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Study of the Influence of Cotton Seed Quality on Electricity Consumption During Oil Production

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ABSTRACT: In this article, based on experiments, some factors influencing the specific energy consumption per unit of product at oil and fat enterprises are studied. The degree of influence of the variety and oil content of cotton seeds on the specific energy consumption per unit of product was noticed using the example of Kagan Oil Extraction Plant JSC. Based on the obtained mathematical models, characteristics were constructed and conclusions were drawn based on the characteristics.

KEY WORDS: electricity consumption, cotton seeds, influencing factor, seed variety, seed oil content, press oil, extraction oil, energy characteristics, meal, husk, electricity.

I. INTRODUCTION

In the production of cottonseed oil, in addition to systematically acting factors (changes in the production program), specific energy consumption is affected by independent factors, the action of which does not depend on the personnel of a given section.

To determine the influence of each individual factor on the specific energy consumption, we use two methods: the first is to isolate the influence of a given factor from other factors, and the second is to determine the net influence of the analyzed factor, taking into account the combined influence of the group of factors under consideration [1].

II. METHODOLOGIY

Let us consider the influence of each factor separately.

Influence of cotton seed variety.

At present, the industry's enterprises do not take into account the grade of seeds when analyzing and determining electric power indicators, and the total amount of vegetable oil produced is included in the calculation. The calculation and statistical method of standardizing electric power consumption adopted in the industry does not allow for taking into account the impact of both the quality of the processed seeds and the quality of the oil produced on specific electric power consumption.

Cotton seeds of all varieties are characterized by moisture, pubescence and contamination. The mixture of varieties in the ratio of 50% I-II and 50% III-IV is mainly fed for processing.

Considering that the processing conditions for each variety are different and lead to different productivity, we considered the issue of assessing the energy consumption indicators for processing the seeds of each variety.

To solve this problem, a method of processing statistical data on power consumption and productivity on a daily basis was used.

For greater reliability, the obtained formulas were verified by experimental measurements. The necessary and sufficient amount of data (N) to obtain equations (2-3) was determined at a significance level of 0.95 and an acceptable error (Ɛ) of 5% using the formula [2, 3]:

$$N = \frac{\sigma^2 \cdot t^2}{\varepsilon^2} \tag{1}$$

where $\sigma^2 = \frac{b}{\sqrt{N^1}}$ is the dispersion;

t – Student's coefficient;
b – sample range by argument;
N^1 – preliminary amount of data.
For example, for grade IV seeds according to the data of the Kagan Oil Extraction Plant at N^1=30.

Based on the data obtained by the Chebyshev method for the Kagan Oil Extraction Plant, the following expressions for the specific energy consumption (kWh per ton of processed seeds) were derived depending on the hourly productivity of the enterprise (As within 15-35 t/h) for seeds:

I-II varieties $$d_{I-II} = \frac{1464}{A_s} + 0{,}42 \cdot A_s \tag{2}$$

III varieties $$d_{III} = \frac{1464}{A_s} + 0{,}30 \cdot A_s \tag{3}$$

IV varieties $$d_{IV} = \frac{1464}{A_s} + 0{,}36 \cdot A_s \tag{4}$$

Similar dependencies, but with different numerical values, were obtained in [6] for YEUROSNAR LLC during mechanical transportation of meal and seeds. The nature of the dependencies we obtained and those described in [6] coincide.

The root-mean-square errors of equations (2) – (4), calculated using formulas [7], do not exceed ±1.5%.

The error of the results obtained on the basis of expressions (2) – (4) in comparison with the data of experimental measurements does not exceed ±2.8%.

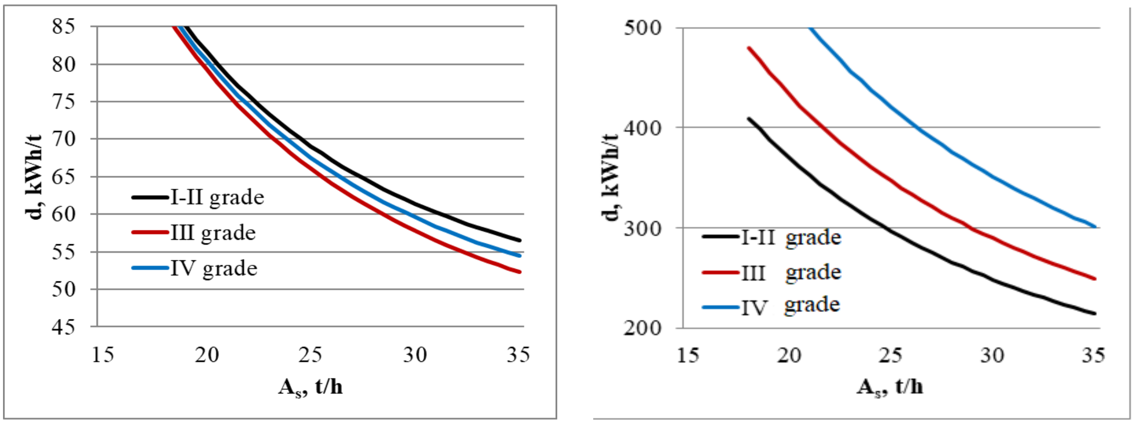
As can be seen from the curves constructed using formulas (2) – (4) (Fig. 1a), the processing of grade III seeds is the least energy-intensive; the specific energy consumption during the processing of grades I–II seeds are 7.44% higher, and grade IV seeds are 4% higher compared to grade III.

