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Development of a fire-proof aerial robot system for fire disaster

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ABSTRACT

Nowadays, the number of high-rise buildings and large complex structures are rapidly increasing due to the development of new construction technologies and other economic reasons. Since these urban spaces are densely populated, fire accident could be critical and accessing the situation at early stage is very important in order to suppress the fire and evacuate the residents. In that, aerial robot platform has advantages because of its ability to access to the place that is hard to reach. In this paper, we developed the fireproof aerial robot platform that can endure the intermittent flame. The robot can pass through the narrow space by climbing the wall.

1. INTRODUCTION

This paper proposes a new fire-proof mechanism for micro aerial vehicles using aramid fibers and air buffers. Drones are very limited in payload and operating time due to battery technology and limitations of its own flight mechanism. Therefore, options are very limited if additional equipment or other elements are installed in the MAV (Micro Aerial Vehicle). The proposed fire-proof aerial robot platform uses lightweight design using aramid fibers and air buffers. In addition, the developed platform is designed based on CAROS (Climbing Aerial RObot System), so that it can pass through collapsed structures by climbing walls in case of fire disaster.

2. FIREPROOF MECHANISM

2.1 Aramid fiber skin

Common materials for a drone frame are carbon pipes, carbon plates, aluminum pipes, and the other lightweight plastic. However, only lightweight steel like aluminum plates and pipes could be used as a main frame for fire-resistant capability. Due to its

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great physical properties, aramid fibers are widely used in various applications, including armor, ropes, cables, tires, sporting goods, fiber-reinforced concrete and thermal-protective clothing. Fiber is the main material in fire-fighting because it can withstand high temperatures up to 500^{o}C.

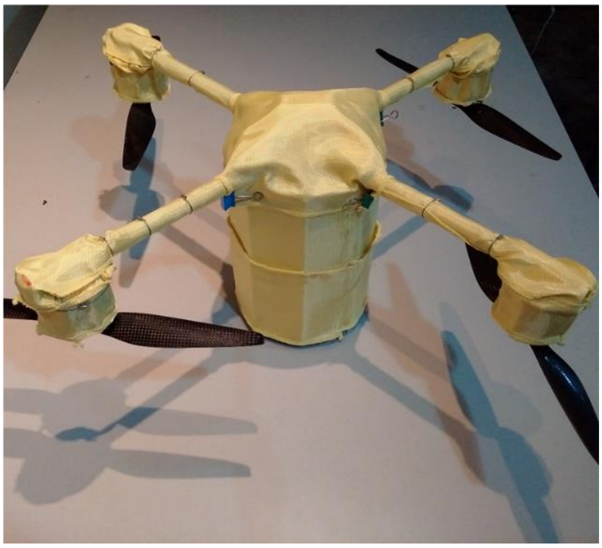

Fig. 1 Aramid fiber-wrapped prototype of the developed robot system

As a first layer of exterior protection, the robot platform is covered with aramid fiber so that the flame and heat cannot reach critical elements for operation. In order to reduce the self-weight, the aramid fiber-based exterior skin armor consists of two pieces for a main body and a few small pieces for the motor and wall-climbing drive. And their connection and finishing is done by needlework and knot work as shown in Fig. 1.

2.2 Inner frame structure

Common materials for unmanned aircraft frames are carbon pipes, carbon plates, aluminum pipes and other lightweight plastic. However, for refractor performance, only lightweight steels such as aluminum plates and pipes are used as mainframes. As mentioned earlier, robots are very limited in size because they are developed for indoor environments. The shape of the main body of the refractory becomes a single tube structure. The body contains all electronic components such as a flight controller, battery, microcontroller unit (MCU) and motor drive. The motor has an external protection structure made of aluminum, and the aramid fiber protects the motor from fire.

3. EXPERIMENTS

In order to verify the feasibility of the fire protection mechanism of the aerial robot platform, a fire resistance test was conducted by a fire where aerosol ethyl alcohol and butane gas are generated. In consideration of normal driving conditions, the test is executed when the rotor is rotating like an idling or flying. Since the number of revolutions of the rotor at idle is slower than the number of revolutions at the time of flight, ignition to the drones is easy, so the test was conducted in the idling state.

As shown in Fig. 3, the fire is uniformly applied to the robot for about 60 seconds. During application of the flame, the external temperature rises but is not proportional to the application time, so there is a limit to temperature rise using aerosol ethyl alcohol fire. When the fire stops, the surface temperature drops rapidly and only returns to normal level after 16 seconds.

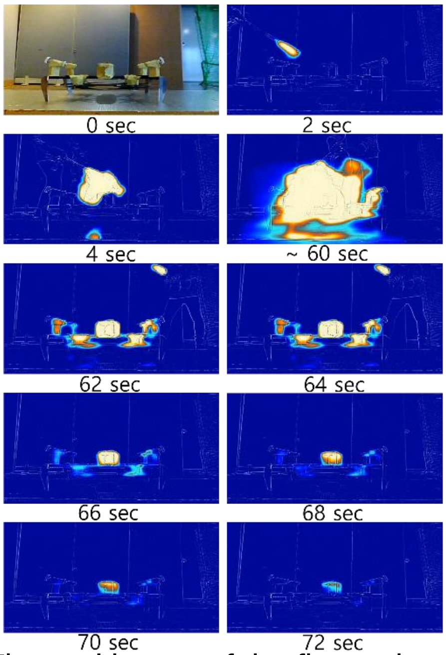

Fig. 3 Thermal image of the fire-resistance test

4. CONCLUSION

From the fire-resistance test, the feasibility of the fire resistance of FAROS has been verified. It is expected that the robot can help firefighters' work by detecting fire or people trying to escape in the early stage of fire disaster.

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