R. MOSZUMAŃSKI

ISSN 0543-5846
METABK 57(3) 171-174 (2018)
UDC – UDK 669.052.14-662.388.336-668.47:66.028:622.84=111

COMPONENTS PRECISE DISPENSING FOR LOW FLOWABILITY MIXTURES

Received – Primljeno: 2017-02-08
Accepted – Prihvaćeno: 2018-02-04
Preliminary Note – Prethodno priopćenje

The conception of precise dosing of multicomponent mixtures, some of which point out low flowability properties or lack of them at all. Laboratory tests of precise dosing were conducted in semi-automatic cycle with manual interruption of dosing and automatic cycle based on indications of electronic balance. The next step was to verify selected results on a test stand in a technical scale. On this basis, the component dispensing model system stand for the manufacture mixer was designed. Model dispensing research was conducted in a virtual environment.

Key words: components mixtures/steel vool/barite/graphite-coke, resin, precise dosing, low flowability

INTRODUCTION

The methods for component precise dosage of the metal-ceramic-polymer multicomponent mixtures. The composition comprises components constituting the skeleton of the material (as a substitute for asbestos used in the past), a binder (generally a phenolic resin) and constituents having the improving effect on both thermal conductivity and high temperature resistance. The percentage by weight of a typical blend is as follows: steel wool – 20 %, barite – 18 %, graphite and coke – 10 % each and resin – 8 %. The remaining 34 % contains numerous enriching admixtures [1]. Most of the components present very poor flow properties, which eliminates volumetric dosing [2]. Therefore, so far the used method has been based on the manual gravimetric dosing needing the human presence due to the fact that required weighing processes cause heavy dusting.

THE RESEARCH WORK

The research and development work undertaken in Cracow University of Technology, Rzeszów University of Technology and the Institute for Sustainable Technologies in Radom in cooperation with the Department of Research Firms STEINHOF has aimed at developing of the methods for dust-free, precision dosing components of mixtures with very low flowability. The first stage of the work was to get acquainted with the structure and properties of the individual components. For this purpose photos of core (Figures 1, 2, 3, 4, 5) and enriching components were taken using the optical (x 5) and stereoscopic (x 50) microscope.

R. Moszumański, (e-mail: rysmos@mech.pk.edu.pl) Faculty of Mechanical Engineering, Cracow University of Technology, Kraków, Poland

It is possible to distinguish materials in the form of powders, granulated products and fibers with strong varying sieve dimensions [3].

The characteristic features of the shape of pulverized materials particles disappear after the mixing process combined with breaking up has been carried out (Figure 6).

Further changes occur in the process of static or dynamic heat pressing [4], soaking with recuperation, coating and grinding (Figure 7).

Preliminary laboratory tests of dispensing accuracy carried out in a semi- automatic cycle in which the dosing start and finish time of the process comes both manually and automatically based on the dosing scales indications (Figure 8.).

