

# Investigation of power consumption by a laboratory roller mixer

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Received 26.02.2009; accepted in revised form: 30.03.2009

## Abstract

This study compiles the recorded values of instantaneous voltage and current levels in a three-phase system designed to power-supply the laboratory roller mixer. The measurement technique is outlined and relevant algorithms are provided for computing apparent power, active and reactive power, as well as power factors  $\cos\phi$  and  $\tan\phi$ . Calculation data reveal some fluctuations of power demand in the function of the amount and moisture of the synthetic system sand being mixed. Conclusions were drawn concerning the potential compensation of reactive power demand by an investigated roller mixer.

**Keywords:** power consumption, roller mixers used in foundry engineering

## 1. Introduction

The analysis of power demand by mixers used in foundry engineering aims to determine the impacts of major parameters of the sand mixing process on the selected parameters of the power-supplying systems. These relationships are of key importance when designing control systems to support the sand mixing operations and to minimize the consumption of electric power by the mixers.

This study is focused on power consumption by roller mixers widely used in foundry plants. Application of the specialised recorder of instantaneous voltage and current levels, fabricated by two collaborating AGH-UST units: the Department of Metrology and the Laboratory of Mechanisation, Automation and Foundry Plant Design, afforded a more thorough analysis of power demand than the previous methodology, outlined in [2].

Conclusions based on the analysis of power demand by the roller mixer might be of great significance in terms of cost-effectiveness and operation and maintenance requirements.

## 2. Experimental setup

The Simpson type roller mixer (Fig. 1) is equipped with a three-phase 1 kW motor, power-supplied directly from the mains.

Power levels are recorded by the microprocessor system fabricated specially for the purpose of the research program and intended for measurements of instantaneous voltage and current levels in three-phase power-supplying systems. Recorded data are fed via a USB port to a computer to store, process and graphically display the results.

The detailed functional and technical description of the microprocessor system is shown elsewhere [3, 4].

The functional diagram of the system for measuring power demand by a laboratory roller mixer is shown in Fig. 2.

Algorithms for computing particular power components and power factors are given elsewhere [3, 4, 5].

## 3. Measurement and calculation data

Rollers fitted in roller mixers may vary in width. Tests were run on rollers 80 mm in width (weight of each roller 14 kg) or 120 mm in width (21 kg). Fig 3 shows the parts of the windows for archiving and visualisation of computation data derived for an empty roller mixer, the roller width being 80 mm and 120 mm.

Plots of particular power components shown in Fig. 3 reveal that apparent power in the steady state approaches 1 kVA, active power consumed by the mixer reaches 280 W whilst the factor  $\tan\phi$  assumes the value 4.0, which corresponds to  $\cos\phi=0.24$ . Of

major importance are fluctuations of power components in the function of roller width.

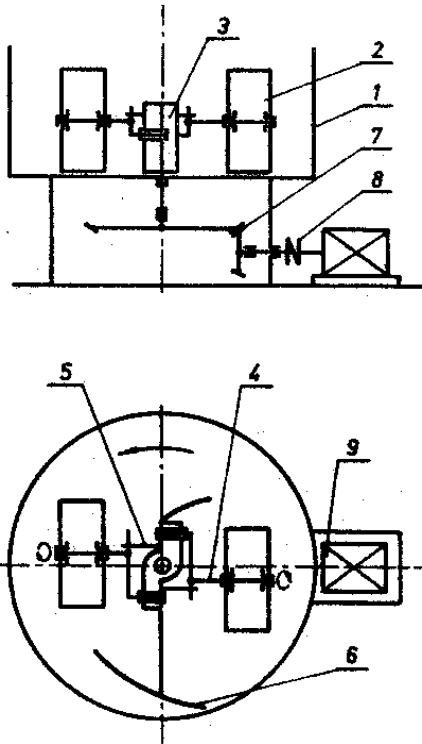


Fig. 1. Simpson type roller mixer [1]: 1- mixer pan, 2- rollers, 3- head, 4- roller axes fixed on balance levers, 5- supports to fix the suspension height

