
ANALYSIS AND MATHEMATICAL MODELING OF THE ENERGY CONSUMPTION OF LINTERING MACHINES IN COTTON CLEANING FACTORIES

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Abstract

Estimating energy consumption in the processing of cotton raw materials in a linter, determining the patterns of changes in electrical loads and relative energy consumption and the most favorable modes. Also, it is important to correctly determine the installed power of the electric drives of linter machines and determine the required power on the shaft of their motors, and analyze the energy performance of the enterprise and workshops.

Keywords: Lintering of fertilizers in industrial plants ,The intensity level of seed supply per liter ,total installed power of linters, efficiency of linters, comparative energy consumption of linters .

Introduction

Cotton seed linting processes in cotton ginning enterprises The cottonseed produced from the cotton gin process contains an average of 10-15% lint, depending on the selected variety of cotton. To separate this lint from the cottonseed, the linting process is carried out. In cotton ginning plants, linting of cottonseed is carried out in sawn linters that undergo various levels of intensive processing.

Depending on the need to remove one or another type of lint, the following technologies for linting seeds can be used - the first two-stage enhanced lint removal, the second two-stage enhanced lint removal and the third stage lint removal. These processes are carried out by the PMP-160M linter machine with a working chamber UPML, and by the 5LP and 6LP linters and units with saw teeth and strong air separation.

In saw linters, the linting process is based on the mechanical action of rotating roller saws with sawdust, as a result of which the teeth scrape off the fiber (lint) from the surface of the sawdust, which is then transported by air to the condenser.

The main indicators of linter performance are: the amount of lint removed from the grain, the rate of lint exiting the grain, and the linter efficiency.

Depending on the selected linting technology and the need to produce the required type of lint, taking into account the control of the linter's operation, the appropriate lint removal for each type of lint is studied through experiments by adjusting the linter's performance.

A comprehensive study of the linting process requires the identification of a number of factors that affect the main indicators of the linting process - productivity, the level of lint removal and its quality:

selection of seed, industrial variety and quality of fiber in the seed (amount of hairs); linter mode; condition of saws and their diameter; parameters of the working chamber of the linter and its working bodies and the speed regimes of the mixer and saw cylinder are calculated.

The effect of cotton selection and industrial varieties on the productivity of linting machines and linting quality is determined, in particular, by the significant difference in the linting characteristics of the seed after ginning. Depending on the need to obtain a particular range of lint, the appropriate linting technology is selected. To obtain a full range of lint, it is necessary to undergo a three-stage linting technology, the first one is obtained by removing 2%, the second one up to 4%, and the third one by removing 2% or more. Double linting, removing the first reinforced lint (up to 6%) ensures the maximum yield of the second type of lint, and in the second linting (with 2% removal), the third type of lint is produced.

The removal of lint in the first linting process by more than 6% leads to a significant unevenness of the produced lint along the length, which is related to the third type, as well as to an increase in its clogging. The technology of double linting with an increased secondary removal leads to an increase in the first type 1 lint (removal up to 2%) and an increase in the second type 3 lint with a linting of 6% or more [20; pp. 52-67].

During the first linting, the condition of the machine's working chamber and the agitator in it has a significant impact on the work efficiency. The most important factors in lint removal are the condition of the chamber and the agitator, the spacing of the agitator bars and saws, the protrusion of the saws, and the pitch of the saw teeth.

it is necessary to calculate the equations related to the work efficiency (while maintaining a certain lint removal) taking into account the 3 most important factors - the position of the working chamber relative to the saw cylinder, the speed of the mixer and the saw :

1st linting (2% lint removal):

$$A_1 = 1121 + 1,2n_{ny} + 15,7\alpha - 0,1n_{ny}\alpha + 0,2n_B\alpha, \text{ kg/h} \quad (1)$$

2nd linter (4% lint removed)

$$A_2 = 2431 - 1,5n_{ny} - 4,4n_B + 65,7\alpha + 0,006n_{ny}n_B - 0,006n_{ny} \text{ kg/h} \quad (2)$$

where - A_1, A_2 the productivity of the saw linter during the first and second linting of seeds, kg/h;

n_{ny}, n_B - rotational speed of saw cylinder and mixer, rpm ;

α - angle of rotation of the working chamber relative to the cylinder (5 LP from the main position in the linter), grad.

values $n_B = 600$ of $n_{ny} = 830,400$ the following factors $n_{ny} = 630$ is ensured in the experimental field; $\alpha = 10^\circ$.