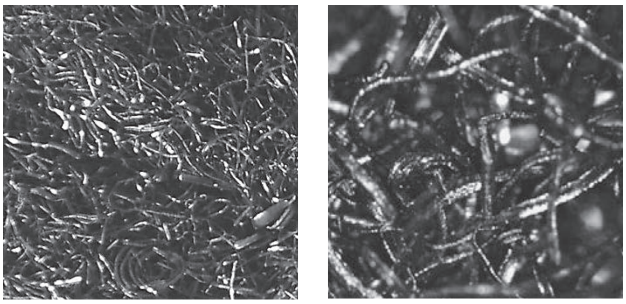

Figure 1 Steel

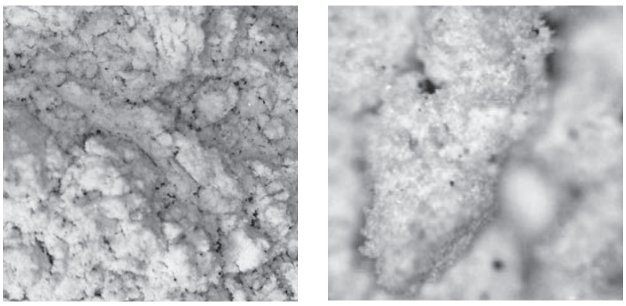

Figure 2 Barite

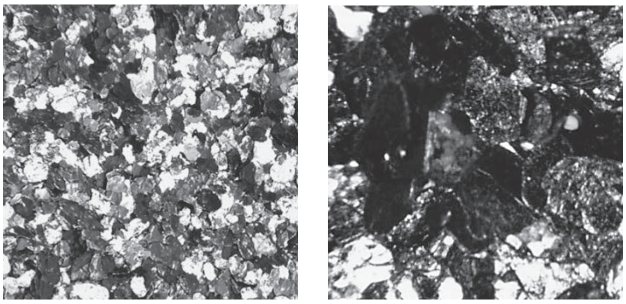

Figure 3 Graphite

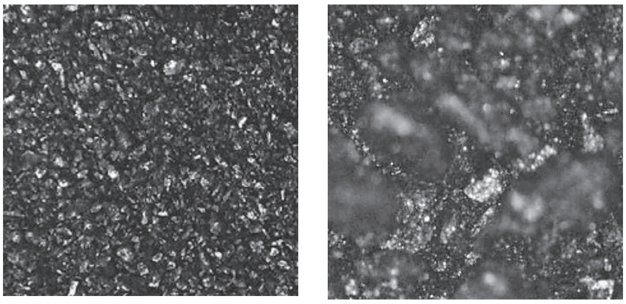

Figure 4 Coke

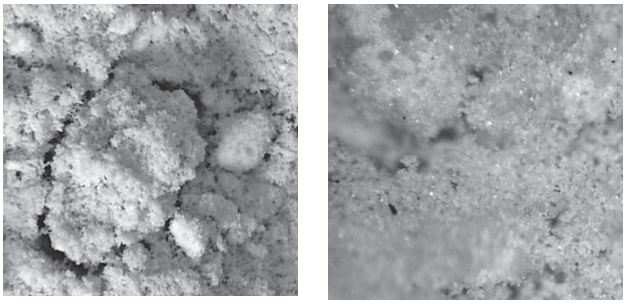

Figure 5 Resin

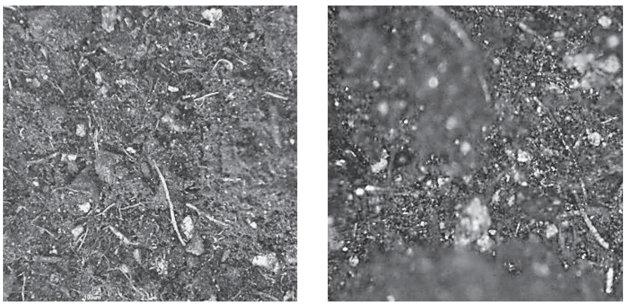

Figure 6 The multicomponent mixtures

Figure 7 A final product - a brake block

Figure 8 The dispensing model system stand

Technical conducting of the experiment consisted in moving the dispensed component from the dispenser 1 (Figure 9) with screw 2 placed in a transparent sleeve and driven engine 3 with variable rotations given by controller 4. The component falls in to a vessel 5 placed on the dosing scales 6 allowing engine 3 to be stopped when the component has reached the desired weight. Analytical scales 7 makes it possible to estimate the accuracy of the process of dispensing.

During semi-automatic and automatic dispensing maximal and minimal values of the dosed components weight i (from 1 to 16) were fixed - Figures 10, 11. The significance was assumed at the level of α = 0,05 therefore the probability is of p = 0,95.

Afterwards, dosing errors $Dm_{śri}/m_{pi}$ * 100 % calculated on the basis of the average differences between the values of charging weights $m_{śri}$ and the values of weights assumed in the formulation m_{pi} for components i (from

