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Improving Energy Efficiency and Reliability by Operating Electrical Drives Through Frequency Converters

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ABSTRACT: In this article, experimental studies on increasing the energy efficiency and reliability of electric vehicles and their results are analyzed. Experimental studies of direct start-up of the electric drive and start-up through the frequency converter, the obtained results were comparatively analyzed. The research was carried out on a 22 kW electric motor. The obtained results are presented on the basis of a graph. The analysis of the results was researched on the basis of the graphoanalytical method. The influence of energy efficiency and reliability when the electric drives are started through the frequency converter has been evaluated based on the results of the experiment.

KEY WORDS: Electricity, electrical energy, energy efficiency, reliability, electric motor, current, voltage, phase, frequency converter, power, harmonics, phase shift angle.

I. INTRODUCTION

Today, about 20% of the electricity produced in the world is consumed by electric devices used in the irrigation system. This, in turn, requires the implementation of a number of practical activities aimed at increasing energy and resource efficiency under conditions of shortage of energy reserves. Energy efficiency and reliability of electrical systems play an important role in this. The direct activation of electric drives in the irrigation of today's agricultural crops causes many problems. In particular, working in a system with low energy efficiency, the working life of electrical circuits due to the high starting current, the insulation of the stator coils cannot fulfill its characteristics in the required period, as a result, it leads to a reduction of their maintenance periods and an increase in economic costs. As one of the solutions to such problems, we are researching the operation of electric drives through frequency converters[1].

Experimental studies were conducted on the ETsV 10-160-35 electric motor with a capacity of 22 kW in the start-up of electric drives. Table 1 lists the technical parameters of the electric motor [1].

Table 1.

Indicators	
Productivity, m³/s	160
Pressure, m3	35
Motor power, kW	22
Tension, V	380
Tension, V	47±4,0
Network frequency, Hz	50
UWC, %	85

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Experimental studies were carried out in three stages: a) phase-to-phase changes of voltage and current during direct start-up of the electric motor; b) obtaining the results of starting current, nominal voltage and current changes when starting an electric motor through a frequency converter; s) mutual analysis of the obtained experimental results [1].

An AR5 analyzer was used for the experimental studies. This device is widely used today. Because it is reliable in operation, the accuracy class is relatively higher than other measuring devices, and the measuring range is wide. The appearance of this device (Figure 1) and technical characteristics (Table 2) are described below[2]:

Table 2.

Characteristics	Designation
Number of phases	3
Maximum voltage	500 V
Maximum current	2000 A
Current and voltage accuracy class	0,5
Accuracy class by power	1,0

Figure 1. Appearance of the AR5 analyzer used in conducting experimental studies [2]

II. DIRECT START ELECTRIC DRIVE.

First, the results of starting current, rated current and voltage were obtained when the electric motor was started directly. From 11:20 to 11:40 a.m., the change of current in each phase of the electric motor is presented based on the results of experimental studies (Fig. 2). It was found that when the electric motor is started, the current increases sharply, the current of all three phases reaches a maximum of 33 A, and the value of the third phase current changes significantly from the nominal value. This has a negative effect on the reliable operation of the electric motor.

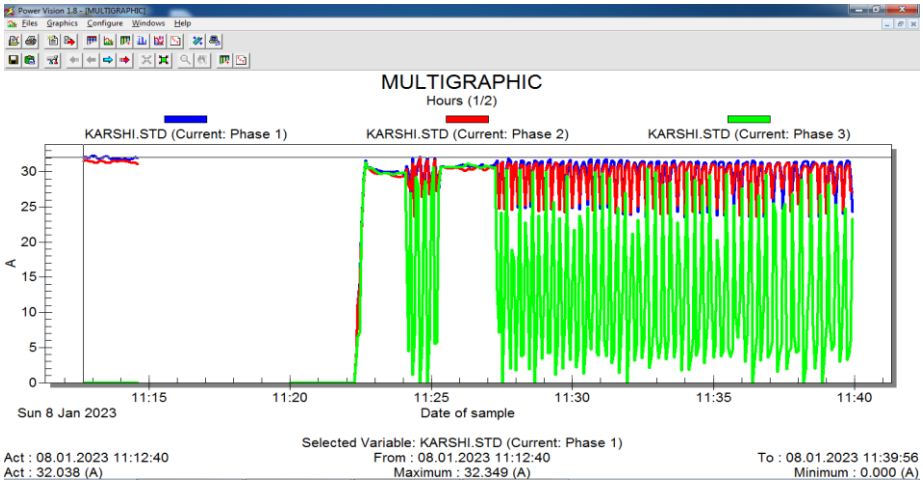

Figure 2. Graph of change of phase currents of asynchronous motor over time [1]

