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Design and Analysis of Slat Mounting Bracket in Tejas Aircraft

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Abstract- **Aircraft design is an evolutionary process rather than a revolutionary process. This report presents the background and process involved in the analysis and assembly of a slat system for the LCA Tejas aircraft and details the application and theory behind slat system. In LCA Tejas 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 and also increase in drag because of improper slat assembly. This is one of the short term recommendations. It is mainly aims to provide a solution for remounting the Slat bracket which is having errors. By various analysis and problem solving techniques it is been found that by using an eccentric bush in the jack bracket, the slat can be adjusted during installation with greater accuracy and the asymmetry could be overcome by inserting an eccentric steel bush . This is to be compiled on the aircraft and to be checked and ensured that the dimensions and deviations are accurate as per the aircraft manufacturer's maintenance manual.**

Key words**: Analysis, asymmetry, drag, remounting and slat bracket**

I. INTRODUCTION

Slats are aerodynamic 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 maneuvers which take the aircraft close to the stall, but are usually retracted in normal flight to minimize drag. 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 and also it cannot be called high-energy air since all the air outside the actual boundary layers has the same total head. The actual effects of the slat are the slat effect, the circulation effect, the dumping effect, off the surface pressure recovery, and fresh boundary layer effect. The types of slats are automatic, fixed, powered and the parts of the slats are ribs, trailing edge block, and track and jack brackets.

II. LITERATURE SURVEY

C.J.E.Smith , Suggested that improvements have been achieved in the performance of coatings used in the corrosion protection of military and civil aircraft. New methods of paint stripping and novel processes for the repair of pre-treatments and metal coatings are being developed which will lead to reductions in the cost of corrosion maintenance and improved levels of protection. There have been advances in aluminum alloy technology with the development of new tempers. The paper reviews recent developments in aerospace coatings and considers their application in ameliorating some of the corrosion problems associated with aircraft.

TimoleonKipouros, proposed that, the Multi-objective and multi-disciplinary design optimization tools are becoming a necessity for the development of innovative and more efficient advanced aerodynamic configurations. The successful application of multi-objective optimization design for high-lift configurations has been presented. The objective functions of the optimization process were the lift and drag coefficients of the configuration. The design variables were represented by gaps and deflection angles of slat and flap with respect main element. No constrain has been applied to the slat and flap positions but only an allowed rang of variability of the design variables. In more realistic optimization the kinematics constraints of the deploying system should be taken into account.

III. MANUFACTURING AND INSTALLATION OF SLATS AND SLAT RIGGING

A. Assembly Process of Slat

1).Fasteners

A **fastener** is a hardware device that mechanically joins or affixes two or more objects together. Fasteners can be broadly classified as:

- Permanent fasteners – Rivets ,Blind rivets / Blind bolts, Lock bolts
- Temporary fasteners – Bolt and nut attachment

2).Sealants

A **sealant** may be viscous material that has little or no flow characteristics and stay where theyare applied or thin and runny so as to allow it to penetrate the substrate by means of capillary reaction.

3).Sheet metal forming

The controlled application of heat to aluminum alloys caused physical changes in metallic structure which can be used to advantage depending upon the length of exposure and degree of temperature.

Annealing is a heat process whereby a metal is heated to a specific temperature and then allowed to cool slowly. This softens the metal which means it can be cut and shaped more easily.

Quenchingis a process of cooling a metal very quickly. This is most often done to produce a marten site transformation.

Solutionising is the heat treatment of aluminum method is usually done to increase the strength of an alloy. It involves heating an alloy at a high temperature for a specific period of time, and then rapidly cooling or quenching the material by immersing it in water or a water-glycol solution.

