Experimental investigation of a one-level eight-channel cyclone-separator incorporating quarter-rings

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Abstract

The main aim of this investigation was an experimental analysis of the air cleaning efficiency in a mock-up next-generation air cleaning device – one-level 8-channel industrial cyclone-separator with quarter-rings – while changing parameters of the inner structure and the assessment of the effects of dispersion of particulate matter. Therefore, the research was carried out in two stages: the first stage covered the analysis of the efficiency of the multi-channel cyclone with particulate matter of <20 and <50 µm. During the second stage, a cascade impactor was used to measure the particle collection efficiency in the multi-channel cyclone by fractions: PM1, PM2.5 and PM10. Results of the tests with using the cascade impactor were compared to show changes in the PM composition before and after the multi-channel cyclone-separator. According to the obtained experimental data, the one-level 8-channel cyclone-separator collects 70 to 80 % of PM up to 10 µm in size, 45 to 60 % of PM up to 2.5 µm in size and 21 to 25 % of PM up to 1 µm in size.

Keywords: multi-channel cyclone-separator; particulate matter; air treatment; channel; cascade impactor.

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1. INTRODUCTION

Industrial progress is closely related to environmental protection objectives with one of the most important being treatment of air pollution. Electrostatic and sleeve filters are the most commonly applied devices in world practice due to high efficiency in removing particulate matter (PM) from the air. However, they are expensive and rather difficult to maintain [1–4]. Centrifugal filter is a kind of industrial equipment used for gas (air)-PM separation in thermal power plants, fluidized bed combustion processes, control of air pollution as well as for sorting/sieving materials [5]. Advantages of this filter type include collection and fractional efficiency and low pressure drop [6].

Air treatment facilities are under ongoing development aimed at cleaning the air from increasingly complex chemical compounds and finer PM, with improved cleaning efficiency and reduced operational costs. The term particulate matter (PM) refers to diverse tiny particles found, for example, in exhaust emissions and technological process emissions. It is widely recognized now that fine PM has extremely severe effects on human health. These particles affect lungs and may have adverse effects on humans of various ages, but primarily on people diagnosed already with lung and heart diseases [7,8]. It should be also noted that airborne PM can pass through the skin or eye mucous tissues, but most of PM enter the respiratory system [9]. The smaller is the diameter of the particle, the deeper it settles in the respiratory system. In addition to the respiratory system, PM affects the cardiovascular system causing various heart diseases. Moreover, deposition of these pollutants in the lungs creates an additional load on the heart as it tries to compensate for the reduced oxygen content. Combustion products containing carcinogen benzo[a]pyrene may cause cancer [10]. Likewise, exposure to PM has been found to be associated with lower body resistance to infection. Pneumoconiosis, a common and serious lung disease, is caused by inhaling polluted air containing free silica, or SiO_2 particles. Pneumoconiosis remains a severe global public health issue due to lack of PM prevention in the workplace [11]. Free silicon dioxides

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(sand, quartz) not only affect the lung tissue locally, but also have adverse effects on the entire human body causing functional disorders in the cardiovascular system, central nervous system, etc. Silicosis is a common disease suffered by people working in dusty conditions [12].

Selection of gas treatment equipment should consider a number of factors such as physical/ chemical characteristics of polluted gas and characteristics and contents of gaseous pollutants and PM. Complex pollution of dusted gases requires the use of multistage treatment systems, including dry and wet cleaning devices, which increases capital and operating costs [17, 18]. Apparatus for complex purification of off gases operates in the regime of developed turbulence and is a promising tool for solving this problem [13,14].

Cyclones have been so far some of the most popular devices used for removing PM from air. The reason is a simple structure, low cost and easy operation of these devices. Cyclones are recommended for gas pre-treatment, while the secondary treatment phase usually involves other air treatment devices [15–17] collecting particles smaller than 20 µm. Multi-stage air treatment systems, however, are more complex and expensive [18]. Analysis of PM separation principles shows that for intensification of the dust collection process in gas-PM systems, the use of centrifugal and vortex interactions in fluid flows are the most effective. PM is affected by inertial and centrifugal forces, which significantly exceed the force of gravity. Devices with a regular movable nozzle are an example of vortex interactions of fluid flows. Packing bodies are mounted on flexible strings at fixed steps in vertical and radial directions in the contact zone [14]. Wet-based cyclone design is less implemented due to production of mud or sludge with small particle size (less than 50 µm) and high mass concentration. The conventional hydrocyclone has a poor separation effect in gases with high concentrations of fine particles [19].

Cyclones are incomparable in terms of the price and simplicity of their structure and operation. Due to the specific structure without any movable parts or filtering surfaces that would require regular maintenance, resulting in comparatively small aerodynamic resistance and high efficiency, cyclones are likely to remain competitive in the modern market of air cleaning systems for a long time [20].

