

STRESS ANALYSIS OF STEERING OF A FIGHTER AIRCRAFT

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Abstract— Carrier based aircraft with nose wheel steering shall be designed to permit 360 degree free swiveling. The carrier deck provides limited space for the ground operations of aircraft, which includes take off. Landing, taxiing, turning, braking and parking. The steering system on the landing gear has to steer the fighter aircraft for a maximum steering angle in order to perform these operations. These requirements increase the complexity of design of the steering system. The project concerns the structural analysis of typical gearing arrangement to achieve maximum steering angle. The main objective is to examine the static and fatigue strength of the critical parts of the steering assembly for the operating condition. The steering assembly includes the major components rack, pinion and planet carrier. A steering system gearing arrangement is modelled using CATIA V5 and analysed using finite element software Hypermesh 12.0 as pre-processor and Optistruct as post processor. The material used for the components is NCM Steel (AISI 4340). The finite element method adopted by the analysis software produces the maximum principle stress plots. The static strength criteria is given by the reserve factor, which must be above one for the components to be safe. The from stress analysis, the reserve factor is found to be above one for the all components. Hence, the critical naval steering system components are satisfactory from the static strength.

Keywords— *Nose landing gear; Static Analysis; Hypermesh; Hyperview.*

1. INTRODUCTION

Landing gear is a vital structural unit of an aircraft which enables to take off and land safely. The landing gear of modern aircraft with tires, brakes, wheels, landing legs and associated retraction equipment represents the substantial unit of the aircraft. It accounts 15-20 Percent of the structure weight of the aircraft [1]. A variety of landing gear arrangements are used depending on the type and size of an aircraft. The orthodox arrangement of landing gear on an aircraft is to use three wheeled elements, two main ones close to the center of gravity of the aircraft in elevation, and an auxiliary leg either at the tail as a tail

wheel, or at the front of the fuselage as a nose wheel. Almost all modern aircraft are of the nose wheel type [2]. This is because of the fact that the aircraft is inherently stable, in landing especially with-wind, as the center of gravity is ahead of the main wheels and provides good pilot visibility. The auxiliary wheel of a tail wheel or nose wheel layout will normally be castoring to enable the aircraft to manoeuvre about the main wheels. Although a few aircraft have had mechanically steered tail wheel, it is on nose wheel aircraft that the main problems occur [3].

The projective concentrates on the nose gear steering system components of a fighter aircraft. The carrier based aircraft have to meet the requirements as per MIL-S-8812. The nose gear has to steer for maximum angle for turning and close parking on the carrier deck. Thus for the maximum steering angle the loading condition should be determined by considering the loads acting on the primary components of the steering system. Structural components must have a satisfactory static. The main objective of this project is to perform structural analysis on the nose gear steering components.

2. LITERATURE REVIEW

Gowda [6] studied on linear static and fatigue analysis of nose landing gear for trainer aircraft. The nose landing gear is designed using CATIA and the material selected for the components are AL 2014-T6 and NCM steel. The different static and critical loads that act on the landing gear are considered along three axes x-direction (drag load), y-direction (vertical load) and z-direction (side load). Using MSC Patran/Nastran the model is analysed for the applied loading and boundary conditions. Static test results show that the model is safe because the reserve factor for the nose landing gear is $RF > 1$. Fatigue life is estimated using calculations

Vijayan [7] studied on design and stress analysis of nose landing gear barrel of a trainer aircraft. This paper focuses on the static loading cases of a nose landing gear barrel and it is designed using CATIA V5 the material used is AL-CU alloy. For different loading cases of landing, the stress and displacements are found using MSC Patran/Nastran. The ultimate tensile strength of the material is compared with the maximum principal stress of the barrel. The

reserve factor obtained is more than one for all the cases and hence the component is safe from static strength criteria.aintaining the Integrity of the Specifications

Theodore R.Smith [8] in his patent work on Nose gear steering system describes two nose gear steering systems which employs a hydraulic actuator and a centering spring to impart steering movement. A valve, electrically operated, controls the flow of fluid actuator and therefore controls movement. This systems is very complex and servomechanisms introduce a substantial weight penalty to the aircraft. The second type of nose gear steering system utilizes cantering springs to normally bias the nose gear to a center or straight-ahead position. Steering is accomplished by differential braking which overcomes the biasing action of the centering springs to turn the nose gear. Although this system is simple, it causes extreme brake wear.

