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Design and Analysis of Latch Access Panel of Aero Engine Components

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Abstract

Background/Objectives: To reduce the production cost by implementing Design for casting instead of machining a component. **Methods/Statistical Analysis**: A machined component is analysed for its strength to failure. Using casting allowable, the same component is re-analysed and verified for feasibility. The design is compromised without making changes at the interfaces so that the installation is simple. Finally the weight is compared to conclude the application of appropriate production method for cost effectiveness. CATIA V5R21 software is used for designing and PATRAN/NASTRAN is used to analyse the components. **Findings:** Based on the analysis results critical portions are identified and further changes have been made based on casting design without disturbing the critical portions of the components. The re-designed casting model is analysed to monitor further changes and to find effective method of manufacturing. **Application/ Improvement:** In this paper, analyses have been made for conventional model and casting design model using PATRAN/ NASTRAN software. Further research will show the effective method to manufacture Aero Engine components.

Keywords: Aero Engine Components, Latch Access Door, Pressure Relief Door

1. Introduction

Aircraft engine components which are prone to high heat and design complexity needs to be precisely assembled to make aircraft air worthiness. The strength of the aircraft structures is never compromised in order to produce high heat capacitive components. For example, Titanium being one such material which will be mainly seen in almost all components this is exposed to high heat. But the cost of production is high and the surplus due to machining from the available billet size makes it even high cost in production. In[1] from Naval Air System command states that Affordable readiness will become increasingly important as the Navy's aircraft continue to age. In response to this situation, casting technology will play a big role in reducing cost of aircraft and meet affordable readiness requirements by consolidating sub- components and replacing some aging parts of airframe structures. In[2] from Howmet Research Corporation (2001) presented a paper which states that Investment cast titanium alloys are increasingly being recognized as affordable solutions that are capable of meeting the stringent requirements for structural airframe components. A number of innovative technology advancements have been made in the casting industry over the past five years to promote increased acceptance of castings in fracture critical airframe structures. In[3] presented a paper on Advanced Manufacturing and Quality Control of Compressor Latch Access Doors states that Manufacturing of aero-engine components has been improvised over the years, commensurate with technological developments in the aeronautics sector. In[4] presented a paper on Key Aerodynamic Technology for Aircraft Engine nacelle which gives a clear view on Pressure relief door states that the important set of auxiliary engine outlets is related to pressure relief in the case of duct burst in the nacelle compartment.

2. Latch Access Door (LAD) Assembly

The Latch Access Doors provide an aerodynamic surface for the lower region of the nacelle between the Right

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and Left Latch Beams as well as provides access to the latches during maintenance. Their primary purpose is to act as doors to access Latches through the Latch Beams to open the Thrust Reverser halves during maintenance. Their secondary purposes are: 1. to provide lands and/ or attachment points for baulking features that ensure proper latching of the Thrust Reverser Latches and 2. provide pressure relief of Zone pressures via opening of the two Pressure Relief Doors during a Burst Duct event.

The Latch Access Door (LAD) Installation is composed of two major sub-assemblies the Forward Access Door and the After Access Door. Within each door is a second door that serves as a Pressure Relief Door during a Burst Duct event. The Latch Access Door installation is shown in Figure 1.

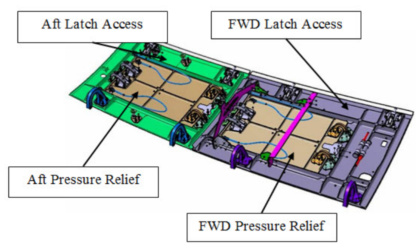

Figure 1. Latch access door assembly

2.1 Forward Latch Access Door

The Forward Latch Access Door is machined from Ti-6Al-4V Plate per AMS 4911. Figure 2 shows the overall key dimensions and component locations for the Forward Latch Access Door. Figure 3 provides a plot from the Forward Latch Access Door FEM detailed illustrating the thicknesses of the different areas.

