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Dust Emission and Efficiency of Local Exhaust Ventilation During Cast Iron Grinding

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A method of determining dust emission and efficiency of its removal by means of local exhaust ventilation from machinery has been described. It complies with Standard No. EN 1093-3:1996 (European Committee for Standardization, 1996) and consists in determining air pollution concentrations in the measurement duct used for air removal from the chamber incorporating devices to be tested. The air volume stream that is pumped is measured at the same time.

Test results are presented for dust emission and the efficiency of local exhaust ventilation for cast iron grinding by means of manual power tools and a bench-sander. It has been found that application of local exhaust ventilation contributes to a significant reduction of dust emission with efficiency greater than 90%.

dust local exhaust ventilation grinders

1. INTRODUCTION

Machining (cutting brittle materials, grinding, polishing, preparing surface for protective coats, etc.) is a process that is accompanied by dust emission. For instance, it has been found that dust concentrations of up to approximately 300 mg/m^3 are possible in the air inhaled by the worker during cast iron

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grinding by means of a dual-disk bench-sander in areas without local exhaust ventilation. Workers involved in machining are usually directly affected by dust emissions, which results in admissible air dust concentration levels being exceeded in respiration zones. Existing machinery and manual power tools are not always equipped with local exhaust ventilation; there is often no local exhaust ventilation at workstations, and general ventilation is insufficient.

Basically every workstation endangered by dust emissions should have local exhaust ventilation and the source of dust emission should be situated where the housing or suction nozzle are efficient. The housing of dry operating sanders is connected to filtrating-ventilation units or de-dusting systems. Manual power tools causing dust emissions are now increasingly provided with their own housings or suction nozzles and with fans and de-dusting systems. Alternatively they can be adapted so they can be connected to mobile filtrating-ventilation units or stationary local exhaust ventilation systems. Exhausted air can be repeatedly supplied to the room or removed outside.

Knowledge of dust emission and the efficiency of its removal is required in order to evaluate operating efficiency of local exhaust ventilation devices and to enable correct designing of general ventilation in a room. Data available in hitherto existing literature were insufficient. Also no information regarding dust emission values caused by machining of various materials and regarding the influence of machining process parameters on dust emission values has been available. Dust emission tests for beech wood and chipboards machining by means of manual electric power tools, and for operating efficiency of local exhaust ventilation devices have been carried out by Berufsgenossenschaftliches Institut für Arbeitssicherheit (BIA), Sankt Augustin, Germany (Georg, Heimann, Leßnich, & Post, 1998; Heimann, 1989).

Working Group No. 15 for Machinery Safety in the European Committee for Standardization (CEN) Technical Committee No. 114 has been engaged in the standardisation process regarding emission of pollutants from machinery into ambient air. However detailed standards applicable for groups of machines and machines and tools are not available yet.

On the basis of experimental tests (Gliński, 2000) carried out for a dual-disk sander and a manual electric sander, it has been found that application of local exhaust ventilation for sanders in the form of their own housings or suction nozzles results in a significant reduction of dust emission into ambient air.

2. METHODS AND SCOPE

Tests were carried out in compliance with European Standard No. EN 1093-3:1996 (CEN, 1996) at a test stand—a chamber (Figure 1). They consisted in determining dust concentrations in the air carried out of the chamber with equipment to be tested and the volume of air flows.