The studies we conducted confirmed the reliability of the results obtained in [8]: the ratios of specific consumption by grade are the same with the same productivity.

The increased energy intensity of other grades is explained by the greater efforts required for hulling and crushing full-weight seeds of grades I-II, and the greater specific gravity of solid particles (husks and empty seeds) when processing seeds of grade IV.

Thus, the research has confirmed the conclusion about the feasibility, from an energy point of view, of working with a seed mixture whose composition is close to the characteristic features of the third grade, since this grade has the lowest energy intensity.

The influence of seed grade on the specific energy consumption during oil production was also studied. Although the oil content value is not regulated by state standard when determining the grade of cotton seeds, in real conditions the oil content of seeds can be of decisive importance when determining the energy intensity of oil production obtained from seeds of different grades.



a) b)

Figure 1. Dependences of specific energy consumption per 1 ton of seeds (a) and oil (b) on productivity d=f(As) in seed grade.

Influence of seed oil content.

It is known that the seeds that are processed contain from 15 to 23% oil.

Due to different oil content with practically the same energy consumption for processing the same number of seeds, the specific energy consumption indicator may be different. Studies of the influence of this factor on the energy indicators in [9] are considered separately for both the pressing and extraction processes of production, and for the enterprise as a whole when producing black unrefined oil.

Below, using the example of the Kagan Oil Extraction Plant, we examine the effect of seed oil content on electrical energy indicators during the production of refined oil (products ready for sale).

The amount of cottonseed oil is determined by the oil balance [5, 7]:
- for press production

$$Q_{pr} = m_s \cdot Q_s - m_h \cdot Q_h - m_c \cdot Q_c - H_{pr} \quad (5)$$

- for extraction

$$Q_e = m_c \cdot Q_c - m_m \cdot Q_m - H_e \quad (6)$$

- for the plant

$$Q_p = m_s \cdot Q_s - m_h \cdot Q_h - m_m \cdot Q_m - H_p \quad (7)$$

where Q_{pr}, Q_e, Q_p – production of unrefined oil, respectively, in press, extraction production and by the plant, (t);
Q_s, Q_h, Q_m – seed processing, production of husks and meal, t;
m_s, m_h, m_c, m_m – oil content coefficients of seeds, husks, cake and meal;
H_{pr}, H_e, H_p – coefficient of unaccounted oil losses in press and extraction production and throughout the plant;

Oil balance analysis shows that the oil content of seeds and cake, as well as oil losses in the husk and meal, are the main technological factors influencing oil yield.

The dependence of specific energy consumption on the oil content of seeds in press production can be expressed by the formula:

$$d_{pr} = \frac{W_{pr}}{m_s \cdot Q_s - m_h \cdot Q_h - m_c \cdot Q_c} \quad (8)$$

where W_{pr} is the energy consumption in press production, kWh.

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Equation (8) is expressed through the specific energy consumption per ton of seeds (dsp) taking into account the coefficients of output of processed products and has the form:

$$d_{pr} = \frac{d_{spr}}{m_s - m_h \cdot K_h - m_c \cdot K_c} \tag{9}$$

where d_{spr} – specific energy consumption per 1 ton of seeds in pressing production, kWh/t;

$K_h = \frac{Q_h}{Q_s}$ – husk yield coefficient;

$K_c = \frac{Q_c}{Q_s}$ – cake yield coefficient.

During the calculated calendar period, the productivity of seeds, as well as the amount of oil loss in the husk and cake, have minor deviations from the average value, therefore, it can be assumed that

$$m_h \cdot K_h + m_c \cdot K_c = \alpha = const \tag{10}$$

Taking into account (10), expression (9) will take the form

$$d_{pr} = \frac{1}{m_s - \alpha} \cdot d_{spr} \tag{11}$$

For press production of the Kagan Oil Extraction Plant with productivity A_s=30 t/h; d_{spr}=46 kWh/t; m_h=0.0273, K_h=0.21, m_c=0.138; K_c=0.528, α=0.0786

$$d_{pr} = \frac{46}{m_s - 0{,}0786} \tag{12}$$

Figure 2 shows the curve (a) $d_{pr}=f(m_s)$, constructed using formula (12).

