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Analysis of effectiveness of energy saving measures using frequency converters of electrical drives of vertical belt conveyors used in elevators of flour production enterprises.

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ABSTRACT: This article provides information on the study of the effectiveness of energy saving measures based on the use of frequency converters to increase the efficiency of the electric drives of vertical belt conveyors in the elevators of flour production enterprises. Various control and adjustment methods were learnt to analyze this process, and through these results, the energy efficiency of vertical belt conveyor electric drives was based on technical and economic aspects. Also, the impact of additional parameters was taken into account which performing these analyses. In particular, we can cite tape speed, additional parameters of the motor, parameters of the reducer as an example. It has been theoretically and practically researched that the use of frequency converters can significantly reduce energy consumption and improve the overall efficiency of elevator systems.

KEYWORDS: Vertical belt conveyors, frequency converter, energy efficiency, induction motor, gearbox.

I.INTRODUCTION

Elevators used in flour production enterprises play an important role in the process of grain storage, cleaning and drying. One of the main components of elevator systems is vertical belt conveyors (Noria) [1]. The efficiency of elevator systems directly affects the productivity and economic benefits of enterprises.

However, electric drives used in vertical belt conveyors often operate at a constant speed, which can lead to inefficient use of energy [2,5,10]. Frequency converters can be used to increase the efficiency of electric drives and reduce energy consumption, which allows adjusting the speed and torque of motors depending on the load.

A vertical belt conveyor is a device designed for vertical movement of scattered loads (grain, flour, grain, fodder, etc.) in elevators, grain mills and feed mills.
Noria can be divided into the following types [4]:
a) according to the type of traction device - belt and chain;
b) by purpose - grain, flour and corn on the cob;
c) by design - one and two;
d) according to the nature of unloading the product from buckets:
- with NTsG type centrifugal-gravity unloading (belt speed 1.0 - 1.8 m/s) - for grain and flour products in flour mills and feed factories and seed cleaning stations;
- with centrifugal unloading type NTs-1 - (belt speed 2.2 - 3.6 m/s) - for mixed feed in elevators, drying and cleaning towers, grain receiving plants and feed mills;
- with centrifugal unloading type NTs-2 - (belt speed 3.8 - 4.0 m/s) - for grain with a moisture content of up to 17% in elevators.

The reason for the widespread use of Noria is that they have a number of advantages. In particular, it has advantages such as the simplicity of its construction, small dimensions, the ability to deliver cargo to a great height (50 - 70 m), and a large productivity range (up to 700 m^3 per hour). At the same time, they are not without flaws. Examples of this include constant non-uniformity of the load on the belt, the occurrence of belt breaks, especially sensitivity to overload and problems in the process of uniform delivery of material.

ISSN: 2350-0328
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Vol. 10, Issue 10, October 2023

II. METHODOLOGY

In this study, the electric drives of vertical belt conveyors in flour production enterprises were analysed. The initial data for calculation are as follows [3,6]: Production quantity Q_p, tons/hour; volume mass of grain ρ_m, kg/m^3; type of loading (against the direction of the belt or along the direction); lifting height H, m.

In the initial calculations, the type of buckets is selected, for which the capacity of buckets per 1 m of tape is determined by the following formula, based on the given productivity *i/a*:

$$\frac{i}{a} = \frac{Q_i}{3{,}6 v \rho_M \psi}$$

where, v is the speed of the belt; ψ is the filling coefficient of the bucket.
The ratio *a / i* is called the linear capacity of Noria buckets. It should be noted that the loading of buckets at this stage is nominal, that is, the power reserve is included in the calculation itself. The mass of the load per 1 meter of the traction belt, q, kg/m, is determined by the following formula:

