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IMPROVING POWER QUALITY AT COMMON POINT OF CONNECTION IN FERROUS METALLURGY ENTERPRISES

Annotation. The article examines the issues of improving the quality of electricity in the metallurgical industry by replacing the power transformer at the main substation, consumers of high-harmonic currents in a mining and metallurgical enterprise, namely frequency-converting devices, consumers with abruptly changing power characteristics.

Keywords: Power quality, voltage deviation, voltage fluctuation, voltage non-sinusoidal, voltage asymmetry.

The urgency of the problem.

The concept of "quality" is applicable to electrical energy, as well as to any type of product. Inconsistency of electrical energy with the requirements for its quality leads to the fact that the consumption of electrical energy under normal conditions can pose a danger to human health, the environment and harm the property of consumers and increase the energy intensity of technological processes.

The quality of electrical energy is determined by the totality of its characteristics, in which electrical receivers can work normally and perform their functions. Now the entire set of parameters characterizing the suitability of electrical energy for transmission and consumption processes is summarized in GOST 32144-2013 "Standards for the quality of electrical energy in general-purpose power supply systems" [1].

Non-sinusoidal voltages and currents are one of the most important indicators of the quality of electrical energy, since it affects the operation of almost all types of electrical receivers.

The quality of electricity depends not only on the processes of electricity production, but also on the processes of its transportation to the place of consumption, as well as on the processes of its consumption by electrical installations, i.e. the culprit for the occurrence of non-sinusoidal voltages can be both the power supply organization and the consumer with nonlinear volt-ampere characteristics.

The main forms of the impact of higher harmonics on power supply systems are:

• increase in currents and voltages of higher harmonics due to parallel and serial resonances;

• decrease in the efficiency of the processes of generation, transmission, use electricity;

• aging of electrical equipment insulation and reduction of its service life;

• false operation of the equipment.[2,3]

Problems with the deterioration of the quality of energy efficiency in the metallurgical industry.

In the article, consumers of high-harmonic currents in a mining and metallurgical enterprise, namely frequency-converting devices, consumers with abruptly changing power characteristics (various types of connecting devices and low-power electric devices, short-circuit power devices) are studied and also the process of changing the quality of the voltage on these tires was studied by transferring consumers from one tire to another. This research work was conducted using the ETAP program.

In the " ETAP®" program, a model of the internal power supply scheme of the metallurgical plant was developed. The program studied the formation and change of harmonics in the tires of the power supply circuit of the metallurgical plant, in particular, the 5th, 7th, 11th, 13th, 17th, 19th, 23rd and 25th harmonics on the voltage curve. Figure 1 shows the power supply scheme of the metallurgical plant. Here Bus1 bus is supplied through the 35 kV line of the power system. Bus1 is connected to the bus with a transformer with a capacity of 10 MVA and a voltage of 35 kV. This transformer is a main step-down transformer, which reduces the bus bus voltage to 6.6 kV. Bus2 uses a 300 kW asynchronous motor with a 1 km cable, a load of 4

MVA from a cable of the same length, a 160 kVA transformer that reduces the 6.6 kV voltage to 0.4 kV, and a range of 5 to 5 gallons of power. The device consumes 300 kW of asynchronous motor power. In addition, a 0.4 kV to 6.6 kV transformer with a capacity of 250 kVA on the Bus2 bus transmits the power coming through the inverter of the solar panels on the Bus3 bus.

