Models for the Future Technological Development of Fire Safety in the Russian Federation

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Abstract: The topic of this work is relevant, because the field of fire safety suffers enormous material damage and in some cases is accompanied by loss of life. As an object of study, a potential model for the development of fire equipment and fire safety in the Russian Federation as a whole was chosen. It is believed that this study is justified, since it traces the goal of maintaining a high level of fire safety in the country in cities, towns, places of concentration of material assets and at national economy facilities, by bringing them to an exemplary fire-fighting condition. The article is devoted to familiarization with the issues of fire safety, the organization of fire protection, it also provides a literature review of previously conducted similar studies. The result of the study is an announcement and a proposal for the use of modern fire extinguishing equipment, as well as tools using geographic information systems. Ultimately, the use of the proposed means of fire protection and prevention can be a key factor in their reduction, including the reduction of casualties and property damage.

1 INTRODUCTION

The Russian Federation has a system of fire safety, which is a combination of forces and means, as well as measures of a legal, organisational, economic, social, scientific, and technical nature, aimed at combating fires.

One of the main elements of the Federal Fire Service is the State Fire Supervision in the Russian Federation. It is carried out by officials of the state fire supervision bodies under the jurisdiction of the federal executive body authorized to solve problems in the field of fire safety.

Scientists Sh.Sh. Dagirov and M.V. Aleshkov argues that the technology for creating modern models of equipment consists of several stages. At the initial stage, the need for the developed type of technology is established. For this, statistical data on fires and emergencies are analyzed and summarized, in which it became necessary to attract equipment with the required new tactical and technical indicators. Then, an assessment is made of world practice in the manufacture and use of such equipment. After completing these tasks, the customer forms a technical assignment for the manufacturer or design bureau for a detailed study of possible options for technical solutions for a new model of fire and rescue equipment

S.G. Aksenov in his research notes that when developing a modern fire truck, one must clearly take into account the technological complex, which includes all the characteristics that must correspond to the solution of functional problems of fire equipment. Light aluminum, titanium alloys, adhesive technologies for joining body elements should be used in car structures. Manufacturers of fire equipment pay serious attention to the design of the car, its ergonomics are also taken into account when creating new models. The direction of development of fire engineering is also determined by the situation that develops during the extinguishing and elimination of disasters and fires.

Scientist V.A. Dragin argues that the development and mastering of the production of fire and rescue equipment and fire-technical products by Russian enterprises made it possible, in general, to solve the problem of providing fire departments with fire-and-rescue equipment, fire-technical equipment and fire extinguishing agents. Currently, fire equipment covers a large arsenal of various means: primary fire

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extinguishing equipment, fire engines, fire extinguishing installations and communications equipment. At the same time, in order to improve the quality and reliability of fire and rescue equipment, work is being done to develop new technologies in the organization of domestic production. A variety of fires and fire fighting conditions, as well as the work performed during the hostilities, required the creation of fire trucks for various purposes.

Today, digital technologies are increasingly being used in the field of occupational, environmental and fire safety. In this paper, we would like to draw attention to how modern technology is already helping firefighters to deal with fire outbreaks and how it may help in the future.

The purpose of this work is to study the impact of digital technologies on the efficiency of the work of the State Fire Supervision in the Russian Federation. The paper discusses the main areas of application of modern technologies, such as video surveillance systems, automatic fire alarms, unmanned aerial vehicles and others, as well as their practical application in the work of firefighters.

During the study, we will analyze various aspects of the use of digital technologies in fire safety, including their effectiveness, ease of use, opportunities for expansion and improvement. We will also consider examples of the practical application of modern technologies in fire safety on the territory of the Russian Federation and beyond.

The study of this topic is relevant and important, given the growing number of fires and the need to improve the efficiency of fire services. The results obtained can be useful for determining the optimal strategies for the use of digital technologies in fire safety and for improving the efficiency of the work of the State Fire Supervision in the Russian Federation.

