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Universal disinfecting installation UMID for decontamination of viruses, bacteria and fungi

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Abstract:

The article discusses the disinfection problem in terms of combating the SARS-CV-2 virus that causes an infectious disease called COVID-19. In the epidemic era the focus was on reviewing the methods and means of disinfecting everyday items that are currently used. The concept and design of a solution for disinfection of outerwear of employees moving along the main communication routes in mining plants, developed by KOMAG in cooperation with Elektron s.c and Budryk mine belonging to JSW S.A., is presented. The structure and principle of operation of the device are presented together with the selected disinfectant based on silver colloid. The first stages of creating a prototype solution are discussed, as well as the effects of implementing the developed universal UMID disinfecting installation for decontamination of viruses, bacteria and fungi. Additionally, a demonstration disinfecting installation built for the needs of KOMAG employees is presented.

Keywords: coronavirus, mist, disinfection

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1. Introduction

In 2020, the world faced the pandemic caused by the SARS-CV-2 virus (Fig. 1). To this day, the spreading virus causes an infectious disease called COVID-19, which, although in most cases is mild, can lead to pneumonia or multi-organ failure resulting in death in some groups [1]. A major threat at the beginning of the development of the pandemic was the lack of the so-called "Herd immunity" in society, with the result that there is a high risk of collapse in the functioning of the health service [2].

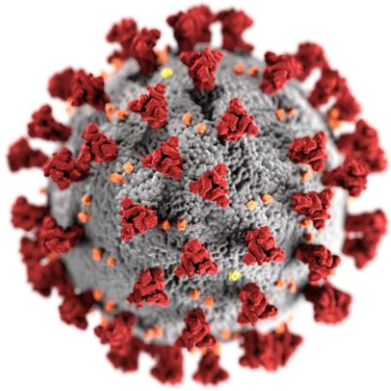

Fig. 1. Visualization of SARS-CoV-2 virus [3]

The COVID-19 epidemic that is present in everyday life has completely reorganized people's lives, both from a medical and social point of view, both at home, in shops and at work, significantly reducing the sense of security. Everyone has got used to the need to maintain social distance, to disinfect hands, and in particular cover the mouth and nose. Unfortunately, a virus that is spread by airborne droplets from coughing or sneezing can settle on a variety of everyday items, including clothes. The virus can survive on such surfaces for up to 9 days, and in extreme cases even 28 days [4]. That is why disinfection of places and things exposed to contact with the virus turns out to be so important [5]. Workplaces, especially hard coal mines, are an excellent source of infections. In the case of hard coal mines, the high incidence of disease is influenced by people due to the nature of the work (going into cages into the underground of the mines and close cooperation of employees). At the turn of spring and summer 2020, some mines had to suspend or limit mining for several weeks due to the scale of coronavirus infections among miners. In total, in five coal companies, more than 10,000 have become infected since the epidemic began. employees [6]. The activities undertaken by companies and mines, consisting in ad hoc disinfection, reducing the number of employees per shift, did not solve the problem. Therefore, KOMAG specialists, having high competences and extensive experience in water atomization, gained within the ROCD European project [7,8,9,10] designed a disinfection and decontamination solution based on spraying a silver colloid using the compressed air.

2. Review of disinfection methods

The most popular disinfection methods include biocides based on alcohol, which are used to wipe potentially contaminated surfaces [11,12]. Disinfecting agents are available in various variants: concentrates, ready-made liquids or wet wipes. Their advantage is low costs, but the disadvantage is the time needed to wipe the surface and incomplete wiping. Ozonation (O_3), which shows disinfecting properties [13] is another method of disinfection as ozone is rapidly decomposed into diatomic oxygen and atomic oxygen (Fig. 2). It is one of the strongest oxidants as it destroys both viruses, fungi, bacteria and mites. The disadvantage is that it is harmful to living organisms and cannot be used in the presence of humans.

Fig. 2. Visualization of ozone particles [14]

The method of irradiation with UV-C rays is also known and used to control viruses. UV-C radiation is one of the three types of waves emitted by the Sun [15]. This type of waves does not reach living organisms on the Earth, thanks to the ozone layer, but we know that they are suitable for rooms disinfection. They are produced by special lamps that can be used in the absence of people because they are harmful to the skin and eyes, while destroying bacteria and viruses and their spores. The advantage is fast action and the disadvantage of lack of penetration, making them work, where the microorganisms are on external surfaces (Fig. 3).