Operation of a usual cyclone is based on the widespread principle of separating PM by centrifugal forces created by the turbulent airflow within the equipment shell. The efficiency of such cyclones ranges between 75 and 85 %, for particles larger than 20 µm in size. However, this is not sufficient in terms of the objectives laid down in the EU Directive 2008/50/EC on ambient air quality and cleaner air for Europe [21–25].

On the other hand, multi-channel cyclones can remove very small particles down to 2 µm in size from contaminated airflows. These devices present a possible alternative to more expensive air treatment technologies that are currently in use. In addition, application of a multi-channel cyclone-separator for air cleaning is possible in environments with high temperatures and humidity [26,27].

One of the problems in calculation of the efficiency of a cyclone is the effect of flow dynamic parameters. The flow, which is turbulent in the cyclone body, may be laminar at the entrance. Laminar flow operating parameters have a greater influence on the cyclone efficiency than those of turbulent flow. In small cyclones, it is extremely difficult to predict the effect of flow regime on efficiency and pressure losses compared to the effects of geometrical parameters. It is even more complicated to identify parameters and evaluate a two-phase flow movement in a multi-channel cyclone, as flow dynamics is turbulent and involves such aspects as a swirling movement and backflow circular areas [28,29]. Closed-vortex-flow theory has so far not been able to identify features of a number of flow fields. In addition, assessment based on the turbulence isotropy assumption cannot be adapted to quickly swirling flows [30].

The purpose of this research was an experimental analysis of the air cleaning efficiency in a mock-up next-generation air cleaning device, a one-level 8-channel industrial cyclone with quarter-rings. The aim was to vary the parameters of the inner structure as well as to assess the effects of PM dispersion on the cleaning efficiency. Therefore, the research was carried out in two stages: the first stage focused on the efficiency analysis of the multi-channel cyclone-separator with PM of <20 and <50 µm in size. During the second stage, a cascade impactor was used to measure the particle collection efficiency in the multi-channel cyclone-separator by fractions: PM1, PM2.5 and PM10.

2. RESEARCH METHODS

The mock-ups of one-level, two-level and three-level next-generation multi-channel cyclones have been made at the Research Institute of Environmental Protection of Vilnius Gediminas Technical University (VilniusTech) (Fig. 1) [31,32]. The contaminated air 1 enters the cyclone and passes through channels 3 where particulate matter is collected and then deposited in the collection hopper 4. The purified air 2 exits the cyclone. The use of two-level or three-level cyclones is reasonable in cases of cleaning larger quantities of contaminated air. The novelty of the mock-ups of the multi-channel cyclone-separator provides the opportunity to clean larger quantities of contaminated air by using a smaller cross-section of the cyclone. For this purpose, the number of cyclone levels is increased while the cross-section of the separation chamber remains the same.

Multi-channel cyclones work by centrifugal forces with the additional filtration effect (Fig. 2). The two-phase airflow tangentially passes through the inlet 1 and enters the first channel of the cyclone 8 which is restrained by the peripheral wall and the first quarter-ring 6. Moving gradually in the radial direction, the flow is cleaned from PM by centrifugal force. The flow proceeding to the following channels encounters the quarter-ring wall and is distributed into two flows: peripheral and transitional. The peripheral flow passes to repeated filtration in the cyclone, while the transitional flow goes to the following channel towards the axis of the device and the outlet of the cyclone. In this way, the airflow is distributed evenly in channels with different curves and is filtered through the spaces between the quarter-rings. Turbulent flow is dependent on the fluid velocity, where the turbulent intensity influences the effect of centrifugation while the additional filtration effect occurs in the flow distribution zone. The overall effect of the forces is precipitation of PM at the bottom of the multi-channel cyclone and the particles settle into a conical settlement hopper. Having passed through all six channels of the cyclone, cleaned air flows out of the system through the outlet 4. The dusty air is filtered in the active zone of each channel space. It is a difficult task to investigate dependencies of aerodynamic and separation efficiency parameters, as the flow is influenced by many other parameters (specific geometry, distribution of feedback flows into channels (peripheral and transitional), emission and properties of particulate matter) in addition to its three-dimensional nature [11].

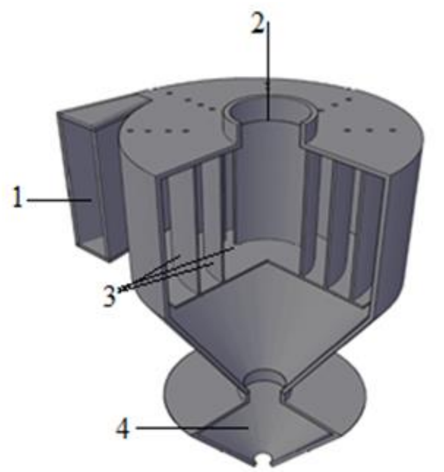

Figure 1. Basic diagram of a one-level multi-channel cyclone-separator: 1– contaminated air, 2 – purified air, 3 –channels of the cyclone, 4 – dust collection hopper