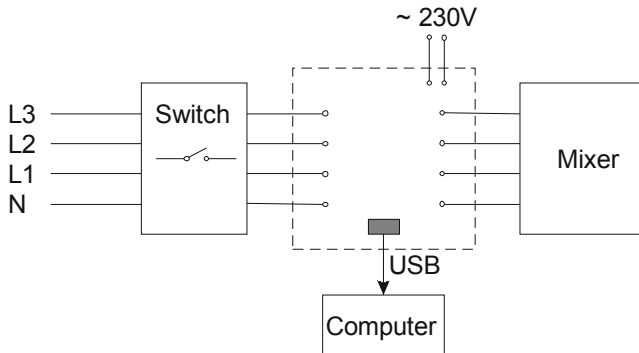


Fig. 2. Computer system for recording power consumption by a roller mixer

Instantaneous voltage and current levels were first recorded for an empty mixer, in the subsequent stages the roller mixer was filled with sand mix in the amount of 1 kg, 2 kg, 3 kg and 4 kg. The sand mix contained 8% of Special bentonite (by weight) and the 3% proportion of water. Fig. 4 shows the recording window for all these cases.

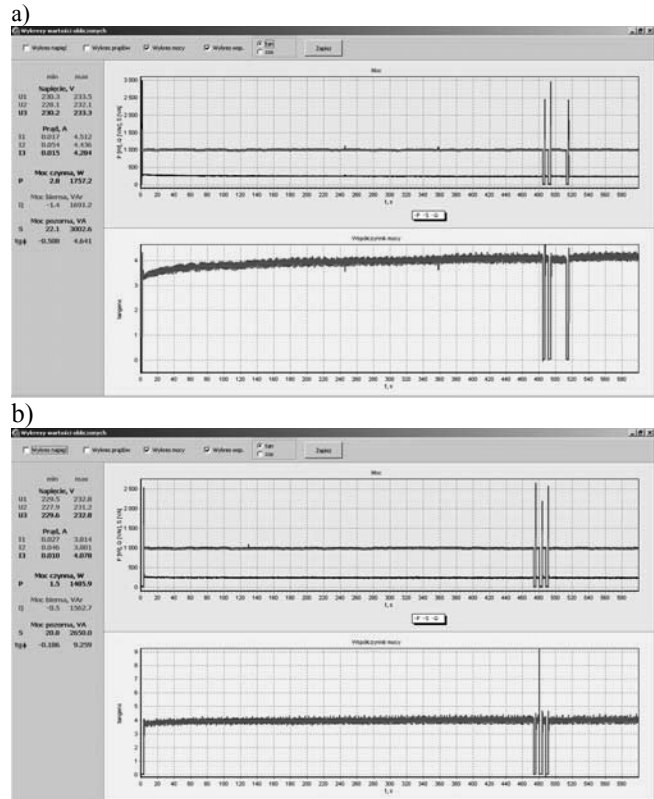


Fig. 3. Windows showing calculated power components and the factor  $tg\phi$  for an empty roller mixer: a - roller width 80 mm; b - roller width 120 mm

In all cases when the mixer was filled with the sand mix, the value of absorbed active power would slightly change and so would the factor  $tg\phi$ . Fig. 5 shows the factor  $tg\phi$  in the function of the amount of sand mix for the investigated roller mixer. The value of  $tg\phi$  fluctuates in the range from 3.3 to 3.9, which is equivalent to  $cos\phi$  variations from 0.25 to 0.29.

In the next stage the measurements were taken for a roller mixer with the roller width 120 mm and for the sand mix containing 4.6 kg of sand, 400 g of bentonite and 150 ml of water. After mixing for 60 s, water was dosed in the amount of 150 ml. That meant the moisture increase from 3% to 6%. Such high water contents in the sand mix is not justified in terms of process requirements. In this particular case, however, tests were run to show how power consumption should change when the sand mixture is sharply enhanced.

Fig. 6 shows the windows displaying the plots of power components and the factor  $tg\phi$  during the registering of power consumption by a roller mixer with parameters specified in earlier sections.

