ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 9, Issue 10 , October 2022

Active Filtering of Higher Harmonics in the Conditions of Hydrometallurgical Plant №1

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ABSTRACT As technology develops, the most attention is paid to the quality of products or raw materials. Not only the quality of products depends on the quality of electricity; the durability of electrical equipment as a whole also depends on it. The deterioration of the quality of electricity leads to an increase in transmission losses. Many scientists around the world are actively researching in the field of power quality (reasons for the deterioration of power quality, methods for eliminating disturbing factors, eliminating unwanted harmonic components).

KEY WORDS: consumers, semiconductor devices, spectrum of harmonic components, symmetry and asymmetry, deviation, oscillation, rectifier, filter-compensating devices, active, passive.

I. INTRODUCTION

Mining and metallurgical plants are included in a number of enterprises with a continuous technological process. They belong to the first category in terms of power supply reliability, have a main working load of 6 (10) kV and are supplied with electrical energy mainly from power systems. The technological process of hydrometallurgical production requires continuity of power supply and does not allow interruptions, false alarms of switching devices under the influence of external disturbing factors. Sources of disturbing factors are widely used semiconductor devices, especially thyristor converters, which contribute to the emergence of higher harmonics with a constantly changing spectrum of harmonic components. Their deviation from acceptable standards contributes to the formation of voids in ingots, which leads to marriage and the need to remelt them, this contributes to great economic damage. The existence of higher harmonics causes resonant phenomena in the network, which leads to overheating and failure of power transformers and cables.

Below are the requirements for the quality of consumed electricity, which contribute to the normal operation of consumer electrical equipment:

coefficient of distortion of sinusoidality of the voltage curve - a general measure of distortion of sinusoidality, determined by the presence of voltage harmonics up to the fortieth order;

coefficient of the n-th harmonic component of the voltage - the ratio of the effective value of the voltage of the harmonic of order n to the effective value of the fundamental harmonic (i.e., order 1);

temporary overvoltage coefficient - calculated according to the table given in the standard on the basis of the measured values of the maximum voltage and the duration of exceeding the set voltage limit value.

steady-state voltage deviation from the normal value - i.e. deviation from the norm of the effective voltage value averaged over one minute;

voltage change range - amplitude of fluctuations of the effective voltage value with a period of less than a minute;

voltage unbalance coefficients for negative and zero sequences (only for three-phase networks)– determine the differences in operating voltages between different combinations of phases or between different phases and the neutral wire, as well as the difference in the phase angle between successive phases from 120 degrees;

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frequency deviation from the normal value - i.e., for the Republic of Uzbekistan, from 50 Hz;

voltage dip duration - the duration of the time interval during which the voltage dropped below the set minimum allowable value. Applies to voltage changes lasting from ten milliseconds to several tens of seconds;

impulse voltage - the parameters of short-term impulses that occur as a result of the effects of a thunderstorm or switching in electrical networks.

II.POWER QUALITY IMPROVEMENT METHODS

In modern frequency-controlled electric drives, static converters have received the greatest use for controlling the output voltage level, which can be implemented on the basis of autonomous voltage inverters and active rectifiers. The voltage value is controlled by a DC voltage regulator (DC/DC) and an algorithm for controlling the power switches of an autonomous voltage inverter, which provides for changing the duration of the transistor opening half-wave. This technology is usually the cause of the deterioration of the harmonic content of the voltage, due to the inclusion of the AC regulator.

Figure 1.1 shows the block diagram of the frequency converter.

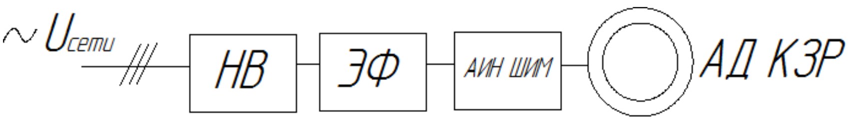

Figure 1.1 - Structural diagram of a static frequency converter

The structure of the power part of the static frequency converter includes: NV - uncontrolled rectifier, EF - electric filter, AI PWM - autonomous voltage inverter with pulse-width modulation, AD KZR - asynchronous motor with a squirrel-cage rotor.

Modern frequency converters are based on various types of rectifiers.

In most operated adjustable electric drives, diode rectifiers are most often found, made according to a 3-phase two-half-wave rectification circuit (Larionov's circuit) Figure 1.2

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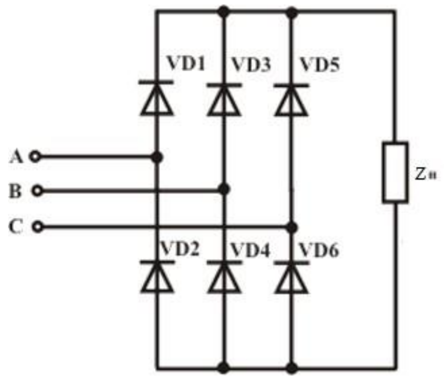

Figure 1.2 - Scheme of an uncontrolled rectifier

In Figure 1.2: A, B, C - phases of the power supply system, VD1-VD6 - diodes, ZH - load impedance. The uncontrolled rectifier performs the process of converting 3-phase to unregulated DC voltage. After rectification, and the transition from AC to DC voltage, a pulsating form appears, shown in Figure 1.3.

