Influence of equipment modernization to parameters of electricity – case study

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This paper is concerned with the impact of modernization of the machinery on parameters of of electricity for example the aluminum industry company. Examined was due to changes in factory equipment for power energy parameters. Was shown the selected parameters for the state before and after the upgrade. Statistical analysis were carried out. It was shown that the upgrading its machinery has a positive impact on the power supply parameters. It has been shown that, despite a substantial increase in installed power has decreased power consumption due to power factor correction. In addition, showed an increase in uneven power consumption.

KEYWORDS: power quality, the analysis of the electrical load changes, modernization of machinery

1. Introduction

An important issue for both the supplier and the end user of electricity is its quality. For a supplier, it is important that the loads did not introduce the network interference that may negatively affect its functioning. Hence, the conclusion of the contract the supplier undertakes the recipient to maintain adequate reception parameters, such as adequate power factor. In turn, the energy suppliers are obliged kept, and the supply of energy imposed by the Energy Law [7].

Because not take the appropriate type of power may, in extreme cases, result in oversizing the installation [3] or even incorrect operation of the equipment and the transfer of reactive power to the network or the higher harmonics [1] may adversely affect the operation of the network, hence the understandable attention of both sides to maintain the best performance of energy electricity.

The relevant legal conditions, the PN-EN 50160 [6] standard and the contract concluded between the supplier and the consumer are the tools that define the relevant parameters power and their limits. In addition to the provisions in these regulations, it is necessary to proper monitoring of these parameters. Some of them, such as tan (φ) is monitored by the supplier on an ongoing basis, while the others are checked periodically or at all. This lack of monitoring, common in recipients of low power, often due to lack of knowledge of the issues - in small companies often do not have a specialist in the power sector. A concern arises at the time of a significant change in

the amount to be paid to the power company. The most common reason is exceeded, penalties imposed under contractual or non-compliance with the relevant tan (φ).

Audit can provide valuable information on the needs and present energy management in company. Such audit is performed rarely because of the expected costs and meanwhile their height, according to information obtained from the audited company, does not exceed a few hundred zlotys. [3]

This work shows the influence of modernization of the machinery, namely the exchange of machining center to a newer model with higher technological opportunities, and much more electrical power (an increase from 10 to 25 kW) on the parameters of electricity in considered company.

2. Analysis of power supply parameters

2.1. Characteristics of the facility

Atlanta Aluminium Company sp o.o. belongs to the sector of small and medium-sized enterprises located in the district of Buk in the Wielkopolska Region. Activity profile includes the manufacture and installation of aluminum joinery. Wherein it is not mass production, but atypical products aimed to clients with high quality requirements. Most of the work is done with the use of specialized equipment, but some operations require the use of hand tools. It has been observed that the probability of use of multiple machines at the same time is minimal - usually work one or two, and the other workers perform manual work. This cycle is enforced by specifics of product. [4]

The analyzed factory is supplied from a medium voltage transformer 15/0, 4 kV, a power 160 kVA. The measurement system is a system of half intermediate with peak power indicator.

However, electrical equipment, from the viewpoint of power each device is as follows. The biggest receivers has the power of 30 kW, and the power of other loads do not exceed a few kW. The dominant devices are: air compressor supply pneumatic devices, CNC machine tools, lighting. Other facilities include infrastructure and office equipment.

Upgrading equipment consisted of replacing the factory machining center for new, more powerful, allowing to improve the quality of products and speed up production. For reasons of electrical modernization resulted in the increase of installed power. Do not change the size of the ordered power because no adjustment was necessary (there was adequate supply of power).

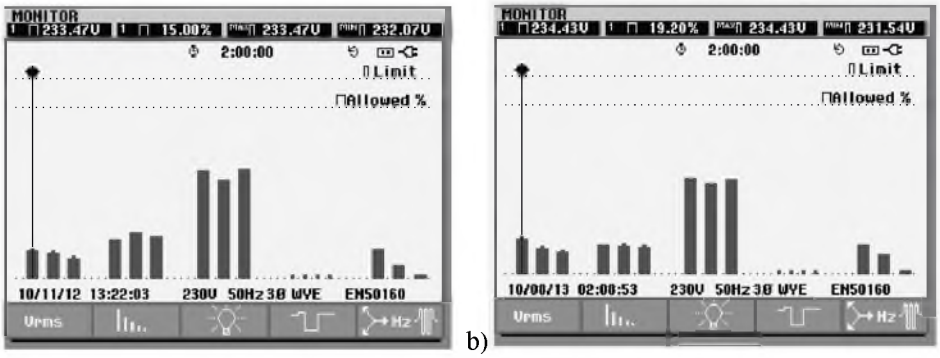
Measurements were performed during normal factory work, at different times of day and different days of the week. Several measurements were made of several hours to obtain a high resolution and find the average values of parameters at intervals of no longer than a few seconds. For measure the parameters of the grid

Fluke 434 [5] analyzer was used, and FlukeView software and Excel spreadsheet were used for computation.