3 .METHODOLOGY

The problem is improved and maximum steering angle requirement for the nose wheel of a aircraft has been defined. A literature has been done for understanding the procedure that has to be followed for structural analysis and about the steering systems.The steering system components and material for the aircraft has been identified. The forces acting on the components, and the torque required, for the operating steering angle has to be calculated. The steering components have to be designed using CATIA V5 software. The modeled components should be imported to Hypermesh software where the models are meshed to finite elements. The loads, calculated and the boundary conditions are to be applied on the assembled components.The static strength and deformation due to stress are to be determined from the analysis and the results should be checked for the satisfactory requirements.

4. MATERIAL

Steel is the most widely used ferrous material for gears since it can be manufactured and processed to a great many different specifications, each of which has a definite use. The material chosen for the gears is NCM steel. The specification is BS4S99D or AISI/SAE 4340. It is a nickel-chromium-molybdenum alloy steel known for its toughness and its ability to attain high strengths in the heat treated condition. It has very good fatigue resistance. The yield strength is 1010 MPa and the ultimate strength is 1230 MPa.

5. MODELING

The dimensions of the components are used to define the geometry and drawn in the sketch module of the product application and then made solid by using pad option. All the.cat part files are saved separately. The pictures of modelled components are shown below in fig.



Fig.1.Model of carrier



Fig 2.Model of Rack



Fig 3.Model of Pinion

6. FINITE ELEMENT ANALYSIS

Meshing- the components of steering system are solid and the meshing involves three-dimensional mesh. The tetra meshing is preferred and Hypermesh contains two methods of generating tetrahedral mesh, volume tetra mesher and standard tetramesher. Volume tetra mesher works directly with surface/geometry to generate a tetrahedral mesh. This is used for simple models. Standard tetra mesher requires a surface mesh of tria or quad elements as input and suitable for most complex models. The surface of the geometry is meshed with two dimensional quad elements. Then the 2D elements are checked for free edge and t-connection checks to ensure proper connectivity of the elements. The volume of the components are then filled with 3D element, tetra four node elements, using standard tetra mesher option. Then the 3D element checks like Jacobian, aspect ratio, tet collapse and skew are done to ensure proper meshing of the structure. All the three components are meshed separately.

Assemble- the meshed rack, pinion and carrier should be assembled using the organize option in the collectors panel. The rack is meshed along with the pinion teeth. The pinion and carrier is arranged in series. The barrel is inserted inside the pinion and carrier. The assembled steering system is shown in the figure 4.

