LITERATURE SURVEY ON THE EVOLUTION OF AIRCRAFT AND THE FAILURES IN AIRCRAFT

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Abstract

The overall objective of this paper is to carry out a literature survey on the evolution of aircraft body materials. The advantages and disadvantages of the various materials used in the aircraft is studied and the different types of failures in the aircraft also mentioned in this paper. The failures that rises during the use of metals like Aluminium in the aircraft can be rectified by replacing the metals or alloy by composite materials. The paper included the study of different types of joints used in the aircraft.

Keywords: *Aircraft, composite, failure, hydrothermal, materials.*

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1. INTRODUCTION

From the olden days itself the man try to fly in the sky like a bird. Around 400 BC the Chinese invented the kites make the humans to thinking about flying. Kites are the forerunners of balloons and gliders. For centuries the humans are tried to fly like a bird. Many disastrous has happened as the humans tried to fly like a bird attaching light weighted wood or feature on hand. The aeolipile was a major invention by an ancient Greek Engineer, Hero of Alexandria. He worked with steam and air pressure to create power, that it makes the start of engine invention. The first real study of flight was carried out by Leonardo da Vinci in 1480's. The design shows how the man could fly. Later the invention of balloons, gliders etc. are occurred in a period of 1783-1850's. In 1891 a German Engineer named Otto Lilienthal studied aerodynamics and designed a glider that can fly a long distance.in 1891 itself Samuel Langley, realized that the power is required to help the man to fly. He built a model and named as "aerodrome". Octave Chanute was a successful engineer who designed several aircrafts around 1894. Then the Wright Brothers designed and had the first flight in 1903. From there the evolution of flying and aircrafts started.

2. MATERIALS

In the ancient time of manufacturing of aircrafts, the wood and fabric constructions are there due to the availability, low weight and prior manufacturing experience. The streamlining was not a primary consideration during that time, so the aircrafts are of low speed. For structural strength wires, braces, and other devices were used. The woods like 'spruce' are used, which are light and strong. The designers studied the different parts of the aircraft individually, the strength and wind resistance so as to increase the speed. Bracing wires were given a streamlined shape, and some manufacturers began to make laminated wood fuselages of monocoque construction (stresses carried by the skin) for greater strength, better streamlining, and lighter weight.

The metals are started using in aircraft as the aircrafts with wood and fabric were difficult to maintain and subject to rapid deterioration when left out in the elements. The use of metals in aircraft helped to increase the strength of the structure. The first general use was in World War 1, when the Fokker aircraft company used welded steel tube fuselages, and the Junkers Company made all-metal aircraft of dual tubing and Aluminium covering. As the metals are much stronger and durable compared to the wood and fabrics, within a period of 1919-1934, the aircrafts are made with metals in whole body structure. All metals are used in the construction of the aircraft and the metal used for the manufacturing is aluminium and aluminium alloys. From that period various material evolution has been take place in the aircraft structure. By use of metals in aircraft enabled the reduction in weight and the easy of construction. High strength and thermal resistance like properties are added to the aircraft by the introduction of new materials and new alloys. Other than Aluminium, titanium, molybdenum, steel etc. are also used in the aircraft to achieve different properties. The corrosion and metal fatigue were two major problems raised by the use of metals. Also the aerodynamic heating also become a major factor for the crack and damage to the aircraft. So to avoid these hazards new alloys are developed. In 1950's the composite materials are introduced in the aircrafts (Boing 707) which helped to reduce the weight of the aircraft and to increase the strength of the parts. Then different types of composite materials are developed, which helped to increase different properties of the aircraft. In the latest airbus there was 53% was of composite material (Airbus A350XWB).

3. FAILURE IN AIRCRAFT

The failure in the aircraft will cause aircraft destruction. From the time of aircraft using woods and fabrics there were the failure. While using the metals different failures like corrosion, fatigue, wear, creep, high temperature corrosion, brittle fracture etc. are also present in the aircraft [1].

Table 1 *Frequency of failure mechanisms.*

	Percentage of Failures	
	Engineering Components	Aircraft Components
Corrosion	29	16
Fatigue	25	55
Brittle fracture	16	-
Overload	11	14
High temperature corrosion	7	2
SCC/Corrosion fatigue/HE	6	7
Creep	3	-
Wear/abrasion/erosion	3	6

The frequency of failure mechanism in aircraft is shown in the table. Which shows that the corrosion and the fatigue are the major failure reasons for the aircraft.

The corrosion can be occur due to many reasons like the presence of cathode and anode, an electrolyte such as water etc.

The fatigue failure may occurs due to overload, hydrogen embrittlement, corrosion etc.

Table 2 *Summary of fatigue initiation sites observed in aircraft.*

Initiation Site	Number of Accidents	
	Fixed Wing	Rotary Wing
Bolt, stud or screw	108	32
Fastener hole or other hole	72	12
Fillet, radius or sharp notch	57	22
Weld	53	3
Corrosion	43	19
Thread (other than bolt or stud)	32	4
Manufacturing defect or tool mark	27	9
Scratch, nick or dent	26	2
Fretting	13	10
Surface or subsurface flaw	6	3
Improper heat treatment	4	2
Maintenance-induced crack	4	
Work-hardened area	2	
Wear	2	7

The above table shows the fatigue crack initiating sites before cracking and thereby accidents in aircraft [1].