$$q = \frac{Q_i}{3{,}6 v}$$

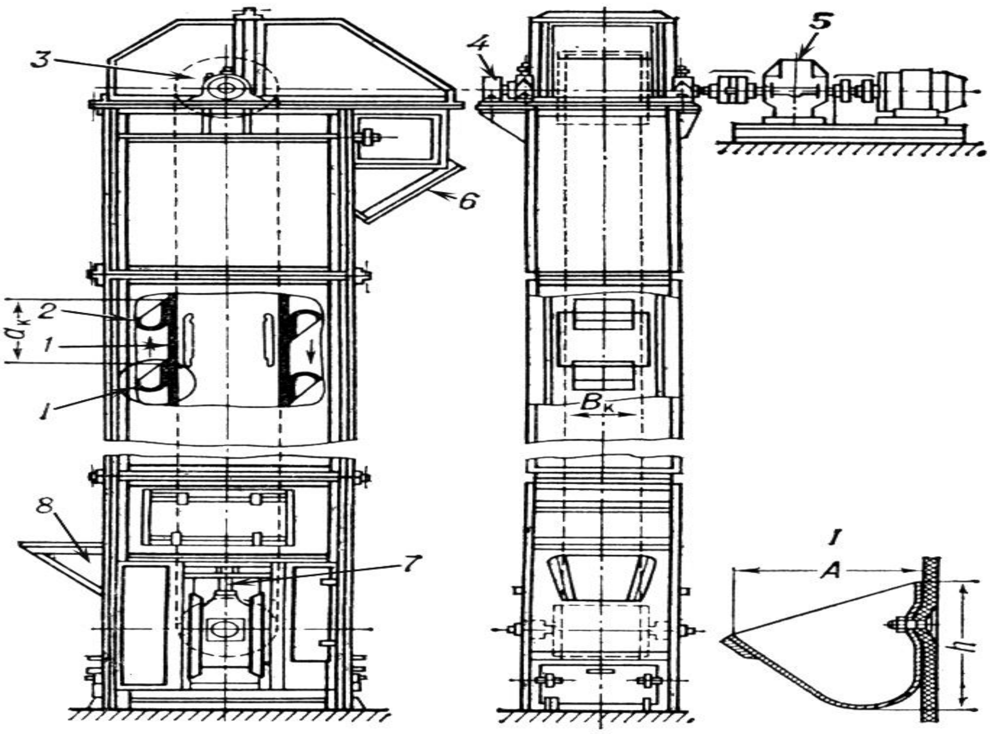

Fig. 1. Vertical belt conveyor (Noria): 1 - pulling belt; 2 - buckets; 3 - driving drum; 4 - stopping mechanism; 5 - drive; 6 - discharge pipe; 7 - tape stretching control mechanism; 8 - loading tube

The initial estimated power P_{est} (kW) is determined by the following formula:

$$P_{est} = \frac{Q_p H}{367}\left(A_H + B_H \frac{q}{Q_i} + C_H \frac{v^2}{H}\right)$$

here, A_H, B_H, C_H are coefficients selected depending on the type of light.

So, the formulas given above are the basis for determining the motor power and the number of buckets. Now we will study the state of energy saving in these processes. Two sets of data were selected for comparison: one using conventional constant-speed electric drives and the other using an electric drive with a frequency converter. A 45 kW asynchronous electric drive in the elevator noria of " Jizzax don mahsulotlari " JSC was taken as a research object.

ISSN: 2350-0328
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Vol. 10, Issue 10, October 2023

The induction motor of this electric drive is 45 kW 4AM-200L - 4 brand, its technical parameters are given in table 1.

Table 1. Technical parameters of induction motor

Rated power P (kW)	Rated Voltage U_n (V)	Rated current I_n (A)	FIK (%)	Multiplicity of starting torque	Power factor cosφ	Multiplicity of starting torque	Number of pairs of poles
45	380	83.6	90	1.5	0.89	2.4	2

Motorvario B163UC type reducer (Fig. 2) is also used as a drive reducer. The technical indicators of this reducer are listed in Table 2.

Table 2. Technical parameters of B163UC reducer

Type of reducer	The diameter of the shaft (mm)	Torque at the output of the reducer (Max)	Transmission ratio	
			Min.	Max.
B163UC	100	13000	8,89	154,83

Fig. 2. View of Motorvario type reducers

First, we will analyze the energy consumption in the period from March 1, 2022 to March 31, 2022, in the direct start-up mode. Table 3 shows the state of energy consumption in this period.

