Journal of Casting & Materials Engineering Vol. 1 No. 2 (2017) 53–58
http://dx.doi.org/10.7494/jcme.2017.1.2.53

Power Consumption Comparison of Model Vibratory Unit in Power Supply System with and without Inverter for Frequency Setting of 50 Hz

Eugeniusz Ziółkowski[a,*], Mateusz Skrzyński[a]

[a]AGH University of Science and Technology, Faculty of Foundry Engineering, Reymonta 23, 30-059 Krakow, Poland
**e-mail: ez@agh.edu.pl*

Received: 31 May 2017/Accepted: 7 July 2017/Published online: 28 July 2017
This article is published with open access at AGH University of Science and Technology Press

Abstract

The article presents the instantaneous voltage and current values recorded in the power-supply system of a vibratory unit directly from the power grid or through an inverter for a frequency setting of 50 Hz. The obtained measurement data was used to perform digital signal processing algorithms, calculations of effective voltages, currents, power (active, reactive, and apparent), and power factor tgφ. The results of the calculations were used to compare the two power systems examined.

Keywords:

model of vibratory unit, selected energy parameters

1. INTRODUCTION

In machines for the mechanical regeneration of used molding mass, vibratory units driven by electric motors are commonly used. An example of such a regenerator is described in publications [1–3]. To study the influence of the selected structural and operational parameters on the efficiency of mechanical regeneration of the used molding mass, a model station was constructed (the view of which is shown in Figure 1a). The model vibratory unit is driven by two electric motors, with the parameters given in Table 1.

The article presents the instantaneous voltage and current values recorded in the power supply system of the vibratory unit directly from the power grid or through an inverter [5] for a frequency setting of 50 Hz. Measurements were made with the use of the original recorder of instantaneous voltages and currents, whose technical characteristics were presented in works [6, 7], among others. Calculations of the selected energy parameters [8–12] were carried out using the author's computer program. A view of the measurement system is shown in Figure 1b.

Table 1
Parameters of MVE 400/3 electric motor used in model vibratory unit [4]

Type of electric motor	MVE 400/3
Producer	OLI WAMGROUP
Voltage supply	Δ 230 V / Y 400 V
Frequency	50 Hz
Power	0,3 kW
Maximum current	Δ 1.0 A / Y 0.58 A
Power coefficient cosφ	0.88
Speed	3000 rpm

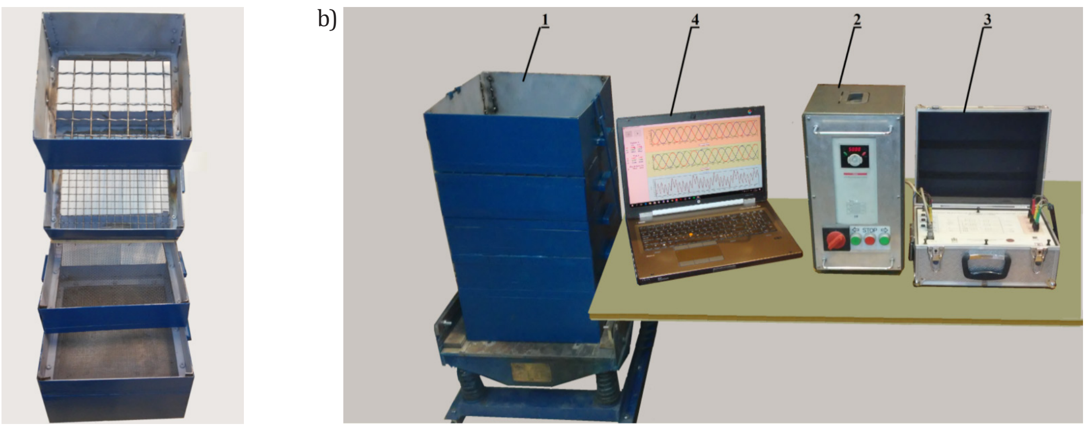
a) b)