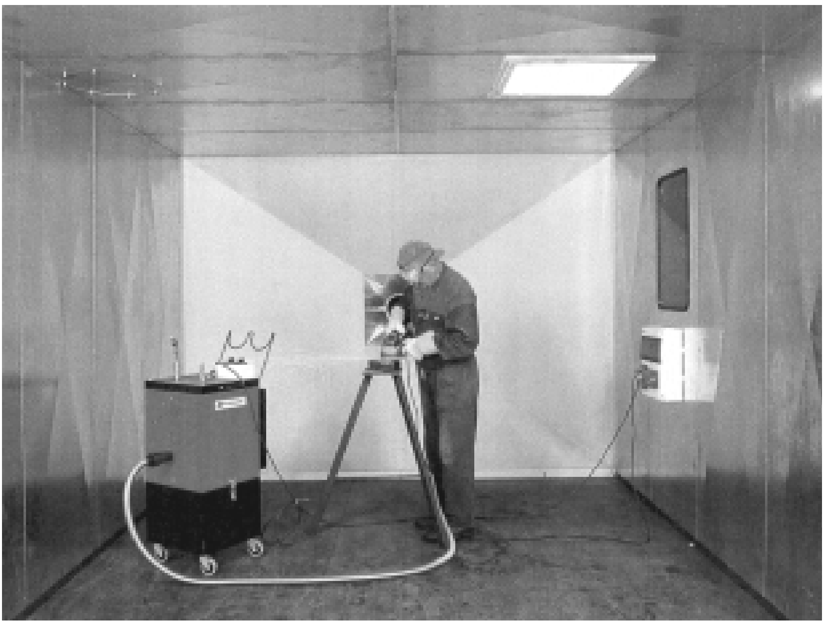

Figure 1. Test stand for determining the efficiency of emission reduction for suction components of local exhaust ventilation during measurements for a manual power sander connected to a filtrating-ventilation unit.

Emission values are determined on the basis of the following formula:

$$E = 1.67 \times 10^{-5} \times V \times S_p,$$

where E—dust emission into ambient air (mg/min), V—air volume stream flowing along the measurement duct (m^3/hr), S_p—average dust concentration in the measurement duct (µg/m^3).

The air volume stream carried out of the chamber is measured by means of a Venturi tube according to Standard No. ISO 5167-1:1991 (International Organization for Standardization [ISO], 1991).

A GRIMM (USA) laser dust monitor model 1.108 has been designed for measuring air dust concentration, that is, for determining concentrations of solid particles (particle number/dm^3) and mass concentration (micrograms/m^3) for 15 intervals of aerodynamic grain diameters. Mass concentration values for specific kinds of dust are obtained by multiplying the measured values by the determined experimentally correction factor C.

Measuring air dust concentration is done in a measurement duct used for removing air out of a chamber. Air samples are drawn using the isokinetic method by means of a GRIMM (USA) probe model 1.152 with one of four interchangeable measurement nozzles designed for measuring air flow velocity in the duct within the range from 2 to 25 m/s.

The values of average dust concentration in the measurement duct are determined for time intervals characterising typical operating conditions of the tested device. These values are obtained as arithmetic mean values of concentration readings stored in the analyser's memory (for successive 1-min suction periods) for real operating time of the tested device, determined on the basis of the operation schedule prepared during the tests. The efficiency of the reduction of dust emission (the efficiency of local exhaust ventilation, capture efficiency) is calculated on the basis of air dust concentration for operating and non-operating local exhaust ventilation installed in the vicinity of the tested device when identical measurement conditions are maintained (air volume streams, operating parameters of the device, properties of machined material, etc.). The value of the reduction of dust emission (in the case of ventilation equipment incorporated in the chamber) equals the total efficiency of suction nozzles and filtrating-ventilation units carrying out the air from the pollution source. This efficiency is calculated with following equation:

$$\eta_c = \frac{S_u - S_k}{S_u} \times 100$$

where η_c—suction efficiency (%), S_k—average dust concentration in the measurement duct with operating local exhaust ventilation (μg/m^3), S_u—average dust concentration in the measurement duct with non-operating local exhaust ventilation (μg/m^3).

During the measurements constant conditions of machining (type of material, constant force of thrust at machining) were maintained.

The following devices were tested:

- a dual-disk bench-sander—Aloxite grinding wheels, diameter of 250 mm; housed and connected to a filtrating-ventilation unit with the catalogue capacity of 900 m^3/h, fan motor power of 1.1 kW;

- an eccentric manual power sander, tested in two variants during coarse grinding (Saphir 50 abrasive material) and at finish grinding (Saphir 80 abrasive material);
- an orbital manual power sander (Brilliant 60 abrasive material);
- a rotary manual power sander (abrasive material in the form of dish grinding wheels).

All manual sanders were electric and they were connected to filtrating-ventilation units: for the rotary manual sander with the catalogue capacity of 430 m^3/hr and power of 2 kW; for the remaining sanders—with the catalogue capacity of 230 m^3/hr and power of 1.2 kW.

The scope of the tests included determining the following parameters:

- total emission (for grain size above 0.3 μm) and emissions in selected size intervals for equipment with operating and non-operating local exhaust ventilation,
- efficiency of the reduction of dust emission (suction by means of suction nozzles incorporated in local exhaust ventilation devices and air cleaning by means of filtering-ventilation units) relating to selected size intervals.

