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Static and Fatigue stress analysis of pylon interface "ADAPTOR" for store integration in modern aircraft.

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Abstract - A pylon serves to connect the frame of an aircraft to an item or object that is being carried hence, it is an adaptor use of a pylon is necessary to clear the carriage item of control surfaces as well as prevent undesired disturbance of the flow of air toward the wing. Pylons are usually designed with smooth aerodynamic shape to reduce air resistance (drag).There are many different forms, sizes and designs of pylons distinctly termed accordingly like a wedge adaptor or stub wing pylon. Adaptor is mounted below pylon. The main function of adaptor is to carry the twin missile on both sides. The load is acting on the cg point (center of gravity) of the adaptor housing. The adaptor design is to be done for reduction of drag force and increasing the thrust force. This is using in a modern aircraft because of to carry the more missiles in a time. By this carrying the missiles load must be consider in the factor of aircraft.

Key Words: adaptor, pylon, patran and nastran, ansys workbench, load of missile and launcher.

1. INTRODUCTION

Missiles have four system components: targeting and/or guidance, flight system, engine, and warhead. Missiles come in types adapted for different purposes: surface-to-surface and air-to-surface missiles (ballistic, cruise, anti-ship, anti-tank, etc.), surface-to-air missiles (anti-aircraft and anti-ballistic), air-to-air missiles, and anti-satellite missiles. In a modern military usage, a missile is a self-propelled guided weapon system, as opposed to unguided self-propelled munitions, referred to as just a rocket.

1.1 TYPICAL FIGHTER AIRCRAFT

A fighter aircraft is a military aircraft designed primarily for air to air combat against other aircraft, as supposed to bombers and attack aircraft, whose main mission is to attack ground targets. The hallmarks of a fighter are its speed, maneuverability, and small size relative to other combat aircraft. Many fighters have secondary ground attack capabilities and some are designed as dual purpose fighters- bombers, often the aircraft that do not fulfill the standard definition are called fighters. This may be for political or national security reasons or other reasons. A fighter's main purpose is to establish air superiority over a attle field.

Fig 1.1: Typical fighter aircraft

1.2 ARMAMENTS SYSTEM IN MODERN AIRCRAFT

Fig.1.2: Armaments arrangement

Modern aircraft of Air Force Fighter account had been provided with 9 hard points and 8 weapon stations such as fallows,

- Three under each wing. (I/B, M/B, O/B Pylons)
- One under the fuselage. (Central Pylon)
- Integral GSH-23 Gun at RH side air-intake.
- Dedicated laser designation pod (LDP) Pylon under LH side Air Intake.

2. TWIN MISSILE CARRY THE PYLON

The position of missile connection depends on design, type and load of aircraft. The basic function of pylon is used to carry the missiles through between the adaptor and launcher. This set up is made in side by side position i.e. pylon to adaptor by side launcher and launcher to typical missile on both side. This designed is for aerodynamics load. It is used in modern aircraft they are providing to carry twin missile with one pylon. Under the pylon connects to adaptor and adaptor carry the launcher and missile on both side. Whole assembly is made up of aluminum alloy and inside brackets are made in steel material.

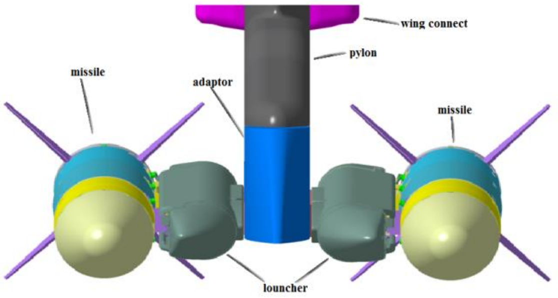


Fig.2.1: Twin missile carry the pylon with adaptor

2.1 ADAPTOR

Adaptor is mounted below pylon. The main function of adaptor is to carry the twin missile on both sides. The load is acting on the cg point (center of gravity) of the adaptor housing. The adaptor design is to be done for reduction of drag force and increasing the thrust force. This is using in a modern aircraft because of to carry the more missiles in a time. By this carrying the missiles load must be consider in the factor of aircraft.