Fig. 1. View of: a) model vibratory unit; b) research system: 1 – model vibratory unit; 2 – inverter; 3 – instantaneous voltage- and current-value recorder; 4 – computer with software for recorder

2. MEASUREMENTS OF SELECTED PARAMETERS POWERED DIRECTLY FROM ENERGY NETWORK OF MODEL VIBRATORY UNIT

In order to record the instantaneous voltage and current values, the recorder was connected between the three-phase power grid (400 V, 50 Hz) and the model vibration test (Fig. 2). All results presented in this article refer to the nominal loading of waste molded mass (21 kg) in a model vibratory unit. Figure 3 shows a view of a computer program window that supports an instantaneous value recorder, containing graphs of voltage and current changes in each phase of the power supply.

The set of instantaneous values was used to determine the effective voltage and current values after switching on the power supply (Fig. 4) as well as the changes in the active, reactive, and apparent power values as well as the coefficient power tgφ values (Fig. 5).

From the graphs in Figures 3–5, it can be seen that the transient state persist at about 0.5 s.

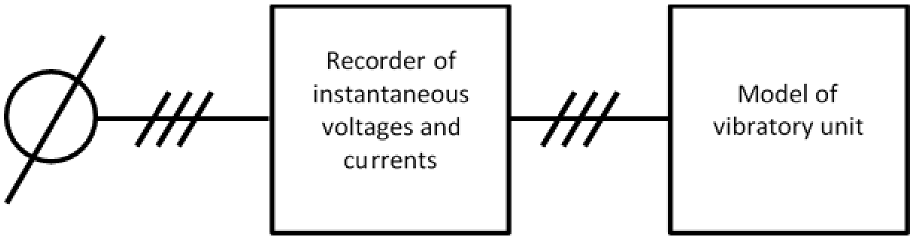


Fig. 2. Diagram of recording system of instantaneous voltage and current values in vibration unit supplied directly from three-phase power grid (50 Hz)