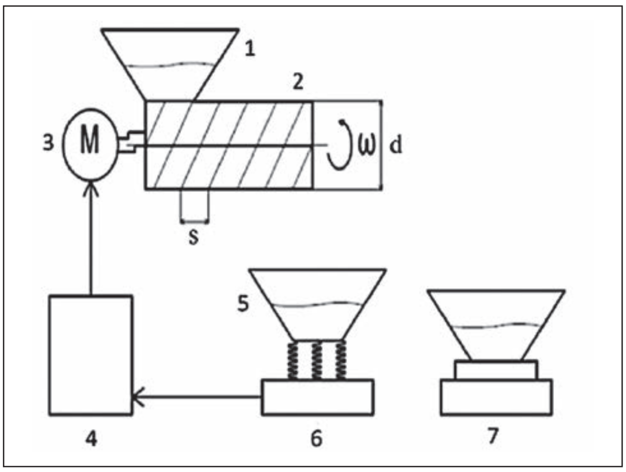

Figure 9 The measuring technique during the dispensing

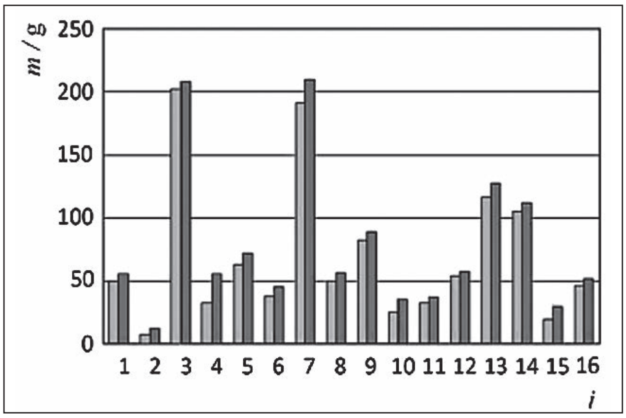

Figure 10 Maximal and minimal values of the components weight during semi- automatic dosing

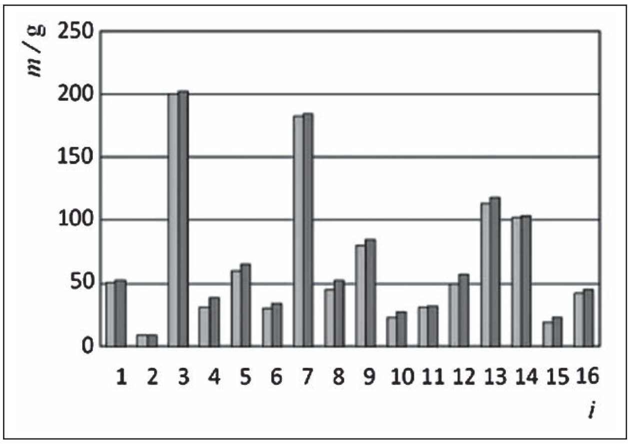

Figure 11 Maximal and minimal values of the components weight during automatic dosing

