MEASUREMENTS OF SPEED AND DIAMETERS OF DROPLETS OF FOGS WITH DEVICES, OPERATING ON THE BASIS OF THE SURFACE PHOTO-CHARGE EFFECT

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Abstract: This work is related to development of a new type of fog sensors and measurement devices. We study fogs, their properties, and especially their ability to clean different contaminants from the air, such as chemical, biological, radiological and nuclear (CBRN) agents. In that sense, fog can be used for effective counteraction to terrorist attacks and for prevention of industrial accidents and disasters. In this paper, we present the possibility for measurements of fog parameters using the Surface photo-charge effect (SPCE) and some results obtained in that way concerning size and speed of droplets. Knowledge of these fog parameters is important in order to gain a more practical insight about the optimization of the penetration and cleaning properties of fogs used for large scale decontamination.

Keywords: DROPLETS DIAMETER, FOG, CLEANING PROPERTIES, SURFACE PHOTO-CHARGE EFFECT

1. Introduction

Fog is a natural phenomenon consisting of a large amount of small liquid water droplets (wet fog) or ice crystals (ice fog) suspended in the air near the ground. When the air cools down to its dew point, it becomes fully saturated with water vapour. This vapour condenses around tiny microscopic particles in the air, such as dust, and forms water droplets with diameters under 100µm. When the amount of water droplets is sufficient, fog is made. In general, the cooling of the earth overnight allows condensation and, hence, fog. Fog can form over ground and over water and is essential for the Earth's climate. The required conditions for fog formation that must be fulfilled are high relative humidity, low temperature and mild wind.

The fog property of great interest for our experiments is the ability of the fog droplets to scavenge boundary layer pollutants and remove them from the atmosphere. A brief example for the importance of fog for human health is the finding [1] that fog inhalation is capable of inducing cough and changes in breathing patterns in healthy subjects. In urban areas, polluting technologies provoke more frequent and longer-lasting fog called smog that can cause allergies in the human population. Fog has effects on plants, microorganisms, public transport and aviation, too. Our data is consistent with other research findings about the smog in towns [5, 6] which state that denser fog events correlate with the amount of polluting substances in the air. This also leads to the conclusion that the amount of fine particles in the air is an important premise for dense fog events.

2. Preconditions and means for resolving the problem

The national security can benefit from the fog property to collect chemical, biological, radiological or nuclear agents. In case of air pollution, fog can be used as an effective and non-expensive method for capturing the pollutant and cleaning the atmosphere. In crowded areas, such as public or private buildings, open space areas in town centres, this is a non-expensive and risk-free method for achieving this goal. This requires the installation of fog generating systems on key buildings in order to reach the maximum of a contaminated area. Some of their components are illustrated in Fig. 1 and Fig. 2. For the optimal use and settings of these devices, we must acquire detailed information about the droplets' size and speed in order to scavenge a variety of substances. Thus, previous studies have shown that the fog ability to collect contaminators depends on the water droplets size and speed.

A new possible solution to this problem is the development of sensors operating on the basis of SPCE which could help us determine the values of many fog parameters, such as presence of the fog in a particular area, diameter and speed of the fog droplets. Such sensor functions as following: The interaction of samples with electromagnetic radiation in the visible region results in generation of an alternating electric signal - surface photo charge effect (SPCE). SPCE is shortly defined as the interaction of every substance with electromagnetic field, which induces a measurable electric, alternating potential difference between the irradiated sample and the common electric ground of the system, with the same frequency as the frequency of the incident field. The measurement is contactless and fast. In contrast to other similar effects, the SPCE is present in any solid body [4].

3. Solution of the examined problem

In the past, the question of how to measure the optimal fog parameters, such as particles diameter and speed, was investigated by other scientists and different particles sizing techniques were invented. Some of them are the interferometric particle imaging, global phase Doppler [2], differential centrifugal sedimentation (DCS), and nanoparticle tracking analysis (NTA) [3]. Most of these methods require lasers, which measure the intensity of the emitted light after the interaction with the particle and deduce from the difference in the intensity the diameter of the particle. Such sensitive apparatus is typically not suited to measure data outside of the controlled conditions in a laboratory. In comparison to this, the devices we work with do not need any specific training for the staff operating them and are less expensive.

In order to test our new method, we developed different devices that provide information about the speed and size of the fog droplets. Such devices are, for example, Fog Detector 2 and 6 and they are displayed in Fig. 1 and Fig.2. Each of them has a different arrangement of components, but they are all capable of giving information about the presence of fog and its properties.