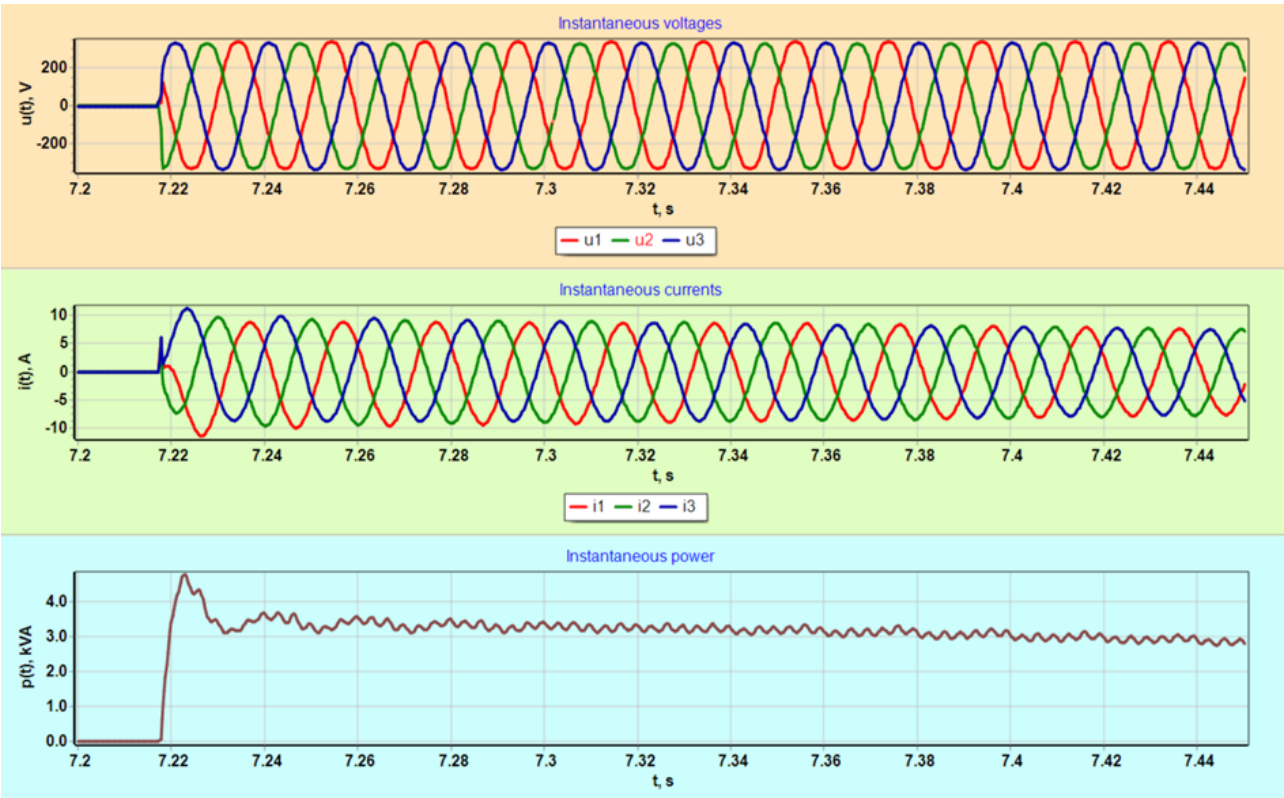


Fig. 3. Program window with graphs of instantaneous voltages and currents in model vibratory unit supplied directly from energy network

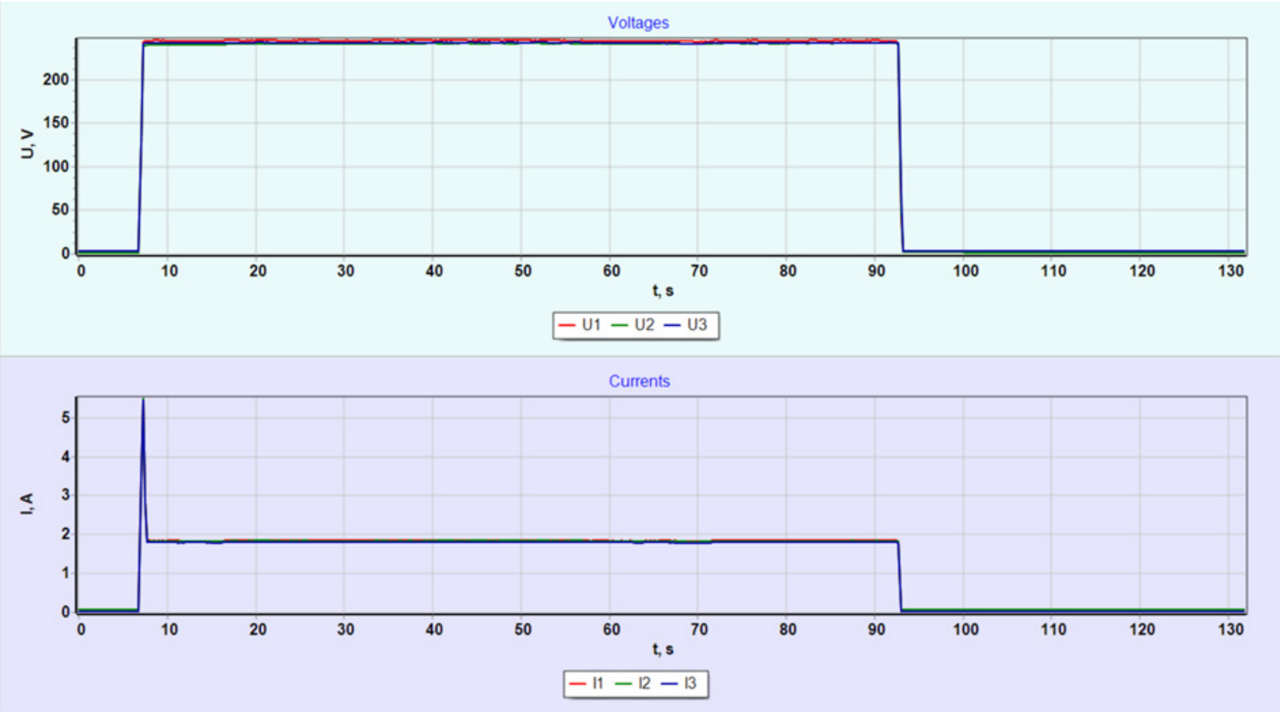


Fig. 4. Graph of changes of effective voltage and current values in model vibratory unit supplied directly from power grid