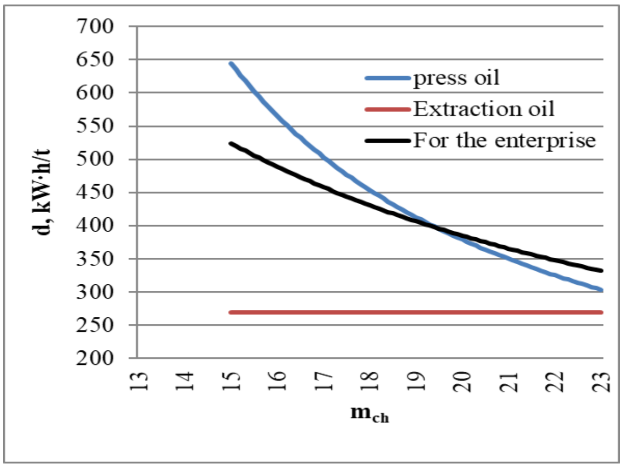

Figure 2. Dependence of specific energy consumption for oil production on the oil content of seeds:

For extraction production, the expression for the specific energy consumption per 1 ton of extraction oil, after similar transformations, will take the form

$$d_e = \frac{d_{se}}{m_c \cdot K_c - m_m \cdot K_m} \tag{13}$$

where d_{se} is the specific energy consumption for processing 1 ton of seeds in extraction production, kWh/t;

$K_m = \frac{Q_m}{Q_s}$ – meal yield coefficient.

Unaccounted oil losses (H_{pr}, H_e, H_p) are not included in formulas (8-13) due to their insignificant value ($H_{pr}=H_e=H_p$=0.01%).

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As can be seen from expression (13), the specific energy consumption per 1 ton of extraction oil does not depend on the oil content of the seeds (Figure 2, extraction production).

The plant-wide specific energy consumption depending on the oil content of seeds during the production of refined oil is determined from the expression

$$d_p = \frac{d_{sp}}{(m_s - m_h \cdot K_h - m_m \cdot K_m) \cdot K_{ro}} \tag{14}$$

where d_{sp} is the specific energy consumption per 1 ton of processed seeds at the plant, kWh/t;
at a given seed productivity

$$m_h \cdot K_h + m_m \cdot K_m = \beta = const \tag{15}$$

$$d_p = \frac{1}{(m_s - \beta) \cdot K_{ro}} \cdot d_{sp} \tag{16}$$

At A_s=30 t/h; d_{sp}=61.7 kWh/t; K_m=0.4212; m_m=0.0254; β=0.0115; K_{ro}=0.85 expression (16) will take the form

$$d_p = \frac{61,7}{(m_s - 0,0115) \cdot 0,85} \tag{17}$$

In Figure 2, the curve (plant) d_p=f(m_s) is constructed using formula (17).

Checking the calculated values with the actual ones gives an error in the specific energy consumption per ton of refined oil at the plant of about 2-3%.

Effect of seed moisture.

The influence of seed moisture on the specific energy consumption in oil production is manifested both as a result of changes in the weight ratio and as a result of changes in the oil content of the husk [6].

Basic seed moisture standards as a percentage of actual weight: 8, 10, 11, 13%, respectively for grades I, II, III and IV. Cotton seeds should be brought to conditioned weight by moisture (by grade) (A_c) using the formula [7]

$$A_s = A_a \cdot \frac{100 - V_a}{100 - V_n} \tag{18}$$

where A_a=A_s is the actual weight of seeds, t;
V_n – humidity norm in % of actual weight.

Thus, the coefficient of deviation of seed moisture from the norm will be

$$\varepsilon = \frac{100 - V_a}{100 - V_n} \tag{19}$$

Where does the dependence of the specific energy consumption for processing a ton of seeds take the form [4]:

$$d_s = \frac{P_i}{A_S \cdot \varepsilon} + \delta \tag{20}$$

Analysis of the operation of process units shows that an increase in seed moisture requires more power to overcome increased friction and adhesion during seed movement in augers, elevators, disk hullers, shakers and bitter separators, as well as in rollers. On the other hand, with an increase in seed moisture, fewer seeds (in terms of basic moisture), i.e. goods (kernels, meal, pulp), are supplied to rollers and presses, according to which the power for processing these seeds should decrease. As a result, it can be assumed that with a certain (given) seed productivity, the total power consumption practically does not change with a change in seed moisture. However, the specific power consumption for seed processing will change as the moisture content of seeds entering production changes.

