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TECHNICAL AND PROCEDURAL RESOURCES OF OVERHEAD BIN SECURITY

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Abstract

The article deals with the design of safety systems to prevent the opening of overhead wires in situations that are not in accordance with safe operation. The paper discusses possible variants of the functioning of the locks, as well as a theoretical part focused on the reasons for such behaviour of passengers. Subsequently, the article describes two options for locking overhead bins and a description of their operation and manufacture. The article concludes with an assessment of the usability of the locks and their potential.

Keywords

Safety, Evacuation, Security, Overhead bin

1. INTRODUCTION

Nowadays it is very easy to get access to records, photos or videos of evacuations. It can be clearly seen that up to 50% of the passengers are taking their luggage out, thus delaying the evacuation and potentially endangering the lives of other passengers. The article therefore discusses the possibility of preventing the removal of luggage from overhead bins. The article discusses in detail two types of locks, one manual, which could be incorporated into existing aircraft, and the other, fully automatic, which could be used in new aircraft.

2. ANALYSIS OF THE JUSTIFICATION OF THE PROBLEM ADDRESSED

2.1. Passenger behaviour in stressful situations

The irrational behaviour of passengers in airplane accidents and subsequent evacuations is probably, according to studies, conditioned by the fact that the common public perception of airplane accidents is that they are extremely rare and, when they do occur, they are mostly unsurvivable.

One of the most significant aviation accidents that contributed to significant changes in aviation safety was the Boeing 737 accident in Manchester. During take-off, the left engine failed unexpectedly and subsequently leaked fuel. The escaping fuel ignited and part of the left engine caught fire. The crew aborted the take-off and the aircraft left the runway with the wind directing the fire towards the rear of the fuselage. The fire service did not arrive at the scene until 5 minutes after the accident, evacuation was made difficult by smoke at the rear door and the failure of the right front door. In the accident, 55 of the 137 people died from toxic smoke inhalation. [2][4]

Extensive studies of crowd behavior and behavioral aspects during evacuation have been conducted as a result of this accident. Thus, it was found that the most critical aspect in evacuation is time. On average, one minute elapses between the detection of a problem, the completion of the cockpit checklist and the signal to evacuate before the evacuation begins. But a minute, if it is obvious that an emergency has occurred, is a very long time for passengers, during which panic is the main word in the passenger cabin. During this minute, passengers take evacuation into their own hands, disregarding the instructions of the cabin crew to remain seated, and begin to take their luggage from the overhead bins and begin to evacuate. One such case can be demonstrated by the 2018 Smartwings incident where passengers began to evacuate themselves after smoke from a vehicle on the tarmac entered the aircraft. Despite the crew's request to calm down, the passengers fired the evacuation slide, which was blown away by the still running engine, and a passenger who was standing by the door fell on her head from the door, fracturing her skull as a result of the fall, and was taken to hospital in a critical condition. She eventually succumbed to her injuries. It is therefore very important that cabin crew are assertive enough to prevent illogical and dangerous behaviour by passengers. [3]

Other major delays in evacuation, apart from taking their hand luggage from the overhead bins during evacuation, include separating family members from the group during evacuation, thus blocking of evacuation areas may occur. In 2004, The Flight Safety Foundation published a memo indicating that passengers do not perceive a life-threatening situation if they do not see smoke or fire. [2]

2.2. Statement of the Problem

Adequate attention should be paid to emergency evacuation during the investigation in order to gain a better understanding of the actual behaviour of the occupants so that evacuation procedure designs can be improved. According to what has already been elaborated about the emergency passenger behaviour, it is found that as a result of the behaviour, almost 50% of the passengers delay the evacuation by removing their belongings from the overhead bins. The lock on the hand luggage compartments, the design of which is elaborated in this thesis, aims at preventing the possibility of opening the compartment. If passengers are made aware in the safety instructions that it is not possible to remove their luggage, the probability that they will not attempt to do so during an evacuation increases, thereby increasing the likelihood of survival for themselves and other passengers.

Aircraft evacuation systems and their safety features, which include, for example, chutes and doors, must be certified for real-life operations and environmental factors such as wind, rain, snow, non-standard aircraft position, etc. The need to ensure that people do not carry their luggage when evacuating from the aircraft may also be a reason why

the use of evacuation slides is necessary. These slides were not designed to be used to evacuate luggage, which can damage them, as can, for example, heels. When a slide is damaged, it is usually impossible to continue using the slide as the air escapes out of the slide and does not maintain its integrity.