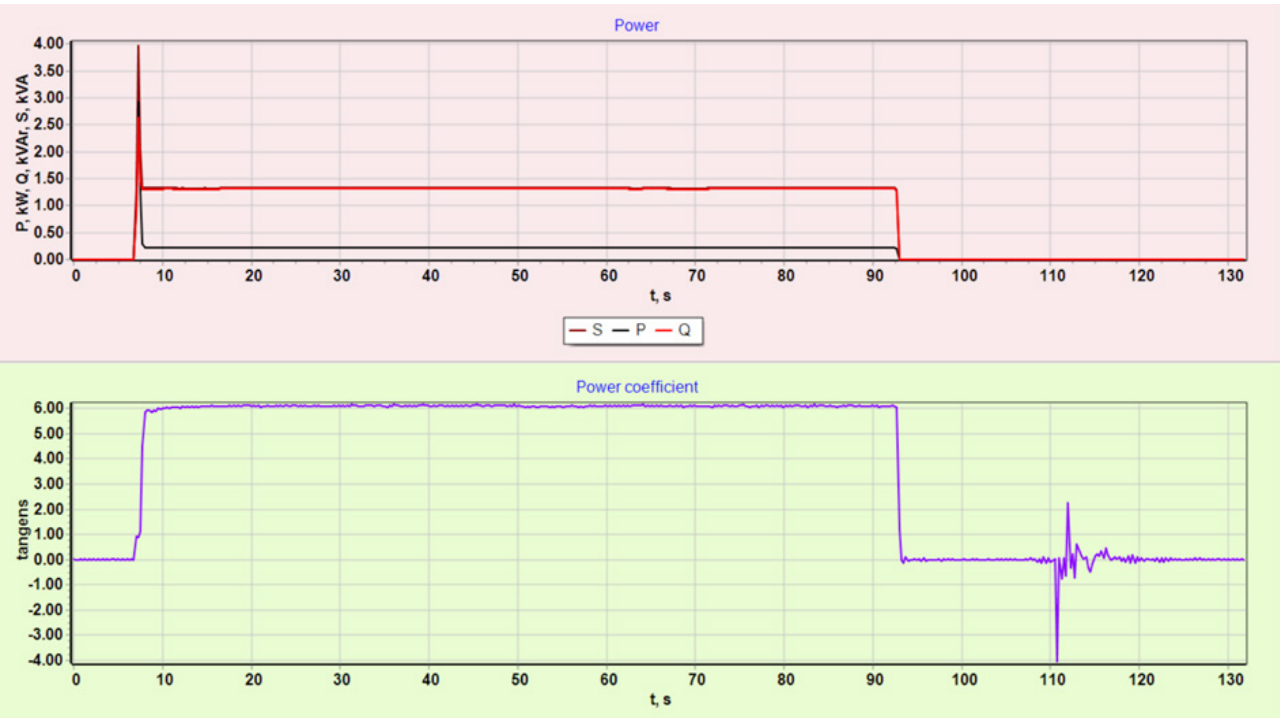


Fig. 5. Graph of changes in active, reactive, and apparent power values as well as coefficient power tgφ in model vibratory unit supplied directly from energy network

Table 2 lists the values of the currents and power parameters in the transient and steady states.