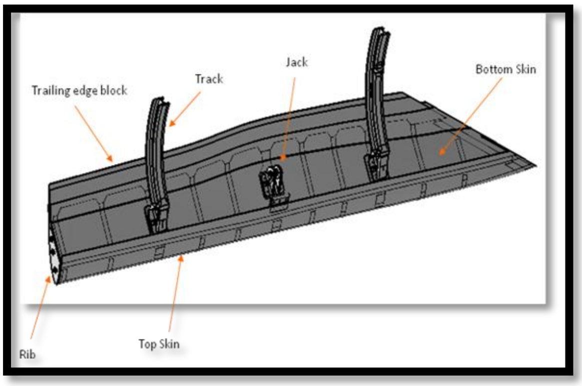


Fig 1: Model View of Slat before Installation

B. Installation of slats and slat rigging

1).Light combat aircraft wing structure

The Tejas is a tailless, compound delta plan form. This plan form is designed to keep the Tejas small and lightweight. The use of this plan form also minimizes the control surfaces need permits carriage of a wider range of external stores, and confers better close-combat, high-speed, and high-alpha performance characteristics than conventional wing designs and refer fig.3.9 for delta wings view.

Fig 2: Delta Wing of LCA

IV. PROBLEM IDENTIFICATION AND RECTIFICATION OF SLAT STEP WITH IMPLEMENTATION OF ECCENTRIC BUSH

A).Introduction

One of the Tejas LSP aircraft has successfully completed the first flight. However, this flight had the limitation on Angle Of Attack and MACH. These limitations were imposed due to the mismatch of leading edge slats surfaces, both in LH and RH. During deploy of slats there is a step identified between the inboard, midboard and outboard slat. The slat in an aircraft has been designed with the designated CATIA model as fig.3.

The catia model is designed with 5%extension.The designed Catia model of LH and RH slat shows that the distance between the nose box assemblies to the inboard slat is about 4.32mm, the value ranging between inboard slats to midboard slat is about 1.89mm, the distance between midboard and outboard slat is about 0.17mm and the ranging value between outboard to Elevon is -5.71.

The CATIA model shows that there is a symmetric value between the LH and RH slat. The slat has to been designed and manufactured as per the CATIA value.

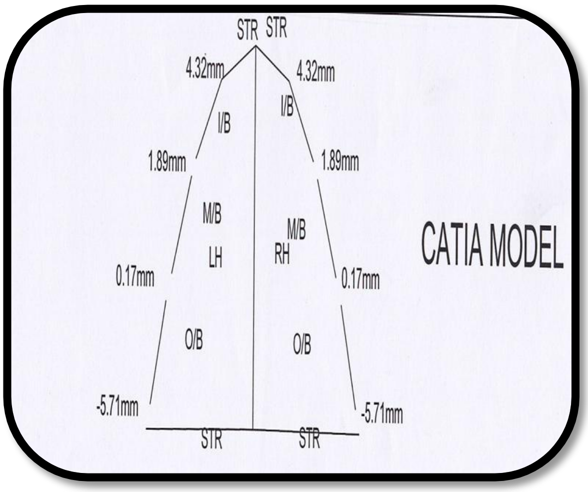


Fig 3: CATIA Model of Slat

1).Problem

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. The tolerance value is almost deviated from the exact value. The amount of deviation occurred

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 Midboard slat	1.89mm	2mm	2.5mm	0.11mm	0.61mm	Asymmetry
Midboard 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

Table 1: Deviation on LH and RH side of Slat

on LH and RH side of Slat has been noted and on comparing with CATIA value it is been illustrated below

2).LH&RH SLAT

The value of LH and RH slat as shown in Table 4.1

B. Analysis and problem solving techniques

1).Description and Analysis

To examine and identify the root cause for the slats mismatch, detailed investigation was carried out in the following areas

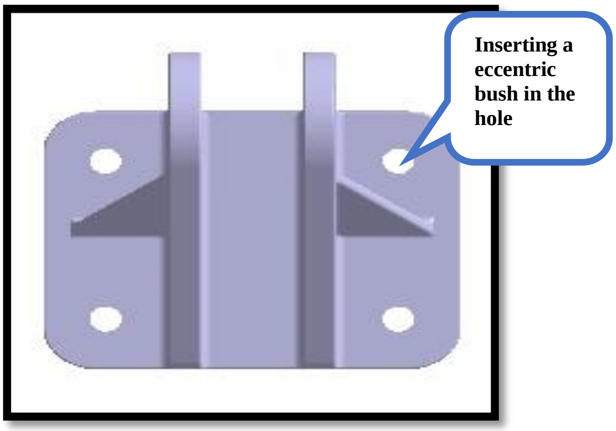
- DFCC
- LES Actuators
- Distance traveled by the slats with respect to inter spar skin edge on fixed wing structure

