Numerical calculation of the flow through a three-way coal dust separator

Grzegorz Borsuk[1, a)] Bolesław Dobrowolski[2, b)]

[1]Faculty of Mechanical Engineering, Chair of Thermal Engineering and Industrial Facilities, Opole University of Technology, Mikołajczyka 5, 45-271 Opole, Poland
a)corresponding author: g.borsuk@po.opole.pl.
b) b.dobrowolski@po.opole.pl

Abstract. The paper presents the results of calculations, in which the construction of a three-way separator. It is to provide a proper distribution of dust in the brown coal power supply system. Numerical studies were carried out using a spatial numerical model and then compared with the results of measurements of the modernized boiler OB-650.

INTRODUCTION

In the professional power industry, conditions are created that, to the maximum extent, the production and operation of energy devices should allow producing energy in the most economical way possible. The design requirements for newly built energy devices and the operational requirements of modernized devices go in the direction of ensuring in the first place high efficiency and availability, then optimal repair conditions. Changing economic and ecological conditions change the requirements for the boiler and all devices. An example of such changes is the necessity to ensure an appropriate distribution of dust to the burners of a brown coal boiler ins such a way that the dust mixture directed to the upper discharge burner was diluted and contained only very small particles. In the power system of Polish brown coal power plants, fan mill is used, which is associated with high humidity of coal reaching 50%. The drying and transporting medium is a mixture of air and flue gas from the furnace chamber. Fan coal mills prepare and pump a fuel mixture that includes dust and heated air by exhaust gases. The purpose of the work is to develop a three-way separator structure installed in the place of the dust-air duct above the fan mill sifter. The distributor is to ensure proper distribution of dust at four different distributor settings relative to the mill sifter: A – angle 30°, B - 70°, C - 105°, D - 135°. Fig. 1 presents the location of fan mills around the OB-650 boiler and the outline of the mill sifter with the distributor mounted before modernization.

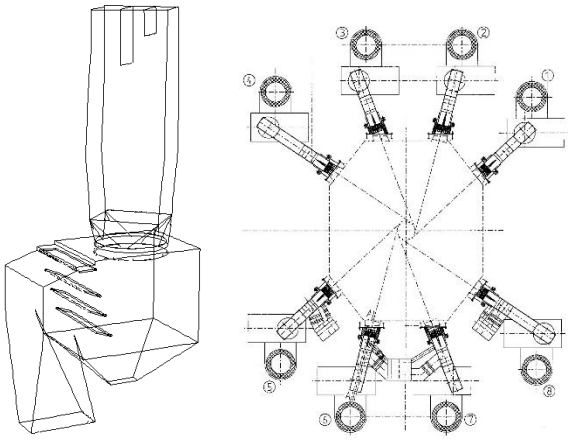

FIGURE 1. Setups of grinding mills around boiler and outline of distributor before modernization

METHOD OF CALCULATIONS

The construction of the dust channel with the blades increases the pressure drop that the mill fan must overcome. In numerical studies [1] a construction was sought in which the assumed dust separation would be achieved and at the same time a pressure drop across the distributor would be as small as possible and acceptable by the system at each distributor setting relative to the mill.

Fig. 2 presents the concept of the canal installation with vanes separating the dust-air mixture and the spatial numerical grid for setting A of the sifter system with the distributor. The adopted system of blades was determined on the basis of preliminary research on two-dimensional models. Which was the verified on three-dimensional models [1]. Numerical calculations were made using the Ansys Fluent package [6].