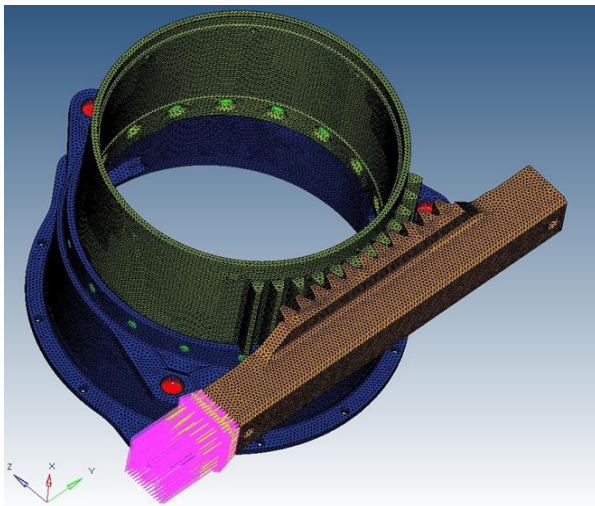


Fig 4. meshed and assembled a steering system

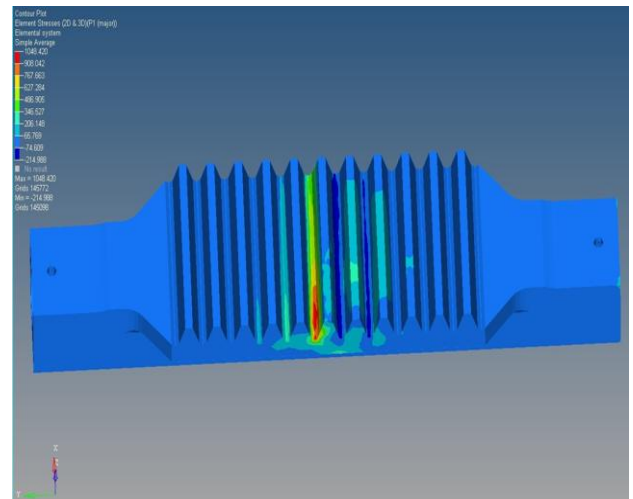


Fig 5.Maximum principal stress plots of Rack

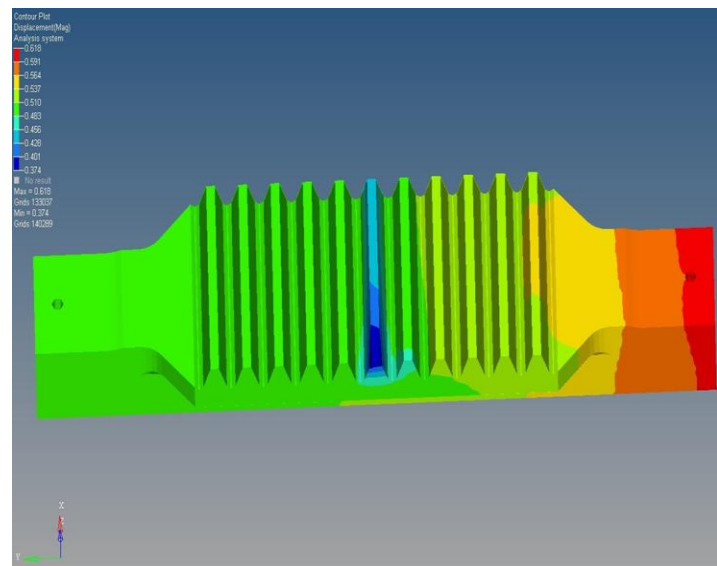


Fig 6.Displacement of Rack

The fig 5 and 6 shows the maximum principal stress occur at 1048.42 Mpa and displacement at 0.618 mm respectively.

Postprocessor – The graphic output of the analysis can be viewed in the HyperView. The displacement and the maximum stress contour can be plotted by specifying result type and orientation. The displacement and maximum principal stress plots for the static load case of 383 kg-m torque on the steering system are shown in below fig.

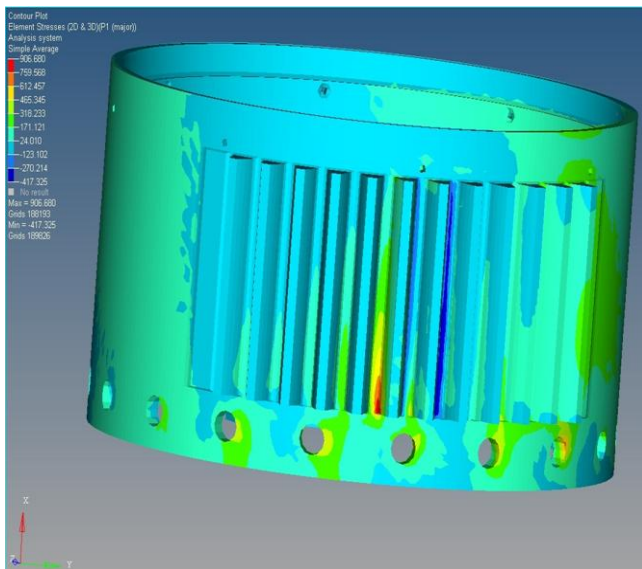


Fig 7. Maximum principal stress plots of Pinion

Fig 7. shows the maximum principal stress occur at 906.680Mpa and below fig 8. Shows the maximum displacement occur at 0.571 mm.