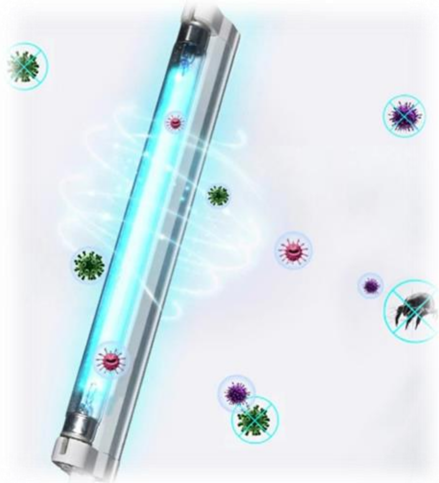

Fig. 3. Visualization of a germicidal lamp action using UV-C light [16]

The presented methods of disinfection have many advantages, but also have some disadvantages [17]. Unfortunately, none of the solutions presented relates to the problem of disinfection of clothing of the people entering workplaces, in particular coal mines. In coal mines, where several to several dozen people go underground together, the virus can infect a significant part of the employees, disrupting the work of the entire mine. That is why KOMAG decided to develop such a disinfection method that enables efficient and safe disinfection of clothes of employees moving in communication routes of workplaces.

3. Concept and design of the solution

KOMAG, just a dozen or so days after the announcement of the epidemic in Poland, developed and built a prototype of an innovative solution for disinfecting viruses, intended to be used in hard coal mines. Several hours passed from the moment of taking the decision to develop such a solution, to the creation of the concept and the test model based on disinfectant mist sprayed by compressed air. The test model was built from the available components used to control dust in the hard coal mining industry, i.e. two-media nozzles, a disinfectant tank and a valve reducing the compressed air pressure (Fig. 4).

Fig. 4. Operational tests of the developed prototype [18]

Spraying system, which delivers and atomises a disinfectant was the main component of the developed solution. The structure of the device is shown in Fig. 5.

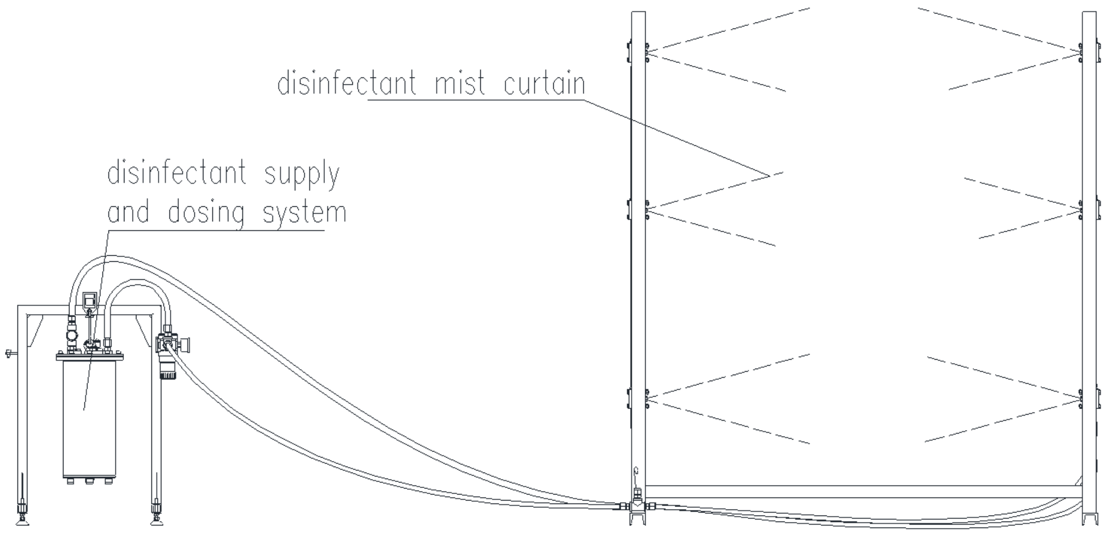

Fig. 5. General view of the installation [18]

In the solution, compressed air is used to pressurize the tank containing the disinfectant and transport it to the spraying nozzles. It is also a carrier of a disinfectant after mixing inside the spray nozzle. The disinfectant comes out of the tank through a nozzle equipped with a tube reaching the bottom. The basic components of the supply and dosing unit are shown in Fig. 6.