While maintaining the position of the working chamber, as in the case of the 5LP linter, the equations are simplified and have the following form:

1st linting (linting removal - 2%):

$$A_1 = -301 + 1,2n_{ny} + 3,2n_B \text{ kg/h} \quad (3)$$

2-Lintering (Linter removal - 4%):

$$A_2 = 2431 - 1,5n_{ny} - 4,4n_B + 0,006n_{ny}n_B \text{ kg/h} \quad (4)$$

Based on the given data and based on the calculations obtained from the equations, it is possible to choose linter technology and its modes in order to increase the efficiency of lint production in cotton ginning enterprises.

Saw linters PMP-160M can replace low-performance linters with 5LP linters and provide the production of products with high quality indicators. The main difference between the 5LP linter and the PMP-160 linter is the enlarged working grain chamber. Adjusting the linting process with a grain comb changes the lint output from the grain and the machine's productivity. Increasing the distance between the grain comb and the grid reduces the removal of hairs from the grain and at the same time increases the grain throughput.

After setting a certain gap between the grain comb and the grid, it is possible to increase work productivity using an automatic control system, taking into account the optimal density of the grain on the roller in the working chamber for a certain length of lint production.

The pulse variator is designed to automatically control the supply of grain to the linter's working chamber by changing the rotation speed of the feed drum depending on the change in the density of the grain in the grain roller. The intensity of the supply of grain to the linter, its working efficiency, is established experimentally, taking into account the required density of the grain roller.

The change in the position of the load on the valve stem and its weight affects the density of the grain shaft and the efficiency of the linter. The constant load of the linter machine itself increases the efficiency of the grain linter and vice versa. Increasing the density of the valve stem is usually used when it is necessary to change the grain supply of the linter slightly.

Depending on the design of the linters, saws with a diameter of 320, 310, 300 and 290 mm are used. To facilitate the process of installing new cylinders or roller saws, it is recommended to try using one or another linter with a constant diameter in the linters. When installing saws of other diameters in the linter, the position of the air chamber and the grate is adjusted.

The saws are removed from the grate by adjusting the support bolts of the shaft under the grate and the suspension mechanism of the linter's working chamber. The separation of sawdust and foreign impurities from the lint is regulated by a sawdust cover that can be moved towards or away from the saw. Since the sawdust is processed three times in the linter after collection, we experimentally determined the energy consumption of each linter and the actual average work efficiency.

Mathematical models of energy consumption characteristics of PMP-160, PMP-160m and 5LP saw linters are expressed as follows:

For PMP-160 and 160M: for first output

$$P'_{\text{ПМП}} = 25,3 + 0,0018A'_{\text{ПМП}} \text{ kW}; \quad (5)$$

$$d'_{\text{ПМП}} = \frac{25,3}{A'_{5, \text{ПМП}}} + 0,0018 \text{ kWh/kg} . \quad (6)$$

for the second exit

$$P''_{\text{ПМП}} = 25,3 + 0,0021A''_{\text{ПМП}} \text{ kW}; \quad (7)$$

$$d''_{\text{ПМП}} = \frac{25,3}{A''_{\text{ПМП}}} + 0,0021 \text{ kWh/kg} \quad (8)$$

for the third exit

$$P'''_{\text{ПМП}} = 25,3 + 0,0028A'''_{\text{ПМП}}, \text{ kW}; \quad (9)$$

$$d'''_{\text{ПМП}} = \frac{25,3}{A'''_{5, \text{ПМП}}} + 0,0028 \text{ kWh/kg} \quad (10)$$

For 5 LP brand saw linters: for first release

$$P'_{5, \text{ПМП}} = 24,8 + 0,0016 A'_{5, \text{ПМП}} \text{ kW}; \quad (11)$$

$$d'_{5,III} = \frac{24,8}{A'_{5,III}} + 0,0016 \text{ kWh/kg.} \quad (12)$$

for the second exit

$$P''_{5,III} = 24,8 + 0,0022 A''_{5,III} \text{ kW ;} \quad (13)$$

$$d''_{5,III} = \frac{24,8}{A''_{5,III}} + 0,0022 \text{ kWh/kg.} \quad (14)$$

for the third exit

$$P'''_{5,III} = 24,8 + 0,0027 A'''_{5,III} \text{ kW ;} \quad (15)$$

$$d'''_{5,III} = \frac{24,8}{A'''_{5,III}} + 0,0027 \text{ kWh/kg.} \quad (16)$$

When operating at nominal capacity, the useful components and load losses of the multi-stage linters do not exceed 5-8% of the energy consumption.

