Study of Structural Failure of Aircraft Using Six Sigma Methodology

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ABSTRACT

Structural failure is an aspect of engineering which deals with the ability of a structure to support a designed load (weight, force, etc...) without breaking, tearing apart, or collapsing, and includes the study of breakage that has previously occurred in order to prevent failures in future designs. Structural failure of a wing isn't a very common occurrence. As it would immediately lead to a major disaster. Metal fatigue would be a leading cause of structural failure. During the process of flight stress, both up and down is applied to the wing. Over a long period of time this repeated movement alters the molecular makeup of the metals or, as is the case with many modern aircraft, the composite materials used to construct the wing. After some point in time cracks develop and if left unchecked the wing will at some point fail and the aircraft will crash .Corrosion may cause damage to a wing weakening its structure. Fatigue failure of components has been the most significant contribution to the major structural failures of civil aircraft. As a result, the attack on the fatigue problem has had the greatest effect on changes in structural design concepts, substantiating tests and operational maintenance and inspection procedures. Stress condition occurring in an engine as a result of a rapid change of temperature. When an aircraft is decelerated rapidly, the engine RPM as well as the temperature decay rapidly resulting in thermal shock.

I. INTRODUCTION

Fatigue failures is operational aircraft thirty-six year ago motivated the united states Air force to established the USAF Aircraft structural integrity program(ASIP).Since that time there has been many technical challenges encountered in the course of acquiring a new aircraft that have changed ASIP from its original formulation, but not it original purpose of maintaining structural integrity. In this paper we are mainly dealing with the structural failure caused on the aircraft. Structural failure mainly occurred due to corrosion, Metal fatigue and so on. Corrosion is a natural process, which converts a refined metal to a more stable form, such as its oxide, hydroxide, or sulphide. It is the gradual destruction of materials (usually metals) by chemical reaction with their environment metal fatigue is the progressive and localized structural damage that occurs when a material is subjected to cyclic loadings.

II. LITERATURE REVIEW

1. Six Sigma Methodology

Six-sigma is an improvement strategy leading towards reducing defects on existing curriculum and strategies efforts in improving the curriculum growth and sustainability. It defines limiting of the number of defects to 3.4(parts per million) This kind of this methodology has two techniques which

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are known as 'DMAIC' (Define, Measure, Analysis, Improve and Control) and 'DFSS' (Design for Six sigma). The main difference between these techniques are that DMAIC is defined as a process improvement strategy applied on developed and existing project or system while DFSS is leading towards designing new product or process. Besides, DFSS is a source intensive method that is very expensive when compared to DMAIC. Hence, DMAIC, a five step process is adopted in this study. The total defects of a Six Sigma refers to the total area to the right and left of +6σ and -6σ as shown in the figure.

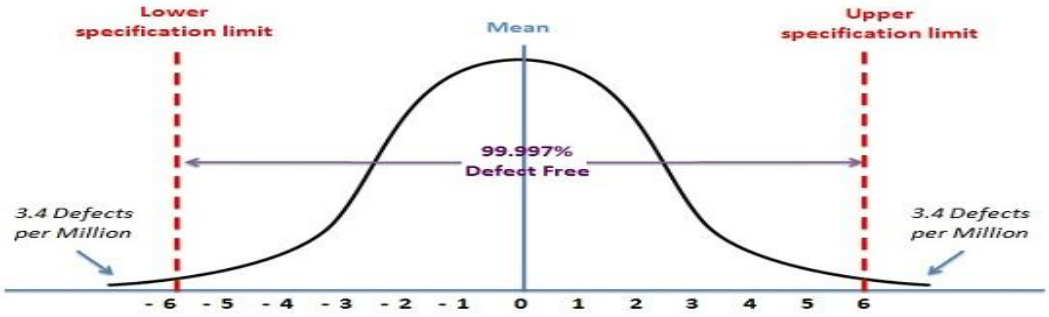

Fig.(1) Six Sigma Curve

The five step improvement phases are

i. Define phase
ii. Measure phase
iii. Analysis phase
iv. Improve phase
v. Control phase

METALLIC CORROSION

Metallic Corrosion occurs when chemical action causes deterioration of the surface of a metal. Most corrosion is galvanic or electrolytic in origin, which means that it has occurred because two dissimilar metals have been together in an electrolyte (usually contaminated water). This effect can also occur at the microscopic grain boundaries within a metal alloy. However it arises, it may go undetected and result in loss of integrity of metallic structures. Prevention in the long term will be by better design and selection of materials, which nowadays include proven non metallic composites. There is also a need for a better understanding of the detailed effects of corrosion on structural integrity. Chronological age is especially relevant to corrosion incidence, as are the ground environment where an aircraft is usually parked and the typical flight environment.