Table 2
Summary of maximum instantaneous and effective values in system of model vibratory unit supplied directly from power grid

Parameter	Transient state	Steady state
Instantaneous current value, A	11.3	2.5
Effective current, A	5.5	1.8
Instantaneous power value, kVA	4.7	0.29
Active power, kW	2.93	0.23
Reactive power, kVAr	2.63	1.30
Apparent power, kVA	3.96	1.33
Power factor, tgφ	6.2	

From an analysis of the data in Table 2, the instantaneous phase current value at the time of switching on the power was 4.5 times greater than the current value at this phase in the steady state of the model vibratory unit operation. The maximum effective value of the phase current in the transient state was 3 times higher than the effective value of the phase current in the steady state. The instantaneous power of the transient state was more than 16 times higher than the instantaneous power of the steady state. The power-supply system of the two motors in the vibratory unit was characterized by a power factor of tgφ = 6.2 (cosφ = 0.16), which means the reactive power compensation is incorrect.

3. MEASUREMENTS IN MODEL VIBRATORY UNIT POWER SUPPLY WITH INVERTER FOR FREQUENCY SETTING OF 50 Hz

A three-phase LS Industrial Systems [5] inverter (SV055iG5A-4) with maximum power of 5.5 kW and maximum frequency of 400 Hz was used in the power supply of the model vibratory unit. The tests were performed for the 50 Hz frequency supply voltage made according to the diagram shown in Figure 6. This allowed us to collect information on the selected power parameters between the inverter and drive motors of the model vibratory unit.

For the recorded changes in the instantaneous voltage, current, and power values (Fig. 7), the effective values of voltages and currents (Fig. 8) have been calculated along with the active, reactive, and apparent power as well as the power factor tgφ (Fig. 9).

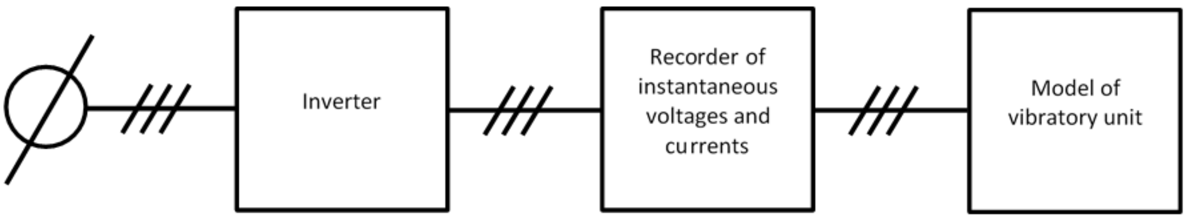


Fig. 6. Diagram of recording system of instantaneous voltage and current values between inverter and model vibratory unit