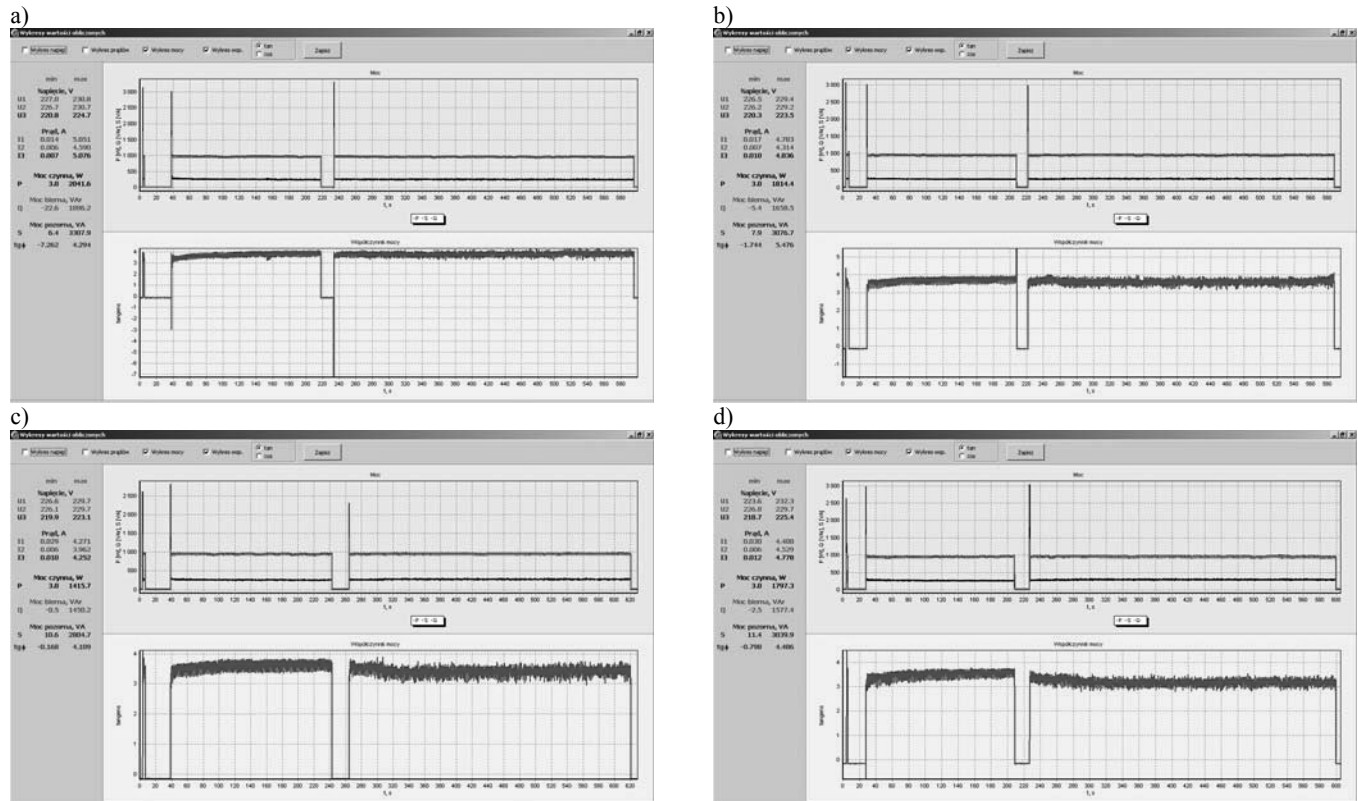


Fig. 4. Computed power components and factor  $tg\phi$  for roller width 80 mm and inside crank 20 mm; a - 1 kg of sand mix; b - 2 kg of sand mix; c - 3 kg of sand mix; d - 4 kg of sand mix

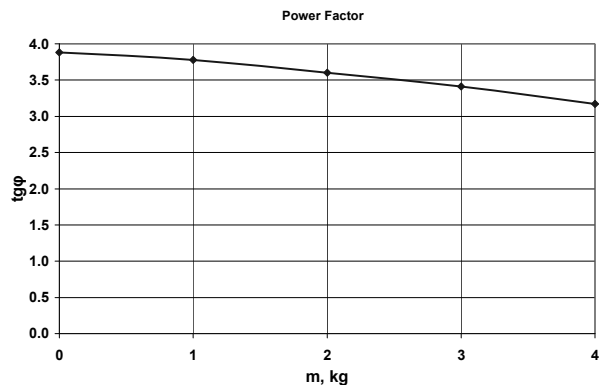


Fig. 5. Factor  $tg\phi$  vs the amount of sand mix in the roller mixer

Fig. 7 shows the variations of the factor  $\cos\phi$ , having relevance to those shown in Fig. 6. To illustrate the change of the factor  $\cos\phi$  before and after an additional dose of water is added, Fig. 8 shows the relevant section of the power record. It is readily apparent that for a roller mixer filled with 5 kg of sand mix, the moisture rise from 3% to 6% causes the factor  $\cos\phi$  to fall from 0.37 to 0.3. Accordingly, the mixer loading is reduced. In the range of widely adopted parameters of the sand mix and rollers, the value of  $\cos\phi$  varies from 0.25 to 0.37. For the given set of

rollers, the change of sand mix moisture changes the value of  $\cos\phi$  in still lesser degree.