2.2. Results of measurement

Studies of power quality parameter, especially their variation in time were carried out several times. The results below are typical values which are characteristic of the case.

Recorded parameters can be displayed on-line during the test, and at the end of the study can be analyzed in detail with the use of specialized computer software FlukeView, or saved in CSV format, which allows the use of a non-dedicated PC software for analysis. In Figure 1 are shown, respectively, for the state before and after the upgrademeasurement results, grouped according to the test criterion. Each group presents the values for the individual phases. And so right from left are shown: the changes rms phase voltage, total harmonic distortion value, voltage dips, voltage swells, and total power asymmetry and the frequency deviation.



a) b)

Fig. 1. Results of the study power grid parameters: a) prior to upgrading b) after upgrading

As you can see, all of the above parameters are within the limit values.

Figures 2 to 5 shows the variation in time of the selected network parameters. To demonstrate the periodicity of these changes are presented results for one-hour intervals. And so the drawings represent, respectively, for the state before (solid line) and after (dashed line) modernization, changes in time: RMS voltage phase for one of the phases, the effective value of the phase current in one phase, active power consumption, power factor the entire plant .

Supply voltage, both before and after modernization varied slightly – of a few volts, but after upgrading slightly increased the maximum value recorded. In the case of current before the update seen significant fluctuations in current, the modernization of the fluctuations have increased and there was a lower minimum and higher maximum. Similarly, high dynamics are characterized by changes in

the active power consumption - in this case, the upgrade resulted in an increase in the range of oscillation on both sides.