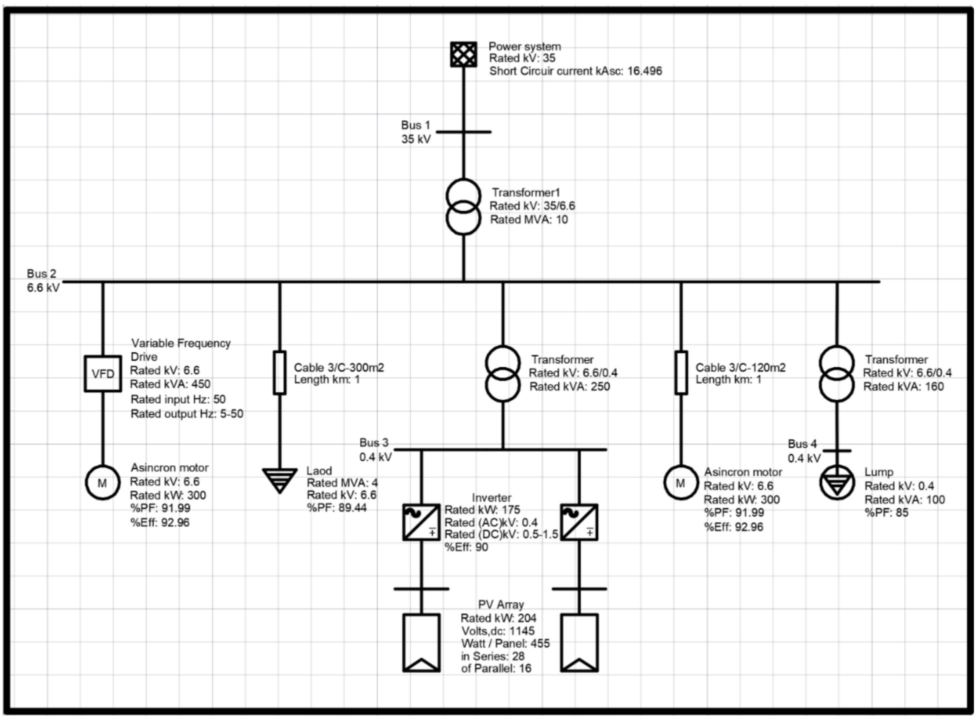

Figure 1: Metallurgical plant internal power supply scheme

When the voltage pattern on the bus 2 was analyzed, it was found that it differed from the sinusoid and contained higher harmonics, in particular, harmonics 5, 7, 11, 13, 17, 19, and 23. The form of the voltage and the diagram of the high harmonics are shown in Figures 2.3.

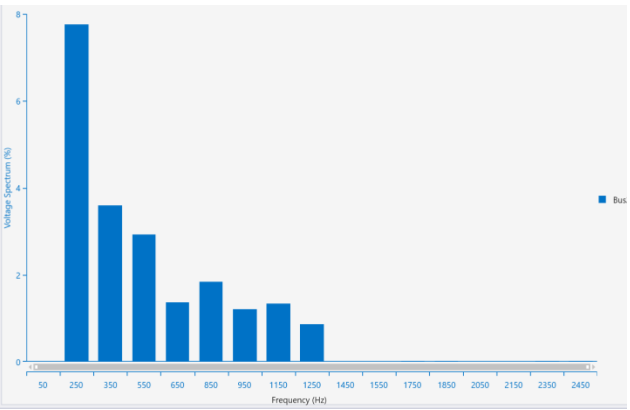

Figure 3: Spectral view of high harmonics of bus2 voltage

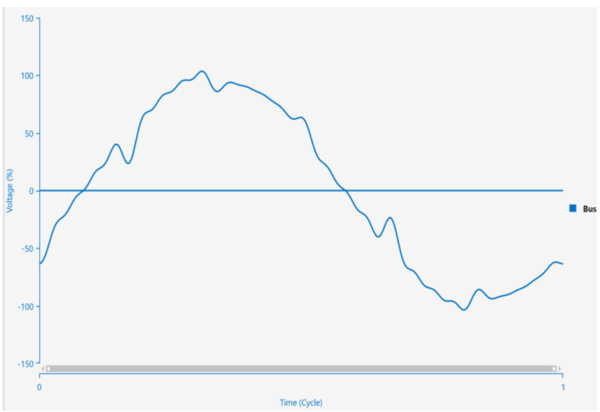

Figure 2: Fluctuation of high harmonics of bus2 voltage

The results of the calculations for levels 1, 2, 3, and 4 of the above power supply scheme using the ETAP program are shown in Table 1.

Table 1

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№	Busbars	Parameters	250Hz (5)	350Hz (7)	550Hz (11)	650Hz (13)	850Hz (17)	950Hz (19)	1150Hz (23)
1	Bus1	Un(V)	290	134	108	50	67	44	48
		Kn(%)	0.828	0.382	0.308	0.142	0.191	0.125	0.137
2	Bus2	Un(V)	512	237	193	90	121	80	88
		Kn(%)	7.757	3.590	2.924	1.363	1.833	1.21	1.33
3	Bus3	Un(V)	29	13	11	5	7	5	5
		Kn(%)	7.25	3.25	2.75	1.25	1.75	1.25	1.25
4	Bus4	Un(V)	29	13	9	4	4	3	2
		Kn(%)	7.25	3.25	2.25	1	1	0.75	0.5

It can be seen from this table that the coefficient of nosinusoidality of the 5th harmonic in tier 2 (Bus2) tires is 7.757%, which is more than 5% of the norm adopted in GOST 32144-2013 for the current quality of electricity.