C. Problem solving methods used in slat analysis

A first and frequently overlooked step in problem solving is to identify the assumptions that are made about the situation. Many of the assumptions will be hidden and unrecognized until a deliberate effort is made to identify them. Often it is the unrecognized assumption that prevents a good solution. However, before we get too critical of assumptions, we should note their value andnecessity. So we begin there. As with creative thinking, flexibility is a crucially important feature in problem solving. Many of these techniques will begin to use regularly for each major problem to be address.

D.Various methods of problem solving

a) Fishbone analysis
b) Brainstorming analysis
c) Pareto analysis



E. Design analysis of eccentric bush and jack mounting bracket

1). Bolt diameter machine design

Load on each bolt at a distance L_1, $W_1 = w.L_1$
and moment of this load about the tilting edge

$$= w_1 (L_1)(L_1) = w_1 (L_1)^2$$

Similarly, load on each bolt at distance L_2,
$W_2 = w.L_2$
and moment of this load about the tilting edge

$$= w_2 (L_2) (L_2) = w_2 (L_2)^2$$

Total moment of the load on the bolts about the tilting edge

$$= 2w (L_1)^2 + 2w(L_2)^2 \quad \textbf{(i)}$$

Also the moment due to load W about the tilting edge

$$= W.L \quad \textbf{(ii)}$$

From equation (i) & (ii), we have

$$W.L = 2w(L_1)^2 + 2w(L_2)^2 \quad \textbf{(iii)}$$

It may be noted that the most heavily loaded bolts are those which are situated at the greatest distance from the tilting edge. In the case discussed above, the bolt at distance L_2 are heavily loaded.

Tensile load on each bolt at distance L_2,

$$W_{t2} = W_2 = WL_2 = \frac{W.L.L_2}{2[(L_1)^2+(L_2)^2]}$$

[From equation (iii)]

And the total tensile load on the most heavily loaded bolt,

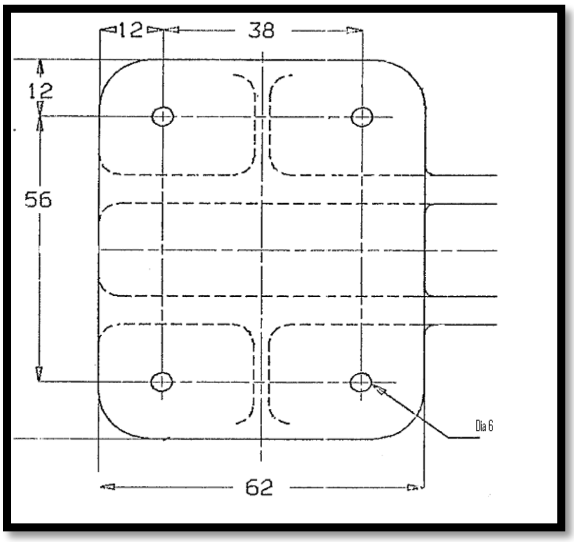
$W_t = W_{t1} + W_{t2}$ **(iv)**

If d_c is the core diameter of the bolt andis the tensile stress for the bolt material, then total tensile load

$W_t = \pi/4 (d_c)^2 (\sigma_t)$ **(v)**

From equation (IV) and (v), the value of d_c may be obtained

2).Jack bracket



All the dimensions are in mm

Fig 5: Jack Bracket Drafting With Circular Hole

$W = 5KN$

$L_1 = 12mm$

$L_2 = 50mm$

$L = 62mm$

$\sigma = 64Ksi$

$= 441.264466$ N/mm

We know that the direct tensile load carried by each bolt,

$W_{t1} = w/n$

$= 5000/4$

$=1250N$

and load in a bolt per unit distance,

$$w = \frac{W.L}{2[(L_1)^2+(L_2)^2]}$$

$$= \frac{(5000)(62)}{2[(12)^2+(50)^2]}$$

= 58.623 N /mm

Since the heavily loaded bolt is at a distance of L_2=mm from the tilting edge, therefore load on the heavily loaded bolt,

$W_{t2} = w.L_2$

$= (58.623)(50)$

$=2931.16N$

Maximum tensile load on the heavily loaded bolt,

$Wt = W_{t1} + W_{t2} = 1250+2931.16$

$=4181.16N$

Let, d_c= core diameter of the bolt.