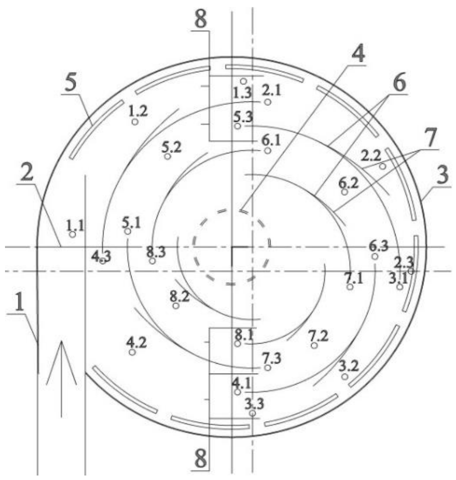

Figure 2. Basic diagram of the 8-channel cyclone-separator: 1 – dusty air flow inlet, 1.1-8.3 – sampling points, 2 – inlet, 3 – cyclone separation chamber, 4 – treated airflow outlet, 5 – segmental ring slots, 6 – curvilinear quarter-rings with a 5° opening angle of plates, 7 – opened plates of quarter-rings, 8 – cyclone channels

Experimental tests were carried out to determine the overall air cleaning efficiency and the efficiency of PM removal by fractions using a cascade impactor system.

The basic diagram of the experimental stand is illustrated in Figure 3. Experimental tests for airflow velocities and pressures were conducted within a system of air ducts with sampling points positioned along a straight section of the steady gas flow so to avoid airflow obstructions (valves, elbows, fans, *etc.)* and in 6 mm gaps made inside the structure of the cyclone, and in the cyclone lid.

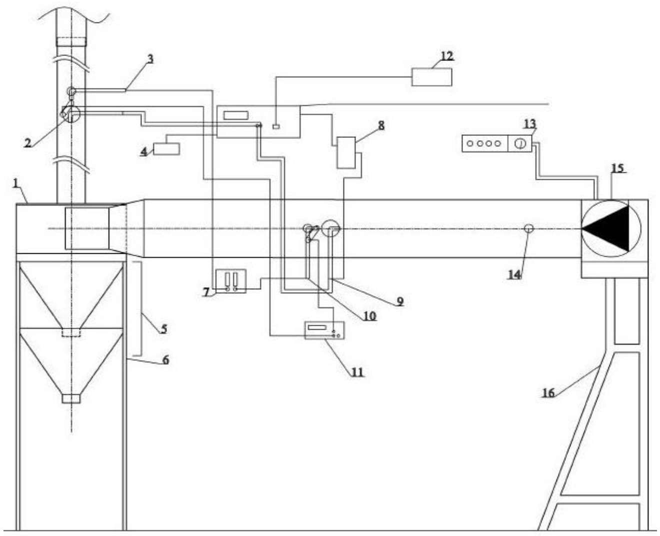

Figure 3. Basic diagram of the experimental stand: 1 – multi-channel cyclone-separator, 2, 9 – isokinetic combined probe of the cascade impactor, 3, 10 – velocity measurement and concentration measurement by using the gravity method, 4 – vacuum pump, 5 – collected PM tank, 6, 16 – supporting structure, 7 – aspirator, 8 – drying tower with the moisture trap, 11 – pressure measurement by a differential pressure gauge DSM-1, 12 – portable computer, 13 – fan control unit, 14 – PM inlet, 15 – centrifugal fan.

To perform the experimental tests, a pre-measurement procedure for airflow velocities and pressures consisted of the following steps: connecting the fan, setting the appropriate airflow velocity, setting the lever of the control unit to the appropriate position, connecting measuring devices.

Airflow pressure in the air ducts was measured before the tangential inlet and behind the cyclone by using a differential pressure gauge DSM–1 (JSC Teltonika, Lithuania, range of measurements: 0–20.000 kPa; deviation ±5 Pa); flow velocity was measured by using the instrument TESTO–400 (Testo SE & Co. KGaA, Germany, range of velocity measurements: 1–30 m s^{-1}, deviation ±0.05 m s^{-1}); aerodynamic resistance was measured by using a Pitot-Prandtl tube (range of velocity measurements: 5−30 m s^{-1}, deviation ±0.05 m s^{-1}).

The airflow within the cyclone-separators is ensured by the 7.5 kW fan system (MBRU 450 T2, CASALS Ventilacion air industrial SLU, Spain, 7.5 kW; rated capacity – 7.5 m^3 s^{-1}). Airflow velocities within the device are analyzed as a function of different airflow rates produced by the fan. Air velocities are measured at three points in each channel of the multi-channel cyclone-separator: at the inlet, in the middle and at the end of the channel. To achieve the maximum accuracy, measurements at each point are taken: 2 cm from the top of the channel, in the middle of the channel and 2 cm from the bottom of the channel.

Airflow velocities and aerodynamic resistance were measured three times in one-level, two-level and three-level multi-channel cyclonic system in order to avoid systemic errors and to reduce the error of the mean of the three results obtained.