2 THE FIRE SAFETY SITUATION IN RUSSIA

Ensuring comprehensive safety is one of the most important functions of the state. Considering the dynamics of fires and the number of people killed in fires, this is one of the priority tasks of the Russian Federation. The Russian State Fire Service assesses the situation with fires as extremely difficult (Figure 1). Thousands of people die in Russia every year because of them (Fig. 2) and entrepreneurs lose their business. Unequivocally, fires have a negative impact on the social, man-made and economic infrastructure of the country.

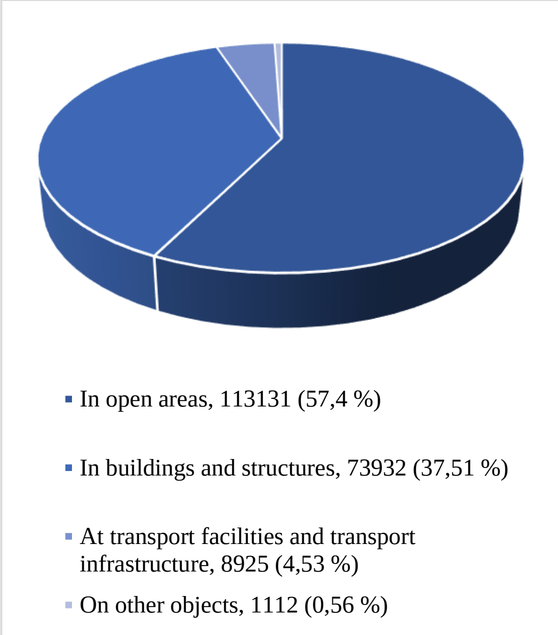

Figure 1: Fire situation by facility group.

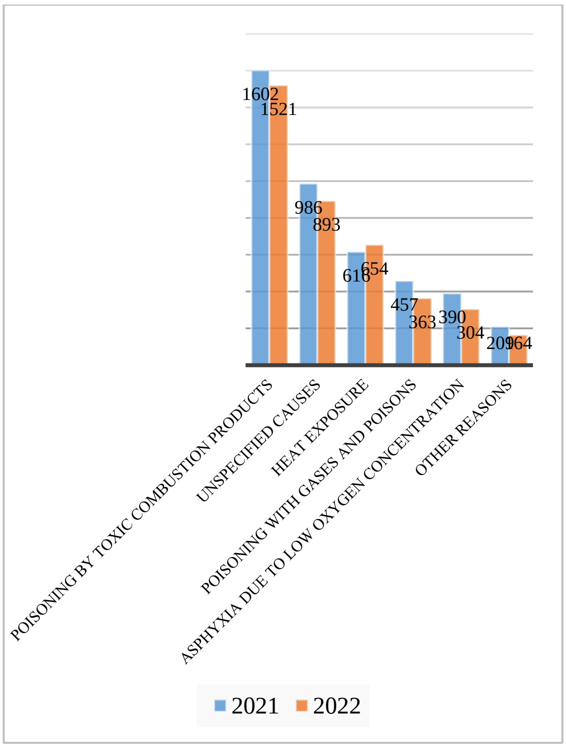

Figure 2: Number of people killed in fires in 2021 and 2022.

There are now several centres in Russia that deal with innovative technologies, develop fire prevention measures, evaluate and develop models of robotic and fire-rescue equipment. The tasks of the structural subdivisions of the Research Institute are to carry out fundamental and applied work and to develop design and technological solutions that would ensure the fire safety of people, facilities and equipment. Experimental research is carried out in the subdivisions which carry out evaluation and improvement of emergency rescue equipment, development of measures to prevent and eliminate consequences of emergencies. Separate tasks are assigned to testing centres, which carry out testing of equipment, materials, and means preventing and eliminating fires, including automatic equipment. Polygon tests of equipment, technical means and materials are carried out in conditions as close as possible to the natural conditions in which they will be operated or used.