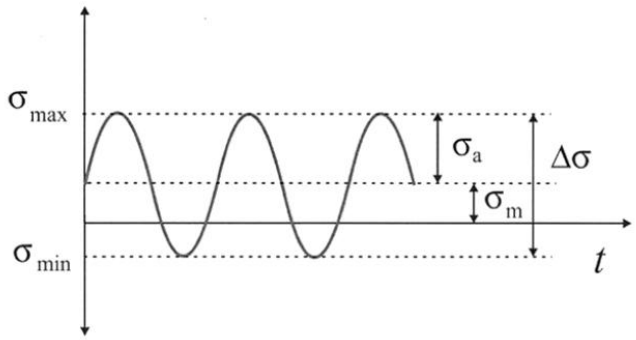
4. FATIGUE FAILURE

One of the major failure in the aircraft is fatigue failure. The fatigue failure is a failure that occurs due to the cyclic load on an object or due to cyclic stress or fluctuating loads. It is a phenomenon that occurs due to the initiation and propagation of the crack and it becomes unstable, cause the fatigue failure. There are mainly 3 stages included in fatigue failure.

- Crack initiation
- Crack propagation
- Fracture due to unstable crack growth

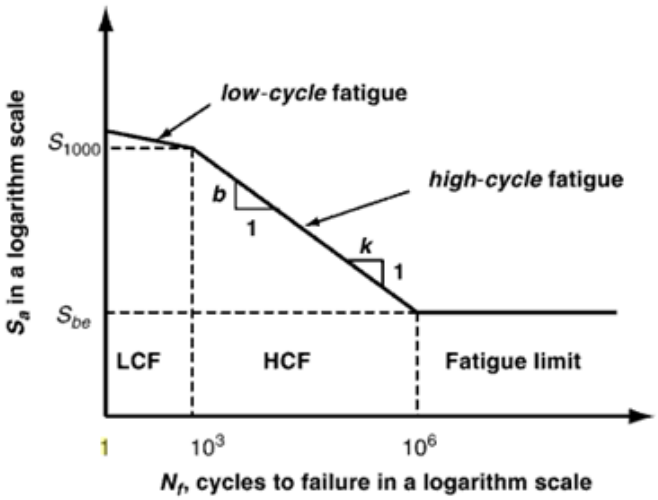
The fatigue failure is of three types.

- Low cycle fatigue
- High cycle fatigue



The Low cycle fatigue or pulse vibration fatigue (i.e. high cyclic or pulse loads) is a fatigue failure occurs when the plastic strains are induced in the object. For low cycle fatigue, high amplitude, low frequency plastic strains are occurred. The low cyclic fatigue occurs if the load is less than 1000 cycles.

The high cycle fatigue occurs if the load is more than 1000 cycles. The high cycle fatigue have low amplitude and high frequency elastic strain.



The above diagram shows the S-N curve to represent the low cycle fatigue and high cycle fatigue. The S-N curve is a graph drawn between the stress and the number of cycles of load to failure. The graph is drawn to represent the fatigue failure of an object. By plotting S-N curve the fatigue life can be predicted.

5. JOINTS IN AIRCRAFT

The aircraft is an assembly of lot of components of different size and different properties with different functions. These different components and parts has to be assembled to form an aircraft. The components may be of same material or different material.

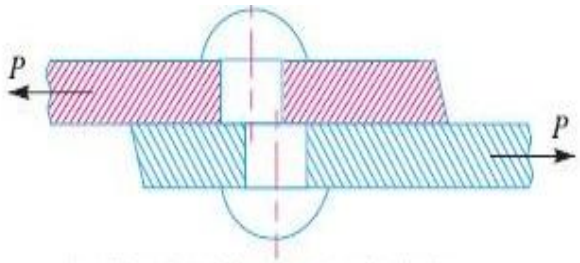
To join these parts various types of joining methods and join types are there. Normally the riveting method is used to join the parts. The riveted joints are strong and can handle high stress. Also the riveting joints having cheaper fabrication cost, low maintenance cost and ease of maintenance, ease of riveting process, also the dissimilar metals can be joined by riveting.

6. TYPES OF RIVETED JOINTS

The riveted joints are mainly classified into two,

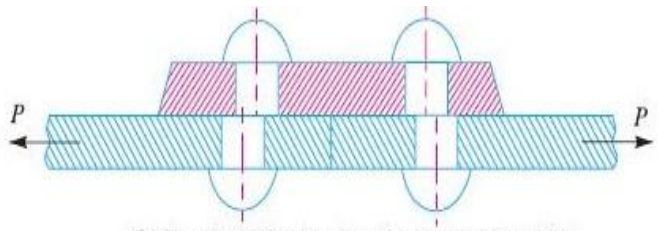
- Lap joint
- Butt joint

In the lap joint, the ends of the parts to be joined is drilled and the parts are placed over another making the drilled hole to come over another. Then through the coincident holes the riveting can be carried out.



(*a*) Shearing off a rivet in a lap joint.

In butt joint the plates to be joined is placed edge to edge in a straight line and the two plates are clamped using another external plate. This will drilled in parallel and the riveting will be done.



(*b*) Shearing off a rivet in a single cover butt joint.

7. CONCLUSION

The aircraft had a faster development in these recent years. The evolution of the structures and the materials used in the aircraft is studied. The different failures that cause damage to the aircraft are studied. The main failures in the aircraft are due to corrosion and fatigue. To rectify the problems when using the metals or alloys of these metals, the composite materials are used. The composite material helps to reduce the weight and to increase the strength of the whole structure of the aircraft. Even though the fabrication cost for the composite is very high, considering the advantages over the metals and metal alloys, the composites are using in aircrafts. By using composite materials in the joints the strength can be increased by reducing the weight and the life span of the aircraft can also be increased.

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