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The Design of Door Handles for Civil Aircraft Cabin Doors Utilizing Addictive Manufacturing for Aerospace Component Manufacturing

Mohamad Shahriz Asraf Samsaimon[1], Md Saidin Wahab[1]*

[1]Faculty of Mechanical and Manufacturing Engineering,
Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, MALAYSIA

*Corresponding Author

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Abstract: Door handles, usually referred to as "door knobs," are the handles used to open and close a door. On a variety of doors, including the outside doors of homes and businesses, the interior doors of homes, the doors of cupboards and cabinets, and the doors of vehicles, door handles are a common fixture. There are numerous types of door knobs, each of which has a distinct function. Significant numbers of door handles, especially those made for residential and commercial doors, either incorporate latching or locking mechanisms into their design or are manufactured to be compatible with a variety of standard door latching and locking systems. Door handles can be created from a bewildering variety of materials. Brass, porcelain, cut glass, wood, and bronze are examples of various materials. The cabin doors of a civil aircraft serve as the key determinant of the user's first impression because they are the user's first point of contact with the aircraft. Doors must consequently be self-explanatory as to their operability and function. This must not represent the first manual and/or technical difficulty when entering a civil aircraft and ensure that all passengers may board the aircraft safely. The term "additive manufacturing" refers to a variety of techniques that begin with a digital 3D model and result in a three-dimensional object. During these operations, material is mixed, deposited, or created layer by layer under the computer's control. Numerous past studies and research have exclusively focused on prototypes and non-critical components when making aerospace components and parts utilizing additive manufacturing. As the technology of additive manufacturing (AM) has advanced and evolved rapidly, more research is being undertaken on the significance of replacing existing methods of producing key parts and components with AM. This research will heavily rely on SolidWorks software to replicate the existing product into a 3D model, which will then be redesigned to make it easier to produce using the additive manufacturing process so that the product can be used immediately without the need for an assembly process by eliminating all design from the component. The 3D model of the new door handles of civil aircraft designs was analyzed with SolidWorks software and found to perform better compared to the original cabin door handle in terms of the amount of displacement and the value of the safety factor.

Keywords: Cabin door handles, addictive manufacturing, aerospace industry

1. Introduction

A door handle, or doorknob, is a handle used to open or close a door. Door handles can be found on various types of doors, including external doors of residential and commercial structures, internal doors, closet doors, and vehicle doors. There are different designs of door handles, depending on their proper function. A great variety of handles, particularly for commercial and residential doors, feature latching or locking mechanisms or are manufactured to fit standardized

Corresponding author: saidin@uthm.edu.my

door locking or latching mechanisms. Door handles can be fashioned out of a wide variety of materials. Examples include brass, porcelain, cut glass, wood, and bronze. Door handles have been in existence for at least 5000 years, and their design has evolved since, with more advanced mechanisms, sorts, and designs.

In contrast to traditional manufacturing methods, where a metal slab is milled or cut away to generate a part, additive manufacturing, also known as 3-D printing, "grows" parts directly from a CAD file using layers of fine metal powder and an electron beam or laser (Schiller, 2015). The approach enables the production of complex parts, such as door handles, without the waste inherent in milling, and in a fraction of the time required by other methods. It also enables GE to build parts with unique shapes that would be impossible to achieve using regular machining procedures. By replacing assemblies with a single component, additive produced components can reduce part count while also reducing weight and increasing engine fuel efficiency. Additive manufacturing (AM) is being established in the aerospace industry as a fabrication method that makes money throughout the supply chain and in maintenance operations. For the past 10 years, the aerospace industry has been one of the most important areas in the additive manufacturing business. The aerospace industry now accounts for 18.2% of total revenue in the additive manufacturing industry. Additionally, the aircraft industry is the fastest growing sector, with an annual rise of 1.6% in 2016, followed by the motor vehicle industry, which saw an annual gain of 1.0% in 2016. Sales from additive manufacturing (AM) were anticipated to be $2.7 billion in 2016 and are expected to reach $100 billion during the next two decades, with most of the income coming from the aerospace industry.

Producing door handles for aircraft or helicopters using the AM method will surely be possible, but there are a lot of factors and issues that need to be carefully identified, like the design of the door handles, materials used, and AM type. With the application of the AM method to important components for the aerospace industry not far off, producing door handles for aircraft or helicopters using the AM method will surely be possible. Previous research and studies related to this research also needed to be done for guidelines or reference, but further advanced studies for this research may be a little bit out of reach considering that access to some classified information and knowledge related to the making of the component for the aerospace industry is limited, so this research will only be focusing on the design of the door handles of cabin civil aircraft that are suitable to be produced for AM with some general relativity. Previous research and studies related to this research also needed to be done for guidelines or references.

