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Design Optimization and Analysis of Slat in Military Aircraft

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Abstract: *Aircraft design is an evolutionary process `rather than a revolutionary process. This paper presents the background and process involved in the Analysis and assembly of a slat system for the LCA Military aircraft. This paper details the application and theory behind slat system. As well it lays out the tools and materials required for the job. Slats are aerodynamic surfaces on the leading edge of the wings of aircraft which, when deployed, allow the wing to operate at a higher angle of attack. In LCA Military aircraft during the slat assembly, the slats are found to be improper in their axis and there is a step found between the slats. When slat assembly is improper the aircraft has to be limited in its performance such as it effects on its angle of attack as well as on its mach number. This is the one of the short term solution recommendation. The objective of our papers aims to provide a solution for remounting the Slat bracket which are having errors. Optimizing the slat bracket and feasible study and analysis of adjusting the jack mounting bracket is to be done. By various analysis and problem solving techniques it is been found that by using of eccentric bush in the jack bracket the slat can be adjusted during installed with greater accuracy and the step issue could be overcome . This is to be compiled on the aircraft and to be checked and ensured that the dimension and deviations are accurate as per the manual*

Keywords: *SLAT, STOL, CATIA*

INTRODUTION

Slats are aerodynamic secondary control surfaces on the leading edge of the wings of fixed-wing aircraft which, when deployed, allow the wing to operate at a higher angle of attack. A higher coefficient of lift is produced as a result of angle of attack and speed, so by deploying slats an aircraft can fly at slower speeds, or take off and land in shorter distances. They are usually used while landing or performing manoeuvres which take the aircraft close to the stall, but are usually retracted in normal flight to minimize drag. The chord of the slat is typically only a few percent of the wing chord. The slats may extend over the outer third of the wing, or they may cover the entire leading edge. Many early aerodynamicists, including Ludwig Prandtl believed that slats work by inducing a high energy stream to the flow of the main airfoil thus re-energizing its boundary layer and delaying stall. In reality, the slat does not give the air in the slot high velocity (it actually reduces its velocity) and also it cannot be called high-energy air since all the air outside the actual boundary layers has the same total heat.

Manufacturing Stages of Slats and Installation Process

Slats

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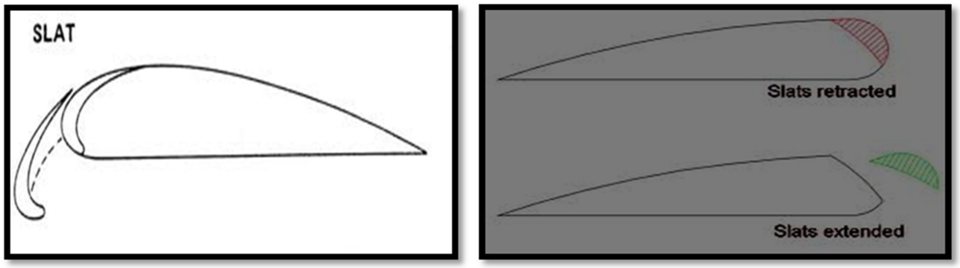

Figure 1: Slats In Extracted And Retracted Positions

A this paper deals with slat assembly & installations and its problems. This report gives the minutiae of installation, assembly process, rigging and problems related to each stage. It is discussed in detail about each problem at every stage and a conceptualized design is brought to triumph over the problem.

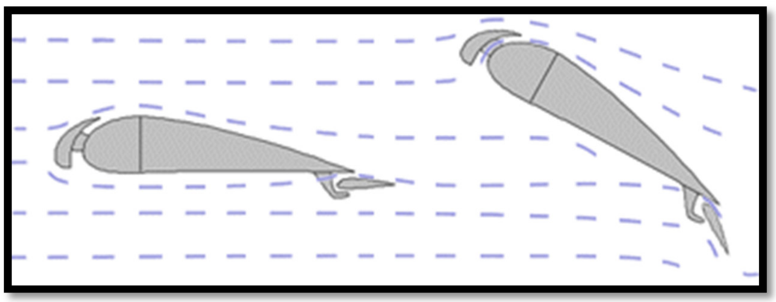

Figure 2 : Airflow Over The Wing

An integral part of the STOL design, leading edge slats have been around for some time. The slat is not an attachment simply bolted onto an existing airfoil, but is a part of a true airfoil that has had the slot "cut" out of it. Chris Heintz has written convincingly about the usefulness of them in a STOL aircraft.