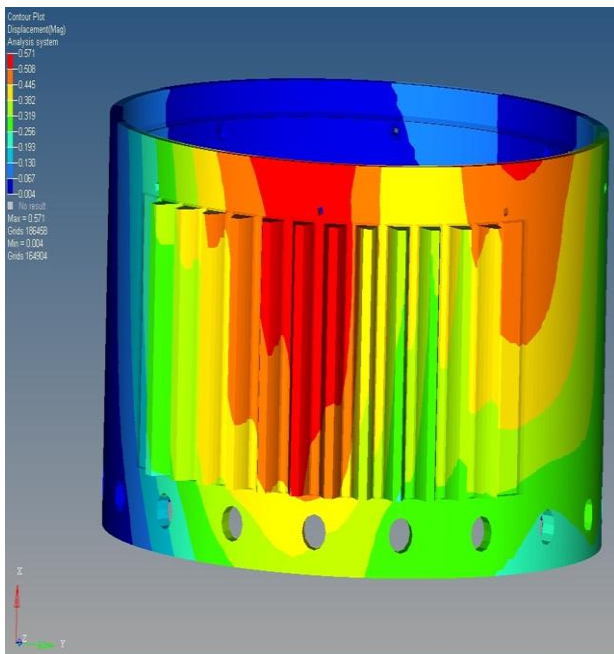


Fig 8. Displacement of Pinion

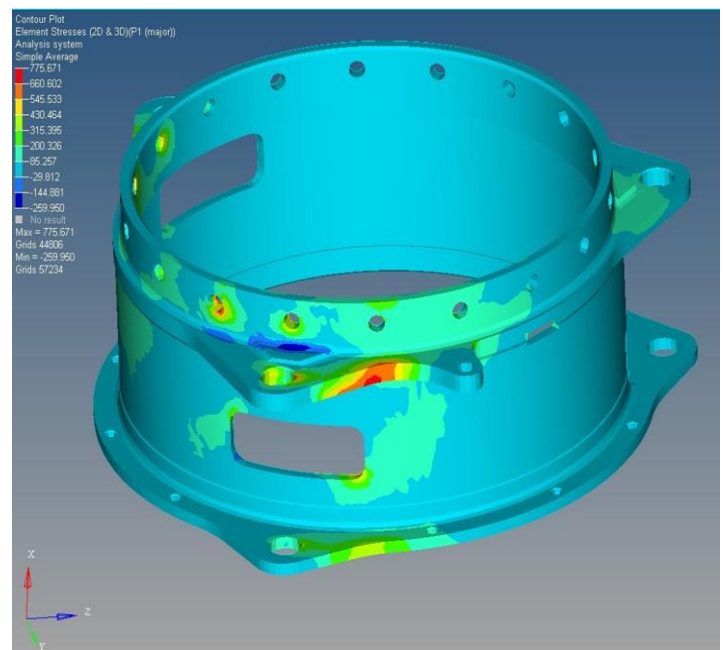


Fig 9. Maximum principal stress of carrier

Fig 9 and 10 shows the maximum principal stress occur at 775.67 Mpa and displacement is 0.435mm respectively.

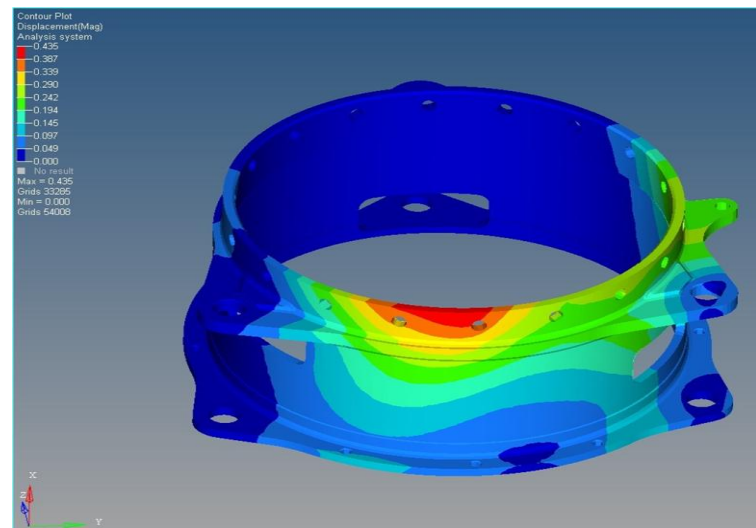


Fig 10. Displacement of Carrier

VII. STATIC STRESS RESULTS

The static strength criteria for the components are defined by the reserve factor. The ratio of the allowable stress of the material to the ultimate stress is called the reserve factor. It should be above one for the operational torque is tabulated in table 1.

TABLE 1. Static stress results for maximum torque of 383 kg-m

S.NO.	Components	Resultant displacement mm	Maximum Principal Stress (Acting Stress) MPa	Ultimate Tensile Strength (Allowable Stress) MPa	Reserve Factor
1	Rack	0.618	1048.42	1230	1.17
2	Pinion	0.571	906.680	1230	1.35
3	Carrier	0.435	775.671	1230	1.58

From above table, the reserve factor calculated for the maximum torque on the steering components are above one. Thus the static strength criteria of the critical steering system components are satisfied.

VIII. CONCLUSION

The project demonstrated the structural analysis of nose landing gear steering components of a fighter aircraft. The different steering system design, components and their operations are studied. The critical components are identified and the design calculations were performed for the maximum torque case. The components are modelled in the design software CATIA V5. The components are

imported to the finite element software Hypermesh and assembled accordingly. The components are meshed and the boundary conditions, constraints, and loads are applied. The non-linear static analysis produces the maximum principal stress plots.

The static analysis results are compared with the ultimate tensile strength of the material being used. Their ratio, the reserve factor is found to be above one for the components. Thus the components are safe from static strength criteria.

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