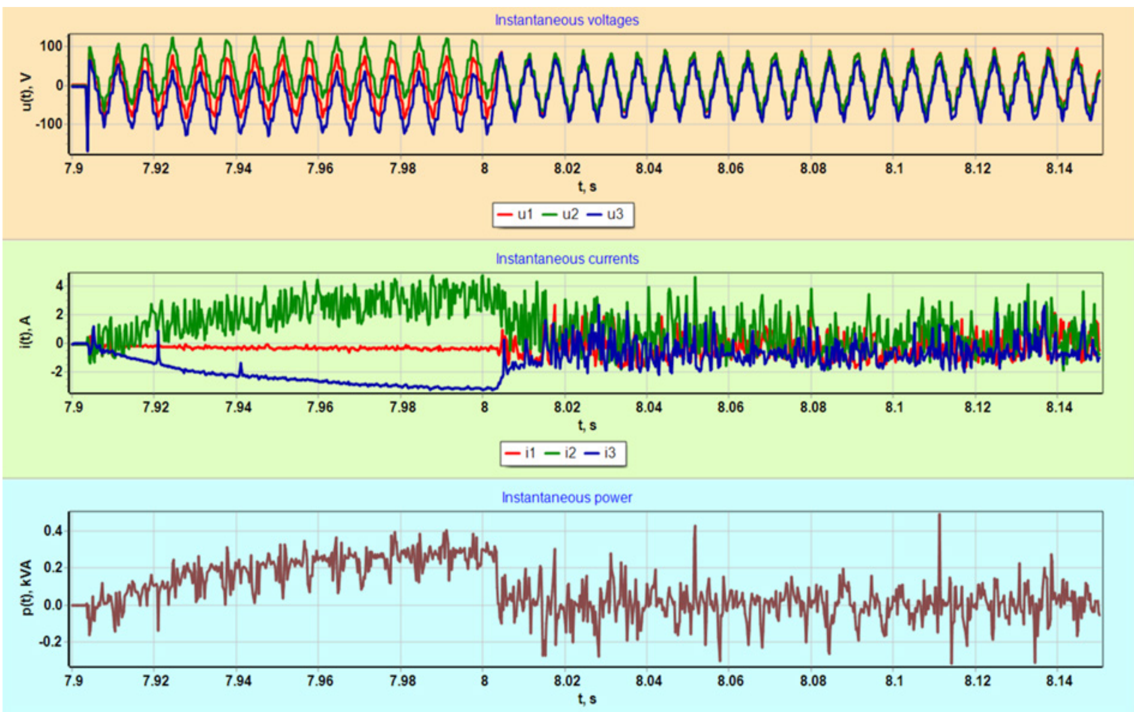


Fig. 7. Graphs of instantaneous voltages, currents, and power in the system according to Figure 6 (frequency inverter setting is 50 Hz)

As can be seen from the graphs in Figure 7, the shapes of the phase currents in both the transient and steady states deviate significantly from the sinusoidal ones. The effective current value in the transient state is more than 30% higher than the effective current value in the steady state (Fig. 8). Power factor tgφ is equal to approximately 6.0 in the steady state, which means the compensation of reactive power is incorrect (Fig. 9).