FATIGUE

Fatigue is the effect resulting from a component being repeatedly loaded. It results in striations starting in grains of a metallic material which then nucleate a crack that at a certain size can be detected by means of non-destructive testing. The number of loading cycles at a defined load is the characteristic for a fatigue life. The following gives a brief description on the various elements being involved in fatigue design.

THERMAL SHOCK

It occurs when a thermal gradient causes different parts of an object to expand by different amounts. This differential expansion can be understood in terms of stress or of strain, equivalently.

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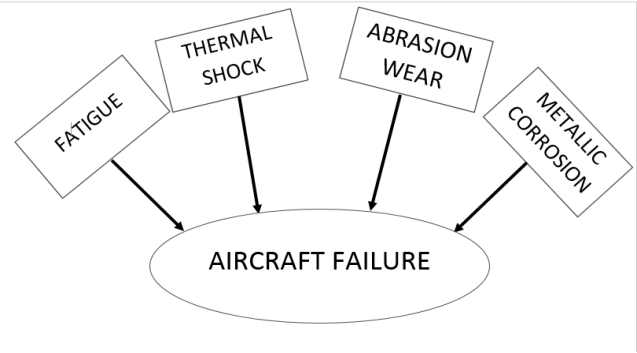
ABRASION/WEAR

An abrasive is a material, often a mineral, that is used to shape or finish a work piece through rubbing which leads to part of the work piece being worn away. While finishing a material often means polishing it to gain a smooth, reflective surface, the process can also involve roughening as in satin, matte or beaded finishes.

STRUCTURAL FAILURE OF AIRCRAFT USING SIX SIGMA METHOD

a. Define Phase

Structural failure of a wing isn't a very common occurrence. As it would immediately lead to a major disaster. Metal fatigue would be a leading cause of structural failure. During the process of flight stress, both up and down is applied to the wing.Metallic corrosion, Fatigue, Thermal shock, Abrasion/Wear are some of the main reasons for failure of aircraft failure



b. Measure Phase

The air accidents occurred between 1995 and 2015 were collected and the data's are given below.

DATE	ACCIDENT/INCIDENT	LOCATION	AIRCRAFT	CAUSE	FATALITIES	NOTES
1997-06-26	Helicopter flight 451	Norway: norwegian Sea	Eurocopter AS 332 L1 Super Puma	Fatigue	12	The accident was cause by a fatigue crack in the spline which ultimately cause the power transmission shaft to fail
2001-11-12	American Airlines Flights 587	USA:New york	Airbus A300	Pilot Error	265	Overuse of rudder leading to loss of vertical stabilizer.
2002-04-30	2002 Eglin Airforce Base F-15 Crash	USA:Gulf of Mexico	F-15 Eagle	----------	1	Near Eglin AFB: Leading edge failed during test drive
2002-05-25	China Airline flight 611	Taiwan: Taiwan Strait near Penghu Islands	Boeing 747	Maintenance	225	Faulty repair: tail section broke off , causing aircraft to disintegrate
2003-02-01	Space Shuttle Columbia disaster	USA:Texas	Space Shuttle	Faulty design	7	Damaged TPS during launch, break up during reentry
2005-12-19	Chalk's Ocean Airway's Flight 101	USA: Miami Beach, Florida	Grumman mallard	maintenance	20	In-flight wing wing break due to metal fatigue
2008-05-30	2008General aviation crash	Spain	Pilatus PC-6	----------	2	Wing failure
2015-10-31	Metrojet Flight 9268	Egypt: North Sinai Governorate	Airbus A321-231	Under investigation	224	Crashed;terrorist bomb