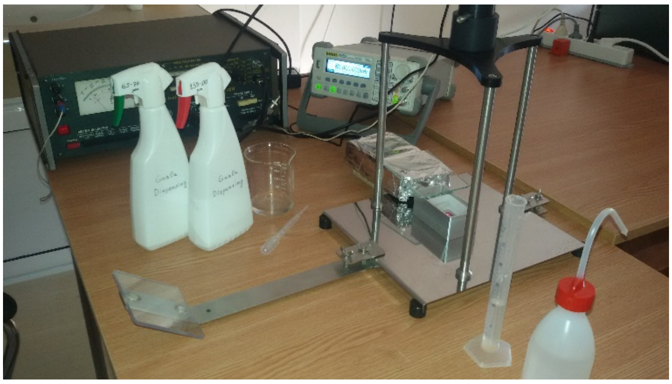


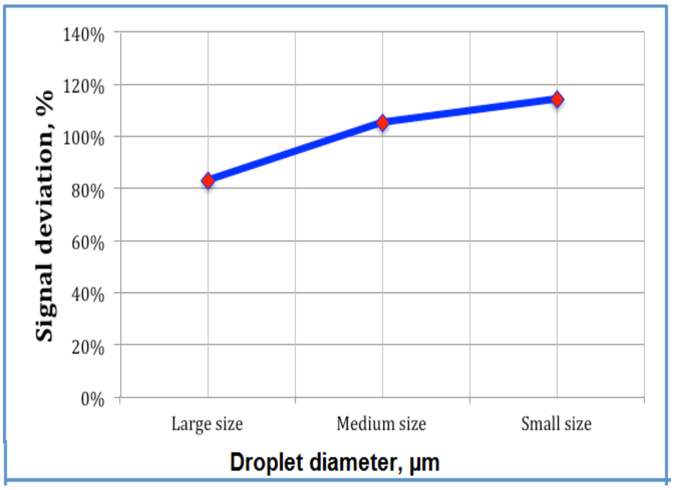
Fig.1. Fog Detector 2

Fig.2. Fog Detector 6

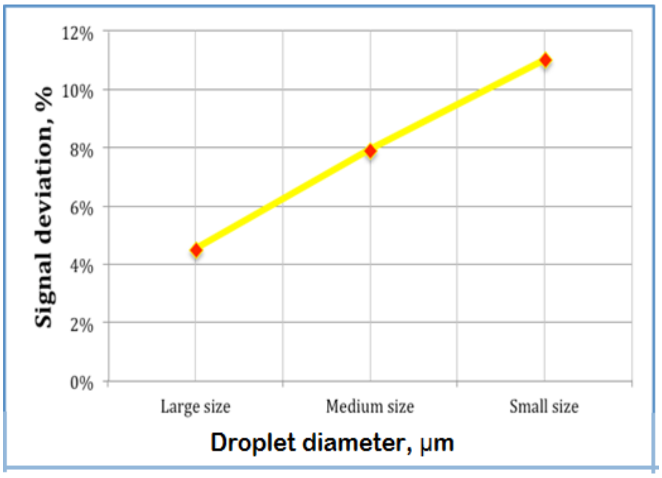
4. Results and discussion

Due to the sensitivity of our devices for a variety of parameters, including the surface of a probe, the size and speed of a droplet also effect the data we receive from them. It is known from previous studies that smaller fog droplets have grater cleaning properties and capture more impurities from the polluted air. The theory behind this fact is that smaller droplets capture also molecules of polluting chemicals unreachable for larger droplets and so manage to scavenge larger assortment of substances. In order to optimize the cleaning process, we need to be able to control the diameter and speed of the water droplets. We conducted many experiment with the fog detectors which showed that it is possible in principle to obtain this information with our devices. To demonstrate this, we provide some of the data in form of diagrams below. It is important to note that using the FD-2 and FD-6 that we mentioned before, we can achieve our goals – to alarm the occurrence of contaminants in the air, to control whether the fog has reached all areas of the area being cleaned, and to receive information about the diameter and speed of fog droplets. Using the SPCE we detect the presence of fog of distilled water in the examined area.

