

Review Paper on Wing Folding Mechanism

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ABSTRACT

In this paper, we will describe the importance and implementation of the wing folding mechanism. These days we are seeing the growth of air passengers, air traffic and the problem lesser space at the airport for parking of aircraft. This paper reviews the wing folding mechanism and its implementation to save the airport space to accommodate more aircrafts. Wing folding mechanism is used to fold the wings of aircraft parked at airport to save the space and reduce the wingspan. Further, this wing folding mechanism is also implemented in flying cars.

Keywords

Wing Folding Mechanism, Flying Cars, Folding Wing, Aircrafts, STO Wings

1. INTRODUCTION

The insight into our future is a sky full of aircraft and flying machines. Future is no far when we will see skies full of flying cars and aircrafts. We are seeing a huge expansion of the Aircraft industry.

In today's era we are seeing a tremendous increase in the production and demand of aircraft and so is the increase in the air traffic. With the increase in the demand of the aircraft, the size and length of the aircraft are also increasing. With this exponential increase in demand and manufacturing of aircraft, there is an increase in air traffic. Air traffic is one of the major problems that all the airports are facing. Due to the increase in the air traffics there is a very less space to park the aircraft at airports or taxiing the airliners at runways. Aircraft like Airbus A380 and Boeing 777 has a wingspan up to 80 m requires a lot of space in the airport to stand and will taxi to the runway. Specialized hangers and maintenance rooms are made for these giant birds.



Fig. Douglas Skyraider

This review paper discusses the solution to the problem arising due to this increased traffic and the availability of less space at the airport to park the aircraft. Wing folding mechanism can be implemented to passenger aircraft to solve this problem. Once, an efficient wing folding mechanism is developed it can be implemented to the huge airliners like Airbus A380 and Boeing 777X or many other passenger aircraft. This will result in saving a lot of space at airport results in lesser demands of extra terminals. It will also result in time-saving as the wing can be folded while taxiing on runways more aircraft can move on adjacent runways and transportation of the aircraft will be easier.

This paper discusses different wind folding mechanism available and their implementation.

2. LITERARY REVIEW

A study on the past Foldable Wing Aircrafts was done.

This concept of Wing Folding was first originated as the necessity of space required for aircraft on naval deck space where there is very limited space. The first wing folding mechanism was developed and patented by the Short Brothers in 1913 for Biplane ship-borne aircraft like their short folder. In that mechanism, the wings were hinged and folded along with the fuselage. Short Brothers were the world's first aircraft manufacturer.



Fig. Grumman F4F Wildcat with STO Wing Folding Mechanism

American World War II birds were loved for their wing folding mechanism as they were saving a huge space at the

naval aircraft carriers. After the Short Brothers, Grumman came with their STO Wing Folding Mechanism. It was the first American company to build the aircraft with wing folding mechanism. Grumman F4F Wildcat by Leroy Grumman was the aircraft manufactured with the wing folding mechanism. It was the carrier-based aircraft which has the STO wing folding mechanism. This STO wing folding mechanism was the major source of the wing folding mechanism implemented to civilian aircraft these days. Grumman E-2 Hawkeye Shipboard Airborne Early Warning Aircraft and its derivative C-2 Greyhound is still used, which works on the same concept as that of STO Wing Folding Mechanism. Another Grumman Naval Aircraft which is based on the STO Wing Folding Mechanism is F-14 Tomcat.

Those days the wing folding mechanism was just limited to the Military and Navy Aircrafts as there was a huge demand for saving the space at naval decks and to increase the fleet of the aircraft.

But with the expansion of the Aircraft industry and an increase in the air passengers and aircraft we are facing the need for space at the airport these days. As the number, if aircraft are increasing there is also an increased demand for the area for them at the airport for taxiing and parking. Folding mechanisms are very rare on the existing airliners and passenger aircraft. The airliners which are very tall or wide also face the problem for getting fit into the hangers. With the aircraft like Boeing B-50 Superfortress, AIRBUS A380 and many huge aircrafts face a problem not only for parking at airports but also for keeping them in hangers. Although Boeing B-50 has its foldable tail which helps it in to enter hanger. Different aircraft like Saab 37 Viggen and Boeing 377 Stratocruiser have folding rear fins which make it easier to enter the hanger. Boeing 777 (Classic) twin jet engine offers folding wingtip.

Folding of Wings are classified into different types:

Simple Fold- In this the wing of aircraft is folded horizontally or vertically. Some of the aircraft using this mechanism are Short Folder S.64, De Havilland Sea Vixen, Hawker Sea Fury, Hawker sea Hawk, F/A-18E/F Super Hornet, F11F Tiger with downward-folded wingtips, MIG 29K, RAD Baccaneer S.2, F-8H and there are many more aircraft.



Fig. F/A-18E/F Super Hornet

Afterward Fold - In this folding mechanism, the aircraft's wing is folded along the fuselage. Different aircrafts in which

the wing is folded along the fuselage are Grumman E-1 Tracer, Fairey Fulmar, Grumman E-2 Hawkeye and many more aircrafts.