Figure 3:Fiesler Fi-156c " Storch "

Types of Slat

- Automatic - the slat lies flush with the wing leading edge until reduced aerodynamic forces allow it to extend by way of springs when needed.
- Fixed - the slat is permanently extended. This is sometimes used on specialist low-speed aircraft (these are referred to as slots) or when simplicity takes precedence over speed.
- Powered - the slat extension can be controlled by the pilot. This is commonly used on airliners.

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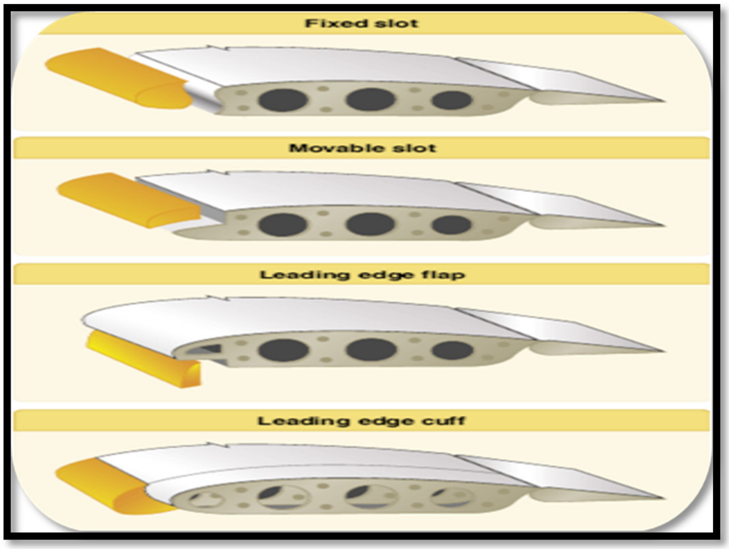

Figure 4: Types of slats

Assembly process of slats is carried out on the specially designed jigs which are separate for inboard, mid board and outboard.

- Contour plates are placed on the jig. Respective ribs are fixed to the jigs with the help of tooling pins.
- Holes are drilled on the ribs with 4mm diameter and with the pitch of 12mm for riveting according to the marking need prior to loading as per drawing.
- Trailing edge block is positioned and fixed temporarily to the jig and T.E. block is riveted to the ribs.
- Then re-assembly on the jig and rivet permanently (8 diameter holes are made on the inboard and 6 diameter holes are drilled in outboard and midboard on the bottom skin).
- Tracks and jack brackets are fixed with respect to the jig locaters to the assembled slat. Then the assembled slat is removed from the jig and top skin is assembled to the slat.
- Inspection of slat is carried out with respect to the contour of ribs.

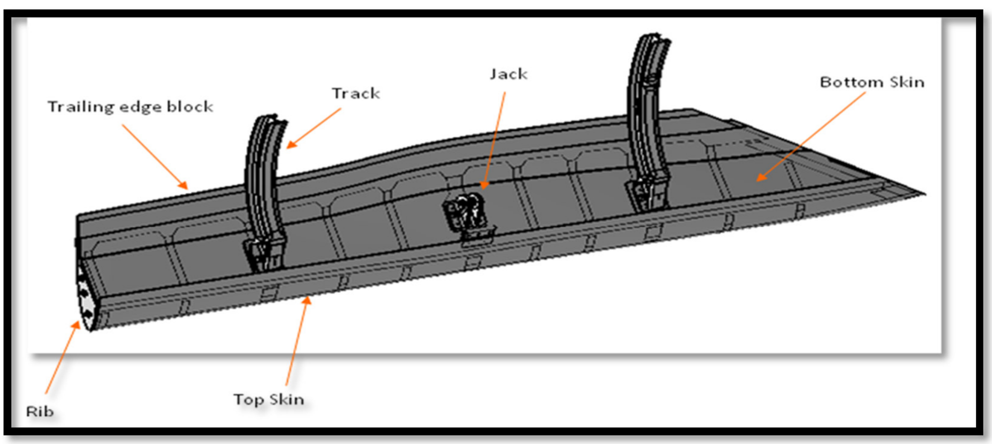

Figure 5: Model View of Slat before Installation

Problem Identification in Slat

The problem has been identified, that during the installation process a step has been found between the various boards of slats. It is been identified that the desired CATIA value is not been achieved and the value is deviated. The allowable tolerance value is about +/-(0.5). But it is found that the tolerance value exceeds the allowable limit during the installation. The exceeded values at various boards of slat is been illustrated below at 5% extension.