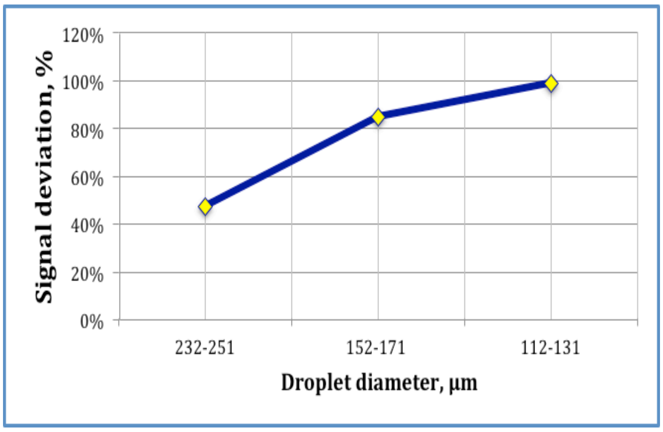
We conducted the experiment with different devices with similar results. In general, the value of the measured deviation from the initial signal irradiation the probe depends on the tested substance and its surface. The results from our experiments are displayed in Figures 3a – 3d.



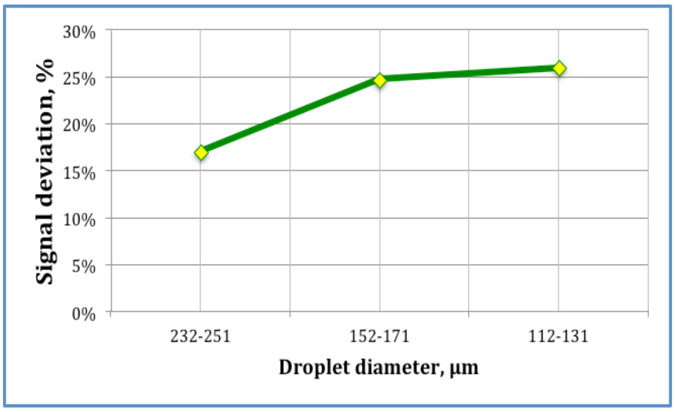
3.a



3.b



3.c



3.d.

Figure 3. Influence of droplets' diameter

Here we illustrate the dependence between the droplet diameter and the deviation from the initial signal when dispersing the fog. For the test results displayed in fig. 3a was used *FD-6*, in 3.b - FD-2, in 3.c - *FD-3* and in 3.d the data comes from FD-4. The distance between the active and passive blocks of FD-3 was 1 m, distance from the nozzle to the optical line was half a meter. In Fig. 3.a and 3.b, large and medium size correspond to particles' diameters of 232-251 μm and 152-171 μm, respectively. The four diagrams state that smaller droplet cause a larger deviation from the initial signal compared to bigger droplets. Probably, the reason for this is that the number of smaller droplets is greater per unit volume than the number of bigger ones.

The second component we must take into account is the speed of the droplets and we measured its influence in a different experiment. Outside of the controlled environment in the scientific laboratory, wind is a common natural phenomena and it is important for us to understand how it changes the values we measure. The data we received from this experiment is plotted in figure 4 below.

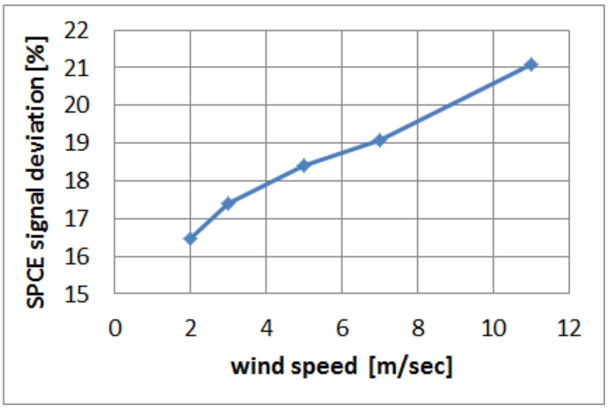


Fig.4. Signals deviation as a function of wind speed with FD6

On this diagram, we have shown the signal deviation in dependence of the wind speed (corresponding to the speed distribution of the droplets). The data clearly states that faster winds cause bigger deviation. A probable explanation for this is that greater speeds of the droplets allows a greater amount of them to interact with the sensor per unit of time.

5. Conclusion

In this paper, we briefly discussed the role of droplets size and speed over fog detectors working with the Surface photo-charge effect. The size and speed of water droplets in the fog influence many fog properties, such as scavenge and clean particles from a particular polluted area. Fog with predominant larger particles' diameter shows smaller deviation in the received by our devices signal in comparison to fog with smaller water droplets. This phenomena could influence the fog ability to collect effectively impurities and how our devices measure this process. The second parameter that has effects on the system in natural conditions is the droplets' speed. Greater droplets' speed interferes with the measurement and permits interaction between larger quantity of droplets and the sensor, which leads to stronger deviation from the initial signal.

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