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APPLICATION OF INNOVATIVE AGRO-FIRE TECHNOLOGIES IN AGRICULTURE AND FORESTRY

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Abstract. The article presents the results of a system analysis of the use of unmanned aerial vehicles (UAVs), incl. for agricultural technologies, as well as airplanes and helicopters for extinguishing fires. On the basis of the obtained analysis results, a system synthesis of a hybrid aircraft was carried out to integrate the solution of these problems, which is an airship.

It is shown that airships are mobile, reliable and autonomous means, with high carrying capacity and weight efficiency, versatility and low total cost: 10 times less than the manufacture of a helicopter and 100 times less than its operating costs. At the same time, unlike UAVs, airships allow the use of nanotechnology (membrane, thermomagnetic) separation of atmospheric gases, as an "endless source of fire extinguishing composition" to suppress fires and landscape fires, and also solve all the problems of UAVs, including innovations in agricultural technologies.

Keywords. Unmanned aerial vehicles (UAVs), helicopters, airplanes, airships, membrane and thermomagnetic nanotechnologies, agricultural technologies, integration of safety technologies and agricultural technologies.

Unmanned aerial vehicles (UAVs) are beginning to be used in various fields of human activity, and obviously the time has come for their use in the largest industry - agriculture.

Already in 2016, about 48% of commercial UAVs were used in the field of agriculture, and according to foreign forecasts, by 2026 this figure will grow to 80%. For example, in Pittsburgh (USA), Skycision actively uses UAVs and infrared technologies, both in the diagnosis of diseases and for monitoring pests of agricultural crops. The UAV operator takes hundreds and thousands of infrared images and then creates a detailed map with photographs. Moreover, infrared sensors are even able to determine the amount of chlorophyll in plants, and this is a marker of diseases - if

chlorophyll is reduced, then the crops are affected. In this case, you can use the "Doctor of plant medicine" program, which will diagnose the problem and give a recommendation for the processing of agricultural crops [1].

Fig. 1 - Helicopter UAV

An alternative solution was the use of motor hang-gliders, equipped with special equipment, which made it possible to get rid of the problems of "big aviation" and to reach a new level of quality of farmland processing. So, for example, the agrochemical complex (ACC) "Agropatrul-04" (fig. 3), developed by specialists of LLC "AVIASPEKTR", has been operating in the Samara region since the end of the last century and has established itself as a reliable and economical ACC, which can work with any soil roads and restricted areas. Installed chemical equipment allows you to add drugs with maximum accuracy [3].

Fig. 3 – Agro-moto hang-glider

Currently, monitoring of farmland, as well as forests and steppe areas is carried out using helicopters, airplanes, satellites, and even a simple bypass of fields with measuring instruments,

which takes a lot of time and resources. Thanks to the UAV, this can be done much faster and cheaper. Equipping UAVs, for example, with ultrasonic "scarers" can protect fields from birds and rodents, and spraying the appropriate chemicals from other crop pests. The use of infrared cameras and other innovations simplifies and accelerates the transition to precision farming [1,2].

In Russia, for eight years now, on the basis of MEPhI, they are engaged in UAVs of various applications on a single platform that allows monitoring the environment, video filming and cargo transportation. However, each complex was manufactured individually, and such a system was poorly scalable, and in order to produce data that the farmer could understand, a lot of work was required, which was beyond the power of one company. Therefore, AgroDronGroup is a group in which there are two laboratories at Moscow State University, the Research Institute of Agrochemistry of Pryanishnikov, the Research Institute of Potato Growing Lorkh, the Research Institute of Biological Plant Protection and even the Korean University of Konkuk, i.e. a group of specialists in the agricultural sector and UAV specialists. With the help of such a combination, field experiments are carried out, which lead to the formation of algorithms for the formation of databases, with the use of which we obtain data that the farmer understands. At the same time, the cost of supplying a UAV depends on several parameters: the volume of areas and the volume of analytics, since for one type of analytics, it is necessary to make one overflight, and for another type, five overflies, including the factor of the distance of the farm from the bases with the UAV [2].

UAV monitoring of farmland and forest areas can solve the problem of early detection of fires, the main causes of which are the type of dominant vegetation, climatic conditions and the "human factor" [4, 5].

The fact is that the real scale of forest fires in Russia and the amount of damage caused by fire have not been reliably established until now, since **regular monitoring of forest fires is carried out only in the zone of active protection of forests, due to the limited material and human resources** [5,6].

Many countries, such as the USA, Canada, Australia, France, for which the problem of forest fires is urgent, have special aviation fire brigades, and Russia is no exception, because firefighting equipment based on aircraft in Russia has been used for almost 90 years: test flights to monitor the fire situation have been carried out on two-seat biplane U-2 (PO-2) since 1931 [7].

