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Enhancing Energy Efficiency and Sustainability in Fiber Removal from Saw Teeth during the Ginning Process

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Abstract. Efficient fiber removal in the cotton ginning process is critical not only for maintaining lint quality but also for ensuring operational safety and energy efficiency. This study focuses on the mechanical and maintenance-related factors influencing doffing performance in saw-type gins. Bent or damaged saw teeth inhibit effective lint removal and must be routinely straightened or replaced. Accumulated lint at the base of gin ribs, if not properly doffed, poses a significant fire hazard due to frictional heat generated by rotating saws. Proper engagement of the doffing brush with the full depth of the saw teeth is essential for effective lint clearance and for generating adequate air velocity to prevent fiber backlash. Brush performance depends on correct belt tension and the condition of the bristles, which require periodic inspection and replacement. Furthermore, worn or unbalanced brushes increase vibration and bearing wear, leading to energy losses and mechanical degradation. When field rebalancing is not feasible, brushes should be returned to the manufacturer for servicing. These findings highlight the importance of regular mechanical maintenance to improve energy efficiency, reduce fire risk, and enhance the sustainability of the ginning process.

1 Introduction

In the cotton ginning industry enterprises for separating fiber from cotton seeds. Saw gins of various brands are used: 4DP-130, 5 DP 130, DPZ The disadvantage of these saw gins is the deterioration of fiber quality due to the impact of a strand of fibers on the inner surface of the nozzle, low reliability, and high energy intensity of the process, which are consequences of incomplete removal of fiber from the saw teeth of the cylinder and the creation of a moment of resistance to rotation of the saw cylinder when the fiber hits the inner the surface of the nozzle, overcoming which requires significant torque and accordingly, energy[1]. The goal of our development is to increase collection efficiency while improving fiber quality increase reliability and reduce the energy intensity of the process [2].

The manufacturer gives specific instructions for setting the air-blast nozzles for each gin. These instructions ensure proper doffing and moting. Figure 1, -Important settings and adjustments for the Keep the nozzle clean and free of tags, and avoid damaging it or the gin saws when removing a saw cylinder [3]. Many tags may be prevented by periodically removing the cap from the end of the air-blast trunk and starting the fan to blow out the accumulation of dust and fines. Check the air-blast pressure frequently to make certain that the correct doffing pressure is being maintained. For some gins, the correct pressure will

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range from 10 to 18 inches of water. Sufficient pressure should be maintained to give proper doffing, but excessive pressure will waste power. Manufacturers can supply an adjustable air-blast fan valve by which the air-blast pressure can be readily adjusted (fig. 2.3). the air-blast fan intake must be equipped with a screen to keep foreign matter out of the fan. It is equally important that the screen be kept clean [4].

2 Materials and Methods.

An air blast or a rotating brush can be used to doff the fibers. Saw blades are categorized as either those that separate the fiber from above or below based on where the air nozzle is placed. The gin, which is cut from below when removing the fiber from the saw tooth, was the subject of scientific investigation in this study. The fiber separation airflow velocity has to be 20 m/s since the fiber flight speed is 3 m/s and the fiber separation airflow velocity v= 12 m/s. Actually though, the airflow leaving the nozzle travels at a speed of 65–75 m/s. The fact that diametrically opposite slots are formed in the air-receiving seed roll box of the saw gin relative to the upper wall of the air-injecting nozzle, while the slots have a parabolic profile, and the width of the slot in the space between the saws is $\mathrm{C} = (2-5)\mathrm{B}$, the length of the slot $\mathrm{L} = (0{,}2-0{,}5)R$, and the distance from the periphery of the saw to the end of the slot $I = (0{,}1-0{,}2)R$. where B is thickness; R- radius of the saw blade of the saw cylinder [5].

In fig. 1 shows a general view of the removal unit: Fig. 2 - section A-A in Fig. 1; in Fig. 3 - view from B in Fig.2.

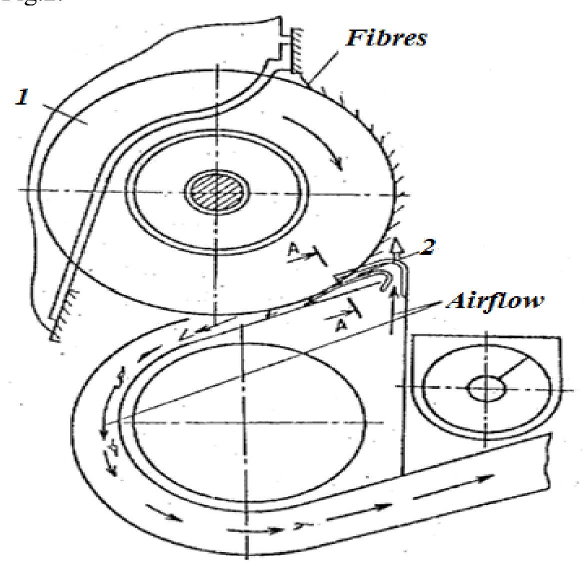

Fig. 1. Cross-sectional illustration of airflow-assisted fiber doffing from saw teeth

The proposed doffing nozzle contains a saw cylinder with saws and an air intake chamber with nozzles 2 located opposite each point of the cylinder, while the chamber nozzles have diametrically opposite slots 3 for the passage of saws towards the air intake.