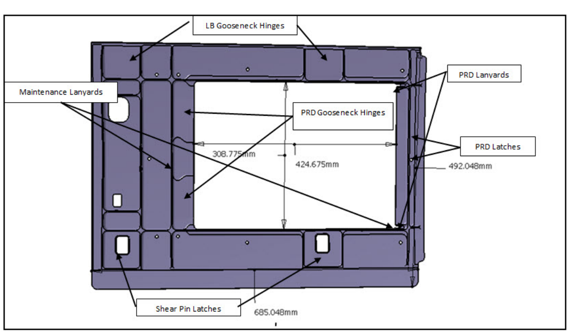

Figure 2. Forward latch access door

2.2 Pressure Relief Door (PRD)

The Forward Pressure Relief Door (PRD) is positioned inside the Forward Latch Access Door. It serves to relieve pressure in the lower bifurcation area of the nacelle during a burst duct event. Figure 4 shows the overall key dimensions and component locations for the Forward Pressure Relief Door. Figure 5 provides a plot from the FEM detailed in illustrating the thicknesses of the different areas of the Pressure Relief Door.

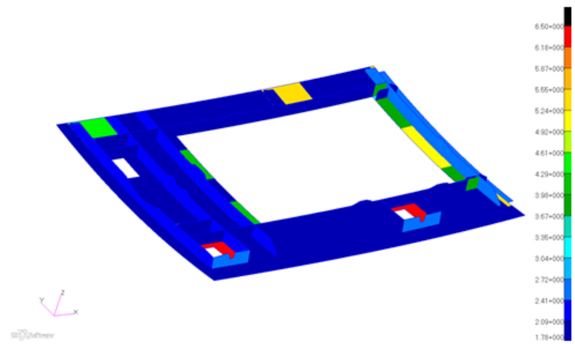

Figure 3. Thickness plot

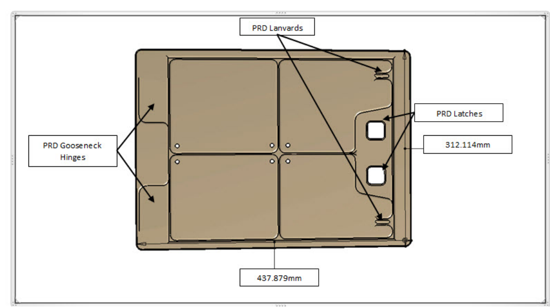

Figure 4. Pressure relief door

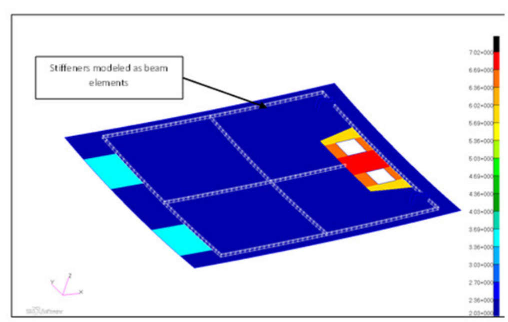

Figure 5. Pressure relief door thickness plot

2.3 After Latch Access Door

The After Latch Access Door is machined from Ti-6Al-4V Plate per AMS 4911. Figure 6 shows the overall key dimensions and component locations for the After Latch Access Door. Figure 7 shows a plot from the After Latch Access Door FEM detailed in illustrating the thicknesses of the different areas of the After Latch Access Door.

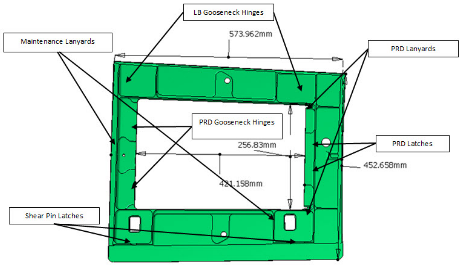

Figure 6. After latch access door

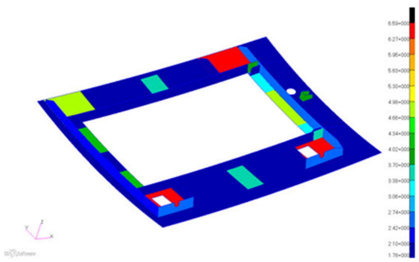

Figure 7. After latch access door thickness plot

2.4 Pressure Relief Door

The After Pressure Relief Door is positioned inside the After Latch Access Door. It serves to relieve pressure in the lower bifurcation area of the nacelle during a burst duct event. Figure 8 shows the overall key dimensions and component locations for the After Pressure Relief Door. Figure 9 shows a plot from the FEM detailed in illustrating the thicknesses of the different areas of the Pressure Relief Door.