During the experiment first stage, air cleaning efficiency is measured by using the gravity method. During the first experimental stage, PM of two sizes (sieved up to 20 µm and up to 50 µm) was used. The tests involved granite, glass, wood ash and wood particulate matter at the mean inlet concentrations of 250, 270, 260 and 235 mg m^{-3}, respectively. The mean size of particulate matter sieved up to 50 µm was equal to: granite – 13.7 µm, glass – 10 µm, wood ash – 14.9 µm and wood – 16 µm. The mean size of particulate matter sieved up to 20 µm was equal to: granite – 8.9 µm, glass – 7.6 µm, wood ash – 10.8 µm and wood – 11.0 µm. The particles are blown in the direction of the flow into the system air duct behind the fan. The appropriate velocity and flow rate of the air to be treated are set in the control unit prior to introducing PM.

Concentration of PM in the air ducts is measured in straight sections with steady gas flow so that to avoid flow obstructions (valves, elbows, fans, *etc*.): the measurement (sampling) point is preceded by a part of the straight duct 5-6 duct diameters in length and followed by the straight duct 3-4 diameters in length. The PM concentrations are measured three times in the system in order to avoid systemic errors and to reduce the error of the mean of the three results obtained. Locations of the sampling points in the experimental stands of one-level, two-level and three-level cyclone-separators are presented in Figures 2 and 3. During the second experimental stage, PM of smaller sizes (sieved up to 20 µm) was used, aerodynamic parameters (gas flowrate) and PM composition were the same as for the first stage.

The quantities of PM are measured by using a KALMAN-type cascade impactor system with an isokinetic probe (Kalman KS-220, Kalman System Ltd., Hungary). Quartz filters of the impactor allow measuring concentrations of individual PM fractions. The samples were analyzed in accordance with the standard ISO 9096.

3. RESULTS AND DISCUSSION

Analysis of the gas velocity distribution in one-level multi-channel cyclone-separator has revealed that the average airflow velocity in the channels was 10.0 m s^{-1} at the air flowrate of 935 m^3 h^{-1}. That air flowrate is often used in boilers (solid fuel (coal, coke, wood pellets used for heat or hot water production). Cyclone-separator is installed behind the boiler for separation of particulate matter from the emitted flow of a boiler of average power (0.5 – 1 MW) while the gas velocity corresponds to the range from 10 to 20 m s^{-1} usually used in conventional cyclone-separators [33,34]. For example, at the gas flowrate of 113 m^{-3} h corresponding to the velocity of 16 m s^{-1}, the cyclone pressure drop was measured as 1200 Pa [35]. On the other hand, a spiral cyclone-separator induces higher pressure drops due to a larger radius of curvature, and therefore the gas velocity should be up to 15.4 m s^{-1} [36]. Next, the aerodynamic resistance was analyzed in the multi-channel cyclone under a 50/50 flow distribution ratio between the transitional and peripheral flows using quarter-rings with a 5° opening angle of plates. The summarized tests data show that the aerodynamic resistance in this case was 1150 Pa. A study of the aerodynamic resistance of a four-channel cyclone [37] demonstrated that an aggressive dispersed gas and vapor flow increased the pressure drop by approximately 10%. Based on a numerical simulation study [34], the highest static pressure zones are at the beginning of the first and second channels where pressure values reach around 350 Pa. The static pressure of gas flow has been experimentally proved to reach 640 Pa prior to entering the cyclone but decreases by 50 % in the next sections [34]. Due to a more complex internal design of the multi-channel cyclone-separator as compared to a hollow conventional cyclone, the pressure drop is for 10–15 % greater at low flowrates, while it is equal in both devices at the maximum inlet flowrate [38]. A study of pressure drop in a small cyclone has shown that the values were equal to 1200 Pa at the same gas velocity (12 m s^{-1} approximately) [6]. The value of aerodynamic resistance is presumed to have increased compared to the conventional cyclone-separator due to additional local obstructions (curved elements and separation chamber).

Efficiency of the cyclone-separator determined for 2 particle sizes (<20 µm and <50 µm) during the first experimental stage is presented in Figure 4. The highest air treatment efficiency is obtained for granite PM with the efficiency of 88.8 % for removal of the coarse particles and 87.0 % for smaller particles.