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From 11:20 to 11:40 hours, the voltage change of the electric motor is presented based on the results of the experimental research (Fig. 3). It was found that when the electric motor is started, the current increases sharply, the three phase currents change from 373 to 380 V maximum.

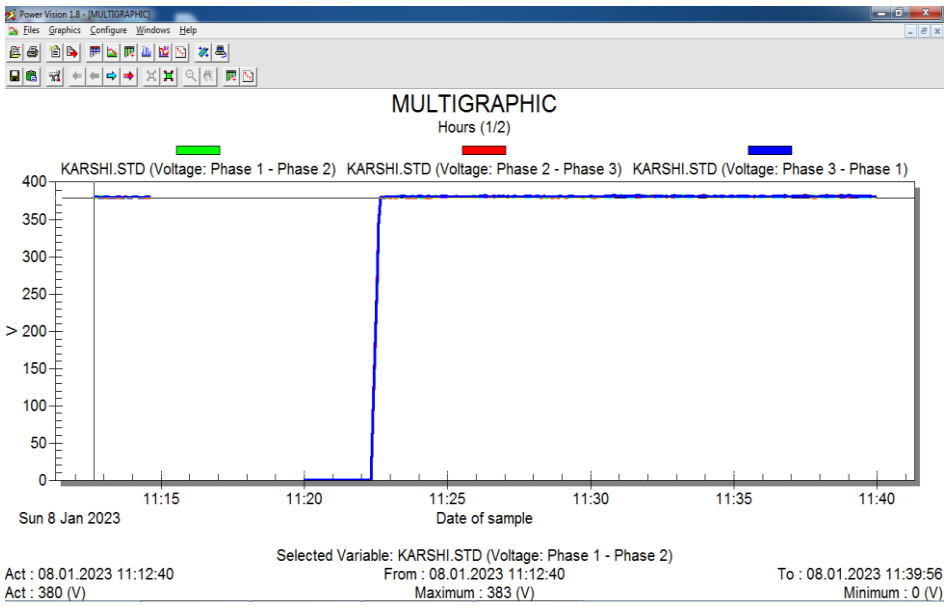

Figure 3. The graph of the change of electric phase voltages over time

The variation of the voltage and current harmonics in relation to the nominal value in the case of starting the electric motor without a frequency converter is presented in Fig.4. In this, the change (in percent) of voltage and current harmonics of each phase is determined [1].

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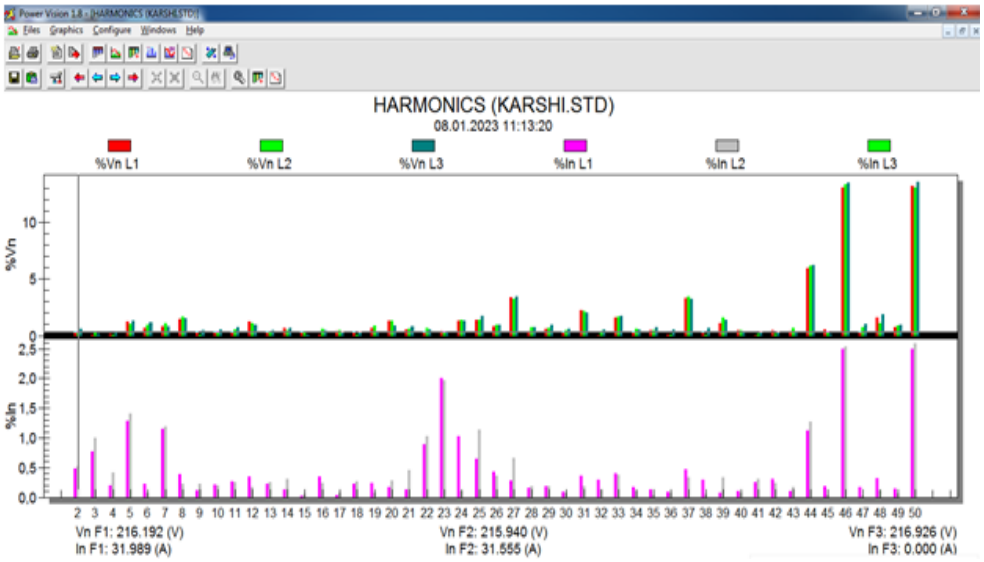