Among the electricity consumers in this system are the VFD and Load consumers who generate high harmonic currents. VFD is a frequency converter used to adjust the speed of an asynchronous motor during production and to start the motor lightly, Load is connected to loads that have a large impact on the quality of electricity (e.g. small power frequency converters, electric arc furnaces, welding transformers, etc.). k) is the load. Consumers who create high harmonics in the factory power supply have a serious impact on the quality of the voltage on the bus. Therefore, substandard electricity affects the work process of other types of consumers connected to this bus, causing them to overheat, wear insulation, sharply reduce operating time and increase production process failures, poor lighting distribution of the lighting system to the eyes of workers and work. may adversely affect productivity.

In addition, solar panels are connected to the Bus3 level tires via inverters, which inverters perform the function of converting a constant current to an alternating current and provide synchronization in the circuit.

If the quality of the voltage in the network exceeds the established norm, it is possible to observe cases of disconnection of solar panels from the electrical system through the inverter, leading to a violation of synchronization. To prevent such cases, devices that generate high harmonics in the design of industrial plants are connected to the busbars separately from other consumers through a separate transformer and secondary winding transformers (transformer s rasshcheplënnoy obmotkoy), (reactor s rasshcheplënnoy obmotkoy) reactors.

Problem Solving

In the above, we will analyze the quality of voltage in each bus separately by replacing the power transformer at the main substation of the metallurgical plant with distribution transformers of the same power, connecting consumers who generate high harmonics to a separate bus and consumers who do not have a significant impact on power quality. In this case, the factory power supply diagram will look like the following (Figure 4).

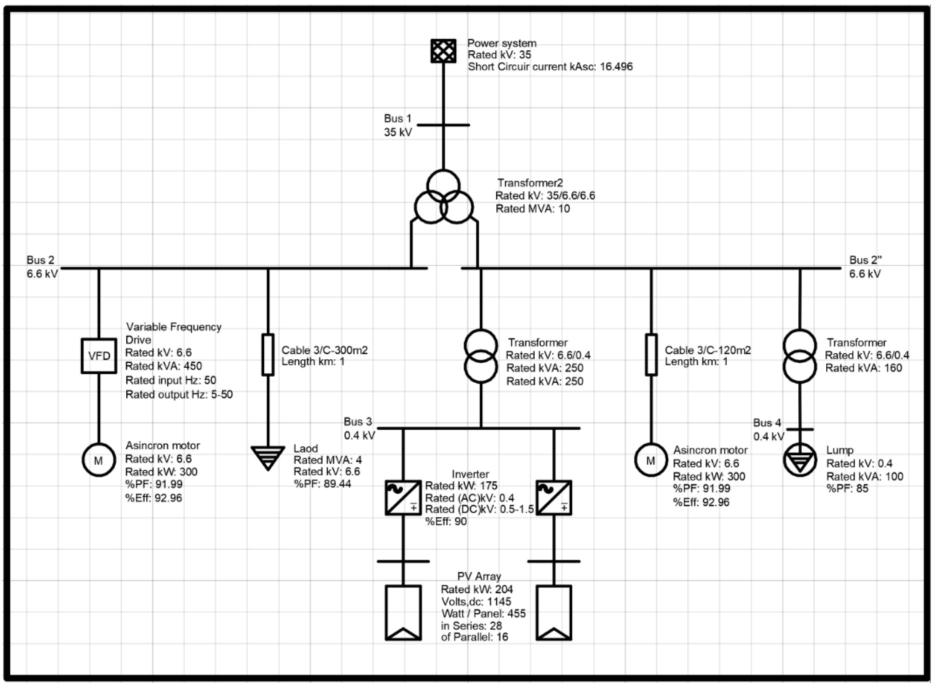

Figure 4: Modified internal power supply scheme of the metallurgical plant

The results of the study show that such separation of consumers leads to an improvement in the quality of tension in the tires. We can see that the nosinusoidality coefficients of the voltage across both tires are reduced. The diagram of the upper harmonics is shown in Figure 5. Table 2 shows the calculation results for levels 1, 2, 3, and 4 of the power supply scheme.