For example, AN - 32P with a full refueling of two tanks with a total capacity of 8 tons at a speed of 240-260 km/h, spraying the composition at a height of 40-50 m, allows you to create a protective strip up to 160 m long and up to 35 m wide. effectively extinguishing a fire using the BE-200 aircraft, which in the planing mode fills its 6-ton containers with water in 14-16 seconds, including on a wave height of up to 0.8 meters. The aircraft is very economical - for one refueling,

it is able to collect and bring down 320 tons of water to the fire. However, the disadvantage of these methods and devices is a very significant complexity of aerobatics, as well as the fact that there are not always reservoirs near fire centers that allow water intake in the planing mode [7, 8].

Unlike airplanes, helicopters MI-8, Ka-32 and MI-26 with spillways, the transport speed of a container with water is much lower and in case of fires in small areas or in mountainous areas, this is a fundamental advantage, since during spills at high speeds, at heights exceeding 40–50 m from the earth's surface, the discharged liquid as a result of the oncoming air flow breaks down to the state of aerosols and most of it evaporates without reaching the fire source [8].

A common disadvantage of these methods and devices is the high cost of both the equipment itself and its operation, as well as low efficiency, since airplanes and helicopters constantly have to refuel with water, fly up to the place of fire, pour out water and fly away to refueling, during which the fire flares up with renewed vigor [8,9].

Recently, both in Russia [10, 11] and abroad, a new class of hybrid aircraft has appeared, combining the principles of an airship, an airplane and a helicopter: in Russia - "BARS" and "DELTOSKAN", in the USA - R-791, in England - Skyship. In China, the French company Flying Whales, together with the Chinese state aircraft company General Aircraft Co., Ltd, are building a plant for LCA60T rigid airships with a carrying capacity of 60 tons, filled with helium, the serial production of which is scheduled for 2021 [12].

Thus, **airships are mobile,** reliable and **autonomous** means, with **a high carrying capacity** and weight efficiency, versatility of application, up to the solution of manned astronautics problems [13] and a **low total cost,** including the cost of **manufacturing - 10 times lower than helicopters, and operating costs - 100 times lower.** However, all of these aircraft (airplanes, helicopters, airships) use water to extinguish fires, which, as a rule, is absent in the steppe and forest areas [7-13].

A systematic analysis of the above agrotechnical problems and tasks of protecting farmland, steppe and forest areas leads to the conclusion that it is possible and necessary to integrate them using airships (fig. 4), including in unmanned modes, using nanotechnology (membrane, thermomagnetic) separation atmospheric gases, as an "endless source of fire extinguishing composition" [14], to suppress fires in mountainous areas, forest and landscape fires, as well as for the above innovations with UAVs and in agricultural technologies [15,16].