Figure 4. Graph of variation of electric motor voltage and current harmonics [1]

It is clear from the results of the experiment of direct start-up of electrical circuits that the nominal current and voltage values have the character of an unstable operation mode by phases [1].

III. Starting the electric drive through the frequency converter.

When carrying out such a start-up, it is necessary to know the specifics of the load in order to select and calculate the frequency converter of the required size. Then you need to choose a frequency converter with a suitable output power. The required output power can be calculated in four ways. The calculation method is related to the passport data of engines [3,4]. *When choosing a frequency converter, a DELIXI CDI-E100G022/P030T4 30 kVA frequency converter from DELIXI was selected based on the power of the electric motor.*

Figure 5. E100G022/P030T4 model frequency converter [3,4].

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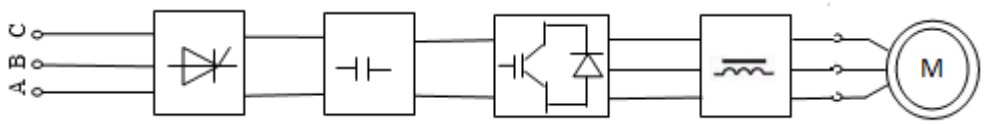

Figure 6. Connection diagram of the frequency converter to the electric motor.

It was connected to the selected Delixi E100G022 frequency converter for a 22 kW water pump based on the connection diagram in Figures 7.8.

Figure 7. Overview of the installed frequency converter

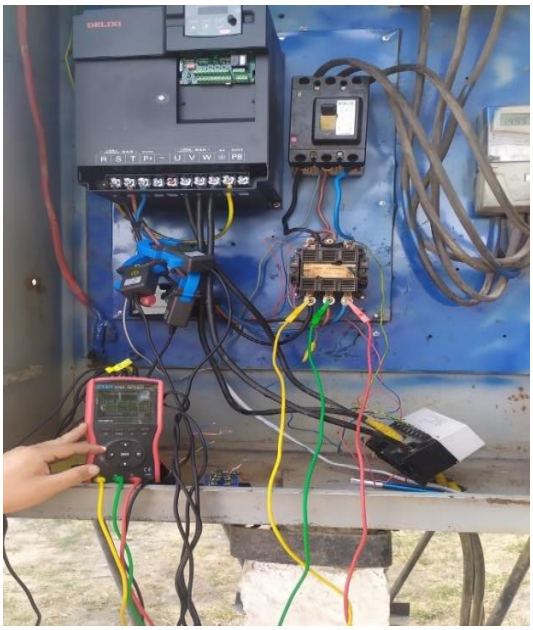

Figure 8. The process of conducting experiments using a built-in frequency converter

Measurement results were obtained using the ETCR4700 electrical analyzer after the frequency converter was installed. Figure 9 shows the graph of the phase shift angle change between A phase voltages and currents based on the research results for the case where the frequency converter is installed. From Figures 9, 10, it can be determined that the symmetry of the electrical quantities in all coils of the electric motor has changed from the normal state, as a result, it affects the perfect operation of the electric motor [5].