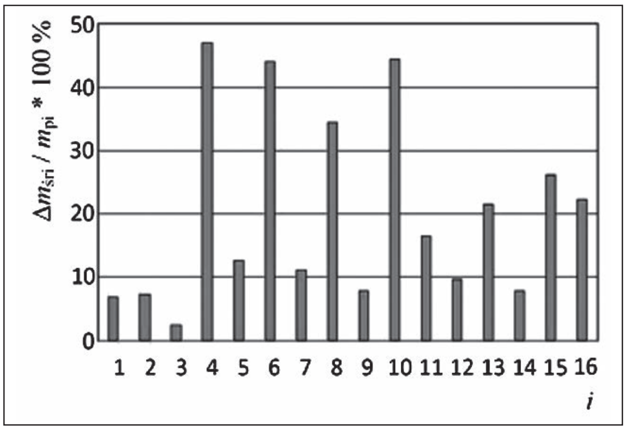

Figure 12 Errors for component weights *i* during semi-automatic dosing

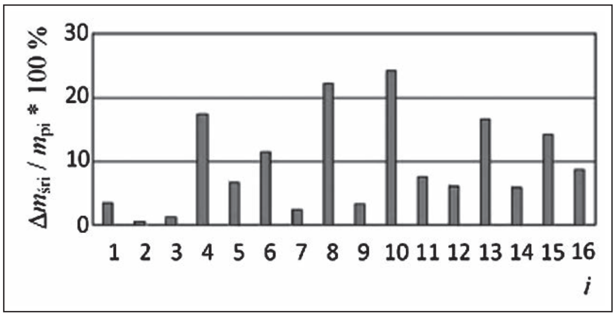

Figure 13 Errors for component weights *i* during automatic dosing

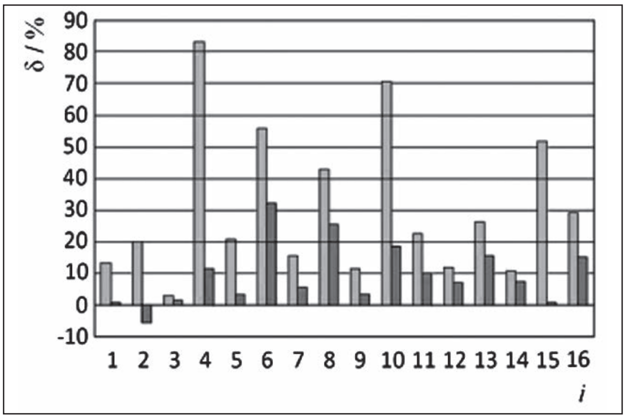

Figure 14 Maximal and minimal errors for component weights *i* during automatic dosing

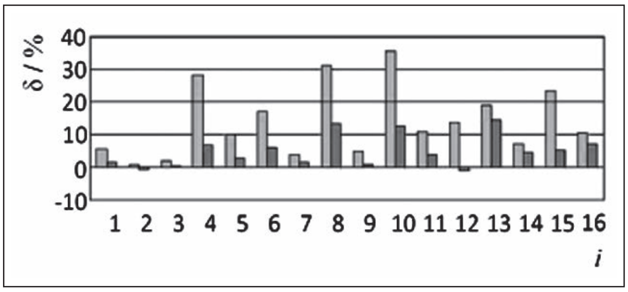

Figure 15 Maximal and minimal errors for component weights *i* during automatic dosing

1 to 16) during semi-automatic and automatic dosing. The results are shown in Figures 12, 13.

Finally, maximal and minimal errors for component weights *i* during automatic and semi- automatic dosing were set (Figures 14, 15), where:

$$\delta = \frac{m_{ij} - m_{pi}}{m_{pi}} \times 100 \ \%$$

THE DEVELOPMENT WORKS

Based on the observation of phenomena and the results of dosing accuracy the automated dispensing method was developed.

The method uses a transport screw optimized in diameter and stroke for each group of components, the two-level rotational speed (ω) and the pulse frequency (A) ending the process of dosing (Figure 16).

The verification of the laboratory research results on the test stand in a technical scale was carried out. For this reason, the component dispenser which one wall was made of a transparent material and equipped with a feeding screw was designed on industrial scale. Owing to this, it was possible to observe the adverse effects associated particularly with falling down the low flowability component load such as the creation of vaults.

Based on obtained results, the model of the dust-free research system related to dispensing components into industrial mixer was designed on technical scale (Figure 17). The system allows to eliminate the direct participation of the servicing personnel in the process of dispensing [5].