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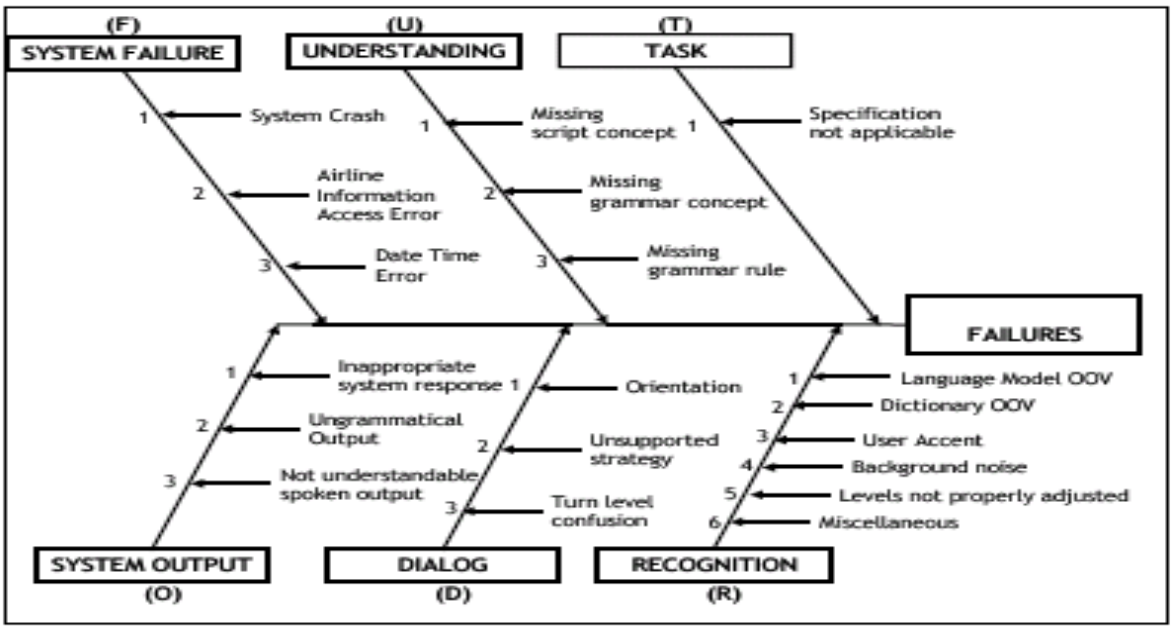
c. Analysis Phase

From the above table of aircraft failures , it is clear that most of the air accidents are due to fatigue and maintenance problem.Fatigue occurs when a material is subjected to repeated loading and unloading. If the loads are above a certain threshold, microscopic cracks will begin to form at the stress concentrators such as the surface, persistent slip bands (PSBs), and grain interfaces. Eventually a crack will reach a critical size, the crack will propagate suddenly, and the structure will fracture. The shape of the structure will significantly affect the fatigue life; square holes or sharp corners will lead to elevated local stresses where fatigue cracks can initiate. Round holes and smooth transitions or fillets will therefore increase the fatigue strength of the structure.

d. Improve Phase

Improve phase has been studied through a fish bone diagram shown below.



e. Control Phase

Recovery from failure is a phrase used to describe a need in aviation to continue real-time operations to a safe conclusion despite a critical part of a system (technical, procedural, or human) failing, sometimes at the most crucial time. Continuation of operations to a safe conclusion can be guaranteed, or at least facilitated, through system design, redundancy, back-up systems or procedures, safety nets and even accurate fault diagnosis and timely, correct responses by human operators. Many of these features are built-in as system defenses, but ,as the subject concerns recovery from failure these features can be considered as “containment” measures.

CONCLUSION

DMAIC process helps us understand the complete structural failure of aircraft, starting from define phase where we list the number of structural problems we analyse. In the measure phase, we list the aircraft accidents occurred and analyse phase we understand the major reasons for those accidents. In the improve and control phase we try to do improvement, that in future no such structural failures occur due to the existing problems faced. Using six sigma method helps us reduce the structural failure by 99.97%, which reduce the number of casualties due to failure of an aircraft.

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