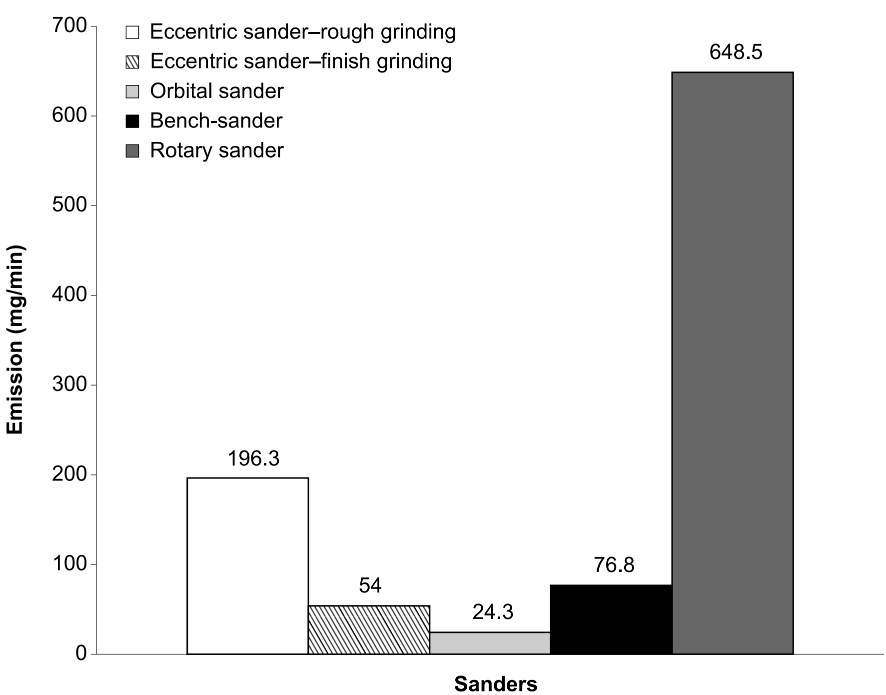

Figure 2. Comparison of dust emission for cast iron grinding with different sanders with non-operating local exhaust ventilation.

3. RESULTS

Figures 2 and 3 present results obtained for selected series of measurements of dust emission performed during machinery operation with operating and non-operating local exhaust ventilation. Figure 4 illustrates the efficiency of dust elimination. Furthermore, for selected measurement series

- Figure 5 illustrates emission percentages for operating conditions with and without air suction (relating to the mass of cast iron dust particles included within the following diameter intervals: 0.3–0.5, 0.5–1.0, 1–10, 10–20, >20 μm) for a dual-disk bench-sander;
- Figure 6 illustrates emission percentages for operating conditions with and without air suction (relating to the mass of cast iron dust particles included within the following diameter intervals: 0.3–0.5, 0.5–1.0, 1–10, 10–20, >20 μm) for an orbital manual sander;
- Figure 7 illustrates emission percentages (relating to the mass of cast iron dust particles included within the following diameter intervals: 0.3–0.5, 0.5–1.0, 1–10, 10–20, >20 μm) for an eccentric manual sander—during rough grinding, for operating conditions with and without air suction;

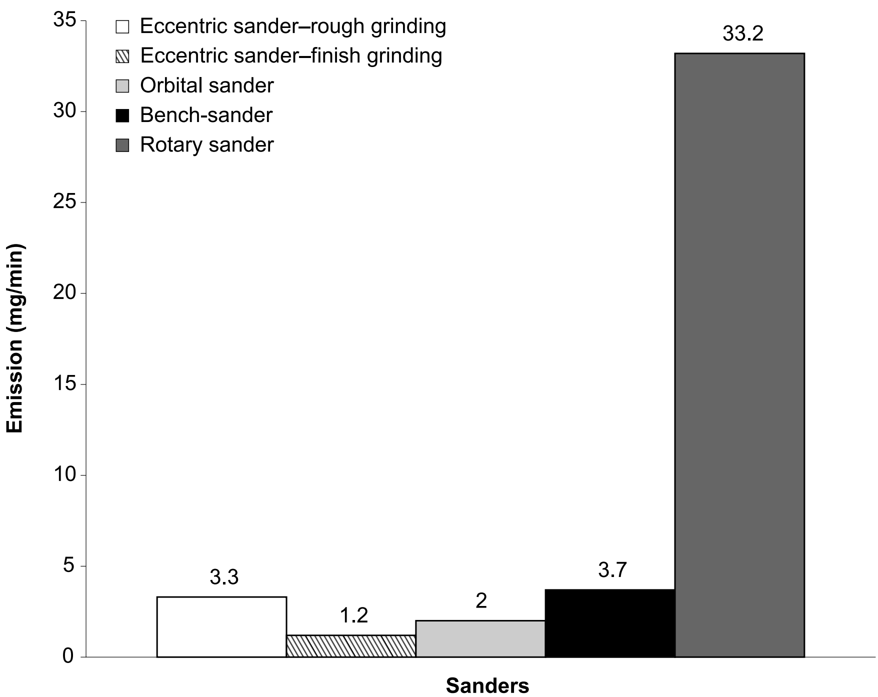

Figure 3. Comparison of dust emission for cast iron grinding with different sanders with operating local exhaust ventilation.