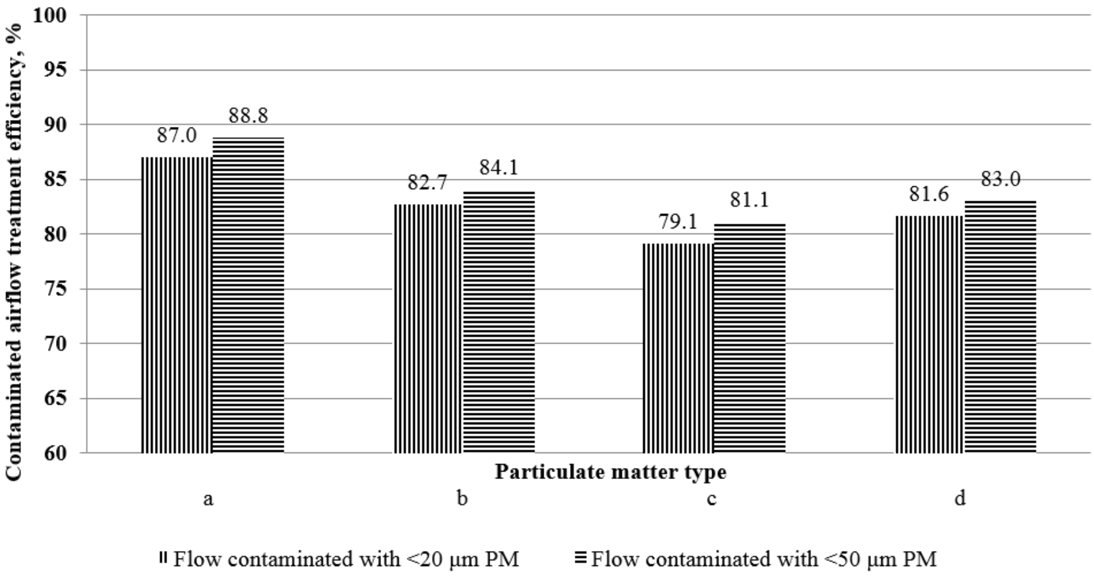

Figure 4. Overall air treatment efficiency in the one-level 8-channel cyclone-separator mock-up for different PM with particle sized of up to 20 µm and 50 µm, under the average airflow velocity in the channels of 10 m s^{-1} and a flow distribution ratio of 50/50, using quarter-rings with 5° opening angle of plates: a) granite, b) wood ash, c) glass, d) wood

Granite PM has the highest specific gravity as compared to the other investigated materials. The obtained overall air treatment efficiency was 9–11 % higher than the results reported for a dust collector of a cyclonic-vortex dry-type plant at an optimal velocity of 5 m s^{-1} [14]. In a previous research study [39] the optimal velocity for a conventional cyclone design with multi inlet guide channels is reported to be 8.8 m s^{-1}. The separation efficiency for particles of up to 2 µm in size was 71.2 % and for smaller particles up to 1 µm in size was 54.6 % [39]. In the present study, the air treatment efficiencies for wood ash PM were lower by 4.7 and 4.3% for larger (up to 50 µm) and smaller (up to 20 µm) particles, respectively, as compared to those obtained for granite PM.

It can be also presumed that the greater efficiency in collecting granite PM is obtained due to higher levels of particle agglomeration and autohesion. This leads to more intensive cohesion (autohesion) of granite PM and settlement into the cyclone hopper as compared to wood ash PM. These phenomena are highly affected by the humidity of gas which can decrease the separation level [37].It is also presumed that the difference in the efficiency of collecting PM of different particle sizes is insignificant. Therefore, it can be concluded that filtration is efficient at a 50/50 distribution ratio between the transitional and peripheral flows, with particular effects on small particles of up to 20 µm in size. Further tests with wood PM demonstrated 83.0 and 81.6 % treatment efficiency for PM <50 and <20 µm, respectively. Deposition of wood PM is influenced by the irregular shape, surface structure and cohesion (autohesion) of the particles. Difference in the efficiency of collecting wood ash PM and wood PM is only 1.1 %. Wood PM has a low specific gravity and is therefore the most difficult to be settled by centrifugation. However, tests with wood PM have shown that the particles get electrostatically charged the most intensively as compared to the other PM. The charged particles shrink, become heavier and thus easier to settle in. Tests with glass PM demonstrated lower treatment efficiencies as compared to those of the other PM being 81.1 and 79.1 % for particles of up to 50 and 20 µm, respectively, which is 7.7 and 7.9 % lower as compared to granite particles, respectively. Removal of glass PM from air is presumably impeded by comparatively low particle aggregation. It is assumed that glass particles are not so sticky as wood or wood ash particles, so that the agglomeration is lower resulting in a lower treatment efficiency in the cyclone-separator.

During the second experimental stage, the cascade impactor system was used to analyze the efficiency of the multi-channel cyclone mock-up for removing fine particles of <1, <2.5 and <10 µm in size of different material types (Fig. 5).