This component, known as a civil aircraft cabin door, appears to be simple and straightforward to manufacture, but it actually requires a significant amount of time and resources, as well as being made in the lab, which can be inconvenient in an emergency or a demanding situation that necessitates the production of this component. The traditional technique of producing this item also required the use of a highly sophisticated machine and only reduced time and money if the components were manufactured in large quantities. Although the additive manufacturing method can produce complex geometrical shapes and designs, it may cause issues if the design does not meet certain requirements. Although the existing door handles of the civil aircraft concept can be produced using the additive manufacturing method, they can still be improved to make them easier and more suitable for production using the additive manufacturing method so that there will be no issue. It is essential to choose the best material and additive manufacturing method in order to produce the best door handles for civil aircraft that meet the standard required for the component to be fit for use on an aircraft. This standard determines the minimum dimensions of the component that must be met for it to be considered airworthy. In order to evaluate whether or not the component can be accepted, a simulation test of it is also required.

This study was focusing on designing a new cabin door for civil aircraft that is suitable for the additive manufacturing process where the produced component doesn't need to be assembled and can be used right away by eliminating all the shafts included in the original design, but the mechanism can still function with the help of SolidWorks software to run a simulation test on all the designs, and then the results will be compared between the original and the new design to see if the new design can surpass the original design. The findings of this study will definitely be of use to the aerospace industry, given that this study is related to the aerospace industry's desire to replace the conventional method of manufacturing components and parts for aircraft with the AM method and could also support the improvement of the aerospace industry due to the fact that using the AM method to produce components and parts is less expensive and more efficient than the conventional method. In addition, the utilization of AM in this study will help to expand the possibility of implementing the utilization of AM method or technology to the industry, factories, corporations, and companies, or maybe to a wider audience such as regular working-class people in Malaysia. This is because, despite the fact that AM has been rapidly evolving and improving over the course of the years, it is still not really relevant to the public, and not many people or companies have utilized the AM method and technology for their own purposes.

2. Methodology

For the objective of this research, several processes and methods were employed in order to collect the data and information required to arrive at the best decision that could possibly be made regarding this research. It is necessary to use CAD software in order to first build a design for the cabin door of a civil aircraft by breaking it down into its component elements and then fully assembling it into a single design. The computer-aided design (CAD) programme that will be used is called SolidWorks software, and it includes all of the features that are required to carry out all of the procedures that are involved in designing the cabin door of a civil aircraft and assembling all of the parts that make up the cabin door of a civil aircraft.

2.1 Development of Designing the Cabin Door of Civil Aircraft

The development process started with a rough idea of how the mechanism for the cabin door of a civil aircraft worked. From there, two possible designs were made based on the existing product, but with some changes that made the product more innovative while still meeting the standards for the C919 and A380 and making it possible to use the AM method to make them. Then, using SolidWorks software, a 3D model of the original design of the door cabin of a civil aircraft is made to be as accurate as possible. Parts for the door handles are modelled separately so that it is easy to imagine how to make them better with a new design, as shown in Fig. 1.

Fig. 1 - Original door handle cabin civil aircraft design

Next is to proceed with a new concept design that can make it suitable to be produced with the AM process, preferably with no assembly needed. Then, we optimized the new concept design to make it more refined and sturdier without changing the original locking mechanism of the door cabin handles of civil aircraft. Lastly, run a simulation test, which is a static study feature on the SolidWorks software, for the critical parts of the original design and the two new designs to then be compared with the original design that acts as a benchmark and see whether the design meets the requirements set by the A380 standards, which then determines whether it is safe or not to be used as a component for an aircraft.

2.2 Conceptual Design

After all the specifications, functions, and ideas are considered, two concept designs of the parts for the cabin door handles of civil aircraft are done using SolidWorks software, with all the designs being eliminated but the mechanism still working without any problem. These are all the models of the two design concepts for the cabin door handles of civil aircraft that were done separately based on the actual cabin door handles of civil aircraft measured using a vernier caliper, ruler, and tape, with the dimensions and size being as close as possible to the real cabin door handle.

2.3 Design Concept 1

Fig. 2 shows the first design concept for the civil aircraft door handle. The locking mechanism previously studied in the original cabin door handles of civil aircraft remains the same. It is either to pull and push or rotate clockwise, depending on the mechanism stated. Based on the original and design concept shown in Fig. 1, the design of each part had been changed following the standards for aircraft components. There is a specific study on force and pressure being compared with the original and design concepts.