- Figure 8 illustrates emission percentages (relating to the mass of cast iron dust particles included within the following diameter intervals: 0.3–0.5, 0.5–1.0, 1–10, 10–20, >20 μm) for an eccentric manual sander, during finish grinding, for operating conditions with and without air suction.

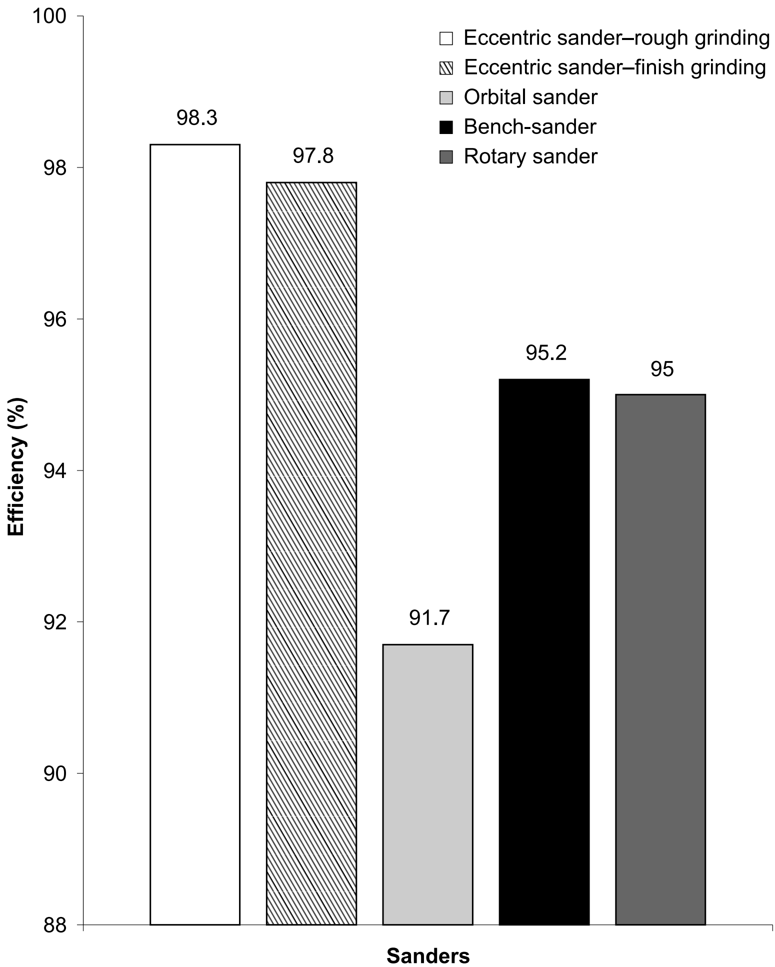

Figure 4. Comparison of capture efficiency for cast iron grinding with different sanders.