Fig. Grumman E-2 Hawkeye

Double Fold- In this folding mechanism the wing is folded into two or more parts. Aircrafts using this technique are Supermarine Seafire, Fairey Gannet, etc.



Fig. Supermarine Seafire

Rotating Wing – In this the wing rotates parallel to the fuselage. An example is V-22 Osprey.



Fig. V-22 Osprey

Over-Swept Wing- In this the wing are in over sweep position. An example is F-14 Tomcat.



Fig. F-14 Tomcat

Apart from these, there are more aircraft which have the folding wing-like Sukhoi Su-33 and Lockheed S-3 Viking.

As per the International Civil Aviation Organization, the maximum wingspan of commercial aircraft cannot exceed 65 meters. So, the wing folding mechanism will help the huge airliners like Airbus A380 having a wingspan of 80m.

Not only the aircraft but many Naval Helicopters have foldable rotor blades which helps in saving space onboard ships.

Apart from the advantages of folding wing mechanism have some disadvantages also. Compared to fixed-wing it is heavier and has a more complex connection of actuators, fuel and electricity.

3. METHODOLOGY

3.1 STO-Wing

All the wing folding mechanism we are seeing today is based on this mechanism or is a derivative of this mechanism. STO-Wing was patented by the Leroy Grumman.

During World War II, with the growing demand of aircraft for the US Navy, the Grumman engineers came up with a solution to accommodate more aircraft on a naval aircraft carrier ship. The obvious solution for that problem was to fold the wings. But every time they tried they failed. And then Leroy Grumman came up with STO-Wing. Initially, these wings were operated by Hydraulics which increased the weight of aircraft. Due to this added weight, the performance of aircraft was reduced. So, a lighter manual system fitted with safety locks were used. When these aircraft were introduced, the capacity of aircraft carriers increased by 50 per cent.

3.2 F4F-4 Wildcat Specifications

This was one of the Grumman Aircrafts which were incorporated with STO-Wing. It has a wingspan of 88 feet and a length of 29 feet. Plane's empty weight is 5,895 pounds and the gross weight is 7,975 pounds. It has 1200 hp Single Pratt &Whitney engine with two-stage, two-speed supercharger.

Besides STO Wing it was the first monoplane in carrier service.

3.3 How Folding Wing Work

The concept of the folding wing is as old as the aviation industry. Wing folding mechanism makes use of the two-stage process. In the first step, the trailing edge of the wing moves up by rotating. They are actuated hydraulically or most recently electrically. Outer wing rotates around the hinge and after getting in two parts they are locked. In the second step, wing slides down while being rotated to the rear of aircraft.

The STO-Wing which was first incorporated to the wildcat had a hand crank like structures underside the wing which allowed the flight deck to control the folding wing manually. Further, it came with hydraulic actuators.

3.4 Advantages of STO-Wing

Out of all the folding wing mechanism available the STO wing is more preferred because of:

Weight of aircraft can be saved by using this mechanism over the existing horizontal axis folding mechanism. It is a relatively simpler mechanism. Since implementing vertical or horizontal folding mechanism is a great problem for big airliners like Airbus A380. Vertically it is not possible because of the size of the hanger. Its horizontal and vertical distance can be changed using its axis rods.

3.5 Requirements and Consideration

The concept of Wing Folding Mechanism was first coined during world war due to lack of space on naval carriers and huge demand for aircraft. World war aircraft were small aircraft and has very small wingspan. For designing or making wing folding mechanism for commercial aircrafts following considerations need to be required:

- a) Simplicity in Design
- b) Should be as per the wingspan of aircrafts.
- c) Area requirement.
- d) Different design for Twin-engine aircraft
- e) Should be made as per space and hanger size of all the airports present in the world.
- f) Commercially Viable

Initially, for the incorporation of the wing folding mechanism in commercial aircraft, there would be the requirement of a lot of investment in terms of human, financial and technological. It should be such made that it can be implemented to both commercial and passenger aircraft. For four-engine aircraft, it is not feasible, so some different mechanism needs to be designed.



Fig. Grumman's TBM Avenger was one of the first aircraft incorporated with STO-Wing

4. CONCLUSION

The increasing population of aircraft passengers and an increase in air traffic need improvement in the aviation industries. As future insights show that the future is full of flying machines and aircraft. Future is not so far and so we need to prepare ourselves for the future to adopt the flying world.

With the increasing air traffic, there is a demand for airside space at the airport for taxiing and parking of aircraft. For that, we can incorporate the wing folding mechanism to aircraft. Once, an efficient wing folding mechanism is developed it can be implemented to the huge airliners like Airbus A380 and Boeing 777X or many others passenger aircraft. This will result in saving a lot of space at airport results in lesser demands of extra terminals. It will also result in time-saving as the wing can be folded while taxiing on runways more aircraft can move on adjacent runways and transportation of the aircraft will be easier.

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