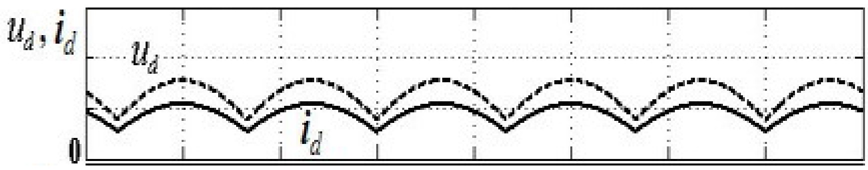

Figure 1.3 - Voltage and current at the output of an uncontrolled rectifier

The value of the average value of the rectified voltage is determined by the expression (1):

$$U_{d\,cp} = 2.34 \cdot U_{\phi}\,, \qquad (1)$$

where U_f - is the effective value of the phase voltage coming to the input of the uncontrolled rectifier.

The phase current coming to the output of an uncontrolled rectifier will have a non-sinusoidal shape and represent a periodic sequence of bipolar pulsed currents, shown in Figure 1.4.

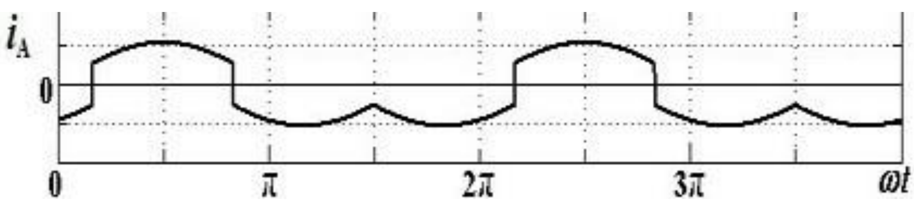

Figure 1.4 - Phase current shape

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Such a periodic sequence of impulse currents can be written as a harmonic series, which contains the fundamental harmonic and a set of higher harmonic components (HHC), the order of which is determined by:

$$n = 6m \pm 1, \qquad (2)$$

where m = 1,2,3

Also, the composition of modern systems of frequency-controlled electric drive, as the main type of non-linear load, includes active rectifiers (rectifiers with an active leading edge), which have certain properties.

To determine the power of distortion in the system active rectifier - supply network, the higher harmonics of current and voltage are considered. It should be noted that the average instantaneous power is zero, but the distortion power leads to additional energy losses in the system.

The non-sinusoidality of current and voltage causes additional and thermal losses for the creation of electromagnetic fields and heating of equipment, as well as accelerated aging of insulation and, in addition, adversely affects the functioning of various types of electrical equipment. The economic component of damage caused by additional losses is, as a rule, small.

The instantaneous effects of HCV include an increase in the level of vibration and noise during the operation of transformers and rotating electrical machines. The effects of higher harmonics often lead to incorrect operation of automation systems.

Modern SCADA systems are sensitive to the effects of higher current and voltage harmonics in the power supply system.

The action of current and voltage harmonics also affect the error of electrical measuring instruments. In practice, during the operation of active and reactive energy meters, measurement errors often occur. In most cases, such devices with non-sinusoidal currents and voltages have a significant error, which can reach up to 10%.

Figure 1.5 shows graphs of the multiplicity of service life reduction γ depending on the total coefficient of non-sinusoidality

THDU for the main electrical power equipment of Mining and Metallurgical Plants. Figure 1.5 shows the decrease in the life of the main power equipment with an increase in the level of the total harmonic content.

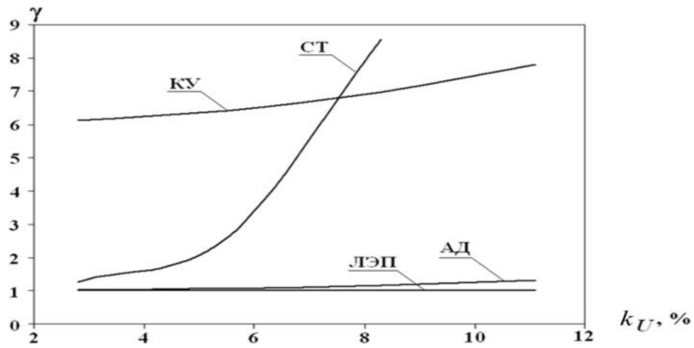

Figure 1.5 - Graph of the multiplicity of service life reduction

Figure 1.5: KU - capacitor unit. ST - power transformer, power transmission line - power line, AD - asynchronous motor.

Quantitative characteristics of GCV values acceptable for enterprises are determined mainly by expert assessment, taking into account linear and non-linear loads included in a given electrical complex of an enterprise,

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
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as well as the national regulatory framework, the norms and requirements of GOST 32144-2013 serve as one of the measures for assessing the effectiveness of correcting the quality of electrical energy by one or another technical means or solution, including active, passive and hybrid filter-compensating devices.

III.CONCLUSION AND FUTURE WORK

Thus, to achieve this goal, it is necessary to solve the following tasks:

a) analysis of the main sources of HCV and their impact on the efficiency of the operation of electrical complexes of enterprises of mining and metallurgical plants. Analysis of the main types, structures and control systems of active and passive PKUs for compensation of HCV current and voltage in order to justify their use as part of HFCs.

b) Development of an algorithm for selecting the structure, HFC control system, based on the required degree of increase in the PQ, the parameters of the supply network and the connected load. Technical implementation of HFCs and determination of the economic effect from their introduction into the electrical complexes of enterprises of Mining and Metallurgical Plants.

c) In order to build a rational power supply system, evaluate the impacts between electrical equipment, determine effective methods of struggle associated with reducing the negative mutual influence of equipment of various subsystems on each other, it is necessary to know what disturbances correspond to each element of the system, caused by harmonics and resonant phenomena, depending on the location its installation in the technological system and the nature of the work.

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