3 MODERN FIRE SAFETY EQUIPMENT

Extinguishing media is improved every year because there is a constant need to preserve health and lives and to minimise losses from fires. Novec1230 is one such fire extinguishing agent (Fig. 3). It can be said to be the "panacea" of 2021. This modern, new-generation agent is highly effective and has excellent environmental credentials. Its molecular formula consists of 12 fluorine atoms. Its action consists in removing heat as a component of the combustion chain reaction by 70% and delaying the combustion reaction (inhibition) by 30%. The colourless and odourless refrigerant is intended for automatic fire-fighting systems. It doesn't conduct an electric current, doesn't decrease concentration of oxygen, doesn't harm a human body (safety factor - 2, 38) and the ozone layer. These distinctive qualities make it possible to quickly extinguish a fire, reduce the high temperature inside the room and gain extra time for evacuation.

Technical characteristics of the innovative Novec unit:

The operating temperature of the unit is from 0 °C to +50 °C.

Atmospheric preservation time - up to 5 days.

Operating pressure - 2.5 to 4.2 MPa.

Type of start-up - manual, solenoid, pneumatic.

Figure 3: Novec gas fire extinguishing system.

Novec 1230 is often called "dry water" because it is very similar in appearance to water. The substance is chemically inert and does not react with structural alloys, metals, plastics, sealing materials. This means that after extinguishing a fire, equipment, documents, machines will remain in working order. In accordance with international certifications, Novec 1230 gas extinguishing agent can extinguish fires of solid combustible materials. The agent is already in use in oil companies, oil refineries, flight control centres and situation centres. In Russia, Novec1230 refrigerant fire extinguishing systems have been installed at more than 15 types of facilities. Among the first were the media centre of the Olympic Games in Sochi, the Russian State Library of Art.

Microcapsules with dispersion of 50 ... 200 microns have also been noted as extinguishing agents. They have found their application in the field of fire protection as:

Thermo-activatable gaseous extinguishing agents (stickers). Stickers are composite plates which are mainly used for extinguishing fires in electrical panels up to a volume of 60 litres. They are glued inside the equipment using a self-adhesive base plate. The actuation temperature is 100-120 °C.

Powder extinguishing agents. Powders are used in modular extinguishing systems. The dispersion of the powder capsules is 150...200 microns.

Heat-activated microencapsulated cloths. They are classified as primary fire fighting equipment, including for extinguishing human clothing. The principle of action of the extinguishing cloths is identical to that of stickers. The microencapsulated cloths are applied to a specific fabric.

Microencapsulated extinguishing paints. Paint with refrigerants and microcapsules is used to protect steel structures and buildings made of combustible materials.

Extinguishing powders with the addition of thermo-activated microencapsules of 10...15% by mass. The powders themselves have no extinguishing effect on smouldering materials. However, at the department of fire safety of protection facilities of

Ivanovo Fire and Rescue Academy of the State Fire Service Ministry of Emergency Situations of Russia conducted a study concerning fire-extinguishing powder and additives of heat-activated capsules with chladones. During industrial tests, it was found that the addition of microcapsules with a refrigerant to the fire extinguishing powder "Volgalit-ABC" increases the fire extinguishing efficiency of the powder when extinguishing a model burning stack of wood. It should be said that powder mixtures can be widely used as an extinguishing compound for extinguishing objects with valuable equipment, items of historical value.

According to the results of the research at the Fire Safety Department of the Ivanovo Fire and Rescue Academy of the State Fire Service Ministry of Emergency Situations of Russia, promising uses of microcapsules with refrigerants as additives for fire extinguishing powders have been established.

The Russian Emergencies Ministry's own staff are thinking about how to prevent fires and extinguish them. In 2020, FGBU IAC EMERCOM of Russia successfully developed a subsystem for data collection and analysis, Thermal Points, using machine learning technology and presented it at the WILDFIRE AI open hackathon. It is part of the Hazard and Risk Atlas information system. Its operating principle is as follows:

1. The system receives data from agencies within the RCHS.

2. The algorithm processes data from all satellites (AQUA, TERRA, NOAA) around the clock.

3. After processing the information from artificial intelligence models goes to web-portal of thermal points of MES, mobile application as a map of object or list.