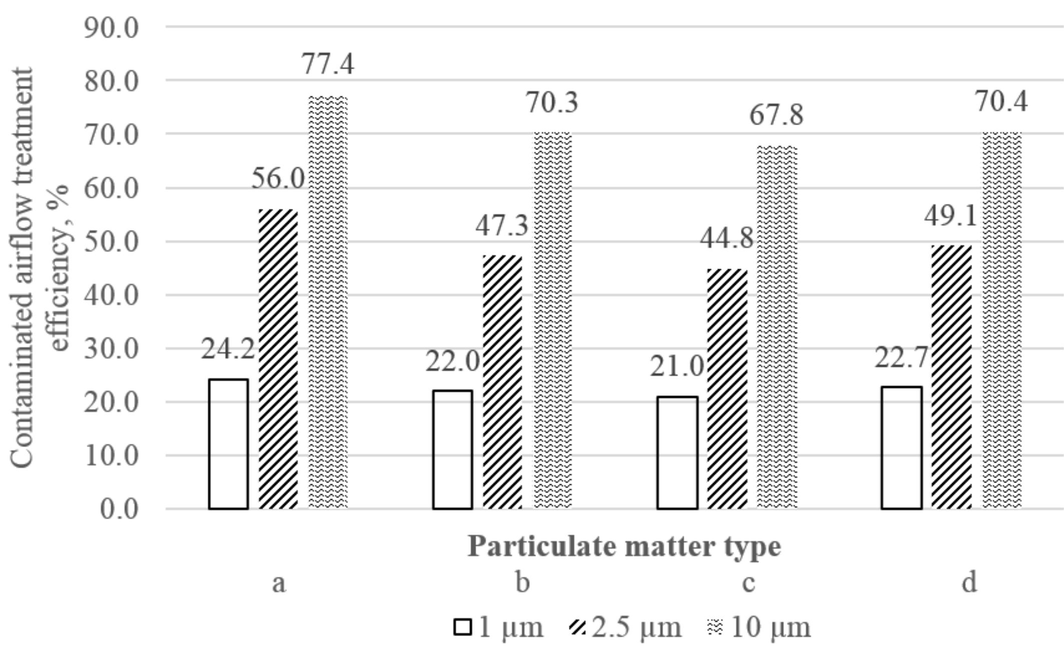

Figure 5. Relationship between air treatment efficiency (Y axis) and PM type and size: a) granite; b) glass; c) wood ash; d) wood

The efficiency of removing granite PM of up to 10 µm was 77.4 %, representing the highest value among other obtained values similarly as in the cases of larger particles. The pre-cyclone fraction of granite PM10 was 56.4 %, while after exiting the cyclone, this percentage decreased by approx. 4.4-fold to 12.8 %. The efficiency of removing finer particles of up to 2.5 µm in size was lower by approx. 1.4-fold compared to that for PM10 amounting to 56 %. Based on the pre-cyclone distribution of PM, it can be concluded that collection of granite PM2.5 is by approx. 1.8-fold lower as compared to that of PM10. The treatment efficiency for ultra-fine particles of up to 1 µm in size was 24.2 % representing the sharpest decrease in efficiency. As compared to the removal efficiencies of PM10 and PM2.5 µm, the removal efficiency of PM1 is lower by 3.2- and 2.3-fold, respectively. The PM1 fraction in the inlet gas was lower than those of PM10 and PM2.5 amounting to 9.4 % and decreasing to 7.1 % after exiting the cyclone. It can be presumed that due to the low concentration, the finer particles failed to agglomerate and thus were more difficult to collect than larger particles. While moving together with the other particles, PM2.5 and PM10 are likely to be additionally influenced by autohesion: the particles are bonded together and settle down under a greater force of gravity acting on the aggregates.

Similar removal efficiency trends were found for all the other PM types being the highest for PM10 and the lowest for PM1. Also, in all cases the initial fraction of the largest particles was the highest, while that of the smallest particles was the lowest. The obtained efficiency of removing wood ash PM and wood PM is more or less the same. Similarly, research on fly ash particles (density of 1989.7 kg m^{-3}) from a coal-fired boiler in a power plant showed separation efficiencies in a cyclone of 62 % for PM10 and 11 % for PM1 [35]. The average difference in removal efficiency between granite PM and wood ash/wood PM is approx. 7 %. The poorest results have been obtained in the case of removing ultra-fine particles of up to 1 µm in size. For removal of submicron particles higher-efficiency devices can be used such as venturi scrubbers, baghouse filters and electrostatic precipitators. In an interesting attempt to improve cyclone efficiency an electric field-assisted cyclone was designed, which achieved high removal efficiencies of ultra-fine particles up to 0.3 µm in size [40].

The analysis of the influence of PM size on the air treatment efficiency shows that the multi-channel cyclone collects up to 80 % of PM10. This is seen as good efficiency. However, the collecting efficiency for small particles is significantly lower, *i.e.* up to 60 % for PM2.5 and up to 25 % for PM1. These values are not high. Yet, it is important to note that other cheap alternative technologies capable of collecting fine and ultra-fine particles do not exist. The air treatment efficiency of the multi-channel cyclone could be improved by increasing the number of cyclonic levels.

An improved design of a cyclone-separator with secondary inlets and a more complicated design is presented in literature. Results in that study obtained based on the numerical modeling predicted the effectiveness of trapping PM10 of 72 %, which was on average 1.7-fold higher than that predicted for PM2.5 amounting to 41.3 %. These results were confirmed, experimentally, reaching average trapping efficiencies of 46.9 and 78 % for particulate matter of 2.5 µm and 10 µm in diameter, respectively [34].

Generally, a strong correlation is observed between the particle collection efficiency and the size distribution (Fig 6), as already demonstrated in work of Majoral and co-workers [41].

