-0012-05

Document code: B **DOI:** 10.13520/j.cnki.rpte.2026.10.005

0 Introduction

In the modern transportation sector, light trucks, as crucial tools for cargo transportation, have garnered significant attention regarding their performance and safety. Tires, being the sole component that comes into contact with the ground, directly impact the driving and safety performance of vehicles. Radial tires for all-steel light trucks occupy a pivotal position in the light truck tire market due to their high strength, wear resistance, and excellent load-bearing capacity. As the light truck industry continues to evolve, the demands for the quality and performance of radial tires for all-steel light trucks are escalating. Consequently, quality control and process optimization during production have become crucial tasks for tire manufacturing enterprises.

In the production of all-steel radial light truck tires, the quality issues at the bead area have always been a focal point within the industry. Defects such as bead bubbles, bead under-rubber, and bead edge protrusion not only affect the appearance quality of the tire but may also reduce its service life and even pose a threat to driving safety. Currently, numerous scholars and enterprises both domestically and internationally have conducted extensive research on improving tire manufacturing processes. Some studies focus on the selection of raw materials and formula optimization, aiming to enhance the overall quality of the tire by improving the performance of rubber materials; others concentrate on adjusting vulcanization process parameters to improve the physical properties of the tire. However, research on the impact of the fan-shaped block structure of the building drum on the quality of the bead area still needs to be further explored.

This study focuses on the production of 16" radial tires for all-steel light trucks at Fengshen Tire Co., Ltd. During the early stages of production, quality issues arose in the

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bead area of the tires. Despite measures such as adjusting the position of the steel bead seat, optimizing the width of the inner liner, and adjusting the overlap position, some quality defects remained unresolved. To fundamentally improve these issues and enhance product quality and production efficiency, this paper conducts an in-depth study on the fan-shaped block structure of the bladder forming drum of the two-drum light truck tire building machine. It proposes an application scheme for micro-angle seamless fan-shaped blocks, providing new ideas and methods for improving the production process of all-steel radial tires for light trucks. This has significant practical implications for enhancing the market competitiveness of tire manufacturing enterprises.

1 Product status

In current production practices, our company's all-steel light truck 16" tires are primarily manufactured using the LTR2-1 model from Beijing Hengchi Company. Production inspections have revealed that during the molding stage, the inner bead of the tire embryo exhibits severe edge warping, and the bead surface displays noticeable wavy indentations, indicating poor flatness. After entering the vulcanization process, the finished tires exhibit quality defects such as bead blisters, bead under-rubbing, and bead overhang (i.e., the bead width exceeding the standard range).

Addressing the aforementioned issues, this article conducts an in-depth study on this matter. Through on-site calibration, it was discovered that the landing point of the 16" product steel ring deviated from the standard position. During the on-site production process, adjustments were made to the steel ring's landing point, and the bead blistering issue was somewhat alleviated after these adjustments. Simultaneously, analysis revealed that there was room for optimization in the width of the inner liner and its overlap position with the tire side. After optimizing and adjusting the width of the inner liner and its overlap position with the tire side, the bead edge protrusion issue also improved. However, quality defects in other tire bead areas still persist, and have not been effectively improved or completely eradicated.

2 Problem analysis

To fundamentally address the quality issues at the bead area, this article conducts an in-depth analysis from both the perspectives of product contour design and equipment structure, and conducts comparative research with other machine structures. Through comprehensive analysis, the existing problems are as follows:

2.1 Structural issues of the forming drum

The all-steel light truck forming drums used by the company in the early stage mostly had a seam structure. During the production process, when the segment rises, there is a large gap between the locking blocks. This structural defect makes it extremely easy to produce tire blank bubbles during the tire blank forming process; at the same time, it leaves obvious segment impressions on the surface of the tire bead, directly leading to quality issues such as bead bubbles and bead under-fill in the finished tire, as shown in Figures 1 and 2.