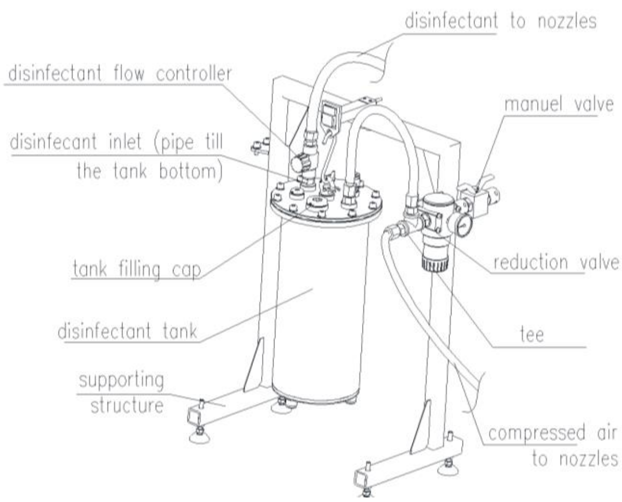

Fig. 6. The system for supplying and dosing the disinfectant [18]

When people pass through the mist curtain, a disinfectant is sprayed on them. Walking takes place in an upright position, arms extended along the body to disinfect as much of the outerwear surface as possible (as shown in Fig. 7)

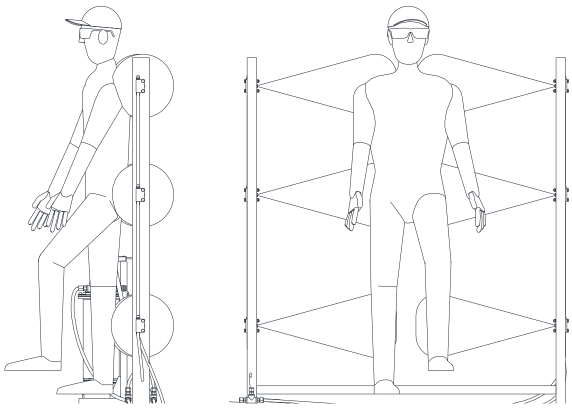

Fig. 7. Method for passing through the disinfectant mist curtain [18]

The model constructed in this way was used to implement a prototype of the UMID solution in Budryk mine of Jastrzębska Spółka Węglowa (Fig. 8). As a result of the implementation, the installation was automated by using the motion sensors (detecting the entry of a person into the decontamination zone) and the nozzles with a flat spray jet to increase the area of sprayed drops.

Fig. 8. A prototype of the UMID universal disinfecting installation in Budryk mine,
made by Elektron s.c. [18]

The applied improvements and positive opinions about the prototype allowed to start work on the documentation of the serial installation (Fig. 9). As a result, the installation was developed with a spraying system that atomises a disinfectant with air-water mist nozzles as the main component. The disinfecting installation requires the supply of a working medium in the form of compressed air with a pressure in the range of 0.3-0.6 MPa. Compressed air is used to pressurize the disinfectant and transport it to the spray nozzles. Compressed air is also responsible for atomization of the disinfectant in the spray nozzles. The standard solution is also equipped with a disinfectant flow controller. The installation is equipped with an automatic control activated by a photocell. The electric control unit i.e. distribution box on which the following components are installed: power switch, signal lamps (green - power, orange - solenoid valve on).