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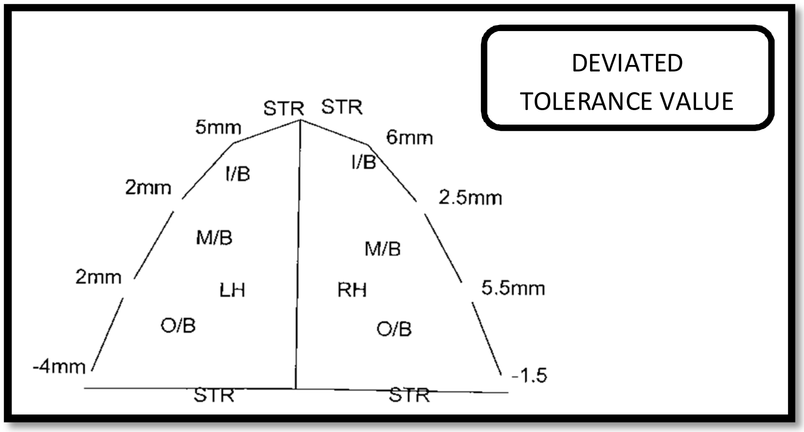

Figure 6: Deviated Tolerance Value

The amount of deviation occurred on LH and RH side of Slat has been noted and on comparing with CATIA value it is been illustrated below:

Table 1: Deviation on LH and RH side of Slat

Description	***Designed Catia Value***	***Obtained Value***		***Deviation***		***Remark***
		LH Slat	***RH Slat***	***LH Slat***	***Rh Slat***	
Nose box to inboard slat	*4.32mm*	*5mm*	*6mm*	*0.68mm*	*1.68mm*	*Asymmetry*
Inboard to Mid board slat	*1.89mm*	*2mm*	*2.5mm*	*0.11mm*	*0.61mm*	*Asymmetry*
Mid board to Outboard slat	*0.17mm*	*2mm*	*5.5mm*	*1.83mm*	*5.33mm*	*Asymmetry*
Outboard slat to Elevon	*-5.71mm*	*-4mm*	*-1.5mm*	*-1.71mm*	*-4.21mm*	*Asymmetry*

Result and Discussion

Due to hydraulic pressure in the range of 280 bar it was difficult to bring the desired value as per the required CATIA model at 5% extension of the actuator. During our study if we try to correct/adjust the fixed and movable guide bush at one end, the variation is noticed at the other end and it was not in liner and proportionate. Also the behaviour of Inboard, Mid board and outboard slat movement is abnormal and difficult to predict the amount in which the bushes need to be adjusted and the direction to be adjusted. while the working pressure is 280 bar Inspection is car STR this STR with hydraulic power ON. The slat step deviation is found improved approximately by 50-70%.

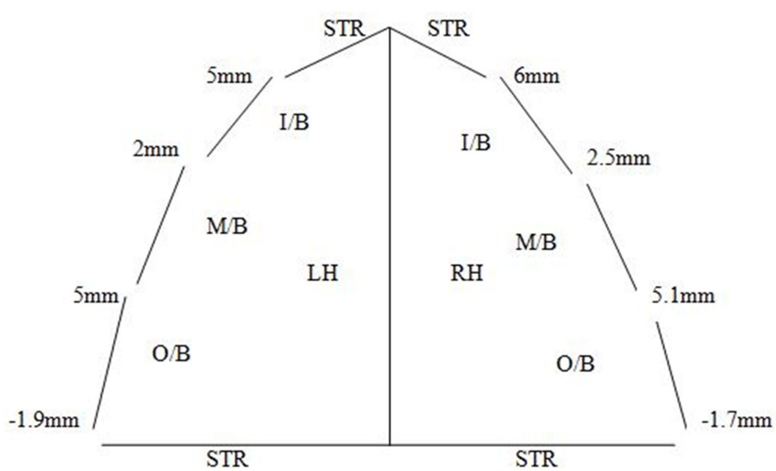

Figure 7: Slat after design optimization

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Table2: Slat before and after the analysis

S.NO	Description	Before	After
1	Maximum symmetry	**3.5**	**1.5**
2	Maximum Deviation at LH slat	**1.83**	**1.7**
3	Maximum Deviation at RH slat	**5.33**	**3.63**

Conclusion

From the analysis stay rod for installation and final assembly of slat which gives 60% to 70% of improvement. As a short term measure to overcome already produced slats, an eccentric bush can be inserted on the jack mounting point to further 10% to 20% of improvement can be obtained. The design calculation for the Bolt which is mounting to the jack bracket is carried out and found that the core diameter of the bolt is 3.4mm and the corresponding size of the bolt is M4.

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