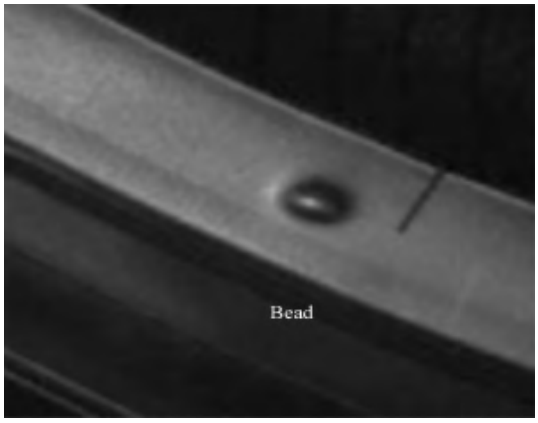


Figure 1 Bead blistering

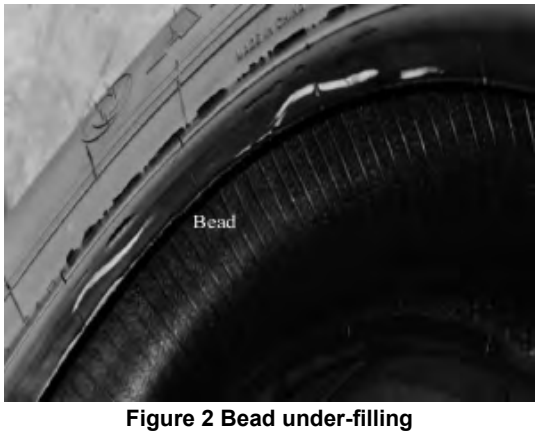


Figure 2 Bead under-filling

2.2 Rubber locking ring issue

The original 16" segment adopts a slit structure, and the rubber locking ring equipped on it gradually experiences changes in thickness and elasticity due to repeated friction, stretching, and other effects during long-term use. These

changes make the locking force of the segment on the carcass cord unstable, which in turn leads to quality issues in finished tires such as bead pull-up. In addition, although the rubber locking ring at the bottom of the original segment is angled, the steel ring is installed on the angled side. When the segment is raised, it stretches the rubber locking ring, resulting in the angle not functioning effectively in practical use.

2.3 Sector depth issue

The original 16" segment has a relatively shallow depth. After the segment is raised, the squeezing height and force on the inner bead of the tire blank are insufficient. This situation directly causes severe edge warping of the inner bead of the tire blank, as shown in Figure 3, which has a significant negative impact on the quality of tire molding.



Figure 3 Edge warping of the inner mouth of the embry o

2.4 Bead mold contour design issues

From the perspective of product bead mold contour design, the bead contour has a specific angle, as shown in Figure 4. However, there is a discrepancy between the shape of the bead after molding and the bead contour, which increases the operational difficulty during the tire assembly step of vulcanization production. During the tire assembly process, the chuck and the bead of the tire are prone to scratching, leading to finished product defects such as bead edge protrusion (bead width), as shown in Figure 5.

2.5 Difference in bead shape of tire blanks for different machine models

As shown in Figure 6, comparing the shapes of the tire blank bead produced by a two-drum light truck building machine and a three-drum light truck building machine reveals significant differences in the outer contour shape of the tire blank bead. The tire blanks produced by the three-drum building machine are relatively smooth during the tire mounting process, and the finished tires do not exhibit the defect of bead edge protrusion. However, the tire blanks produced by the two-drum light truck building machine with the same specifications have a relatively protruding outer contour of the tire blank bead. During the vulcanization tire mounting process, as the tire blank descends, the protruding part of the bead outer side is prone to rub against the vulcanization chuck, leading to frequent issues of bead edge protrusion. After comprehensive comparative analysis, it is found that there are unreasonable design aspects in the original all-steel light truck 16" segment, which urgently need improvement and optimization.

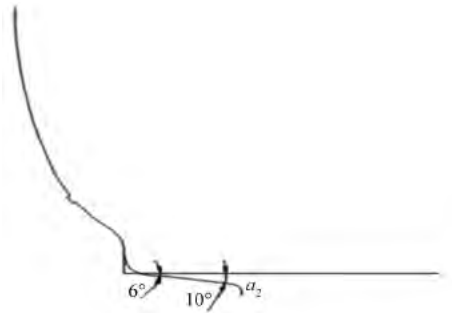


Figure 4 Schematic diagram of bead profile

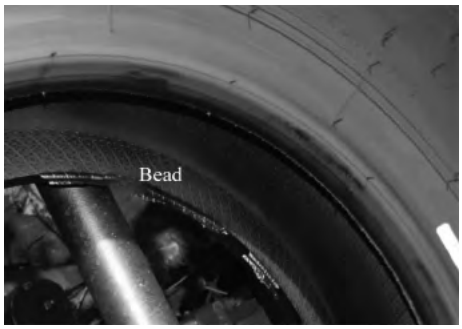


Figure 5 Bead edge protrusion

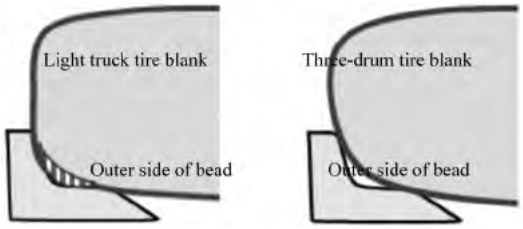


Figure 6 Comparison of bead shapes of tire blanks between a two-drum light truck building machine and a three-drum light truck building machine

3 Improvement methods

Through an in-depth analysis of the aforementioned series of issues, this article proposes a kind of application method for seamless fan-shaped blocks in all-steel light truck radial tires, and formulates comprehensive and targeted improvement measures. The aim is to fundamentally solve the persistent quality issues existing at the bead area of 16" all-steel light truck tires, and comprehensively enhance product quality and production efficiency.