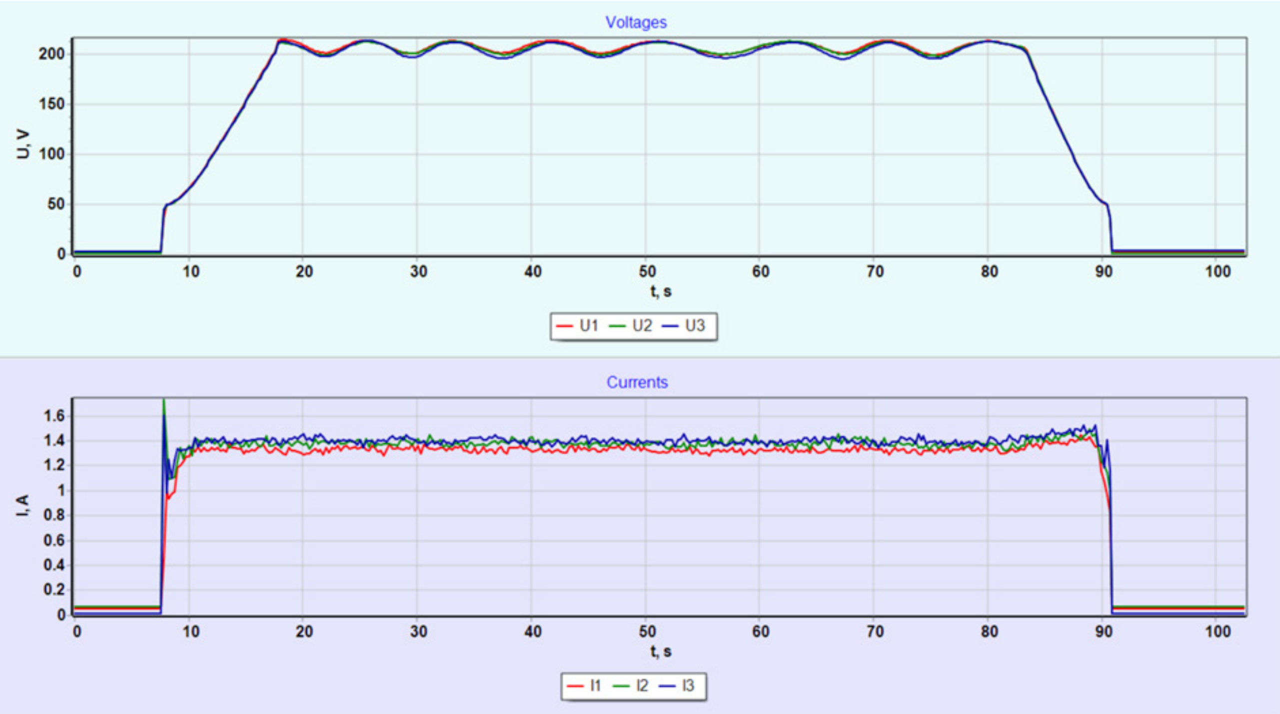


Fig. 8. Graphs of effective voltages and currents in system according to Figure 6 (frequency inverter setting is 50 Hz)

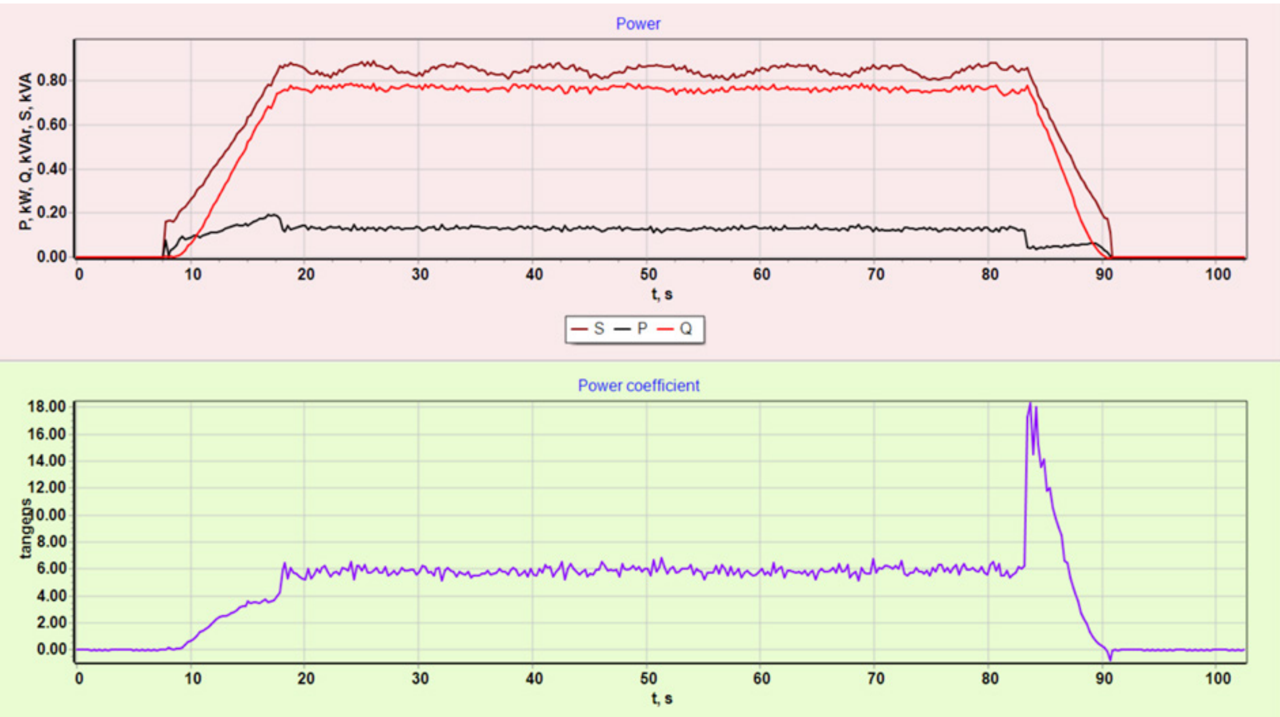


Fig. 9. Graphs of active, reactive, and apparent power as well as power factor tgφ in system according to Figure 6 (frequency inverter setting is 50 Hz)

4. COMPARISON OF MEASUREMENTS AND CALCULATIONS RESULTS

Table 3 summarizes the measurement and calculation results of the selected power parameters for the model vibratory unit supplied directly from the power grid and through the inverter (frequency setting is 50 Hz).