Last but not least, the lock would fulfill as a secondary benefit of directing passengers in situations where it is needed. It would therefore prevent, for example, a passenger walking across the cabin already during taxiing after landing. By preventing passengers from getting up immediately after landing and "queuing" before the aircraft is fully stopped on the stand, it may make the job of cabin crew easier.

3. SURVEY OF TECHNICAL SOLUTIONS

At present, it is not possible to find central locking of luggage compartments on airlines or aircraft. However, the proposal for central locking has already been addressed by ICAO, as the statistics on evacuation speak clearly and it is clear that there is a need to combat delays in evacuation times. According to some debates and suggestions, compartment locking can also have a negative effect on evacuation. [5]

The current designs that are currently available on the market are mostly addressed by companies specialised in the production of overhead bins. Among the most basic is the classic keyed lock, which is also the focus of this thesis. However, these classic key locks are not used as central locking of all compartments to prevent tampering during evacuation, but as overhead bins that are used by the crew. Overhead bins used by the crew are, depending on the type of aircraft, the first or/and last compartment in a row in which the crew store their personal luggage and contain equipment such as first aid kit, passenger blankets, safety cards, nausea bags, etc.[6][7]

3.1. Requirements for locks

Several types of locks were proposed during the development of this thesis. The most ideal design, which has the prospect of working, is further elaborated in the continuation of the thesis, but it was necessary to compare several variants. From the lock as the main criteria of the work requires:

- Seamless functionality,
- simplicity,
- the smallest possible weight,
- the possibility of easy repair,
- the least possible burden on the crew,
- autonomous operation that does not interfere with the integrity of the aircraft,
- heat resistance

4. IV. DESIGN AND MANUFACTURE OF THE OVERHEAD BIN LOCK

4.1. Magnetic manual lock

The entire magnetic lock is designed and constructed for printing on a 3D printer. The lock is composed of a mechanism cover. A movable lever, one side of which extends to block the opening of the movable part of the overhead bin, and at the other end of the lever is a magnet that is magnetically attracted to the outer magnet to open it. A latch which by its movement locks the movable lever with the magnet in the permanently unlocked position. A fuse is created for 3D printing from components not directly on the main locking mechanism, against which the sliding lever and larger magnet are blocked, this magnet is used by the deck crew to unlock the overhead bin from the outside.

The components were designed in Autodesk Fusion 360. Unlike the first theoretical lock design, the lock latch, its location and its shape had to be modified. The movable locking paw and the stop had to be modified so that the lock could be positioned between the movable and non-movable parts of the luggage compartment and still be unlocked despite the thicker material used on the overhead bins.

Figure n.1 – Components for 3D printing of magnetic lock [1]

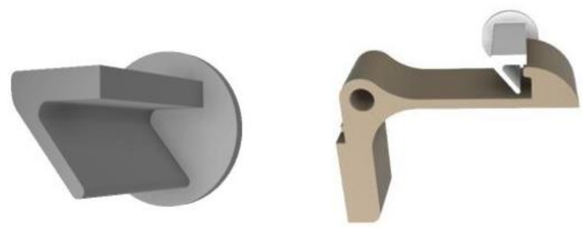

Figure n.2 – Modified magnetic lock release stop [1]

After printing all the necessary parts on the 3D printer, they were cleaned of excess material that is produced during 3D printing, the details were adjusted and the magnetic lock was assembled into a single unit. Once assembled, its functionality was tested and it was placed on a model of an overhead bin where its functionality and reliability was also tested.

Figure n. 3 – Final magnetic lock prototype [1]

4.2. Automatic RFID lock

The RFID lock was more complicated to manufacture, although its technical design did not need to be changed from the original theoretical design. The lock contains more components and also wiring, along with an electrical source,

in the case of this work the source was solved by a battery. In the design, the locking was solved by servo or magnetic lock, for the construction, the final solution was chosen to be electromagnetic locking, because this solution better suits the requirements for the location on the overhead bin.

In this article an open Arduino platform with connected peripherals is used, which is suitable for the purpose of prototyping so-called embedded systems. The next section first describes the components used to build a demonstration system capable of controlling the overhead bin locks according to the commands of the on-board personnel and then the software operation when programmed.

When an authorized access card is inserted, the system goes into an "open" state. At the same time, the user is informed of the progress of the action on the attached LCD display. In the "open" state after opening the locks, a protection interval is set when the system does not read data from the RFID transceiver. Due to the fact that the same RFID authorization card or tag is used to re-lock the overhead bins, this protection interval is necessary to avoid constant switching between open and closed state in case the RFID card is attached to the transceiver for too long an interval. The duration of the protection interval was chosen to be 4 seconds. Changing the duration of this interval is possible by a minor modification of the code.

