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Design and Analysis of Under Carriage Uplock Lever Mechanism of an Aircraft

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Abstract: ***In aviation, the undercarriage or landing gear is the structure (usually wheels) that supports an aircraft on the ground and allows it to taxi. The landing gear being one of the components of the aircraft experiencing very high loads, very high strength materials are made use of in its construction, in order to keep its size and weight to a minimum. This paper deals with the study and design of the uplocks lever, which is an important part of the landing gear in aircraft in an existing aircrafts and record the various design parameters and determining the optimal design. Model of the uplock lever is generated in CATIA V5 and calculation of loads acting at various points is done in NASTRAN and minimum required dimensions of different components in the assembly and their design with drafting tools is done.***

Keywords: Uplock lever, CATIA V5, NASTRAN, Aircraft, gear

1. Introduction

The main landing gear is one of the most critical components of an aircraft, capable of reacting the largest local loads on the airplane. It is primary source of shock attenuation of landing. It controls the rate of compression, extension and prevents damage to the vehicle by controlling load application rates and peak values. The purpose of landing gear is to absorb horizontal and vertical energy during touchdown, Facilitate ground maneuver, Stop the aircraft during runway operation, Provide adequate tail down angle for takeoff rotation and to provide the aircraft with stable support, while on the ground. The landing gear supports an aircraft weighing 735,500 pounds, and yet it can land on bare soil. This requires lots of wheels and relatively low tire pressure. Because the aircraft is so large, its cargo floor had to be lowered for easy loading, using a kneeling system on the nose and main gears. Since drag requirements precluded large landing gear pods, complex retraction mechanisms were developed to stow the huge gear in a low–drag envelope.

2. Literature Survey

A brief review of contemporary research supporting this paper is presented below.

Mark Arnold et.al.[1] analyzed the uplock mechanism frame, linkages and hook. Each machined from billets of steeling having a number of different grades dependent upon the required yield stress and ultimate stress allowables. The bushes and pins were also manufactured from steel. Static loads applied to the uplock mechanism were classified as either a hook load applied by the roller to the hook, an actuator extension or retraction fatigue loads applied to the linkage ,or a combination of these loads.

Kim Cet.al.[2]concluded that aircraft uplock mechanism are designed to lock the landing gear in retracted position and assist in carrying the weight of the gear during flight. Conventional uplock mechanism consist of a spring loaded catch that locks the gear in place and a hydraulic cylinder to release the locking mechanism to free to be the lowered for landing.

Bruhn F et.al [3] studies reveal current aircraft systems typically use a multitude of hydraulic subsystems as a source of mechanical energy. Typical state of the art uplocks employ one hydraulic actuator to perform the unlocking function, and often use a manually actuated cable system to perform the unlocking in the case of a hydraulic system failure. Other existing uplocks employ a secondary hydraulic actuator for the alternate release.

Norman S curry et.al [4] evaluated each main landing gear wheel well contains the main landing gear uplock mechanism. Each mechanism consists of a hook mounted on the wing structure that engages a roller installed on the forward end of the main landing gear trailing arm as the landing gear moves to the uplocked position .The hook is actuated to the lock position by hook and roller engagement, which overrides a spring latch mechanism.

3. Objectives

The objective of the paper is after study of all existing Up-lock design the findings or parameters are tabulated according to each aircraft and they are compared along with other design components. The optimal design of Up-lock is determined after careful comparison of all parameters along with the reasoning for homing in on that particular type of Up-lock assembly design.

4. Modeling and Analysis

Up-locking can be carried out in two different ways – hooking up the leg proper, or resting the leg on the doors and latching the latter. Latching of the leg proper can in turn be done in several ways, for example:

1. By a direct hook on the leg itself.
2. By a hook operating on some part of the radius rod.
3. By an internal lock inside the jack.
4. By an irreversible mechanical gear train or electric actuator.

