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Technologies Used to Purify the Air of Suspended Dust in Local Particulate Elimination Devices †

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Abstract: The changes taking place in the environment, as well as the dynamic development of anthropogenic activity and uncontrolled emissions of pollutants into the air for many years, significantly contribute to the deterioration of air quality, and thus the level and safety of human health and the natural environment. Thanks to increasing awareness of the composition of the air, special attention has been paid to securing controllable pollutants and removing PM2.5 and PM10 dust from the particles of air flowing into living quarters. In this study, the sources of airborne dust occurrence are characterized, and its impact on the environment and the technologies used in devices for air purification from dust pollutants are presented.

Keywords: suspended dust; air protection; air purifiers

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1. Introduction

The development of society affects the increased demand for products, energy and heat, which translate into an increase in the raw materials used and the number of technological processes, and at the same time producing huge amounts of pollutants emitted into the air. In addition to soil and water contamination, air pollution with particulate matter plays an important role. Even though the particulate matter in the air comes from both natural and anthropogenic emission sources, the influence of anthropogenic activity outweighs the influence of emissions from natural sources. This is mainly due to the intensity and amount of dust pollution emitted by human activities, from single cars to huge plants and numerous industrial agglomerations, often exceeding the permissible standards for PM2.5 and PM10 dust concentrations [1].

PM2.5 and PM10 dust flowing from the outside to the inside of rooms and entire buildings is one of the most dangerous air-pollutant phenomena, with direct and indirect impacts on human health and climate. Increased public awareness of the impact of dust pollution on their health, as well as in the workplace and in residential buildings, has resulted in a significant development of devices that use the processes of removing dust suspended from the air. The basic principle of operation of air purifiers used in domestic rooms is based on the use of the process filtration. The deployment of larger sizes of devices is necessary for use, among others in industry, in order to reduce dust emissions. PM2.5 and PM10 may also be removed via the processes of absorption [2,3].

2. The Presence of Dust Suspended in Airborne

Air pollutants in the environment, such as particulate matter, come from various emission sources. Direct emission, i.e., the introduction of pollutants into the air, is expressed as the size of the mass of dust particles in relation to the time unit (mg/h, mg/year), while the amount of PM2.5 and PM10 particles in space is determined by the concentration,

expressed in micrograms per cubic meter ($\mu g/m^3$). Atmospheric dust is both primary pollution, emitted directly from the source to the atmosphere, and secondary pollution, generated in the atmosphere as a result of chemical reactions, mainly under the influence of solar radiation and the presence of pollution precursors. These are compounds that, as a result of reactions in the air, can transform into new gaseous compounds and solid particles classified as dust pollutants [4]. Dust pollutants come from natural or anthropogenic sources. They can be emitted at a point (as an organized emission, mainly from chimneys) or surface—e.g., numerous individual heat sources and fires that occur, as well as linearly—mainly on communication routes [5].

The size of the dust particles has a significant impact on human health. Small sizes of dust particles facilitate penetration into the circulatory and nervous system of humans, and also affect the duration of staying in the air (hence the term—suspended dust). The smaller the dust particle (lower the mass and diameter of the particles), the longer the residence time of the contaminants [6,7].

Often, dusts may induce irritating, allergenic, pathogenic or toxic effects, and the intensity may depend on the concentration of dusts, their chemical composition, time of exposure to the organism, as well as the health status of the exposed people [8]. This leads to depression and irritability, resulting from a limited field of vision and a small amount of solar radiation supplied, as well as numerous respiratory diseases and the intensification of already existing diseases [9,10]. For the climate, the effect of particulate matter is noticeable, among others to changes in the temperature and sunlight of the earth on a local and global scale. Smog created as a result of high concentrations of PM2.5 and PM10 dust creates a barrier low above the ground through which there is no air exchange, which resulting in strong heating of the ground [11].

3. Technologies of Air Purification from Suspended Dust

The established standards specifying the permissible amounts of dust pollutants discharged into the atmosphere, and the increasing ecological awareness of society, have influenced the development of technologies aimed at minimizing the emission of pollutants into the air and increasing the efficiency of removing suspended dust from residential and public buildings [12]. Figure 1 shows the methods of air purification from particulate matter, along with the specification of individual processes using various phenomena.