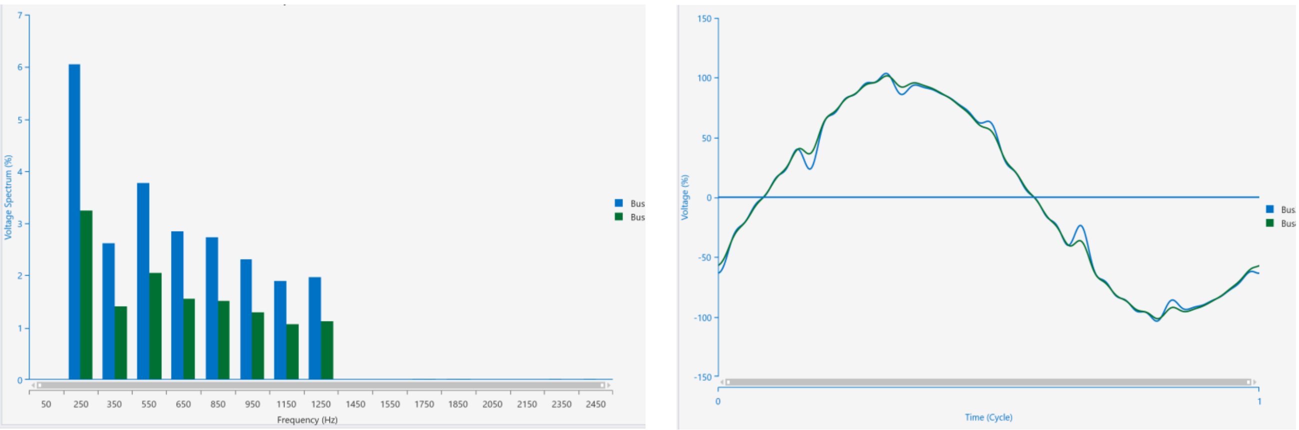

Figure 5: Spectral and wavy view of high harmonics of voltage in Bus2 and Bus2 ’’ tires. The blue images in the images belong to Bus2 and the green images to Bus2.

Table 2

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№	Busbars	Parameters	250Hz (5)	350Hz (7)	550Hz (11)	650Hz (13)	850Hz (17)	950Hz (19)	1150Hz (23)
1	Bus1	Un(V)	191	82	117	88	83	69	55
		Kn(%)	2.893	1.242	1.772	1.333	1.257	1.045	0.833
2	Bus2	Un(V)	399	173	249	188	180	152	125
		Kn(%)	6.04	2.621	3.772	2.848	2.727	2.303	1.893
3	Bus2"	Un(V)	214	93	135	102	100	85	71
		Kn(%)	3.242	1.409	2.045	1.545	1.515	1.287	1.075
4	Bus3	Un(V)	12	5	8	6	6	5	4
		Kn(%)	3	1.25	2	1.5	1.5	1.25	1
5	Bus4	Un(V)	12	5	6	4	4	3	2
		Kn(%)	3	1.25	1.5	1	1	0.75	0.5

From the spectral diagram above, we can see that the high harmonic coefficients of the voltage of the connected bus (Bus2), which generates high harmonics in blue, are expressed as a percentage, which is much lower than in the previous case.

The high harmonic coefficients of the connected bus with consumers with a low level of impact on the quality of electricity are shown in green. In it we can see a significant decrease in high harmonics. In the waveform diagram above, it can be observed that the waveform of the voltage differs from the sinusoid. The high harmonics generated in blue represent the wavy shape of the connected bus voltage. The shape depicted in green is a wavy view of the bus voltage connected to consumers with little effect on the quality of electricity. The two wavy shapes do not differ much in shape from each other. The shape is relatively closer to the sinusoid because the high harmonic coefficients of the voltage form described only in green are relatively lower than those in blue. This means that the effect of the high harmonics generated on one side of the low voltage split transformer on the other side is present, albeit to a lesser extent. The results show that the 5th harmonic coefficient of the voltage on the bus2 bus in the previous power supply circuit (Figure 1) is 7.76%, the 5th harmonic coefficient of the voltage on the bus2 and Bus2 " tires in the next power supply circuit (Figure 5) is 6.04. % and down to 3.242% and on Bus3 and Bus 4 tires from 7.25% to 3%. This leads to the supply of voltage that meets the quality requirements of consumers who do not generate high harmonics and increase their service life.

Conclusion.

The results of the above studies show that high harmonics can occur in the power supply system due to a nonlinear power consumer or a nosinusoidal power generation source connected to the power grid. The connection of consumers to a separate bus, which generates high harmonics in industrial enterprises, leads to a better quality of voltage in the connected bus of consumers with less impact on the quality of electricity. In the considered variant, by using a distribution transformer in the power supply circuit, the curvature coefficient of the 5th harmonics of the high harmonics in the tires ranged from 7.757% to 6.04% and 3.242%, the 7th harmonic curve from 3.59% to 2.62% and 1, To 4%, the 11-harmonic curvature coefficient decreased from 2.924% to 2.045%, and so on.

Consumers who do not generate high harmonics are brought to a state where the voltages on the connected bus meet the requirements of the norm. Therefore, it is advisable for enterprises to take this into account when designing power supply schemes and connect consumers to individual busbars via distribution transformers.

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