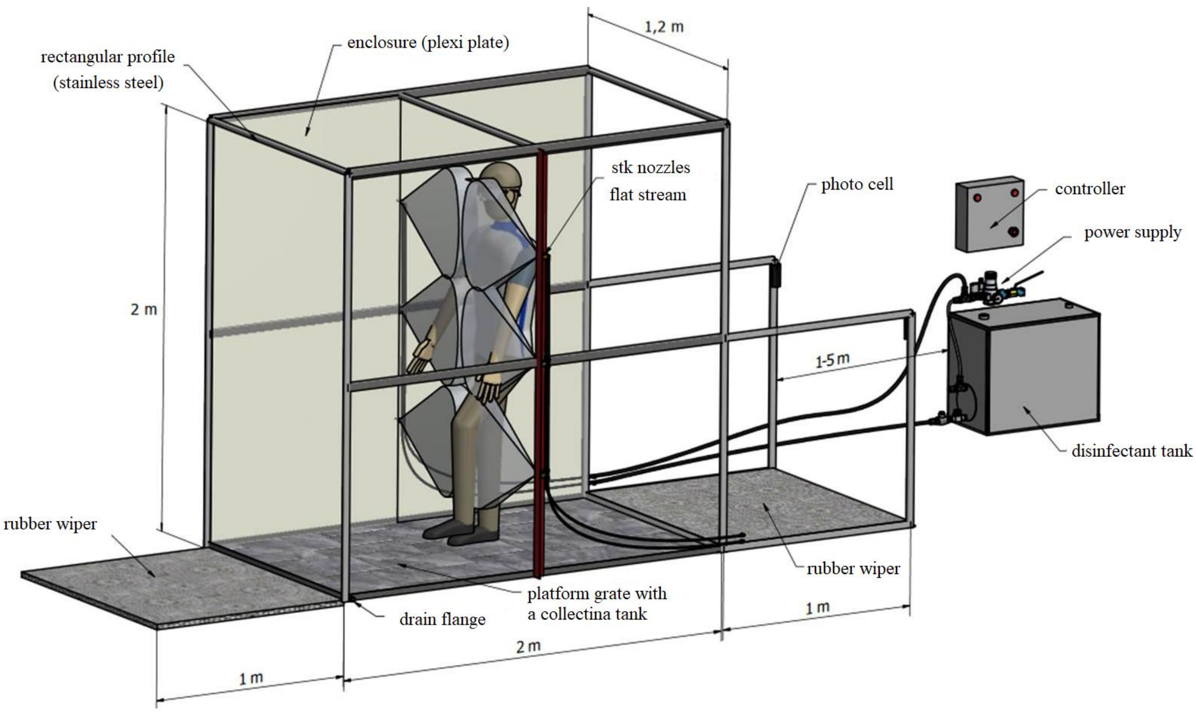

Fig. 9. Universal UMID mist disinfection installation - the serial solution [19]

The solution was used in several hard coal mines in Poland (Budryk mine, Borynia mine, Zofiówka mine) and in the Specialist Services Center of the Central Mining Rescue Station Cen-Rat Sp. z o. o. (Fig. 10). The installed devices use a disinfectant based on metallic silver particles stabilized with polyol, the numerous scientific studies confirmed its antiviral effectiveness. Nano-silver has an affinity for proteins found on the surface of viral capsids and causes their inactivation or physical encapsulation. As a result, silver prevents the ingress of viruses, which inactivates them permanently [20].

Fig. 10. Universal UMID mist disinfection installation **-** the serial solution used in coal mines [19]

Technical characteristics of UMID disinfecting installation:

A) **Operational environment:**

Ambient temperature:	5÷40°C,
Relative humidity:	up to 80% in temp. +20°C,
Supplying hoses:	elastic,

B) **Supply parameters of nozzles**

Compressed air pressure:	p_{min} = 0.4 MPa,
Compressed air working pressure:	p = 0.4÷0.6 MPa,
Air flowrate (in the entire system):	Q_p =600 dm^3/min,
Disinfectant flowrate (in the entire installation)	Q_s =0.6÷1.0 dm^3/min,
Type of nozzles:	STK-ZZ-P
Number of nozzles in the chamber:	6

C) **Technical data of the control unit**

Supply voltage:	230 V; 50 Hz
Rated current:	2 A

4. Development of UMID installation

The experience gained and the effects of implementing the UMID installation in hard coal mines prompted the KOMAG management to build a demo version of the installation for own applications to neutralize and eliminate viruses and fungi on the outerwear of employees entering the institute. The developed demonstration UMID mist disinfecting installation was equipped with an installation for spraying a nano-silver-based disinfectant using the air-water nozzles [21]. The nozzles spraying the disinfectant are placed in the side walls of the disinfecting chamber, made of profiles for high storage, where it has an open entrance and exit. The disinfecting installation requires supply of a working medium in the form of compressed air with a pressure in the range of 0.4-0.6 MPa. Compressed air is used to pressurize the tank with the disinfectant and push it into the lines feeding the two-way nozzles. In addition, compressed air atomises the disinfectant supplied, already in the spraying nozzles. The amount of disinfectant is limited to the volume of the tank, amounting to a dozen or so litters, and the flow controller used at the outlet of the tank allows adjusting the consumption depending on the needs of the installation. The demonstration device is turned on and off by a twilight and movement