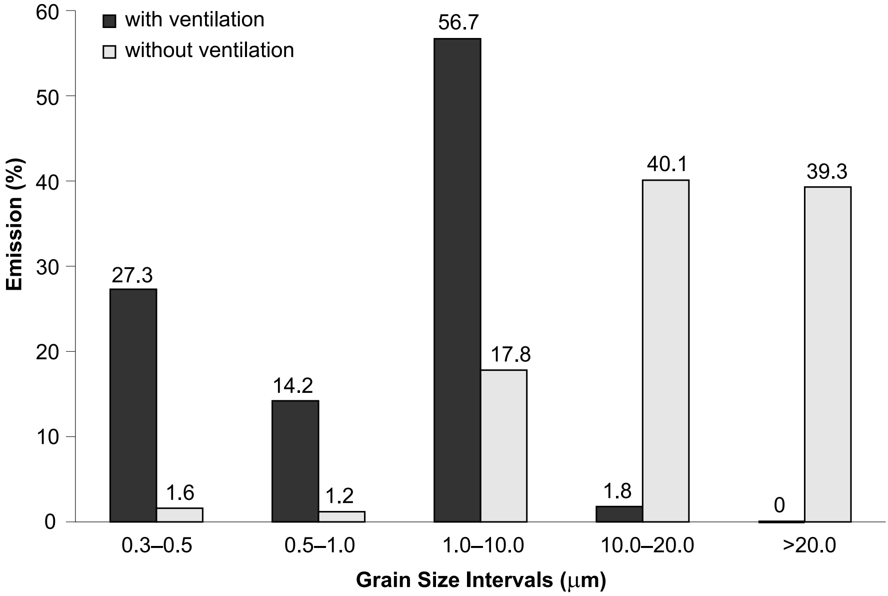

Figure 5. Emission percentages (relating to the mass of cast iron dust particles within several diameter intervals) for a bench-sander with and without ventilation.

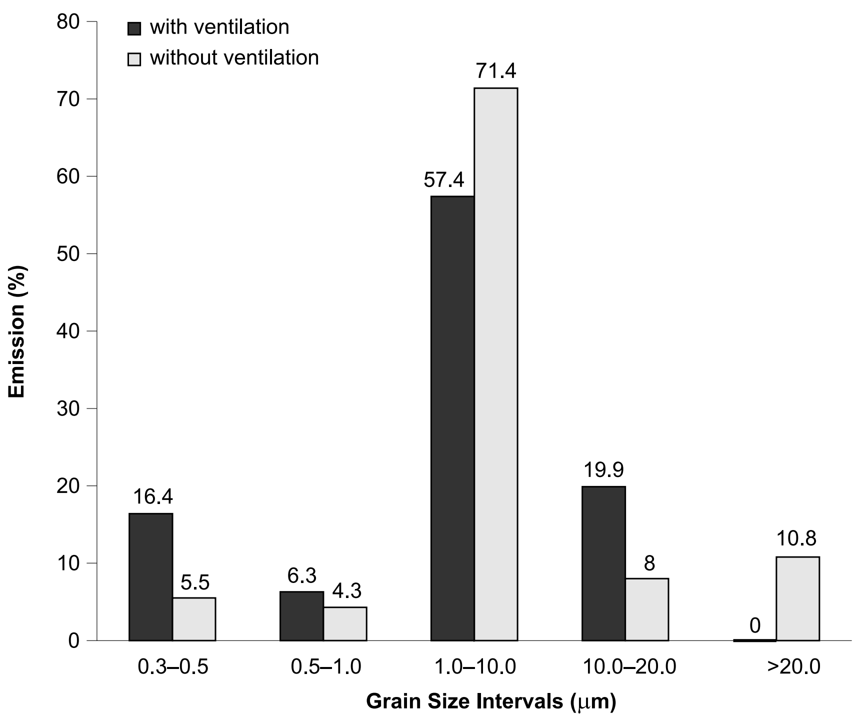

Figure 6. Emission percentages (relating to the mass of cast iron dust particles within several diameter intervals) for an orbital sander with and without ventilation.

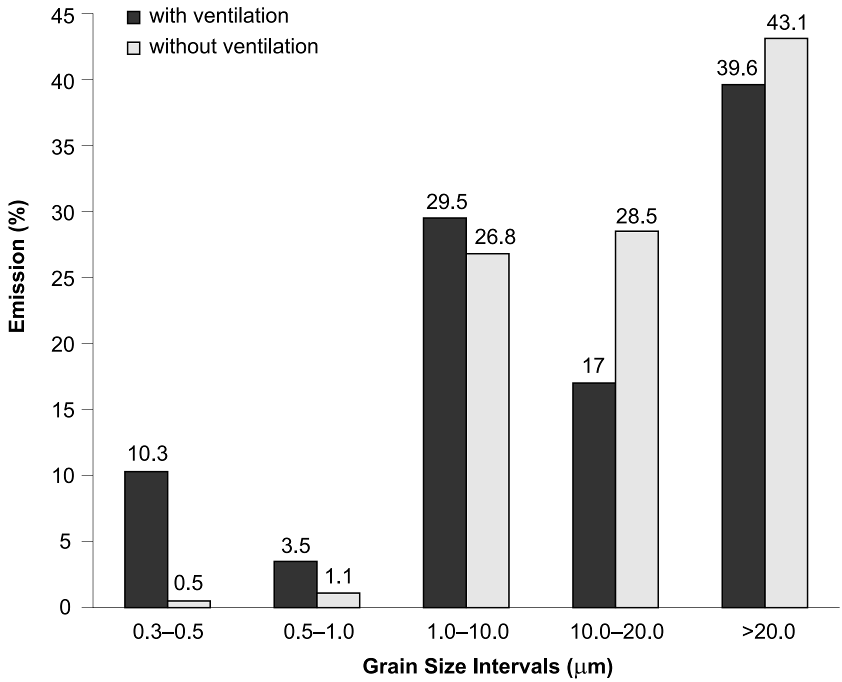

Figure 7. Emission percentages (relating to the mass of cast iron dust particles within several diameter intervals) for an eccentric sander with and without ventilation—rough grinding.