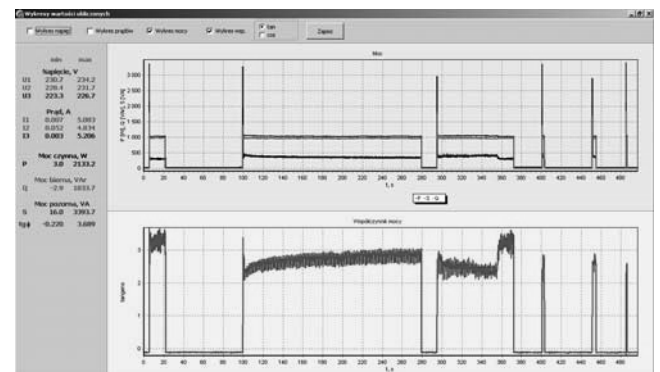


Fig. 6. Plots of power components and the factor  $tg\phi$  for two moisture levels (roller width 120 mm, mixer charge - 5 kg of dry mass plus 3% and then 6% of water)

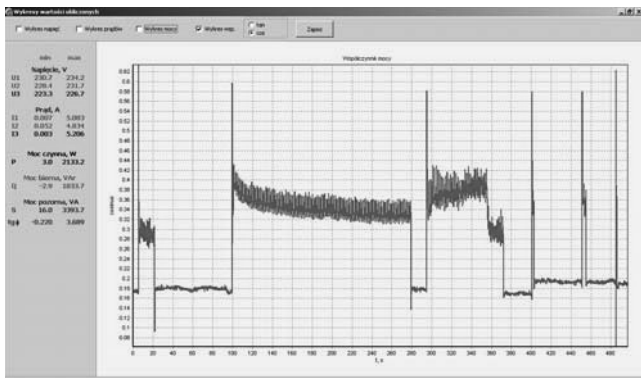


Fig. 7. Registered fluctuations of  $\cos\phi$  (the remaining parameters as in Fig. 6)

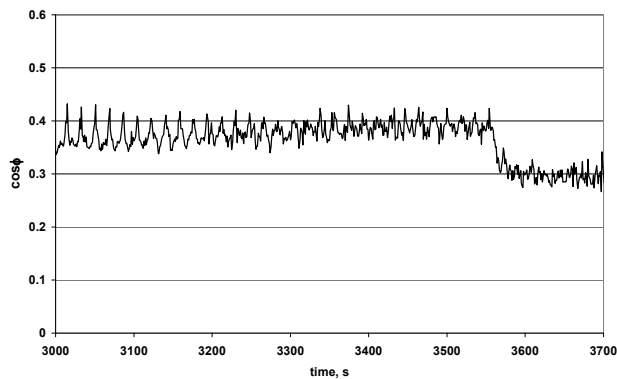


Fig. 8. Change of  $\cos\phi$  after dosing an extra amount of water to the roller mixer

This conclusion is of primary importance from the standpoint of engineering and design. Minor fluctuations of power factors do not allow reliable measurements of instantaneous voltage and current levels required for effective control of the sand mixing processes in roller mixers. Further conclusion can be drawn that the system power-supplying the roller mixer is not fully compensated in the whole range of sand mixing process parameters. A narrow range of fluctuations of  $\cos\phi$  permits the use of batteries of compensating condensers with fixed capacity.

## 4. Summing up

Application of the recorder of instantaneous voltage and current levels in a three-phase power-supplying system allows a reliable analysis of power consumption by the given foundry machine.

Measurements taken on a laboratory roller mixer revealed the roller type and variations of sand mix composition and moisture affect the power demand in a minor degree. That limits the potential applications of the method for measuring power consumption in control systems supporting the sand mixing process. Application of a condenser battery with constant capacity in the power-supply system allows for reducing the costs of electricity and hence the costs of system sand production.

## Acknowledgments

This work was financed by the grant from the resources for scientific research in years 2008-2010.

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