Table 3. The energy consumption in the period from March 1, 2022 to March 31, 2022

Date	Duration of drive operation (hour)	Daily power consumption (kW)	Average power consumption per hour (kW)	Motor load factor (%)
01.03.2022	24	684	28,50	0,63333333
02.03.2022	24	655	27,29	0,60648148
03.03.2022	18	567	31,50	0,7
04.03.2022	0	0	0,00	0
05.03.2022	12	345	28,75	0,63888889
06.03.2022	24	576	24,00	0,53333333

ISSN: 2350-0328
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Vol. 10, Issue 10, October 2023

07.03.2022	24	612	25,50	0,56666667
08.03.2022	24	690	28,75	0,63888889
09.03.2022	24	711	29,63	0,65833333
10.03.2022	0	0	0,00	0
11.03.2022	14	434	31,00	0,68888889
12.03.2022	24	745	31,04	0,68981481
13.03.2022	24	781	32,54	0,72314815
14.03.2022	24	602	25,08	0,55740741
15.03.2022	24	775	32,29	0,71759259
16.03.2022	24	634	26,42	0,58703704
17.03.2022	24	671	27,96	0,6212963
18.03.2022	24	654	27,25	0,60555556
19.03.2022	24	667	27,79	0,61759259
20.03.2022	10	354	35,40	0,78666667
21.03.2022	0	0	0,00	0
22.03.2022	13	473	36,38	0,80854701
23.03.2022	24	897	37,38	0,83055556
24.03.2022	24	769	32,04	0,71203704
25.03.2022	24	673	28,04	0,62314815
26.03.2022	24	615	25,63	0,56944444
27.03.2022	24	764	31,83	0,70740741
28.03.2022	24	659	27,46	0,61018519
29.03.2022	24	786	32,75	0,72777778
30.03.2022	24	662	27,58	0,61296296
31.03.2022	24	631	26,29	0,58425926
Total	**619**	**18086**	**29,5**	**0,6556**

It can be seen from table 3 that on the 4th, 10th, 21st of the month there was no need for the operation of the Elevator vertical belt conveyor (Noria), but on the 3rd, 5th, 11th, 20th, 22nd, it was working for a certain part of the day. It worked continuously for the rest of the month. The operation time of the process during the month was 619 hours and consumed 18086 kW of electricity during this period. So, the average power consumption was 29.5 kW per hour. During this period, 50,000 tons of grain were transferred through the vertical belt conveyor.

When calculating the motor load factor according to the formula for finding the motor load factor, it turned out to be 0.6556.

$$K_{load} = \frac{P_{con}}{P_{rat}}$$

When the electric drive motor works at a load smaller than the nominal load, its useful efficiency also decreases and is determined using the following formula.

$$\eta = \frac{1}{1 + \left(\frac{1}{\eta_{rat}} - 1\right)\beta}$$

Where, $\beta = \frac{\frac{\alpha}{K_{load}} + K_{load}}{\alpha + 1}$; η_{rat} – motor efficiency; α – coefficient for asynchronous motors, which takes values between 0.5 and 1. In normal calculations, 0.75 is accepted.

If we calculate the value of η for this case, it is 86.2%, that is, it is reduced by 13.8% compared to the indicator of the initial useful work coefficient. Taking into account that the total COP of the motor is 90%, its average COP for 1 month was 77.58%. So, this, in turn, confirms that other wastages have also been brought about.

ISSN: 2350-0328
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Vol. 10, Issue 10, October 2023

At the next stage, the Avito frequency converter control system was introduced to this electric drive. The experiment was carried out from May 1 to May 31, 2022. The results are presented in Table 4.

Table 4. The energy consumption in the period from May 1, 2022 to May 31, 2022

Date	Duration of drive operation (hour)	Daily power consumption (kW)	Average power consumption per hour (kW)
01.05.2022	8	190	23,75
02.05.2022	24	451	18,79
03.05.2022	24	576	24,00
04.05.2022	24	542	22,58
05.05.2022	24	564	23,50
06.05.2022	24	523	21,79
07.05.2022	24	528	22,00
08.05.2022	24	587	24,46
09.05.2022	24	556	23,17
10.05.2022	24	668	27,83
11.05.2022	24	565	23,54
12.05.2022	24	597	24,88
13.05.2022	24	663	27,63
14.05.2022	24	775	32,29
15.05.2022	24	643	26,79
16.05.2022	24	523	21,79
17.05.2022	24	520	21,67
18.05.2022	24	582	24,25
19.05.2022	24	591	24,63
20.05.2022	0	0	0,00
21.05.2022	0	0	0,00
22.05.2022	18	473	26,28
23.05.2022	24	549	22,88
24.05.2022	24	562	23,42
25.05.2022	24	554	23,08
26.05.2022	24	532	22,17
27.05.2022	24	569	23,71
28.05.2022	24	572	23,83
29.05.2022	24	678	28,25
30.05.2022	24	657	27,38
31.05.2022	24	698	29,08
Total	**674**	**16488**	**24,46**