Table 3
A summary of the selected energy parameter values in the model vibratory unit supplied directly from the energy network or while using an inverter (frequency setting is 50 Hz)

Parameter (steady state)	Power supply	
	directly from energy network	using inverter
Effective voltage, V	243.0	210.0
Effective current, A	1.8	1.4
Active power, kW	0.23	0.15
Reactive power, kVAr	1.30	0.76
Apparent powerf, kVA	1.43	0.90
Power factor, tgφ	6.0	6.0

The power consumption of the model vibratory drive for the standard inverter parameter settings (frequency equal 50 Hz) represents approximately 63% of the power consumption when supplied directly from the energy network. This is the result of the smaller values in the effective voltages and currents. The power factor tgφ is a constant value only. In the steady state, the use of the inverter in the power supply causes relatively small deformations from the sinusoid for the voltages and a very high level of harmonic currents. It also enables the soft start of the motors after power up as well as their smooth braking. In this power system, there are significantly smaller peaks in the steady state than in the case of direct supply from the power grid.

5. CONCLUSIONS

The performed measurements and calculations of the selected energy parameters in two variants of the power-supply system of the model vibratory unit (directly from an energy network or using an inverter for a frequency setting of 50 Hz) allow us to compare the power consumption and effective voltage and current values in the transient or steady states. Using the inverter with standard setting parameters for a frequency of 50 Hz causes lower power consumption by motors compared to the supply from an energy network, as well as lower effective voltage and current values and very large deviations in the currents from the sinusoid.

Acknowledgements

This work was elaborated under research and development study no. 11.11.170.318, task 6.

REFERENCES

[1] Dańko J., Kamińska J., Skrzyński M. (2013). Reclamation of spent moulding sands with inorganic binders in the vibratory reclaimer REGMAS. *Archives of Metallurgy and Materials*, 3(58), 993–996.

[2] Polzin H., Nitsch U., Tilch W., Flemming,E. (1997). Regenerierung anorganisch gebundener Altsande mit einer mechanisch arbeitender Pilotanlage. *Gieserei-Praxis,* 23/24, 500–507.

[3] Boenisch D. (1990). Reclamation of spent used sands containing bentonite. Guidelines for an economical leading to minimized waste. *Giesserei*, 77(19), 602–609.

[4] *Industrial vibrators.* Retrieved from http://www.wamgroup.com/en-GB/corporate/Family/405/Industrial-Vibrators (accesed 4.05.2017).

[5] *Variable frequency drives*. Retrieved from http://www.lsis.com/usa (accesed 5.05.2017).

[6] Ziółkowski E. (2010). Monitoring of the supply system of electrical foundry equipment. *Archives of Foundry Engineering*, 10(2), 169–172.

[7] Ziółkowski E., Smyksy K., Bień A. (2016). Monitoring power supply systems of electric foundry devices using recorder of voltage and current instantaneous values. In Górny M., Grabowska B., Gurgul D. (Ed.), *Nauka i technika w inżynierii procesów odlewniczych.* Kraków: Akapit, 101–106.

[8] IEEE standard definitions for the measurement of electric power quantities under sinusoidal, nonsinusoidal, balanced and unbalanced conditions. *IEEE*, 1459–2010.

[9] Miller J.E. (Ed.) (1982). *Reactive power control in electric systems.* New York: John Willey & Sons.

[10] Abur A., Expósito A.G. (2004). *Power System State Estimation: Theory and Implementation.* CRC Press.

[11] Zieliński T.P. (2007). *Digital signal processing: from theory to applications.* (2nd ed.). Warsaw: Communication and Transport Publisher.

[12] Czarnecki L.S., Halley P.M. (2014). Unbalanced power in four-wire systems and its reactive compensation. *IEEE Transactions on Power Delivery*, 30(1), 53–63.