Each thermal point outputs data on the risk of fire (e.g. in a peatland, industrial site or bog), as well as sound and text alerts. All users of the subsystem, including regional and municipal authorities and the RF Ministry of Emergency Situations, have access to the information. The operational data is enriched with information on the RF subject, area and nearest settlements, weather forecast on the area, fire danger category. Based on this data, the ML model automatically determines one of 11 types of burning.

"Thermo-points" have been launched all over Russia. With their help: firefighting costs have been reduced, and regional services react 3 times faster to forest fires and eliminate hotspots in time to prevent the fire from reaching populated areas.

Unmanned aerial vehicles (UAVs) have also found their place in the field of fire safety. Drones (Fig. 4) are specialised and remotely controlled by humans. They are equipped with a camera and can navigate on water.

Figure 4: Fire-fighting quadcopter.

Drones can solve several problems at once:

1. Instantly assess a fire in an urban environment. Drones are manoeuvrable, so they can easily avoid obstacles, fly over buildings, and see all details through smoke. Drones with a thermal imaging camera can locate fires (Fig. 5) and find people in poor visibility conditions.

2. Patrol problematic forest areas from the ground. Due to difficult terrain or poor road infrastructure, it is difficult for ground-based EMERCOM teams to patrol forested areas. Drones, however, can do it. They help to explore the forest, determine scales, fire cut-off lines (Fig. 6) and correctly allocate extinguishing tactics and resources. They are much more advantageous than conventional aviation.

3. Carry out search and rescue operations. In hard-to-reach and dangerous areas, drones can become the "eyes and ears" of rescuers. The use of drones aids in correcting evacuations, assessing the scale of impact and predicting the further outcome of events. During disasters, such as an earthquake, they can fly over fallen structures, locate people and identify dangerous spills.

Figure 5: Shooting with a thermal imaging camera.

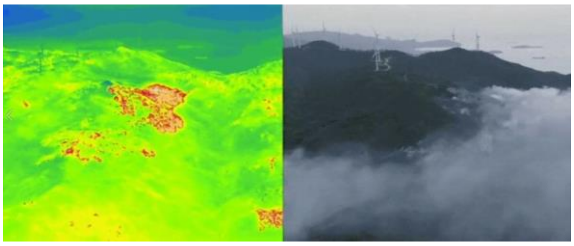

Figure 6: Monitoring a forest fire hotspot from a quadcopter.

Some UAV models are equipped with water hoses and firefighting equipment, but only a limited number of companies use them. Drones are currently being actively implemented and used in emergency services in most of the developed world. For example, drones have been used in Switzerland (2019) to deliver medical supplies and in Ghana (2019) to combat COVID-19. This technique has shown high results during the extinguishing of forest fires in California, South America. The Russian Federation is not far behind. In the summer of 2021, EMERCOM officials used drones to monitor the fire situation in the Moscow region.

Lightning detection technology contributes to fire protection (Fig. 7). They locate lightning strikes with special devices, especially in areas without cellular communication. Their mechanism is simple: the systems record electromagnetic impulses of lightning strikes and send the information to a server. After the data is processed, the location of the lightning strike is shown on a map. This technology helps to prevent fires.

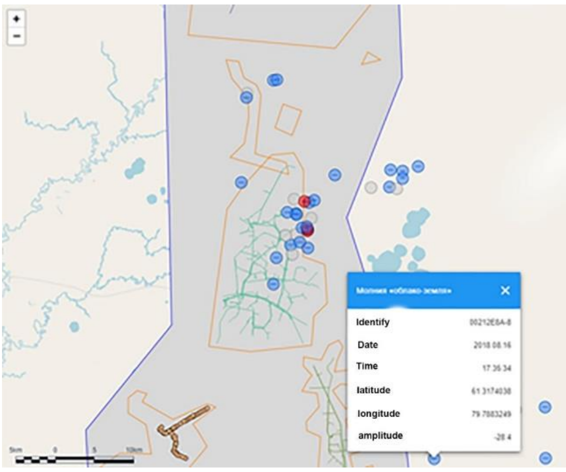

Figure 7: A lightning guidance system using the example of the GIS "Thunderstorm".