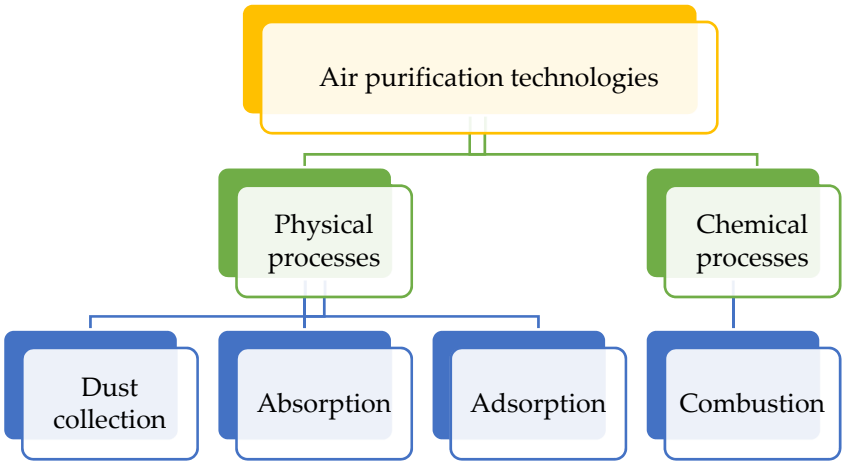

Figure 1. Characteristics of technologies used in air purification from suspended dust The figure contains information from the source: [10–12].

Both physical and chemical methods of removing dust pollutants from the air are used in many branches of the economy, but in the case of local air purification in residential premises, the dominant application of physical processes is mainly based on the filtration of pollutants through porous bodies (e.g., fabric filters, layered) [11]. Combustion (chemical)

processes are used less frequently, when high temperature is required, during which chemical reactions take place that enable the disposal of pollutant particles before emission to the air.

4. Types of Air Purifiers for Living Quarters

The use of indoor air purification devices is often crucial to maintaining an optimal level of air purity. The existing ventilation in buildings, after long periods of use, does not fulfil its maximum functions. This is due to the wear of the material, which can partially release the supplied air through the damage caused, and also as a result of clogging the grilles with larger particles. Unwieldy ventilation limits the supply of fresh air, resulting in reduced exchange of polluted air with new and clean air. In terms of operation, indoor air purifiers are divided into [13]:

- active—the principle of operation is to release negatively charged ions into the air, to which dust particles attach,
- passive—as a result of being forced through the air purifier, dust pollutants are permanently deposited on the filters.

For living compartments, air purification devices are used primarily based primarily on the use of the filtration process. Due to the type of filters used in air purifiers and standards to be met in the room, air protection devices are divided into [14]:

- anti-smog purifiers—used mainly during the heating period, during which PM2.5 and PM10 show the highest concentrations. Thanks to the built-in HEPA (High Efficiency Particulate Air) filter, made of many layers of glass fiber, it ensures high efficiency of air purification from suspended dust, amounting to approx. $\eta = 99.9\%$ [13].
- air purifiers with humidification—they are necessary when there is very low humidity in the room and dust contamination remains suspended in the air for a long time,
- ionizing purifiers—the principle of operation is to release positive and negative ions that surround and inhibit the spread of particulate matter in the air. The particles that fall onto the ground are not inhaled by people, and the room should be cleaned after the cleaning process [15].

It is extremely important that, despite the many available methods of removing suspended dust from the air, the selection of the appropriate technology in relation to the device's workplace, factors and sources of pollutant emission is necessary to maximize the effectiveness of the techniques.

5. Conclusions

The growing awareness of the scale of the problem of air pollution is leading to the development of research in this area, and the search for the best solutions to minimize the effects of human activity and natural causes. The main indicator showing the operation of technologies applied to devices is the efficiency of pollutant removal, the result of which depends primarily on the appropriate selection of the method of the work process in the device, and the place of its operation and the source of pollutant emissions. The implementation of technologies to combat air pollution can be labor-intensive and require constant work from society, but the advancement of clean air and human health should be a priority for everyone.

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