It can be seen from table 4 that on the 20th and 21st of the month, there was no need to operate the elevator vertical belt conveyor (Noria), but on the 1st and 22nd, it was in operation for a certain part of the day. It worked continuously for the rest of the month. The operation time during the month was 674 hours and consumed 16488 kW of electricity during this period. So, the average power consumption was 24.46 kW per hour. During this period, 56,000 tons of grain were transferred through the vertical belt conveyor. It can be concluded that the amount of grain processed from the elevator in March and May does not differ. Despite this, an average of 5.04 kW per hour is saved when using the frequency converter control system, or 16.3% of the previous results.

III. EXPERIMENTAL RESULTS

Based on the conducted research, the following results were achieved:
1. It was estimated that the use of frequency converters can reduce the energy consumption of electric drives in vertical belt conveyors at flour production enterprises by 16.3%.
2. The use of frequency converters significantly improves the performance of vertical belt conveyors, provides more accurate and flexible speed control [9,11].
3. The technical condition of the equipment equipped with frequency converters has improved, as the load on the electric motors has been reduced, the wear and tear and the service life of the equipment have been increased.

IV. CONCLUSION

It was proved that the use of frequency converters for electric drives of vertical belt conveyors in flour production enterprises is an effective measure aimed at reducing energy consumption, increasing labor productivity and improving the technical condition of equipment. These changes can have a significant impact on the economic profit of enterprises and contribute to the sustainable development of flour production.

REFERENCES

[1] Строгина Ю. Б. : дис. – Краснодар : [Кубан. гос. технол. ун-т], Совершенствование электропривода вертикальных установок конвейерного транспорта, Краснодар: Кубан. гос. технол. ун-т, 2004.
[2] Nurali Pirmatov and Uchkun Mirzaev. "Ways to Improve the Energy Efficiency of an Electric Drive with Asynchronous Motors." International Journal of Engineering and Information Systems (IJEAIS) ISSN (2021): 230-233.
[3] Bellure, Anand, and M. S. Aspalli. "Dynamic dq model of induction motor using simulink." International Journal of Engineering Trends and Technology (IJETT) 24.5 (2015): 252-257.
[4] Liu, Yupeng. Induction Machine Modeling and Emulation for Asymmetrical Conditions. Diss. Concordia University, 2022.
[5] Ma, Wenzhong, and Lianping Bai. Energy-Saving Principles and Technologies for Induction Motors. Hoboken, NJ, USA: Wiley, 2018.
[6] Duvlonov, Jaloliddin. "Analysis Of Frequency Control Systems For Asynchronous Electric Drive." International Journal of Engineering and Information Systems (IJEAIS) ISSN (2021): 102-104.
[7] Pirmatov, Nurali, and Abdullo Panoev. "Frequency control of asynchronous motors of looms of textile enterprises." E3S Web of Conferences. Vol. 216. EDP Sciences, 2020.
[8] Berdiyarovich, Pirmatov Nurali, Abdiev Orifjon Xofizovich, and Xoliqulov Doniyor Baxtiyorovich. "Topical conveyors are mathematical modelsof asynchronous motors." European science review 9-10-1 (2018): 228-230.
[9] Mirzaev Uchkun, and Hiloliddinov Diyor. "Methodology Of Energy Audit In Uzbekistan." International Journal of Engineering and Information Systems (IJEAIS) ISSN (2021): 197-199.
[10] Orzikul Nurullaev. "Analysis of Energy Saving In Enterprises." International Journal of Engineering and Information Systems (IJEAIS) ISSN (2020): 130-134.
[11] Дмитриева В. В., Собянин А. А., Сизин П. Е. Моделирование плавного пуска для асинхронного двигателя ленточного конвейера //Горный информационно-аналитический бюллетень (научно-технический журнал). – 2022. – №. 6. – С. 77-92.