From expressions (15) and (16) it can be seen that the average energy consumption of saw linters does not depend on productivity, and this obtained characteristic can be considered universal and describes the laws of changing the power consumption and relative energy consumption for fibers of different lengths produced by a saw linter.

The 6 LP linter machine is produced in 2 types according to its working function: 6 LP and LP-1 are designed to perform two final linting of seeds in one machine, and the linting process is carried out in the same way as in the PMP-160M and 5 LP saw linters. The 6 LP linter machine has two sectional saw cylinders, each with 160 saws .

6 LP-01 linter machine also has two section saw cylinders, each with 100 and 160 saws, which provide a 6% yield of first and second type lint. The high level of lint yield from the upper and lower linting sections, i.e. high work efficiency, is one of the main indicators of the machine.

During linting, the feeder is adjusted in the lower section of the machine's working chamber depending on the volume of grain on the roller. To increase the machine's productivity, it is adjusted by changing the lever connecting the density valve with the variator in the lower linting section of the working chamber, as well as by moving the load to the density valve lever.

The operating mode lasts for a long time with a constant load. The total installed capacity and working efficiency of the 5LP PMP-160M UMPL chamber saw linters can be seen in Table 1.

Table 1 Mathematical models of energy characteristics of PMP-160, PMP-160m and 5LP brand saw linters energy consumption b

No.	Arrali brand of linters	Installed power , kW	The work on Chigitl Ar b is productive , kg/h	S extraction energy consumption , kWh / kg
1.	PMP-160 PMP-160M	31.2	the first release of fiber 2000 second appearance 1700 It's his third appearance 1300	$d'_{IIMII} = 0,0156$ $d''_{IIMII} = 0,0184$ $d'''_{IIMII} = 0,024$
2.	5LP	30.6	the first appearance of the fiber 2300 the second release 1700 in the third release 1360	$d'_{5,III} = 0,0133$ $d''_{5,III} = 0,018$ $d'''_{5,III} = 0,0225$

Linting is carried out in each of the linting sections using grain combs similar to those used in the 5 LP saw linters. The removal of hairs and impurities from the grain is carried out by adjusting the air chamber covers of the upper section.

ensuring their stable operation, is achieved by moving the levers connecting the density valve of the lower section with the variator.

When starting the linter at high load, the upper column of the upper section should be lowered. To speed up the filling of the upper section with seeds, the lower column should be raised. The installed power of the 6LP linter machine is 61.2 kWt . The linter's operating efficiency is 88 kg/h for lint and 1180 kg/h for sawdust. The planned relative energy consumption of the linter is 695 kWt·h/t for lint and 52 kWt·h/t for sawdust.

Calculated formulas for power consumption and specific energy consumption depending on the performance of the linter were developed.

$$P_{6,III} = 44 + 0,009A_{6,III} , \quad \text{kW} \quad (17)$$

$$d_{6,III} = \frac{44}{A_{6,III}} + 0,009 , \quad \text{kWh/kg} \quad (18)$$

According to the expressions (17) and (18), the normative energy characteristics of the power consumption and specific energy consumption of the 6LP linter machine were constructed.

A study of the electrical load modes of the main machines and mechanisms of the cotton ginning industry showed that:

- estimate the energy consumption of all varieties of cotton raw material processed in each cotton ginning and linting machine, based on their design features and production technology;
- determination of the laws of change and the most favorable modes of electric loads and relative energy consumption for saw and roller gin machines, as well as linters. Determines directions for reducing inefficient energy costs by reducing maximum electric loads at the enterprise, reducing operating costs;
- development of a reliable empirical formula that allows to correctly determine the installed power of electric drives of jin-linter machines and to determine the necessary power falling on the shaft of the engine;
- the need to create a base for analyzing and predicting the energy indicators of the enterprise and shops as a whole was justified.

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