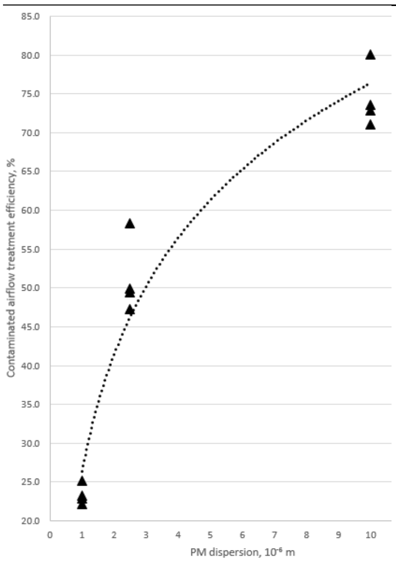

Figure 6. Dependence of air treatment efficiency (Y axis) on PM dispersion (X axis)

Although a good collection efficiency of small PM was achieved by the 8-channel cyclone mock-up it is important to note that the post-cyclone size distribution of PM is different. This should be considered with regards to the air treatment efficiency. The results of tests with the cascade impactor were compared to show changes in the PM distribution before and after the multi-channel cyclone (Figs. 7-10).

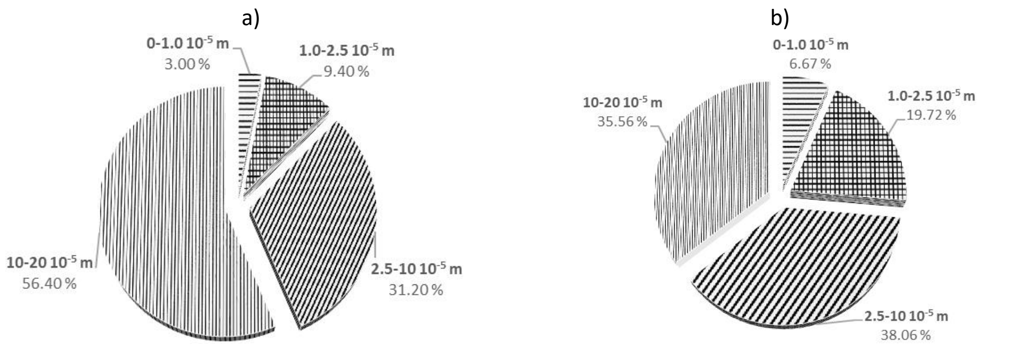

Figure 7. Granite PM distribution before (a) and after (b) in one-level 8-channel cyclone-separator mock-up

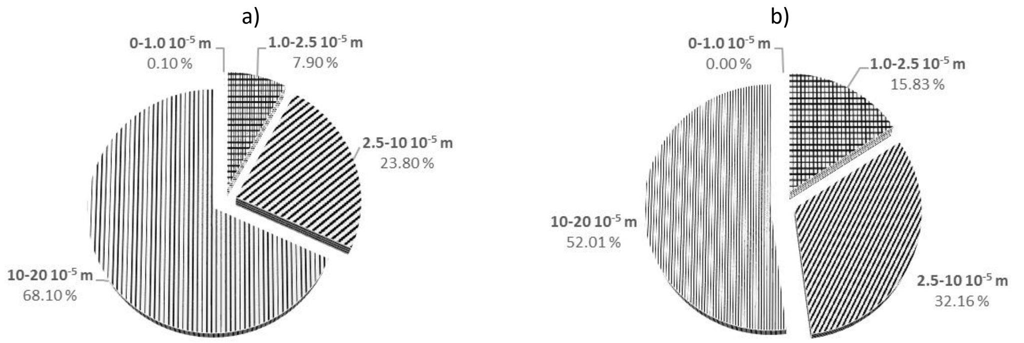

Figure 8. Wood ash PM distribution before (a) and after (b) in one-level 8-channel cyclone-separator mock-up

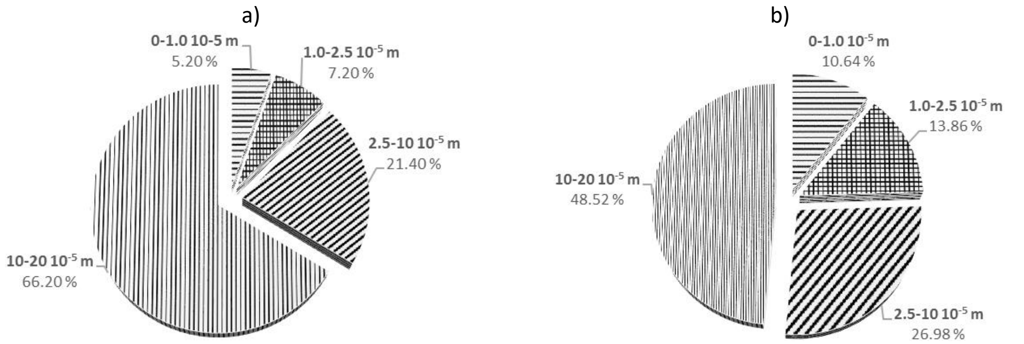

Figure 9. Wood PM distribution before (a) and after (b) in one-level 8-channel cyclone-separator mock-up

