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SUBSTANTIATION OF THE DIRECTION OF RESEARCH TO INCREASE THE PERFORMANCE OF LINTERS

Abstract. *This article analyzes the development trends in linter design and the main shortcomings of 5LP linters used in cotton ginneries. The study examines the influence of such factors as working chamber volume, seed mass, saw cylinder, and seed agitator speed on linter performance. The discrepancy between the productivity specified in the technical documentation of 5LP linters and the actual productivity achieved under production conditions is also analyzed. The study demonstrates that the residence time of seeds in the working chamber and the density of the seed roller are important factors affecting the linting process. Based on the analysis, a research direction aimed at increasing linter productivity by increasing the volume of the working chamber and, consequently, the mass of the seed roller is proposed. The use of an improved working chamber, 160 saws, and a seed agitator with an increased diameter of up to 200 mm is also proposed to improve the efficiency of lint removal and increase overall linter productivity.*

Keywords: *linter, linting, working chamber, productivity, cotton seed, seed roller, saw cylinder, saw, seed agitator, lint, working chamber volume, seed residence time, cotton processing.*

INTRODUCTION

An analysis of the phased improvement of linters showed that the increase in production performance was mainly due to the following trends:

- an increase in the volume of the working chamber of the linter;
- an increase in the diameter and the speed of the agitator;
- an increase in the number of saws on the saw cylinder shaft.

At the same time, the performance actually achieved by the linters operated at domestic ginneries remains considerably below the values stated in their technical documentation, which makes it necessary to substantiate the direction of further research.

MAIN PART

Nowadays, in the technological process of seed linting, linters of the 5LP brand are used at ginneries (Handbook on Primary Cotton Processing, 1995). The machine consists of a feed roller 1, a levelling drum 2, a working chamber 3, an agitator 4, a saw cylinder 5, a luke extractor pipe 6, an air chamber 7, an auger for litter 8 and a perforated mesh 9 (Fig. 1). The linting process on these machines is carried out by feeding the flow of seeds into the working chamber of the linter and scraping the lint from the surface of the seeds with the saw teeth, after which it is taken out of the grate. As the seeds are freed from the lint and exposed, they stand out from the mass of the seed roller and are dumped onto the grate, along which they roll down onto the seed conveyor. The degree of lint removal is determined by the gap between the end of the vertical part of the agitator blade and the surface of the saw cylinder headset. Owing to the significantly low percentage of lint removal (1.5–2.0 %), it is difficult to remove the seeds from the working chamber, which leads to a long stay in the linting zone, increasing the mechanical damage to the seeds and reducing the quality of the lint. In addition, according to the technical specifications, the productivity of the 5LP linter during the first linting is 2000–2300 kg/machine-hour, during the second and third linting 1500–1700 kg/machine-hour and 1200–1300 kg/machine-hour respectively (Passport of the 5LP Linter, 1981). Experimental studies conducted in the field of cotton seed linting, as well as the practice of operating 5LP linters in production, showed that the 5LP linter equipped with a serial working chamber (UMPL) provides only 50–60 % of the performance specified in the passport (Sulaymonov, Karimov & Marufkhanov, 2016). The low productivity of the 5LP linter on seeds is characterised by the inefficient scraping of the fibrous cover from the surface of the seeds. Therefore, in order to ensure the required productivity of the plant in the production line, two batteries of linters

are installed in accordance with the regulations (Coordinated Technology of Primary Cotton Processing, 2016), each of which consists of 6 machines (12 units in total) of the 5LP type.

It is known that the process of linting, like the process of ginning, is carried out as a result of the interaction of the saw cylinder with the mass of seeds, which forms a seed roller rotating in the working chamber of the linter (Primary Cotton Processing, 1978). These processes differ in that raw cotton processed in saw gins consists of 30–35 % of spinnable fibre, 11–17 % of lint and 50–60 % of seeds, whereas linters process ginned seeds with a relatively small fibrous cover consisting mainly of short fibres.