If the system is in the "open" state and the RFID card with authorized access is reattached, the system enters the "closed" state. Both locks are locked at the same time and the LCD display informs the user about the progress of the action. Again, a protection interval of 4 seconds is present to prevent accidental unlocking if the RFID card is moved too hesitantly near the reader.

If in any state, either "open" or "closed", a card with unauthorized access is attached, the system will not perform any action, inform via the LCD display, and remain in the current state.

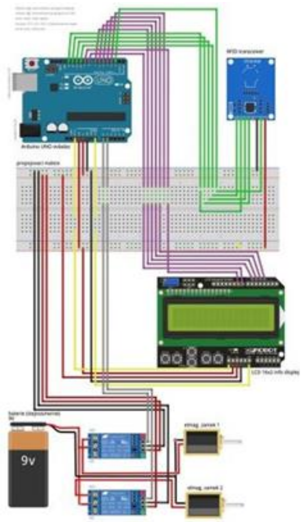

Figure n. 4 – Component wiring diagram [1]

5. EVALUATION OF THE BENEFITS FOR OPERATIONAL SAFETY AND COSTS FOR THE OPERATOR

There are a few basic categories that can be identified as the main benefits of safety locks, which are the problem areas in emergency evacuation as well as in the normal operation and disembarkation of passengers:

- Increased safety on board, reducing the possibility of removing luggage from the compartments and thus considerably speeding up the overall evacuation.
- Organization and restriction of passenger movement in critical situations such as take-off, landing or turbulent conditions. Due to the inability to handle and access their luggage during these and other parts of the flight where it is needed, the movement of passengers around the aircraft is reduced.
- Discharging passengers by group from the aircraft in such a way as to avoid disturbance of its stability on the ground due to movement of the centre of gravity. At the same time, there is new potential for low-cost airlines in the possibility of paying extra for early departure. The locks allow only part of the overhead bins to be opened, there is no need to open them all at once.

The approximate weight of both prototypes was about 150 grams per lock. The overhead bins in an aircraft average, depending on the specific type, are about 20 luggage bins per side, so 40 overhead bins in total and 40 required locks. Thus, there is an approximate weight increase of 6 kilograms per aircraft when locks are installed. This increase will increase the Basic Operating Mass. The locks are evenly spaced, so they do not affect the centre of gravity of the aircraft. At the same time, the Boeing 737, on which the locks have been implemented, has its centre of gravity almost at the centre of the aircraft, it is located near the wings and therefore the effect of the locks is negligible. The total weight of 6 kilograms is also negligible compared to the take-off weight of the aircraft, which is around 79 tonnes.

6. CONCLUSION

The conclusion of this work is the evaluation and development of two selected means to lock the luggage compartments in the passenger cabin. In the first, theoretical part, the thesis deals with topics closely related to the main focus of the thesis. A magnetic, manual, lock and an automatic lock using radio frequency identification for locking and unlocking were selected for further investigation and production.

The selected locks were first designed theoretically. Subsequently, two prototype locks were also manufactured. Several modifications were made during the manufacturing process to make them usable in operation and to meet the requirements imposed on them. Subsequently, their functionality was tested and their characteristics were analysed. At the same time, the benefits of this component when used in operation, their theoretical cost and the cost in operation were evaluated.

It was found that neither the center of gravity nor the cost of manufacturing and implementing them would be so substantial as to affect aircraft operations or economically disrupt airline budgets. The work was based on the fact that a passenger will only experience evacuation from an aircraft once in his/her lifetime, therefore his/her behaviour is often irrelevant. At the same time, the 90 seconds for evacuation assumes a seamless evacuation, where no passenger

intentionally, or due to stress, delays the evacuation. Locks preventing the removal of luggage from overhead bins could speed up evacuation if passengers were informed of the locks. At the same time, the locks are not strong enough to withstand the onslaught of intense efforts to get into the bins. Finally, locks on the baggage bins could help with scheduling passengers to exit the aircraft so that they are no longer trying to lift and climb into the aisles during taxi, as well as coordinating the exit of passengers down the aisles by separately unlocking the overhead bins.

The purpose of this article was to evaluate and design locks to prevent luggage from being removed from the overhead bins at times when this activity is not consistent with security procedures. The two proposed locks meet the purpose of the article and are applicable to real operation. This minor change, the addition of cabin security, could effectively expedite evacuation, thereby potentially saving the lives of other passengers. It would also make the job of cabin crew easier when directing passengers during critical parts of the flight, or in situations where passengers need to be seated. Airline safety departments today are looking for the intersection between financial costs and safety improvements, so the proposed solution could open the door for companies to win new ACMI contracts.

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