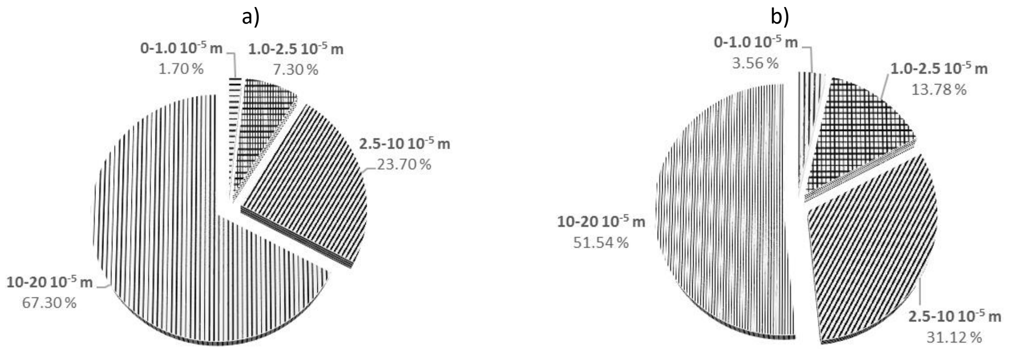

Figure 10. Glass PM distribution before (a) and after (b) in one-level 8-channel cyclone-separator mock-up

As it is known, air treatment is more efficient in collecting larger particles. Therefore, the percentage of small PM fractions is higher after the treatment. For example, the overall decrease in fractions of PM ranging from 10 to 20 µm in size was in the range 16-21 %, while the fractions of finer PM increased for: 5-9 % for PM 2.5-10 µm in size, 6-10 % for PM 1-2.5 µm in size and 2-5 % for PM1. These results point to future development of air treatment technologies capable of more efficient collection of fine and especially ultra-fine PM.

4. CONCLUSION

Based on the results obtained in this investigation, the following conclusions were drawn.

One-level 8-channel cyclone-separator collects 70 to 80 % of PM up to 10 µm in size, 45 to 60 % of PM up to 2.5 µm in size and 21 to 25 % of PM up to 1 µm in size.

Experimental studies have shown that the aerodynamic resistance of gas flow reaches 1150 Pa at the gas flow rate of up to 950 $m^3 h^{-1}$. A chain of eight sequentially arranged cyclone-separator channels, local obstructions and additional intense mixing and turbulence in the inlet and outlet are the main zones of the pressure drop.

The highest efficiency was achieved in removing high-density granite PM of fine dispersion. The analysis of PM of up to 20 µm in size showed 77.4 % efficiency under a 50/50 flow distribution ratio between the transitional and peripheral flows when the average air velocity was 10 m s^{-1}.

At the same conditions the treatment efficiency for medium-density PM (glass) of up 20 µm in size was 67.8 % those for wood ash and wood PM were 70.3 and 70.4 %, respectively.

The separation efficiency of PM up to 2.5 µm in size strongly decreased as the particle density is lower. It could be assumed that the increase in the number of levels in the multi-channel cyclone-separator will improve the air treatment efficiency. However, this solution requires the increased gas flow rate and energy needs due to the increased aerodynamic resistance.

Overall, the multi-channel cyclone-separator was shown to be efficient in removing particulate matter down to 20 µm in size from air. To clean smaller particles, it is reasonable to use other air treatment technologies.

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SAŽETAK

Eksperimentalno istraživanje jednostepenog osmokanalnog industrijskog ciklonskog separatora

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(Stručni rad)

Glavni cilj ovog istraživanja je eksperimentalna analiza efikasnosti prečišćavanja vazduha u prototipu uređaja nove generacije - jednostepenom osmokanalnom industrijskom ciklonskom separatoru - uz promenu parametara unutrašnje strukture i određivanje efekata disperzije čestica. Stoga je istraživanje sprovedeno u dve faze: prva je obuhvatala analizu efikasnosti višekanalnog ciklona sa česticama <20 i <50 μm. Tokom druge faze, kaskadni impaktor je korišćen za određivanje efikasnosti izdvajanja čestica u višekanalnom ciklonu po frakcijama: PM1, PM2.5 i PM10. Upoređeni su rezultati ispitivanja sa kaskadnim impaktorom kako bi se pokazale promene u sastavu čestica pre i posle primene višekanalnog ciklonskog separatora. Prema dobijenim eksperimentalnim podacima, osmokanalni ciklonski separator na jednom nivou sakuplja 70 do 80 % čestica veličine do 10 mikrona, 45 do 60 % čestica veličine do 2,5 mikrona i 21 do 25 % čestica veličine do 1 mikrona.

Ključne reči: višekanalni ciklonski separator; čestice; tretman vazduha; kanal; kaskadni impaktor.