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sensor which, after detecting movement in its field of operation, activates a solenoid valve located on the compressed air supply pipe, which in turn activates a controlled check valve, allowing the disinfectant to flow to the spraying nozzles. The optical sensor is installed in the side of the chamber, on its outer wall, in a special cover. This made it possible to limit the uncontrolled activation of the sensor, activating the sensor only when a person or a hand was present, just in front of the cover opening (Fig. 11).

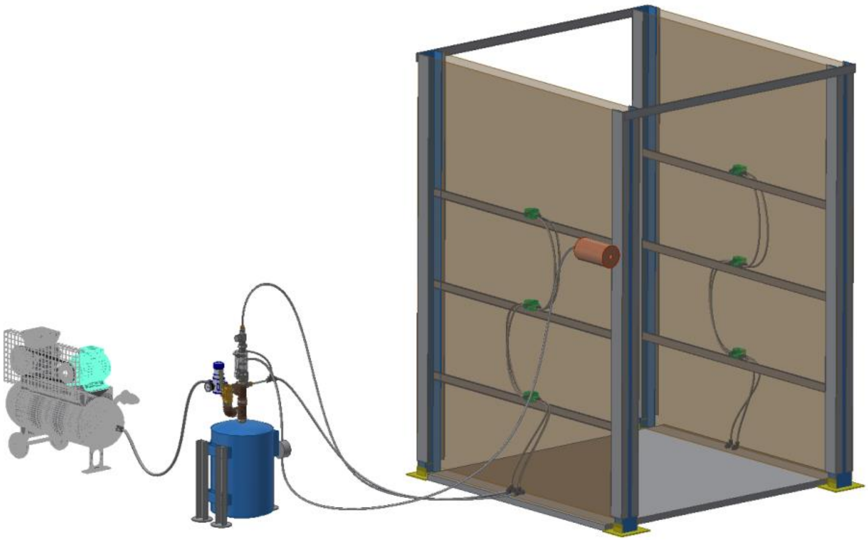

Fig. 11. 3D model UMID demonstrative mist disinfecting installation [21]

The demonstration UMID installation was placed in front of the main entrance to KOMAG, where everyone entering the main building can be disinfected (Fig. 12). The disinfectant used in the installation enabled people passing through without the need to wear protective gloves and glasses. The solution was used in positive temperatures and did not significantly affect the discomfort of passing people.

Fig. 12. Demonstration mist disinfection installation, when a person enters the main KOMAG building [21]

5. Conclusions

The growing threat of the spreading SARS-CV-2 virus in Poland and in the world, causing an infectious disease called COVID-19, has forced the search for new solutions and ways to reduce it. Such a solution was developed by ITG KOMAG just a few days after the epidemic was announced in the country. The proposed disinfection by fogging, consisting in the production of drops of a disinfectant with a diameter of several to several dozen micrometres, allows reaching almost every fragment of the disinfected surface, inaccessible to other solutions. The universal mist disinfecting installation developed by ITG KOMAG is designed to neutralize bacteria, viruses and fungi on the outer clothing of workers moving on communication routes in coal mines and other buildings. The device works by spraying drops of a disinfectant by compressed air, without need for additional spray pumps. The solution works in automatic mode, when a person is passing near the motion sensor, which starts the disinfectant discharge from the spraying nozzles in the disinfecting chamber. The disinfectant used in the device, based on metallic silver particles stabilized with polyol, allows it to be used in the presence of people, and its effectiveness against viruses has been confirmed in numerous scientific studies. Additionally, coating the surface with a disinfectant based on nano-silver creates a microscopic nano-layer on the surface, protecting against deposition and penetration of microorganisms, reducing the accumulation of pathogens. The installation developed at KOMAG was patented in the Patent Office of the Republic of Poland and noticed by the jury during the Invention and Innovation Fair INTARG 2020, where it won the gold medal and the World Invention Intellectual Property Associations WIIPA award [22]. In addition, the solution was awarded in the Innovator of Silesia competition organized by the Upper Silesian Accelerator of Market Entrepreneurship [23].

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