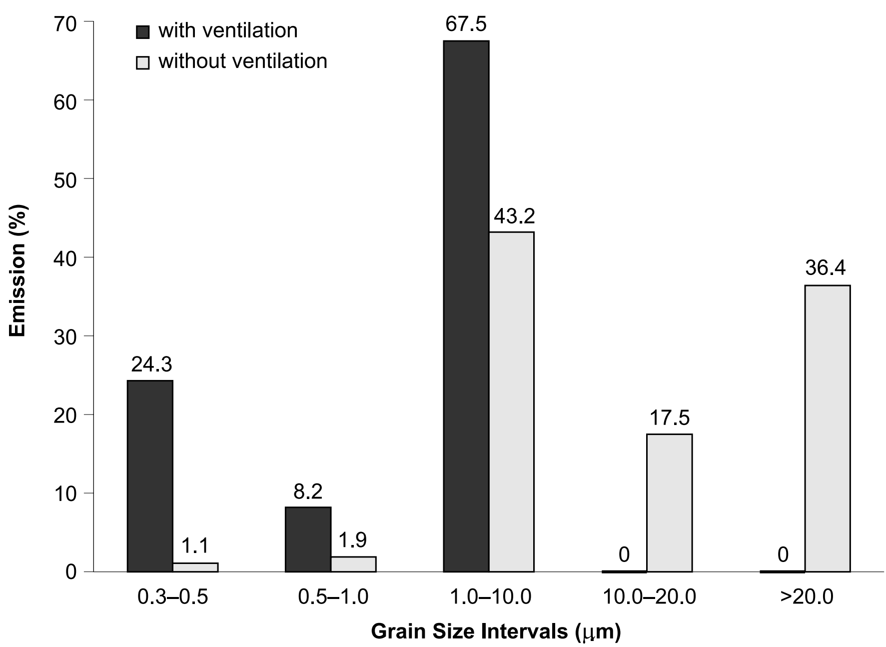

Figure 8. Emission percentages (relating to the mass of cast iron dust particles within several diameter intervals) for eccentric sander with and without ventilation—finish grinding.

4. SUMMARY AND CONCLUSIONS

On the basis of completed measurements and observations of the machining process the following conclusions can be made.

The value of emission depended on the grinding performance affected by the type of material being machined as well as by the machining pressure force.

During cast iron grinding processes, the value of the efficiency of local exhaust ventilation exceeded 90% and was lowest for the orbital manual sander and highest for the eccentric manual sander for rough and finish grinding (Figure 4).

Maximum emission, in the case of non-operating local exhaust ventilation, was found for grinding by means of a rotary angular sander with abrasive material in the form of a dish-type grinding wheel. The emission level in that case was many times higher than for other sanders. Similar relations existed for operating local exhaust ventilation (Figures 2 and 3).

When grinding with non-operating local exhaust ventilation, the majority of emitted solid particles were over 1 µm in diameter (Figures 5, 6, and 7) with the exception of the orbital sander, which produced about 70% of dust emission particles in the interval from 1 to 10 µm (Figure 6).

When grinding with operating local exhaust ventilation, mass predominance of solids emission differs for various sanders, that is, for a bench-sander and an eccentric sander using Saphir 80 abrasive material during finish grinding with the majority of emitted grains having diameters below 10 µm (Figures 5 and 8), for eccentric sander using Saphir 50 abrasive material during rough grinding with the majority of emitted grains having diameters over 1 µm (Figure 7), and for the orbital sander about 60% grains included in the interval from 1 to 10 µm (Figure 6).

The tests confirmed that application of local exhaust ventilation in the form of housings or suction nozzles installed in the direct vicinity of machining elements in the case of cast iron grinding contributed to a significant reduction of dust emission into ambient air. Therefore appropriate selection of a device protecting against contamination emission, operating efficiency of local exhaust ventilation devices, actions initiated in order to modernise machinery, and comparison of various technical solutions for machines with equal application are possible.

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