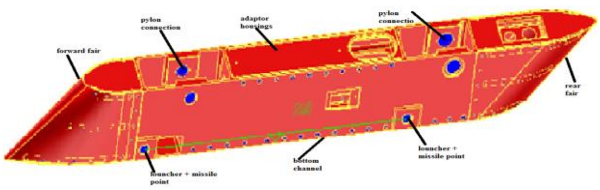


Fig.2.2: Adaptor

2.2 DESIGN OF ADAPTOR

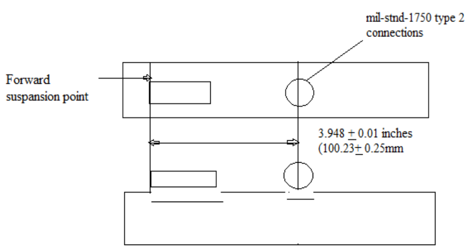


Fig.2.3: Location of connector on rail launched store

Reaction calculation of the adaptor

Here simple loading is assumed to carryout first cut analysis to fix the thickness and other dimension. This will be used to design actual adaptor.

TOTAL LOAD CALCULATION:

W = 2*A*8*1.5
= 24*A

Where, 2 = missiles on both sides
A = weight of launcher and missile
8g = weight carry aircraft up to 8g (gravity) Maximum vertical load.
1.5 = factor of safety

Formulae which is used to calculate the thickness of material and stresses.

- Moment of inertia (I)
  $I = bd^3/12$ for rectangular beam
- Distance of the layer or fibre from neutral axis is in mm
  Y = H/2
- Bending moment (M_b)
  Value from calculated bending moment diagram
- Bending equation
  $$\frac{M}{I} = \frac{\sigma}{y}$$
  $$\sigma = \frac{M * y}{I}$$
- To calculate shear stress
  $$\tau = \frac{\text{force}}{\text{area}} = \frac{F}{A}$$
- Reserve factor:
  $$RF = \frac{\text{allowable stress}}{\text{working stress}}$$

Conclusion: RF value it must be greater than one (≥1). So which is my design value is greater than one (≥1). So my design is safe. These basic dimensions are used to design actual adaptor housing parts. Some places, thickness is increased to account for big holes. Maintenance cut out. To accurately analyse the adaptor, FE software is used while be described in subsequent chapter.

3. OVERVIEW OF SOFTWARES USED

Patran provides a rich set of tools that streamline the creation of analysis ready models for linear, nonlinear, explicit dynamics, thermal, and other finite element solutions. From geometry cleanup tools that make it easy for engineers to deal with gaps and slivers in CAD, to solid modeling tools that enable creation of models from scratch, Patran makes it easy for anyone to create FE models.

MSC Nastran is based on sophisticated numerical methods, the most prominent being the Finite Element Method. Nonlinear FE problems may be solved either with built-in implicit or explicit numerical techniques. A number of optimization algorithms are available, including MSCADS and IPOPT. The fatigue capability in MSC Nastran has been developed jointly by nCode International Ltd. and MSC Software.

3.1 PROCESS FLOW OF FEA

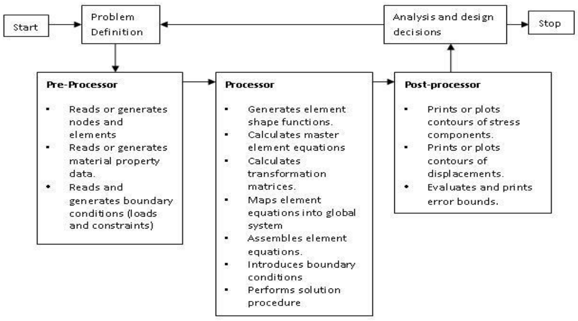


Fig.3.1: Process flow of FEA

3.2 STATIC ANALYSIS

Structural analysis is the determination of the effects of loads on physical structures and their components. Structures subject to this type of analysis include all that must withstand loads, such as buildings, bridges, vehicles, machinery, furniture, attire, soil strata, prostheses and biological tissue. Structural analysis incorporates the fields of applied mechanics, materials science and applied mathematics to compute a structure's deformations, internal forces, stress, support reactions, accelerations, and stability.

3.3 FATIGUE ANALYSIS

Fatigue is the weakening of a material caused by repeatedly applied loads. It is the progressive and localized structural damage that occurs when a material is subjected to cyclic loading. The nominal maximum stress values that cause such damage may be much less than the strength of the material typically quoted as the ultimate tensile stress limit or the yield stress limit.