We know that the maximum tensile load on the bolt (W_t),

$(W_t) = \pi/4 (d_c)^2 (\sigma)$

$4181.16 = \pi/4 (d_c)^2 (441.264)$

$(d_c)^2 = 12.070$

$d_c = 3.474mm$

From the Design Table, we find the standard core diameter of the bolt is 3.5mm and the corresponding coarse series of the bolt is M4.

F. Analysis of eccentric bush

1). Software used

ANSYS 9.0

2).Analysis type

Ansys main menu → Preferences → structural

PREPROCESSOR → ELEMENT TYPE

Element type >Add/Edit/Delete >Add > solid > Brick 8 node 45 > ok

PREPROCESSOR > MATERIAL PROPS

Material Props > Material models > Structural > Linear > Elastic > Isotropic

We are going to give the properties of Steel. Enter the following when prompted:

EX 200000
PRXY 0.3

APPLY CONSTRAINTS

Define Loads > Apply > Structural > Displacement > On Areas

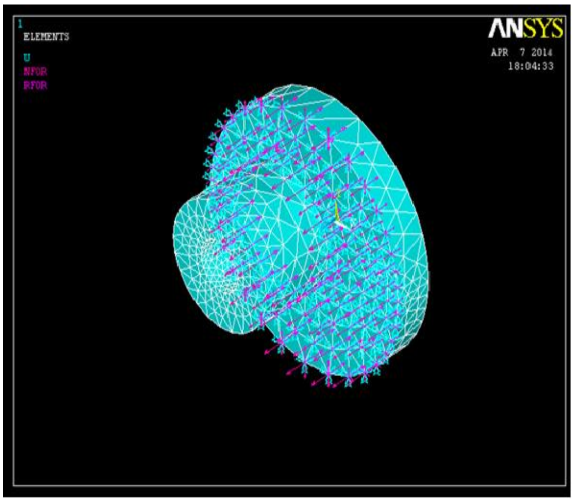


Fig 6: Constraints

PREPROCESSOR > MESHING
Meshing > mesh > select an element

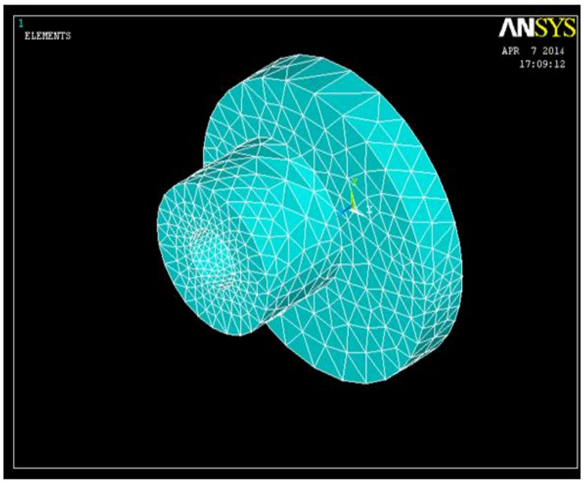


Fig 7: Meshing

APPLY LOADS

Load applied is about **2KN**
Solution > Define Loads > Apply > Structural >force/moment > on Areas

SOLVING THE SYSTEM

Solution > Solve > Current LS> ok

DEFLECTION

General Postproc> Plot Results > Contour Plot > Nodal Solution then select DOF Solution
Alternatively, obtain these results as a list. (General Postproc> List Results > Nodal Solution...)