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III. CONCLUSION

Analyzing the influence of seed quality on the specific energy consumption per ton of refined cottonseed oil, the following conclusions can be drawn:

1. Existing methods for calculating electrical energy indicators without taking into account the cotton seed variety lead to large errors.
2. It is shown that the energy capacities of cottonseed oil production by processing different technical varieties of cotton are different. It is proven that oil production from first and second grade seeds requires the least energy. Oil production from third and fourth grade seeds leads to additional electricity consumption of 14% and 36%, respectively.
3. Depending on the change in seed oil content within 15-23%, the change in specific electricity consumption is 52% in the production of press oil and 37% in the general plant.
4. The obtained mathematical models (9, 11, 13, 14, 16, 20) for determining the effect of seed oil content on the production of press and extraction oil, as well as on the specific electricity consumption of the entire plant can be applied to all cottonseed oil plants by placing the initial data of a specific enterprise.

REFERENCES

[1]. S.T. Latipov, N.R. Narziyev. Yog‘-moy korxonalarining energiya samaradorligni oshirish tadbirlarini ishlab chiqish // Energiya va resurs tejash muammolari. Maxsus son (№87). Toshkent – 2024. 268-272 b.

[2]. Latipov S.T. «Yog_-moy korxonalarida mahsulot birligiga to_g_ri keladigan elektr energiya solishtirma sarfiga turli omillarning ta‘sirini regression tahlili». Mashinasozlik ilmiy-texnika jurnali №4, 2024 yil. *84-92 b.*

[3]. Latipov S.T. Study of energy efficient operation modes by construction of energy characteristics of the main technological units of oil extraction plants // International Journal of Advanced Research in Science, Engineering and Technology. -India, 2023. Vol. 10. -P. 20398-20403.

[4]. Jalilov R., Latipov S., Choriyev A. Development of energy characteristics of electric drives of technological equipment and normalization of electric consumption of fat-and-oil enterprise. Scopus, Conference Paper. (RSES 2020) E3S Web of Conferences, 216, article № 01141. – P.1-7.

[5]. Jalilov R.B., Latipov S.T. “Yog‘-moy korxonalari texnologik mexanizmlari elektr yuritmalarining energiya samarador ish rejimlarini aniqlash dasturi” nomli EHM uchun dastur. O‘zbekiston respublikasi adliya vazirligi huzuridagi intellektual mulk agentligi № DGU 11799. 07.07.2021 y.

[6]. Latipov S.T., “YEVROSNAR” MCHJ yog‘-moy korxonasida elektr energiya iste’moli ko‘rsatgichlarini tadqiq qilish. “Fan va texnologiyalar taraqqiyoti” Ilmiy – texnikaviy jurnal. №2/2021. 96-102 b.

[7]. Jalilov R., Latipov S., Choriyev A. On the issue of drawing up the energy balance of a fat-and-oil enterprise. Scopus, Conference Paper. (RSES 2020) E3S Web of Conferences, 216, article № 01140. – P.1-8.

[8]. S.T. Latipov, G.N. Aslanova, *L.A.* Nematov, *A.A.* Akhmedov, *M.R.* Charieva. Calculation of reliability indicators of power supply systems of consumers. Scopus, Conference Paper. (2019) E3S Web of Conferences, 139, article № 01037.

[9]. Jalilov R., Latipov S. To the question of ensuring reliability of energy systems under the conditions of their digital transformation. *Rudenko International Conference “Methodological Problems in Reliability Study of Large Energy Systems” (RSES 2021).*

[10]. Kobzar A.I. Prikladnaya matematicheskaya statistika. Dlya injenerov i nauchnix rabotnikov. - M.: Fizmatlit, 2006. - 816 s.

[11]. Teoriya veroyatnostey i matematicheskaya statistika: ucheb. posobiye / Ye.A. Trofimova, N.V. Kislyak, D.V. Gilyov; [pod obsh. red. Ye.A. Trofimovoy]; M-vo obrazovaniya i nauki Ros. Federatsii, Ural. feder. un-t. – Yekaterinburg: Izd-vo Ural. un-ta, 2018. – 160 s.

[12]. Nurbek Kurbonov, Khurshid Sattarov, Saidmurod Latipov, Sardor Sayfiev. Developing logical steps to integrate technical university students into the virtual reality laboratory learning environment. E3S Web of Conferences 461, 01098 (2023), *RSES 2023*, https://doi.org/10.1051/e3sconf/202346101098.

[13]. Rashid Jalilov, Saidmurod Latipov, Qodir Aslonov, Alisher Choriyev and Charieva Maxbuba. To the question of the development of servers of real-time management systems of electrical engineering complexes on the basis of modern automation systems. // Scopus, Conference Paper. (2021) CEUR Workshop Proceedings, 2843, “ITIDMS” 2021.

[14]. Jalilov R.B., Latipov S.T., Aslanova G.N., Akhmedov A.A., Shayimova S.P. Key directions of development of measures to improve the reliability of electrical power systems. Scopus, Conference Paper. (2019) E3S Web of Conferences, 139, article № 01001.