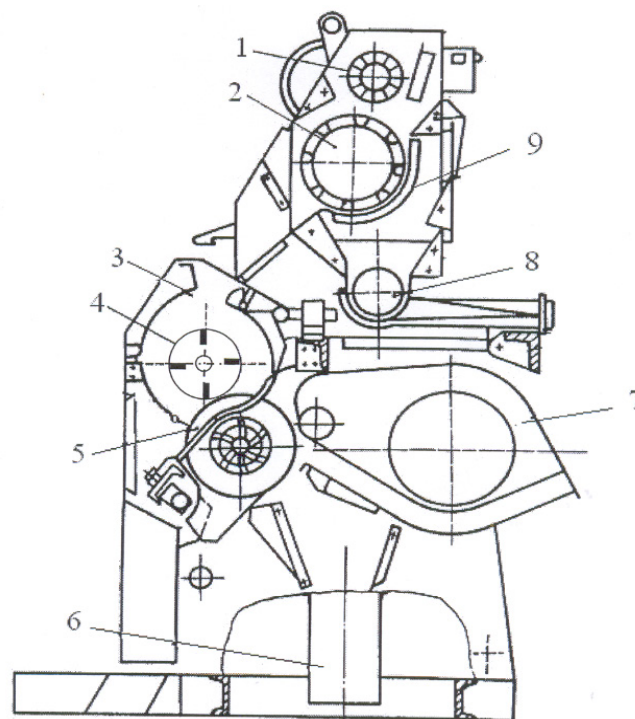


Fig. 1. Scheme of the 5LP linter

**1 – feeder; 2 – levelling drum; 3 – working chamber;
4 – seed agitator; 5 – saw cylinder; 6 – lute pipe; 7 – air chamber;
8 – screw for litter; 9 – perforated mesh.**

Owing to the high adhesion forces between the individual cotton balls, the impulse received from the saw cylinder is sufficient to rotate the raw roller in the working chamber of the gin. In linting, the connection between individual seeds is weaker, and a single impulse from the saw cylinder is not enough to rotate the seed mass in the working chamber of the linter. For this reason an agitator is installed in the working chamber in order to rotate the mass of seeds.

The course of seed linting is greatly influenced by the speed of movement of the tops of the saw teeth and of the agitator bars. For linters, the peripheral speed of the saw teeth is 12.2 m/s, and the peripheral speed of the ends of the agitator bars is 3.4 m/s. Because of such a relative speed in the area of the working impact of the saws, the seeds are, as it were, held by the bar of the agitator and by the mass of the compacted layer of the seed roller, and thereby acquire the stability necessary for the lint to be scraped from the surface of the seeds by the working edges of the saw teeth.

The resistance of the seeds is characterised primarily by the density of the seed roller: the denser it is, the greater their resistance. When the density of the roller is insufficient, the seeds are deprived of the necessary support and the linting process slows down.

The movement of the seed roller is limited by the volume of the working chamber. The renewal of the seeds in the working chamber occurs only after a certain period of time, so that the seed roller repeatedly performs a circular motion with the same seeds.

The residence time of the seeds in the working chamber is essential for ensuring high productivity of the linter. This is confirmed by the following equality, which takes into account the continuity of the linting process:

$$B \frac{100 - P_1}{100 - P_2} = q t = \frac{100 - P_0}{100 - P_2} \quad (1)$$

from which

$$q = \frac{B}{t} \cdot \frac{100 - P_1}{100 - P_0} \quad (2)$$

where:

q – seed linter throughput, kg/s;

B – seed roller weight, kg;

t – average residence time of the seeds in the working chamber, s;

P_1 – average pubescence of the seed roller, %;

P_0 – pubescence of the seeds entering the chamber, %;

P_2 – pubescence of the seeds emerging from the chamber, %.

If the ratio $(100 - P_1)/(100 - P_0)$ is denoted by k , then

$$q = k \frac{B}{t} \quad (3)$$

With a steady linting process under a certain lint removal regime, k may be considered a constant value; consequently, an increase in linter productivity can be achieved either

by increasing the mass of the seed roller or, with its mass held constant, by reducing the average residence time of the seeds in the working chamber (Primary Cotton Processing, 1978).

CONCLUSION

The objective of our research is to increase productivity, which can be achieved by increasing the mass of the seed roller in a working chamber of the linter with an increased volume, thereby increasing the productivity of the linter in removing lint.

On the basis of the analysis presented above, the direction of further research was chosen as follows: to use the working chamber of a gin shortened in length to the length of the working chamber of the 5LP linter, with gin grates polished to the required width, linter saws in the amount of 160 pieces with a saw-to-saw distance like that of a linter, and a seed agitator with a diameter increased to 200 mm. Owing to the distinctive features listed above, the mass of the seed roller in the proposed working chamber increases, since the volume of the gin chamber is 1.5 times larger than that of the 5LP linter; this makes it possible to improve significantly the operation of the linter equipment and to increase the productivity of the linter through more efficient lint removal.

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