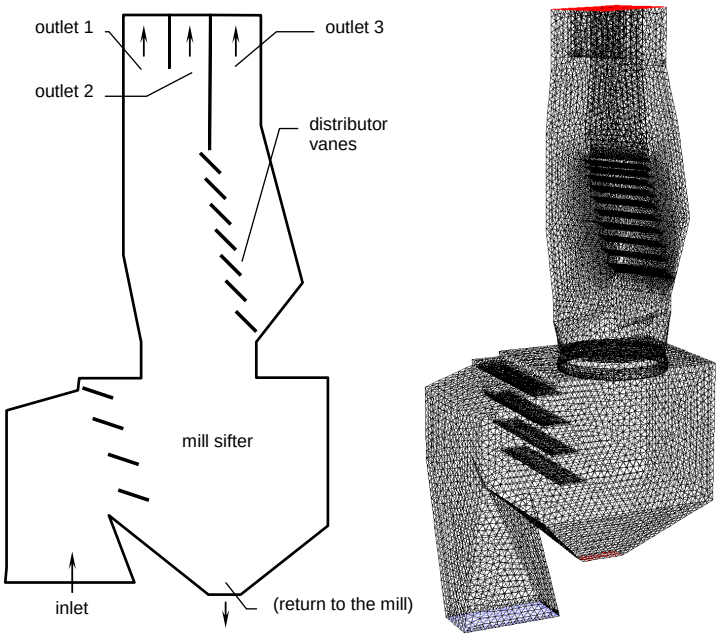

FIGURE 2. Renewal concept and numerical grid

Fig. 3 presents the results of the dust distribution calculations for individual outlets at the sifter blade setting horizontally. Despite the differentiation of dust distribution to outlets 1 and 2, the calculations showed that the adopted multi-vane manifold design ensures delivery of less than 15% of dust to outlet 3, which was the main requirement for ecological reasons (reduction of NOx emissions).

Assuming gas distribution at individual distributor outlets, a distribution of velocity and pressure in the flow area was sought, the mass distribution of dust was calculated as a result of determining the trajectory of the dust particles divided into 15 discrete dust fractions in the diameter range from 1 to 1500 μm. The mass fraction was determined based on the knowledge of the RRS distribution parameters (residual R900 – 58%, residual R1000 – 4%, polydispersity n=0,738, disintegration number b= 0,0197 and substitute diameter d=204 μm).

An additional factor that can affect the work of distributors is the angle of the blades in the mill sifter. In the calculations, the position of the sifter blades was taken horizontally and with a deflection at an angle of 20° down.

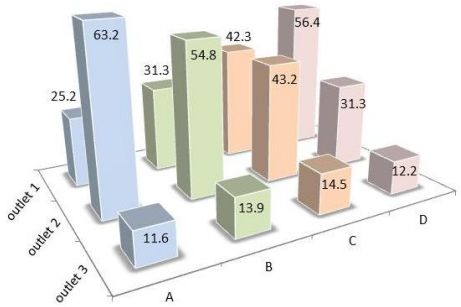

FIGURE 3. Distribution of mass of coal depending on configuration

CONCLUSIONS

The design of the distributor selected in the work with a large number of blades with inter-blade distances reduced in the upper part of the distributor ensures the assumed separation of dust at each distributor setting relative to the sifter. The calculations have also shown that the change in the position of the sifter blades affects the separation of dust between two first outlets, but does not significantly affect the amount of dust directed to the 3rd outlet.

REFERENCES

1. G. Nowosielski, B. Dobrowolski, *Inzynieria Chemiczna i Procesowa vol. 25, Issue 4*, 2097-2104 (2004).
2. G.Borsuk, S. Pochwała, J.Wydrych, *Engineering Mechanics* 2016, IT AS CR, Prague, pp. 78-81 (2016).
3. J.Wydrych, G. Borsuk, S. Pochwała, *Engineering Mechanics* 2017, Brno Technical University, Brno, pp. 1074-1077 (2017)
4. A. Olcay, M. Kahraman, S. Atas, *ISI Bilimi ve Teknigi Dergisi – Journal of Thermal Science and Technology*, vol. 36, Issue 2, pp. 135-146

5. S. Atas, U. Tekir, MA. Paksoy, A. Celik, M. Cam, T. Sevgel, *Fuel Processing Technology* 126, 441-452 (2014)
6. ANSYS Fluent, Ansys Inc., (2018)