3.3.1 Typical cyclic loading parameters

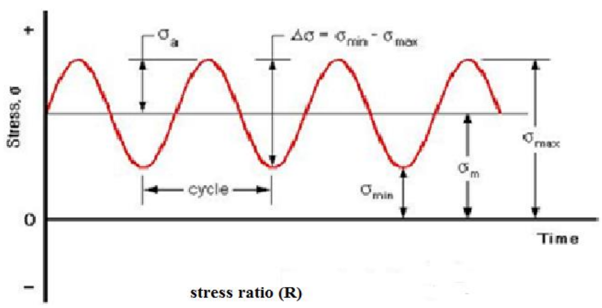


Fig 4.3: Typical cyclic loading parameters

3.3.2 S-N diagram (Stress life diagram)

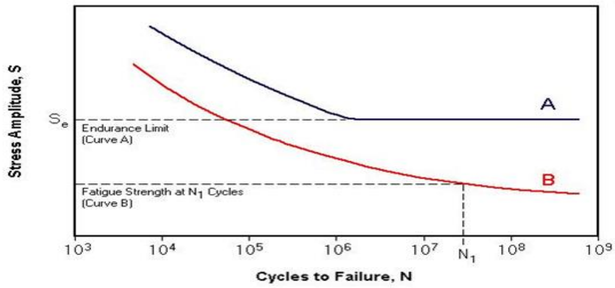


Fig 4.4: Typical S-N curve

4. ANALYSIS OF ADAPTOR

4.1FE MESHING VARIOUS ADAPTOR PARTS

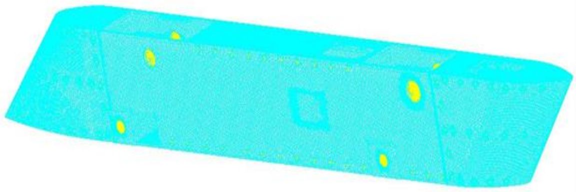


Fig.5.1: Meshing adaptor

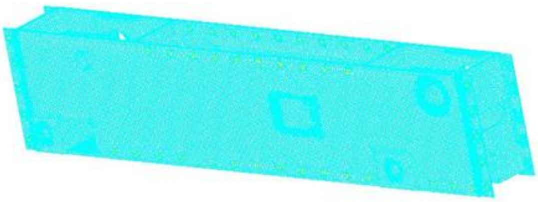
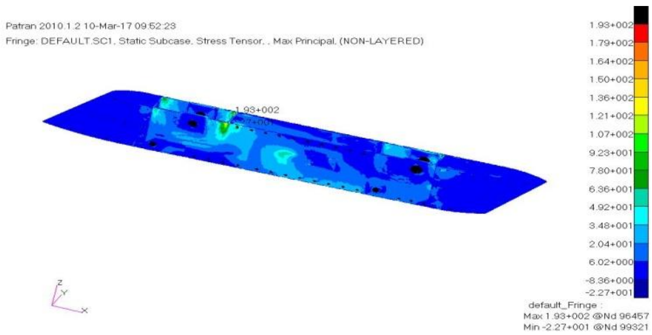
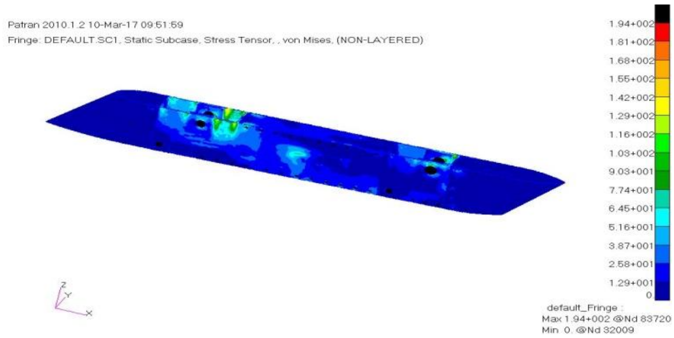