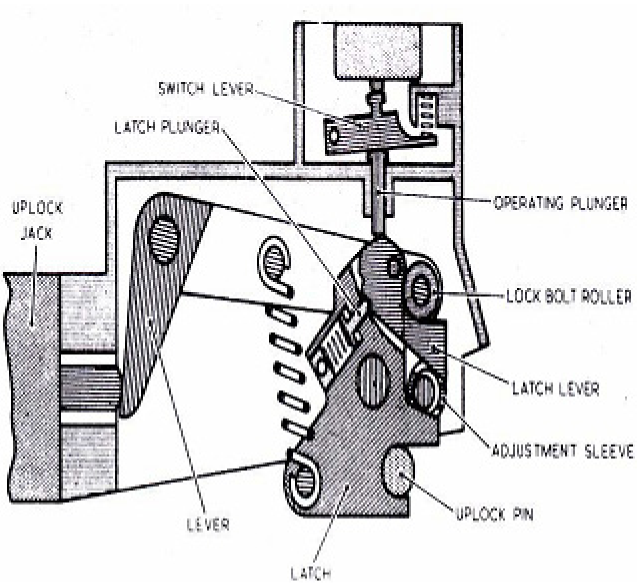

Figure 1: Up-lock Mechanism in locked condition

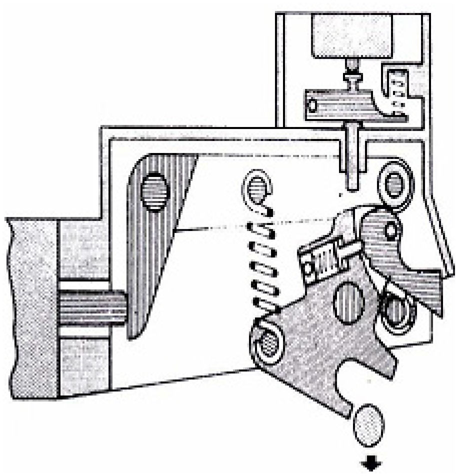

Figure 2: Up-lock Mechanism in unlocked condition

There are two basic types of lock, which may be classified as of the first order or direct type, and the second order or indirect type. First order locks are ordinary spring-loaded hooks or latches; a compression spring (generally preferred than the tension type) pushes the lock against a stop when the leg pin is not in position; the pin abuts on a fixed plate which allows a small clearance between the pin on the latch.

5. CATIA V5

The lever is one of the most critical parts in the Uplock assembly. It transfers the force from the hydraulic jack to the hook during locking and unlocking of the Uplock. Hence the lever plays role of a gear in a transmission system and so must be designed with utmost precision.

The profile of the lever is more or less uniform without any critical regions except for the hole in the left hand side of the profile which hence becomes a critical area. Therefore it is enough if we calculate the thickness required at the critical junction which would hold good for the rest of the profile. Total load acting on the lever (due to the roller) = 1393.02 N. Therefore load acting on one side of the lever = 696.51 N

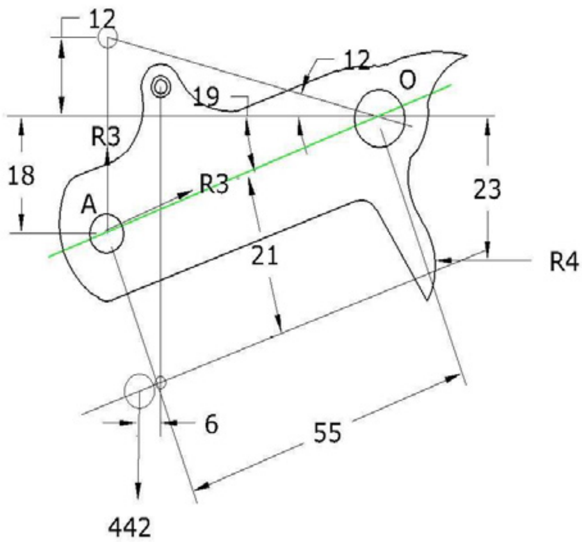

Figure 3: Lever of Uplock Assembly

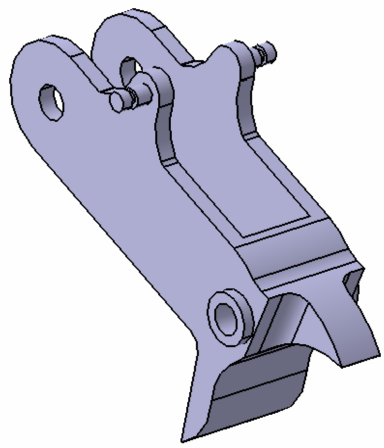

Figure 4: Lever Model using CATIA V5

6. NASTRAN

A finite element analysis usually consists of three principal steps: Pre processing, Processing (solution) and Post processing. MSC Nastran for Windows to complete FEA software projects. MSC. Nastran for Windows products addresses a wide variety of engineering applications, from the design of surgical equipment and circuit breakers to the more unusual needs of the entertainment industry.

MSC.Nastran 4D (vN4D) is a Windows®-based engineering tool ideal for the mechanical engineer who designs products with moving components. This unique application merges motion and stress analysis into a single functional modeling system.