The principle of operation is as follows. Strands of fibers torn from the seeds, when the saws 1 rotate, under the influence of centrifugal force and the force of their weight, the free end rushes towards the radius of the saws - they are straightened. When approaching the nozzles, 2 fibers move as far as possible from the center of the saws and in this position intersect the line of the nozzles [6].

Due to the formation of opposed slits in the nozzles 2, strands of fibers pass freely into the nozzle space, where they are acted upon by a directed air jet, which removes the fibers from the teeth of the saws 1 and transfers them to the suction jet [7].

Thanks to slot 3, there is no impact on the inner surface of the nozzles; the fiber strands pass through the field of action of the forced air stream with maximum straightening, and the midsection of the strands increases and they are subject to a greater removal force than with a known the doffing nozzles [6]. To further enhance the effect of the airflow on the strands, the nozzles should be brought closer to the periphery of the saws, which was impossible due to the lack of slots in the lower wall of the nozzles of the prototype of the doffing nozzle. This allows for the most complete removal of fibers from saws and increases the gripping ability of saws [8].

3 Results and Discussion

It was observed that there are two types of airflow in the zone separating the fiber from the saw teeth: one is the active airflow that is supplied to the saw from the fan through the nozzle, and the other is the ejection airflow that is drawn into this zone by the saw seals. Both air streams combine to form a working stream of air and are directed to the tube along with the fiber separated from the saw teeth [8]. The efficiency of the doffing nozzle device depends on the width of the air nozzle, the speed of the active airflow from the nozzle, the time the saw teeth are in the airflow, the length and curvature of the air guide, the ejection coefficient, the shape and location of the hole that receives the airflow with the fiber. The width of the nozzle gap depends on the volumetric flow rate of the active airflow per unit of time, which affects the doffing nozzle [9].

To reduce air consumption and improve the mixing of active and ejection air flows, the active airflow should be as thin as possible. But if the nozzle hole is smaller than 4 mm, it becomes difficult to separate the fiber from the saw tooth, if it is larger than 6 mm, the active air consumption and ejection air flow will also increase, making the work more difficult. A nozzle width of 5...5.5 mm is accepted for existing gins. The distance from the smallest gap (1.5...2 mm) between the saw cylinder and the guide surface to the saw is 30-35 mm [10].

Based on theoretical and experimental studies, it is proposed to make slots with a depth of $L = (0,2 - 0,5)R$. width in the initial section (in the spaces between the saws) $\mathrm{C} = (2 - 5)\mathrm{B}$. In this case, the distance from the end of the slot to the periphery of the saws should be $1 = (0,1 - 0,2)R$, where B is the thickness; and R is the radius of the saw.

B-section

Top view

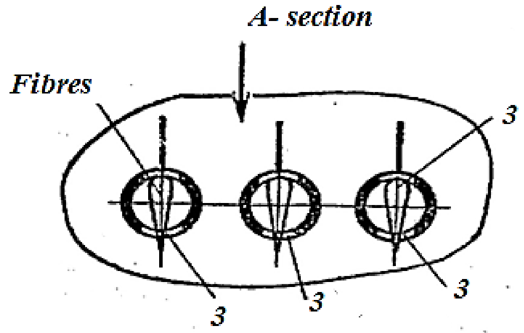

Fig. 2. Extracted profiles of fiber doffing from saw teeth: (A) initial stage, (B) advanced stage.

To reduce excess air consumption, it is proposed to make slots in the form of a parabola, since the beam of the fibers captured by the saw teeth is precisely this shape. The depth of the slot *L*and and the distance from the periphery of the saws to the depth of slot 1 is determined theoretically. Width C was established experimentally.

4 Conclusion

The nozzle facilitates more effective fiber removal from saw teeth, resulting in improved lint quality and a reduction in fiber entanglement and mechanical damage. Additionally, the system enhances the reliability of the ginning operation by minimizing mechanical wear and the risk of blockages, which in turn contributes to more stable and continuous processing. A notable advantage of the system is its ability to lower energy intensity, thereby reducing overall power consumption per unit of processed cotton. This improvement not only supports energy conservation goals but also contributes to cost efficiency. Economic assessments estimate that cotton factories implementing the new doffing system could achieve savings in the range of 8 to 12 million UZS per season, depending on operational scale and conditions.A practical application of this innovation has already been realized at the Uychi Ginning Factory in Namangan, where the nozzle has been successfully integrated into the production process. The early results from this implementation indicate measurable gains in productivity and process stability, underscoring the potential of the proposed system to contribute to more sustainable, high-performance ginning operations across the industry.

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