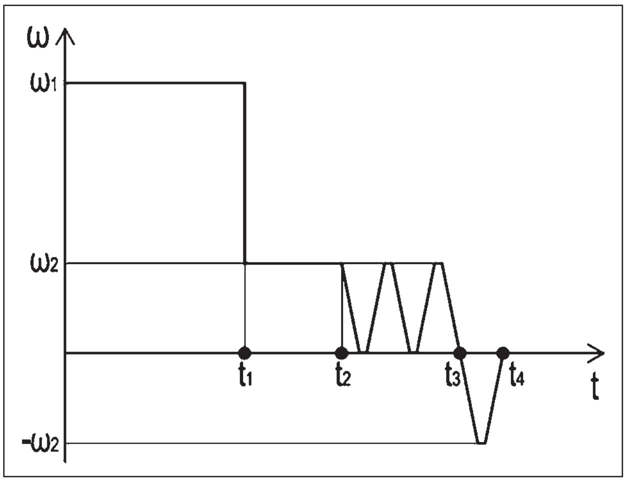

Figure 16 The research methodology during the dispensing

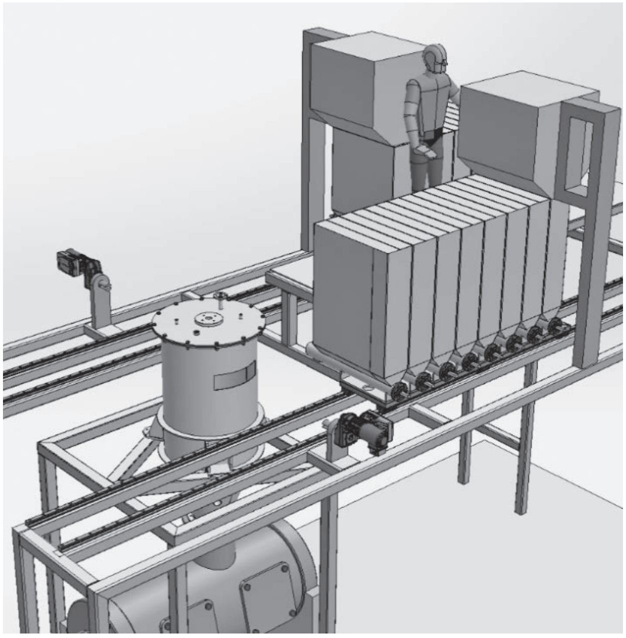

Figure 17 The dispensing model system stand

Component dispensers are filled successively in the common charging cabins. Following dispensers are replaced under the cabins by the trolleys on rails and the task for the worker is to place the suitable packaging in the cabin and make it to be emptied. After filling all dispensers, the system is ready to prepare the mixture.

If the given is emptied below the limit, it filled with specified component by using the selected charging cabin. Basically, eight dispensers of the volume V1 are used to prepare the first batch of components. The dispensers are successively connected with the weighing container and moored with power and then followed by a three-stage gravimetric dosing of the components. After the last dosing of the first batch is over, the upper outlet of the mixer is opened. Next the weighing container and the component fall down gravitationally into the mixer. When the mixer and the weighing container have been closed, the first phase of the process mixing and grinding starts. At the same time the second batch component predominantly from eight dispensers of the volume V2 are being dosed. After the processing of first batch has been finished to components of the second batch are poured into the mixer. When the process of component mixing has been finished, the transporting container is placed and mud the mixer which the upper lock is opened. The container is unmoored and displaced to the press feeder or to the silo of the mixture. The research carried out on the model system will make it possible to design the experimental prototype incorporated into the pilot production line of brake linings for motor- cars, trucks and sport cars.

CONCLUSIONS

The accuracy of laboratory semi- automatic dosing was improved in the applied process of automation. It should added that in the process the procedure of experienced operators was used.

The dosing research on the test stand in a technical scale made it possible to verify the observation in a small scale and the detection of new phenomena occurring during the movement of material from the dispensers through the screw feeder to the weighing vessel.

The virtual experiment of dosing carried out in a technical scale by using the research system model of the dust-free component dosing for the industrial mixer has confirmed correctness of the made assumptions and the applied technological and structural solutions.

Therefore the planned construction of the dust- free system of components dosing for the industrial mixer will be fraught with a minimal risk of malfunctions in operation.

Aknowledgements

The study was performed as part of the research - development project entitled “Innovative brake lining assemblies of cars with high durability and reliability of modern composites obtained using a unique, energy-saving and environmentally friendly technologies of particulate materials, to improve the safety of people and property great value” – Contract No. POIR.01.01.01-00-1044/15 made with the Center for Information Processing - National Research Institute.

REFERENCES

[1] L. Han et al., Composites Science and Technology 66 (2006) 2895–2906

[2] W. Missol, Spiekane części maszyn, Wyd. „Śląsk”, Katowice (1978), 212-238

[3] S.F. Ścieszka, Hamulce cierne, Wyd. ITeE, Gliwice-Radom (1998), 76-121

[4] K. H. Cho, M. H. Cho, S. J. Kim, H. Jang, Tribological Properties of Potassium Titanate in the Brake Friction Material; Morphological Effects, Tribol Lett (2008) 32:59–66

[5] R. C. Dante, Types of friction material formulas, Handbook of Friction Materials and their Applications (2016), 29-56

Note: The person responsible for English language is Mrs. Krystyna Bany, Kraków, Poland