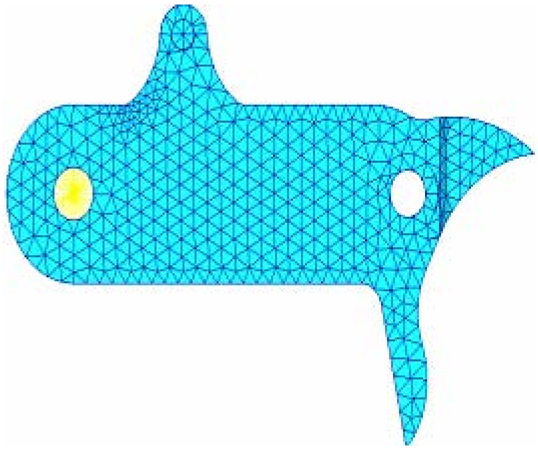

Figure 5: FEA Model of lever

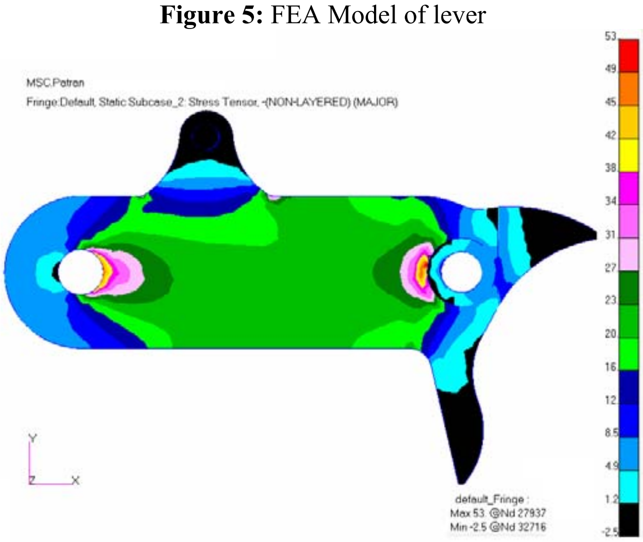

Figure 6: Maximum Principal Stress of Lever

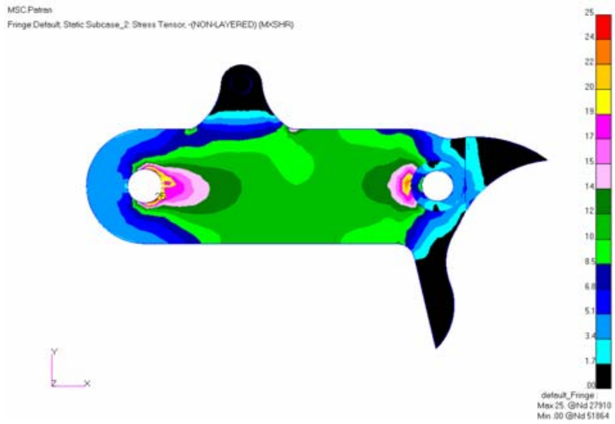

Figure 7: Maximum Shear Stress of Lever

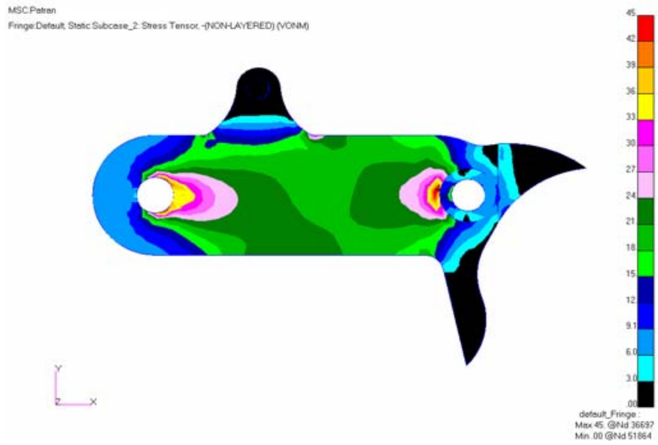

Figure 8: Maximum VON Mises Stress of Lever

Comparison of Stress

S NO	STRESS	HOOK	LEVER
1	Maximum Principal Stress in Mpa	956	53
2	Maximum Sheer Stress in Mpa	942	25
3	Maximum VONM Stress in Mpa	1711	45

The comparison of the maximum stress on the hook and the lever of the uplock assembly is shown in the above table. Relatively hook experiences maximum stress compared to lever. Since all the maximum stress magnitudes as observed from the stress analysis results show that they are less than their respective strength properties of the material. These results indicate that for the given loading and boundary condition the lever and the hook have sufficient margin of safety and they will not fail due to static loading for which they are designed.

7. Conclusion

The components design of uplock lever of this configuration are all well within design limits. Only the main load carrying parts are considered for FE analysis. The parts related to functional aspects are not considered for the design. Parts are designed individually. Explained the finite element method and CATIA software.

8. Scope for Future Work

Design & Analysis will be carried for remaining parts of Undercarriage uplock assembly i.e. Hook. Hydraulic cylinder, spring, Bay etc. Optimization of the design for the reduction of stress concentration. Providing Good adequate aerodynamic strength

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