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Mini Review

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Nitrogen Fire Extinguishing System in Airplanes Cargo Compartments

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Introduction

In all large passenger transport airplanes, halon fire bottles are used to extinguish fire in the cargo compartments. Halon as a fire-extinguishing agent, contributes to the destruction of stratospheric ozone in the atmosphere and it is banned in many countries. The European commission ruled that halon 1301 and 1211, must not be installed onboard new airplanes by 2018 and by 2040, halon must be removed and replaced in all operating aircraft. The International Civil Aviation Organization (ICAO) adapted a resolution that requires a halon replacement agent for lavatory extinguishers and hand held halon extinguishers by 2011 and 2016, respectively [1]. There is, however an increasing concern, for aircraft manufacturers, to find an effective halon replacement before the deadline.

Currently, on all transport airplanes, halon agent is used to extinguish fire on the engine, however, halon cannot be applied to inside of the engine because it decomposes to form hydrogen fluoride and hydrogen bromide and it results in metal corrosion and damages the internal engine parts [2]. Therefore, currently, halon is applied to extinguish fire located outside the engine which is considered one of the main disadvantages. In addition, the other disadvantage of using halon fire bottles, is that the cargo smoke detectors in the cargo can generate spurious false warnings, which result in crew deploying the halon agent unnecessary thus in case of real fire warning, then no halon in the bottle will left to extinguish real fire. Spurious cargo smoke warning is due bleed air supply contamination which can be due to either APU internal oil leakage or re-ingestion of oil, hydraulic or de-icing fluids.

In the proposed methodology, we will present an alternative approach, as regard of using halon 1301 as a fire fighting agent. In the proposed method, nitrogen is first extracted from the atmosphere by using air separator module (ASM), polymer membranes based upon hollow fiber and its pressure increased, in order to increase its effectiveness, and routed into the cargo compartments to suppress any fire [1-3]. Gas separation membranes are often packaged in hollow fiber modules. As air flows under pressure into the module through the bores of the hollow fiber, some of the air gases permeate through the wall of the fibers into the shell of the hollow fiber. The gas in the shell side of the fibers leaves the module as the permeate stream. Since oxygen, water, and carbon dioxide are more permeable than nitrogen and argon, the gas in the fiber bore is enriched as it moves from the feed to the residue end of the module [4]. The main challenge is the flow rate limitation from the air separator module to extinguish fire in a large compartment such as cargo.

The proposed approach presents several methodologies to increase the flow rate from the air separator module. For illustration, increasing the size of the ASM or the feed pressure will increase flow rate. High bleed air supply to ASM can be applied by either tapping bleed air supply from HP compressor stage instead of IP compressor stage on the engine. Alternatively, an air compressor can be used to supply pressurized air to ASM. The air compressor can be driven electrically or mechanically [5]. In mechanical type, the compressor is mounted on the engine gear box and it can be impellers or positive displacement. In addition, using more ASM modules increases the flow rate. A single membrane ASM at sea level altitude, when ASM inlet pressure is equal to 25 psi and ASM inlet flow rate of 1.48 lbs/min, it produces 0.36 lbs/min. Two membranes ASM configuration produce twice nitrogen flow rates. The proposed approach uses other different approaches to overcome the challenges. Alternate approach is to use airfreight containers in cargo compartment, which are installed with a smoke detector, a nitrogen port and a mechanical pressure relief valve. In such technique, the airfreight container is placed inside the cargo bay and it have to be connected to the aircraft side nitrogen flexible hose, and electrical receptacle to power the smoke detector. Should one container generate smoke warning, then the processor energizes applicable solenoid valve to supply nitrogen to the effected container [6]. When nitrogen pressure inside the container reaches a predetermined value, the relief valve opens to vent excess nitrogen and to prevent over pressurization of the container. As safety feature, if the aircraft nitrogen hose or electrical receptacle connectors are not connected to the container, then a message appears in the cockpit for the crew to take corrective action. This can be done by means of using a proximity sensor in the connectors.

Another alternative approach is that the airfreight containers can be filled with inert nitrogen gas, to 2 to 3 psi. When the container is filled with nitrogen, it reduces the risk of fire/smoke. In such case, each container will be inerted with nitrogen, one at a time, when certain conditions fulfilled (cargo door closed and engine operation). The airfreight container installed with a pressure sensor, to sense the nitrogen pressure inside the container and sends data to the processor [7]. The proposed containers will be installed with a pressure relief valve, to dump excessive pressure. Experiments conducted and result showed that nitrogen of 2 psi, can extinguishes fire effectively.

Another technique, in order to increase the ASM flow rate, is to store nitrogen from ASM in a cylinder bottle, to be used during fire/smoke condition. The cylinder bottle pressure is continuously monitored and if it falls below certain value, it sensed by the pressure sensor, and the system, supply air to ASM to generate nitrogen, that is pressurized and stored in the cylinder bottle. The advantage is that the bottle nitrogen refilling is done automatically and without man power [8].

Nitrogen is considered as alternate suitable fires suppress to halon by civil aviation authorities such as FAA and EASA. Nitrogen is suitable to suppress class A-petroleum products, cellulosic materials and polymers, class B-flammable or combustible liquids, and class C-energized electrical equipment fires [9].

A series of experiments conducted, aimed at gathering information

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by using dry nitrogen under different pressure values to extinguish different size of fire [10]. The analysis of the experiment research showed that increasing nitrogen pressure, resulted in quicker extinguishing time. This is because nitrogen under higher pressure, quickly decrease the oxygen concentration in the air for the fire already in the process of combustion. In principle, there are two approaches to fire suppression: Either decreasing the oxygen concentration or inerting the combustible environment. For fire to occur it requires oxygen and by supplying nitrogen at higher pressure, nitrogen pushed away the oxygen from fire at faster rate, hence inhibited combustion process sooner.

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