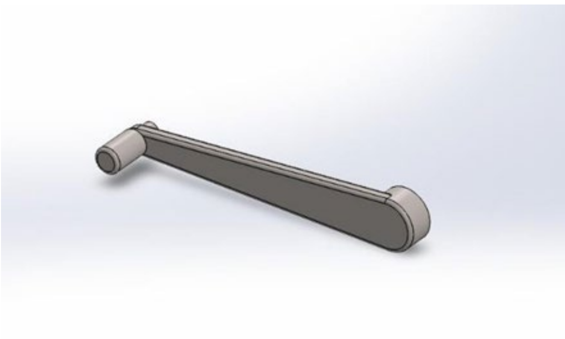

Fig. 2 - Door handle cabin civil aircraft design concept 1

The width of the part that connected the guide wheel with the shaft latch has been changed to be smaller in order to allow the shaft guide to pass through the locking mechanism of door handles. The latch body and the hole for the rocker arm that connected the locking mechanism with the shaft guide have been connected for better support. To make the part under the rocker arm with latch body and shaft guide pass through the handles section in the body, the thickness needs to be reduced, and the hole position for the rod that connects the shaft guide and locking mechanism needs to be changed. Other parts don't need to be changed because it is unnecessary, as the door handles in cabin aircraft can still be locked and unlocked without any problems.

2.4 Design Concept 2

Fig. 3 shows the second design concept for the civil aircraft door handle. This design concept changed the same parts as design concept 1 with better consideration and improvement except for the latch body because it is already a good design to make it possible that all the parts can be assembled and the mechanism can work as the original design. The width of the part that connected the guide wheel with the shaft latch has been changed to a precious size in order to allow the shaft guide to pass through the locking mechanism of door handles. The latch body and the hole for the rocker arm that connected the locking mechanism with the shaft guide have been connected for better support. The thickness of the part of the body and guide wheel has been changed back to its original dimension. To make the part under the rocker arm with latch body and shaft guide pass through the handles section in the body, the thickness remains the same, and the hole position for the rod that connects the shaft guide and locking mechanism needs to be changed. Other parts don't need to be changed because it is unnecessary, as the door handles in cabin aircraft can still be locked and unlocked without any problems.

Fig. 3 - Door handle cabin civil aircraft design concept 2

3. Results and Discussion

The analysis will first be calculated using a simulation of how the product will respond and be affected in actual situations or tests using the SolidWorks software. Utilizing SolidWorks software, simulation tests will be conducted on all three designs of cabin door handles for civil aircraft. There will be only one static study, but it will be conducted twice. The first static study will involve the application of pressure, while the second will involve the application of force. After calculating the safety factor and the amount of displacement, the results will be compared. Force and pressure are applied to the model's centre of gravity for each of the three cabin door handles, with the value of force and pressure set at 50,000 N. Displacement and safety factor are calculated and compared between the models.

Table 1 shows the results of the static study using force. Based on the simulation test, there are six different results from the three-cabin door handles of the civil aircraft design. The design with the lowest amount of displacement compared to the original design and a value of less than one for the factor of safety will result in a failed design, whereas the other two designs with a low amount of displacement when compared to the original design and a value of more than one for the factor of safety will result in a safe design. The results of the static study using pressure are shown in Table 2. Based on the simulation analysis, the original design has the highest amount of stress and the lowest value of factor of safety, while the other two designs have the highest amount of displacement compared to the original design and a higher value of factor of safety compared to the original design. Based on the results obtained from the simulation tests, both Design Concept 1 and Design Concept 2 demonstrated the capability to replace the original cabin door handles. However, Design Concept 2 was selected for manufacturing using SLM (Selective Laser Melting) technology due to its slightly superior refinement compared to Design Concept 1.

Table 1 - Results of the static study using force

Cabin Door Handles	Maximum Displacement (mm)	Factor of safety
Original Design	3.370 x 10	0.82
Design Concept 1	3.496 x 10	1.1
Design Concept 2	7.411 x 10	1.1

Table 2 - Results of the static study using pressure

Cabin Door Handles	Maximum Displacement (mm)	Factor of safety
Original Design	7.431 x 10^8	4.1
Design Concept 1	7.694 x 10^8	6.7
Design Concept 2	7.591 x 10^8	6.1

4. Conclusion

The objective of this research is to make a new design without changing the original mechanism that is suitable to be produced using the AM process, which was successfully done in SolidWorks software. The results of the simulation test of the new selected design were compared to the results of the original design that was set as a benchmark and replicated from the real existing cabin door handles. Parts of the cabin door handles have been disassembled so it will be easier to draw them into a 3D model and to determine which parts need to be changed or redesigned. It was also decided that the new design will not use any complex parts that were originally used in the existing cabin door handles. The new design, along with the original design, undergoes a simulation test run on the SolidWorks software, which is a static study including force and pressure applied to the designs. The results that will be taken to be compared are displacement and factor of safety, in which the two new designs perform much better than the original design, and one of them being selected as the new cabin door handles of civil aircraft design proves that the objective has been successfully achieved.

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