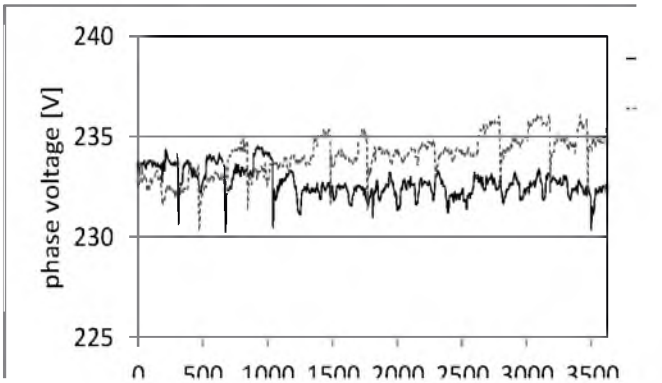


Fig. 2. An example of changing the effective value of the phase voltage in time

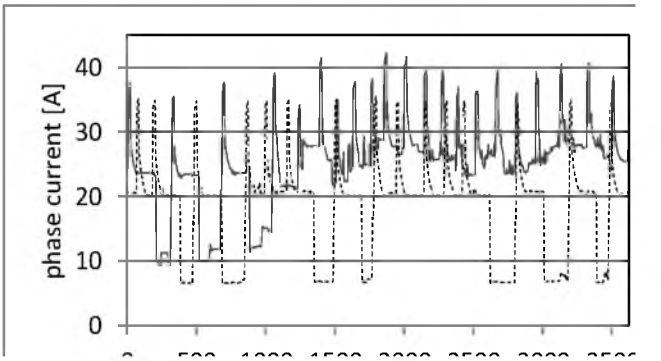


Fig. 3. An example of changes in RMS of the phase current in time

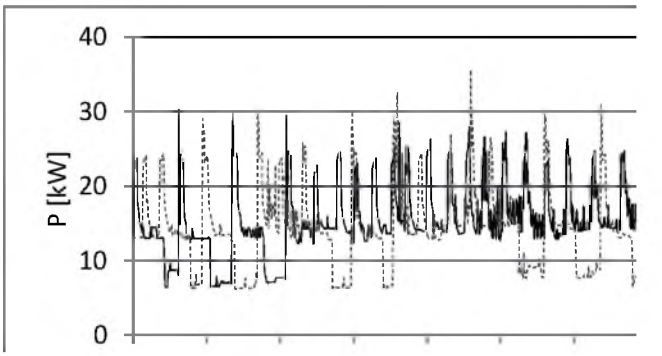


Fig. 4. An example of changes in active power consumption in time

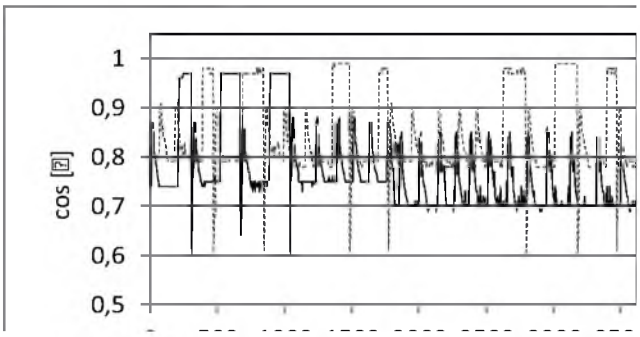


Fig. 5. Examples of changes in the power factor in time

Below is a statistical analysis of the results for both states of the system. Analyzed parameters are: minimum value, maximum, mean, median, standard deviation, coefficient of variation. In the calculation, it was assumed that the distribution is a normal distribution and the sample is a numerous sample. [2]

Table 1. Statistical analysis of the measurement results

Measured parameter		Min. value	Max. value	Average value	Median value	Standard deviation	Coefficient of variation
U [V]	before	230,23	234,50	232,71	232,62	0,70	0,30
	after	230,33	236,15	234,06	234,14	0,99	0,42
	change [%]	0,05	0,70	0,58	0,65	40,28	39,47
I [A]	before	9,35	42,15	25,48	25,75	6,58	25,82
	after	6,50	35,30	18,33	20,40	7,57	41,28
	change [%]	-30,45	-16,26	-28,07	-20,77	14,98	59,85
P [kW]	before	6,34	30,34	15,50	14,30	4,75	30,67
	after	6,16	38,39	14,39	13,90	5,54	38,52
	change [%]	-2,82	26,50	-7,17	-2,77	16,61	25,61
cos (φ) [-]	before	0,60	0,97	0,77	0,75	0,08	10,75
	after	0,60	0,99	0,84	0,80	0,08	10,00
	change [%]	0,00	2,06	9,25	6,67	1,63	-6,98

The results of the statistical analysis indicate that the relatively constant is voltage, its coefficient of variation U indicates that the deviation from the average value does not exceed 0.3% before and 0.42% after upgrading. The largest fluctuations in the index on the current drawn VI respectively 25.82% and 41.28%

before the upgrade and the power of VP equal respectively 30.67% and 38.52% before the upgrade. The changes in the power factor is the average level of Vcos (φ) = 10%. Changes in the current drawn and power are related to the nature of the collection, and the power factor due to the same receivers.

3. Effects of modernization

Too low power factor of factory, in addition to extra voltage drops, power losses and the need to oversize installations also entails economic consequences. In the analyzed factory, as in most, the agreement requires that tan (φ) was maintained at less than 0.4 [3], which implies cos (φ)> 0.93. As a result, the company prior to the investment costs borne by non-fulfillment of this parameter [3]. According to the indications of the measuring system (data for 6 months), the mean values were fifteen minute peak power of about 19 kW, and tan (φ) average of 0.67.

Modernization of machinery resulted not only an increase in the average power consumed by the factory, but also contributed to the other system parameters. If the voltage changes are negligible. However, when the phase current observed a significant, from 16 to 30%, reductions in all measurands. Of particular note is the median decrease of 20%. However, increase in the coefficient of variation of 60% shows how unstable is a current consumption (new machine takes less power at idle and less time working with high power). In turn, the power consumption showed an increase in the maximum value, but the value of the mean and median are maintained at a similar level, which may result in minor changes in the amount of electricity consumed. Another positive aspect of modernization, in addition to the production values and the changes in power consumption, is the increase in the power factor. Mean and median values of this index increased by a few percent and a decrease in the coefficient of variation, i.e. its value is higher and more stable. Change of power factor will also have positive economic impact - reducing the amount of energy consumed reactive and therefore charges for it.

4. Summary

The issue of power quality analysis of the recipients of low power, the order of a few tens kW is often neglected. It is noted in the most difficult times for the company, for example, at times of crisis, when looking for possible savings, or in the case of abnormal operation of equipment sensitive to power supply parameters.

The study allows us to formulate conclusions that may be an indication for the people responsible for energy management companies:

- monitor power parameters can be used to observe and verify the status of individual devices and installations,
- knowledge of current consumption and power is a valuable information in the event of a change in equipment (e.g. increased power consumption),

- factory equipment with more modern machinery and equipment may result in the improvement of parameters such as cos(φ) and the fluctuations of electrical current and power.

In conclusion, knowledge of the installation and loads requires a tests becouse calculated power demand for the aluminum industry plants is flawed (usually overestimated). In addition, it seems necessary periodically analysis of the network especially when change in equipment is expected or sudden significant change in the financial burden from costs of electricity. Measurements after modernization, especially in the event of significant changes in equipment, allows observation of changes in the system and the appropriate response to them.

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