3.1 Structural upgrading

The original segmented structure with seams was upgraded to a seamless structure, and the rubber locking ring at the bottom of the segment was removed. By measuring the thickness of the material under the bead and the thickness of the bladder, the expansion circumference parameters of the segment were redesigned to enhance the locking force of the segment on the bead area, thereby solving the quality defect of bead pull-up. The initial design of the segment had an excessively large expansion circumference, resulting in noticeable wavy patterns in the carcass cords during the molding process, and exposed cord at the bead after the tire blank was vulcanized. Through a second design improvement, the expansion circumference of the segment was reduced, and no finished product defects were observed after the tire blank was vulcanized.

3.2 Eliminate the gap between fan-shaped blocks to enhance the appearance quality of tire beads

The original design with seam-like segmented blocks resulted in certain gaps between the segments, which directly impacted the appearance quality of the bead area. Especially after molding, wavy indentations often appeared on the bead surface, affecting the appearance quality of the finished product and potentially leading to quality defects such as bead blisters and under-rubber. The new seamless segmented block design eliminates these gaps, resulting in a smoother bead area after molding, with no wavy indentations on the surface, and a significant improvement in appearance quality.

3.3 Increase the depth of the lock block

Upon analyzing the depth of the original fan-shaped block, it was discovered that its depth H1 is relatively shallow, as illustrated in Figure 7. This results in insufficient squeezing height and force on the inner bead of the tire embryo, leading to edge warping on the inner bead during the molding process. This severely impacts the appearance and performance of the product. Therefore, in the new design, we have increased the depth H1 of the lock block of the fan-shaped block, as depicted in Figure 8. This improvement effectively enhances the squeezing force and height applied to the inner bead of the tire embryo after the fan-shaped block is raised. It resolves the edge warping issue and ensures a more regular bead shape and smoother appearance.

3.4 Optimize the angle of the bottom of the fan-shaped block

In the original design, a rubber locking ring was set at the bottom of the segment, and the locking ring had an angle a1, as shown in Figure 7. The steel ring was located on the angled side. As the segment was raised, the rubber locking ring was stretched, but this angle did not fully function, resulting in uneven compression of the rubber compound, which affected the consistency of the bead shape. To improve this issue, the newly designed version increased the bottom angle a1, as shown in Figure 8, making the segment angle more aligned with the bead angle, thereby optimizing the fit between the steel ring and the rubber locking ring. At this time, when the segment is raised, the rubber compound can be compressed more evenly, stabilizing the locking force, improving the uneven distribution of the rubber compound, ensuring the consistency of the tire bead shape with the bead mold contour, reducing the bead edge protrusion issue caused by equipment differences, and enhancing the stability of the molding process.

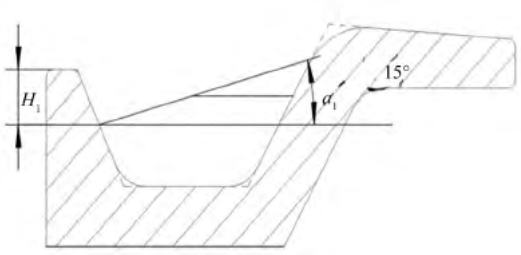


Figure 7 Original lock block

4 Conclusion

This study proposes an innovative application scheme for micro-angle seamless fan blocks to address the quality issues of the bead area during the molding process of all-steel 16" radial tires for light trucks. By optimizing the design of the

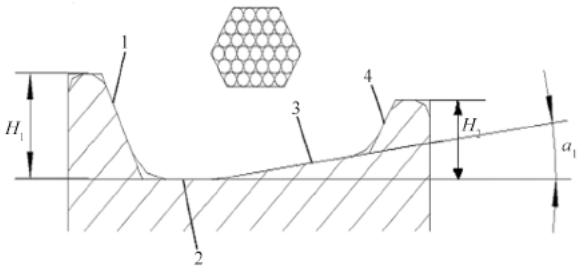


Figure 8 Newly designed lock block

fan block structure on the molding drum, the molding quality and production efficiency of the tires have been significantly improved. By optimizing the bottom curve and seamless structure of the fan blocks on the original two-drum light truck molding machine, the problems of wavy indentations and bubbles on the bead surface during the tire blank molding process have been successfully eliminated, improving the appearance quality and physical properties of the finished tires. Especially in terms of solving the issue of bead edge protrusion after vulcanization, optimizing the matching between the bottom curve angle and the bead mold contour has enhanced the consistency between the shape of the tire blank bead area and the mold contour, effectively preventing deformation and defects during production.

The technology proposed in this article reduces operational costs and quality risks, providing strong technical support for the company. In the future, with technological advancements and process improvements, this optimization scheme is expected to be widely promoted in tire production. Subsequent research can explore the optimization of molding processes for other tire models, especially the adaptability of different specifications and material combinations, in order to further enhance product performance and market competitiveness.