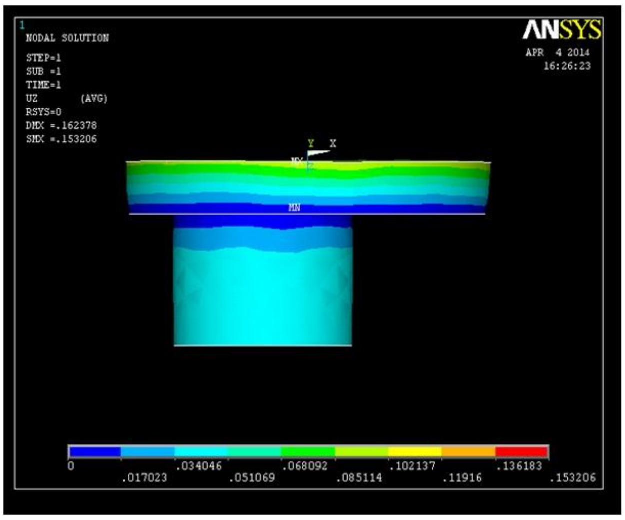


Fig 8: Deflection

DEFORMATION
General Postproc> Plot Results > Deformed Shape >Def + unreformed

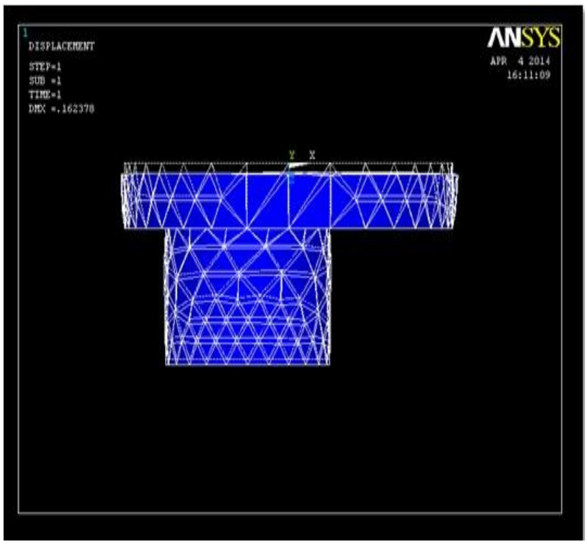


Fig 9: Deformation

3). Assembly of eccentric steel bush in jack mounting bracket

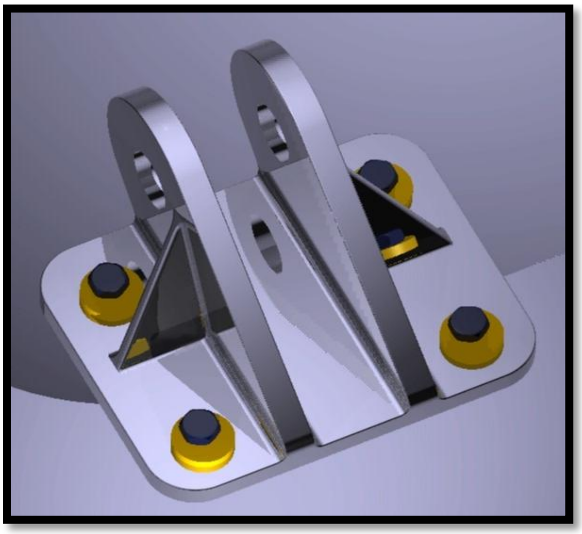


Fig10: Eccentric Steel Bush Assembly

V. CONCLUSION

A first and frequently overlooked step in problem solving is to identify the assumptions that are made about the situation. Many of the assumptions will be hidden and unrecognized until a deliberate effort is made to identify them. Often it is the unrecognized assumption that prevents a good solution. As with creative thinking, flexibility is a crucially important feature in problem solving.

Based on the study and analysis carried out by using fishbone diagram, brain storming diagram, Pareto analysis, and subsequently practical implementation, following actions are recommended to overcome slat step and asymmetry.

- Stay rod for installation and final assembly of slat which gives 40% to 50% of improvement.
- As a short term measure to overcome already produced slats, an eccentric bush can be inserted on the jack mounting point to obtained further improvement.
- 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**.**
- An Eccentric steel bush have been designed and analyzed such that the eccentric bush can be inserted on the jack mounting point for the correction of error occurring in slats and to overcome the asymmetry.

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