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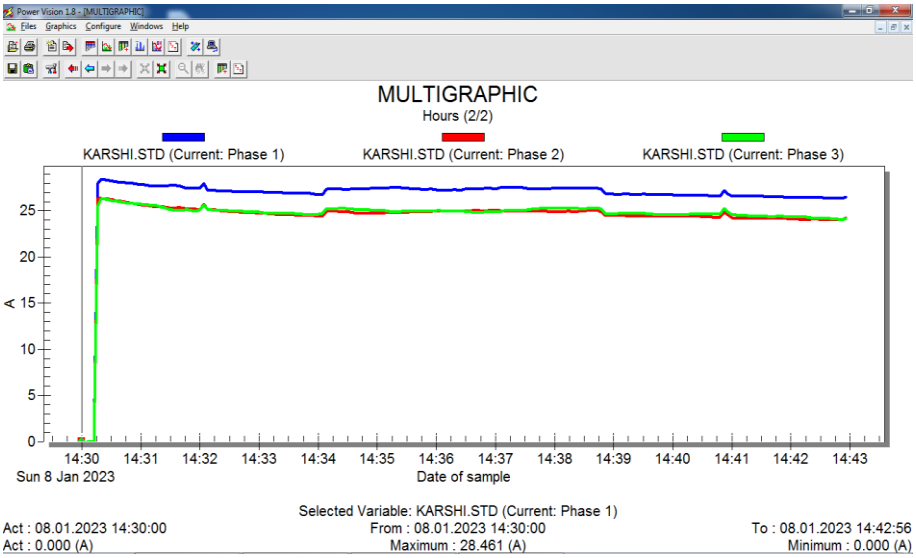

Figure 9. Graph of electric motor phase currents change over time [1]

The graph of the change of phase currents of the frequency-controlled electric circuit is presented in Fig. 9. It was found that in the period from 14:30 to 14:31, i.e., during the start of operation, the current increased its value from 0 to 28 A (to stable operation mode), and it changed smoothly from 14:31 to 14:43.

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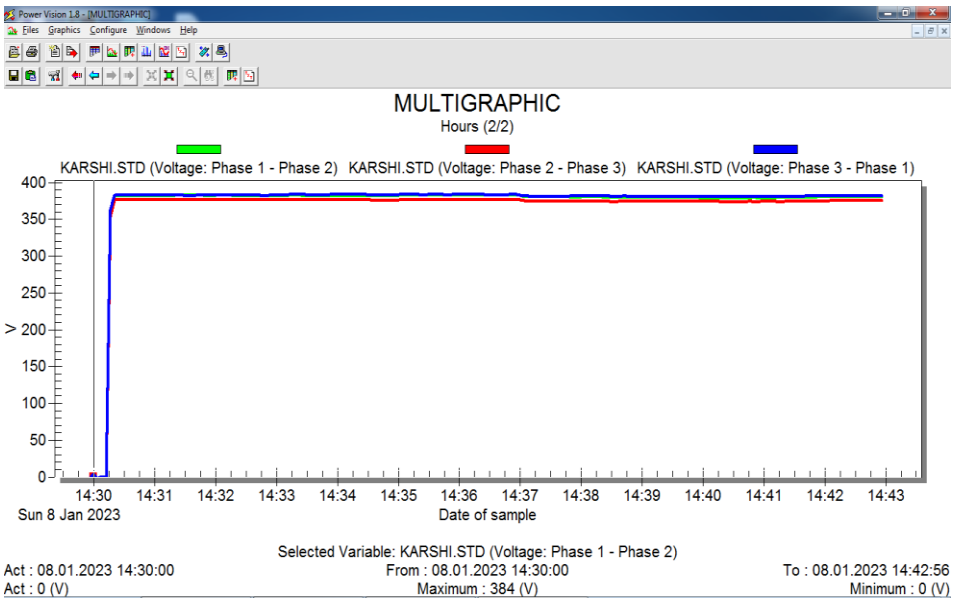

Figure 10. The graph of the change of electrical phase voltages over time [1]

The graph of the phase voltages of the electrical circuit over time is presented in Fig. 10. Based on the obtained results, it was determined that the voltage will reach the value of 380 V between 14:30 and 14:31. The results of the experiment conducted from 14:31 to 14:43 showed that the phase voltages took the same values.

IV. CONCLUSION

From the obtained result, we can see that the nominal current and voltage values of the three phases have the character of a stable operation mode, which ensures smooth operation of the electric motor. This, in turn, is evaluated by increasing the maintenance period of the electric motor and energy efficiency.

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