The most difficult fire-fighting conditions occur at facilities such as: thermal power plants, nuclear power plants and oil refineries. Fire spreads quickly, visibility is reduced and the room begins to fill with toxic substances and smoke. There is also the possibility of an explosion and an increase in radiation levels. Forest fires are also a difficult situation as they can spread at 30km/h. In order to prevent possible disasters and avoid human casualties, robotic technology has been developed. The MRC (Figure 8) is controlled remotely. The uncrewed, tracked combat unit has increased cross-country mobility. The first robotic fire-fighting units with baton trunks were installed at LNPP and Russian thermal power plants. They were suitable for water spraying of roof structures in engine rooms. However, the robotic complexes are equipped with fire detection, heat and video surveillance and even a self-testing programme. They have successfully coped with:

- reconnaissance of a fire in conditions of radiation, chemical contamination, and fragmentation contamination;

- firefighting;
- emergency rescue operations.

The designs are not afraid of high temperatures, so are able to work where a rescuer cannot.

Figure 8: A firefighter robot created by Tensosensor engineers.

It must be recognised that artificial rainfall can save the forest fire situation. The artificial natural phenomenon is completely environmentally friendly. The method consists of spraying silver iodide into the sky. This method is already used for fire prevention and extinguishing. Special planes with pyropatrons are used for precipitation control. They demonstrated their effect in Yakutia (in 2022), when they extinguished 152 forest fires in 10 days. It is worth adding that the pyropatrons for them are produced in Russia - at the Research Institute of Applied Chemistry, part of Rostec State Corporation.

The need for innovations in fire extinguishing is because standalone systems are not able to meet all current fire protection requirements. Some of them use extinguishing agents that can cause significant damage to the property and equipment in the room. In addition, there are no feedback devices on such systems, so a fire is only reported some time later, when some property may have already been damaged.

4 CONCLUSIONS

It has become apparent that in 2022 the approach to fire safety regulations and control and supervision activities has gradually begun to change due to the transition to risk-based inspections. The Russian EMERCOM is working to improve the responsiveness of fire departments, expanding the conditions for compliance of protection facilities with fire safety requirements. Rescue services are introducing new prevention mechanisms in the area of fire safety, investing in the development of firefighting technologies and techniques and a bias towards various robotics, unmanned aerial systems and modern domestic monitoring equipment.

Pozhtekhnika Group of Companies plays a major role in the development of fire safety in Russia. It is a leading manufacturer of integrated fire safety systems and automation systems for facilities of any level of complexity. Pozhtekhnika's products equip more than 10,000 facilities throughout Russia and the CIS countries.

There are several centres now operating in Russia that deal with innovative technologies used in fire and rescue teams, develop measures to prevent fires, evaluate and develop models of robotic and fire and rescue equipment. The tasks of structural divisions of Research Institute are: carrying out fundamental and applied works and development of design-technological solutions, which would provide fire safety of people, objects, equipment. Thus, there is no doubt - the future of the fire industry is highly promising.

In conclusion, it can be noted that fire safety issues are relevant and will always remain in the first place in the list of priorities of any society. Modern technologies already today help firefighters to cope with challenges and improve the quality of their work, as well as prevent fires preventively. At the same time, innovations and the latest technologies are needed to effectively fight fires and improve fire safety.

The Pozhtekhnika company and research institutes are an example of the successful application of technologies and innovations in the field of fire safety. Leading experts in the field of safety and risk management believe that the use of modern technologies and innovations can significantly improve the level of fire safety in the world.

Thus, we can conclude that the introduction of innovative technologies in the fire industry in Russia and the world is a necessity and a promising direction of development, which will help reduce the number of fires and improve the quality of fire services.

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