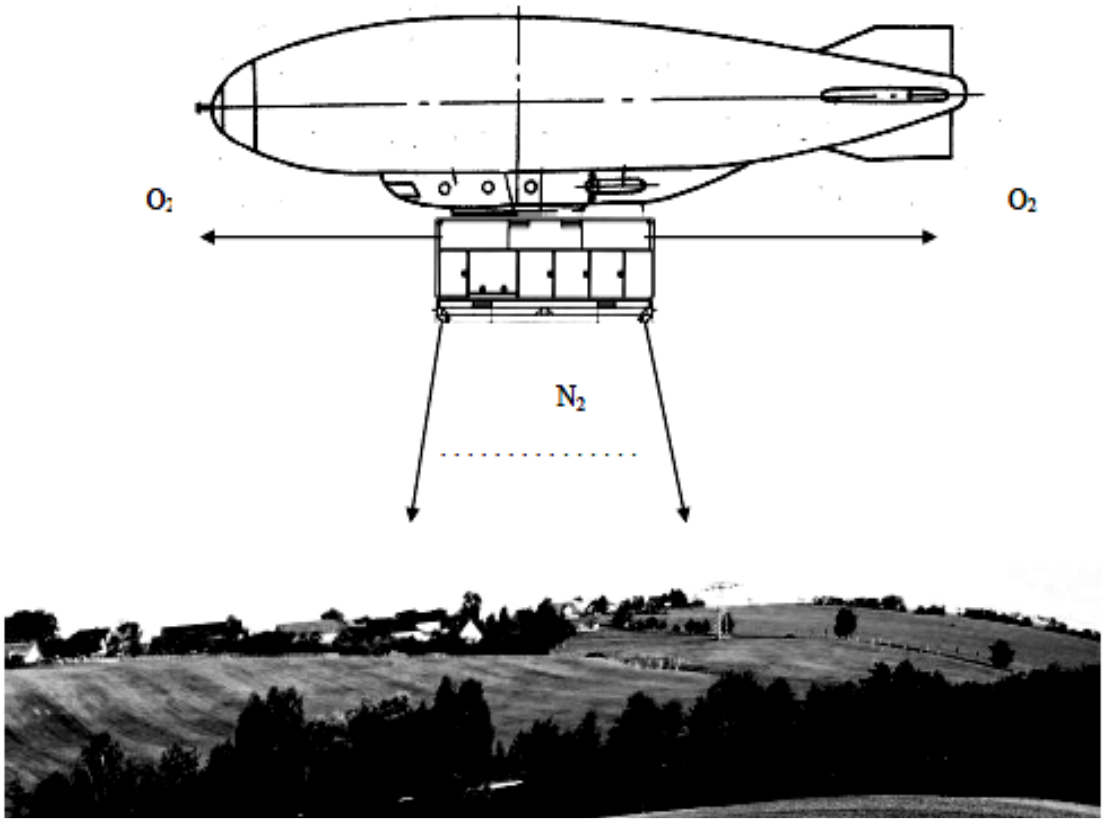

Fig. 4 - Schematic of the model with NMU

Unlike the configuration of the airship according to the claimed method of detecting and extinguishing farmland, steppe and forest fires with atmospheric nitrogen [17], a nitrogen membrane unit (NMU) container can be the "1st floor" of a rigid suspension complex, which, due to its weight and size characteristics (dimensions - 6.0×2.5×3.6m, weight - 11500 kg) may well replace the necessary "mooring devices", and on the "2nd floor" the cockpit and other necessary compartments can be mounted (fig.4), for the implementation of technological and auxiliary functions.

The results of the system synthesis of models for the integration of agrotechnical and fire-fighting tasks have shown their high efficiency [4,14-17]:

firstly, due to the possibility of equipping airships with any equipment for diagnosing the environment and underlying surface, which cannot be installed on a UAV, and is difficult to adapt to onboard versions for helicopters and airplanes,

secondly, due to the possibility of convenient (without parachute) "landing" of agricultural specialists and/or firefighters-rescuers with the necessary technical means anywhere on the airship patrol route, which is impossible not only for UAVs, but also for aircraft, as well as for all helicopters, except for MI-26,

thirdly, because of the economy of movement and the simplicity of "hovering and landing" of the airship as needed when patrolling along the route, including watering, spraying fertilizers and protection chemicals,

fourthly, in the absence of duplication and the possibility of economically creating and maintaining in real time a unified database of farmland, steppe and forest areas,

fifthly, in the possibility of round-the-clock patrolling and response to emergencies along the optimal routes of the territories of all regions of Russia, including hard-to-reach and mountainous areas, which is impossible neither by existing means, nor by UAVs, nor by individual services (Ministry of Emergency Situations, Rosles, Agroprom) due to the limited material and human resources,

sixth, they do not require the construction of special "berthing facilities",

seventh, in the emergence of such a synergistic system that ensures both fire and food security.

If, to perform agrotechnical or rescue tasks, it is necessary to transport water for irrigation or solutions for spraying, fertilizers or equipment, then the obvious solution is to dock the NMU container with a similar container for these purposes (fig. 5), without increasing operating costs (within the carrying capacity of the airship).

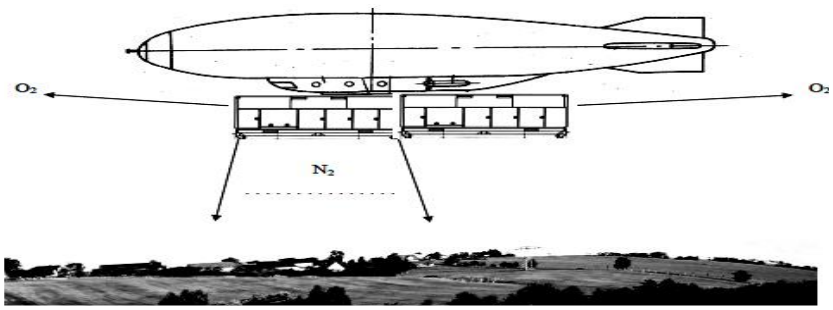

Fig. 5 - Schematic of a model with NMU and an additional container for equipment and/or passengers

Thus, in terms of carrying capacity and spaciousness, the airship surpasses all today's means of aviation forest protection and means leased by the agro-industrial complex, in connection with which, it can be argued that the combination of solving the problems of ensuring security and agricultural technology will reduce the unit costs for each of them by at least two orders of magnitude. them, because the airship, due to the aerostatic scheme, has constant costs for its movement, which does not depend on the load (within the limits of its carrying capacity), since according to the calculations of the specialists of the Russian Aeronautical Society, the flight hour of the airship costs about 4 thousand rubles, i.e. **almost 3 orders of magnitude cheaper than a helicopter** (on average 40 thousand rubles). Moreover, if the average density of the cargo is less than 0.4 t/cu. m, then their transportation by airships is more economical than by airplanes, and at a density of less than 0.2 t/cu. m - more economical than any ground means of transport [18].

In addition, the proposed integration of the tasks performed by the airship's crew and its technological capabilities make it possible to protect against the spread of fires in the steppes and forests by installing "electrical protection strips" instead of mineralized, because with the help of the airship it is possible not only to "carry them with you" for an infinitely long time, but also use them, since the power plant of the airship can provide the required high-voltage voltage for this. Domestic studies of the influence of electric and acoustic fields on the processes of combustion and extinguishing fires, carried out at the end of the last century [19-21], have shown their high efficiency. In particular, it was found that high-voltage pulsed electric fields emitted by a metal mesh (fig. 6) block the spread of fire much more efficiently than mineralized stripes, and also do not require special equipment to create an embankment [21].

Fig. 6 Radiated metal mesh

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