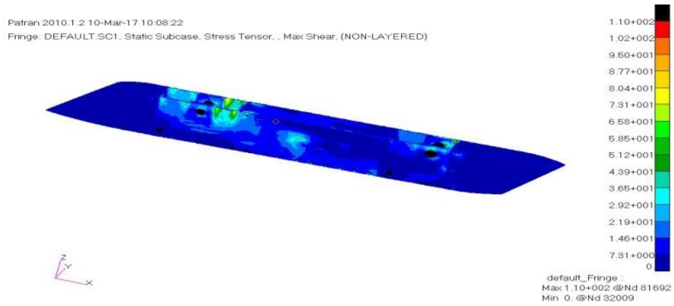
Fig.5.2: Meshing adaptor housing

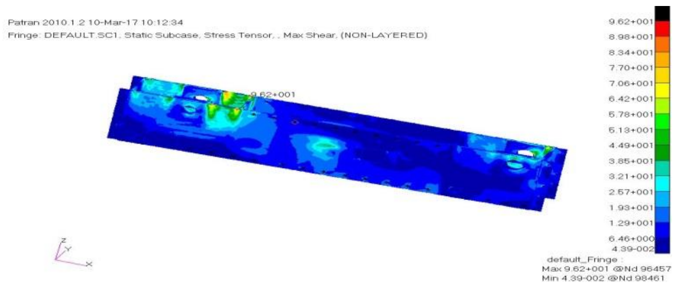
4.2 FE STRESS PLOTS OF ADAPTOR PARTS

4.2.1 Maximum load case (static load)

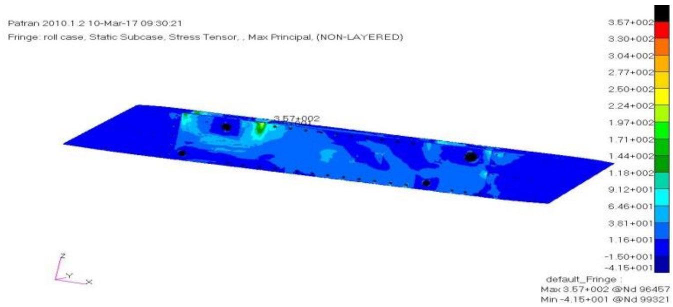


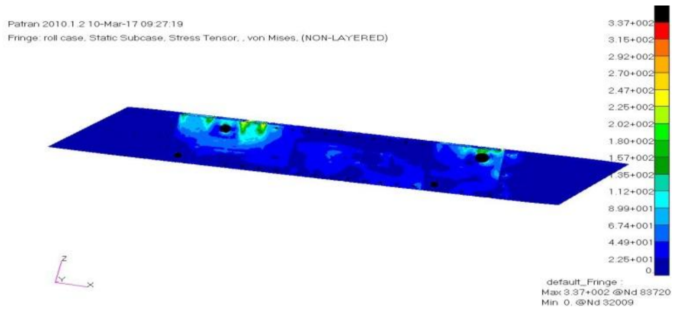


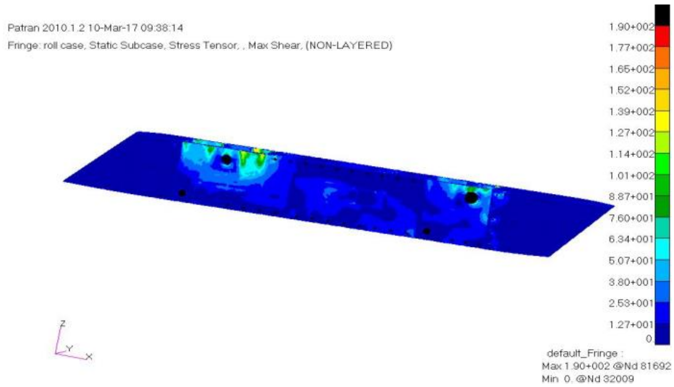




4.2.2 Roll load case







5. CONCLUSION

- The results obtained through static stress analysis of the pylon interface adaptor attachment frame are compared with the material allowable for ensuring the adequacy of strength.
- Now a factor called reserve factor (RF) is calculated, which should be more than one. In our case, RF is coming out to be greater than 1 for pylon interface adaptor. Hence the redesigned pylon interface adaptor is safe from strength perspective.
- The fatigue analysis of the pylon interface adaptor done. The damage of the component for various load cases is calculated. Using the calculated damage for different load cases, Factors life was calculated and found to be **48192** cycles which is greater than the required cycles of aircraft.
- Hence, the redesigned pylon interface adaptor is safe from strength and fatigue perspective.

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