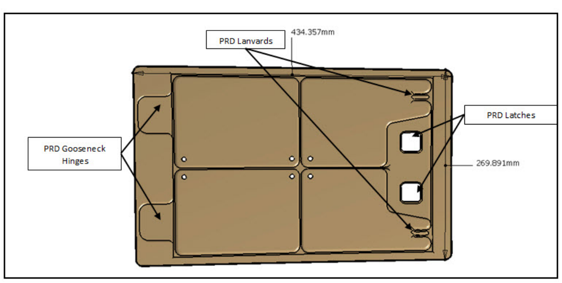

Figure 8. After pressure relief door

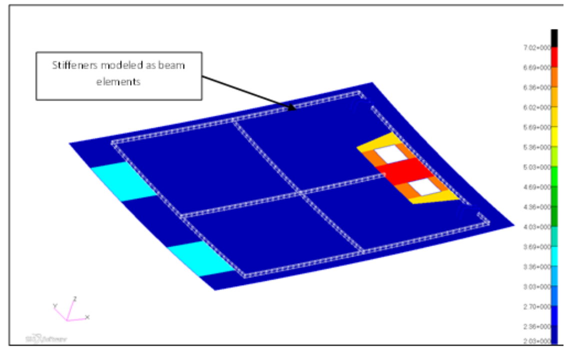

Figure 9. After pressure relief door

3. Loads and Boundary Conditions

3.1 Unit Burst Pressure Load Case

A unit burst pressure of 0.006895 MPa (1 psi) is applied normal to the Forward and After Latch Access Door and Pressure Relief Door skin elements, except for the areas under the Latch Access Door Gooseneck Hinges, Pressure Relief Door Gooseneck Hinges and Pressure Relief Door Hinge Bases, as shown in Figure 10. In these excluded areas, the unit burst pressure is instead applied normal to the top surfaces of the Latch Access Door Gooseneck Hinge. The unit burst pressure is also not applied to the After Latch Access Door elements representing the flange overlap with the Forward Latch Access Door.

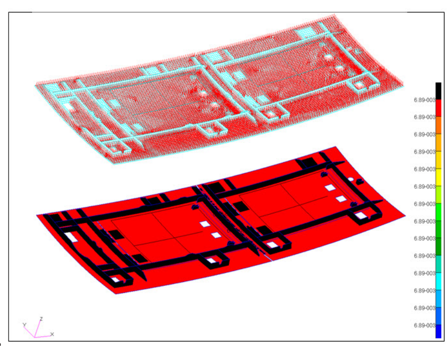

Figure 10. Unit burst pressure load case

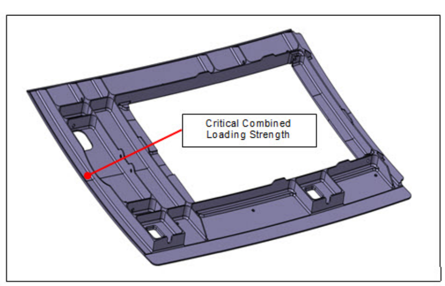

Figure 11. Forward latch access door

4. Static Analysis

4.1 Forward Latch Access Door

The Forward Latch Access Doors were analysed and the resulting critical margins are presented herein for Limit and Ultimate (Critical MS for Maximum Pressure or Steady State). The critical location for the limit strength analysis of the Forward Latch Access Door is presented in Figures 11-15.

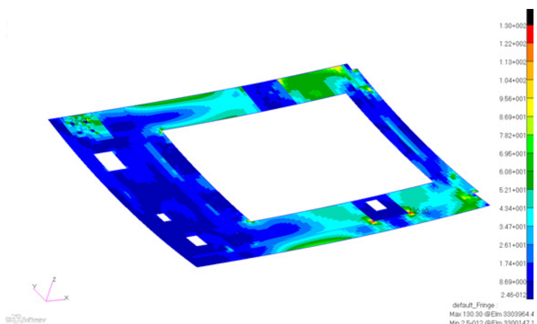

Figure 12. Fringe plot of von mises stress at Z1 – forward latch access door skin

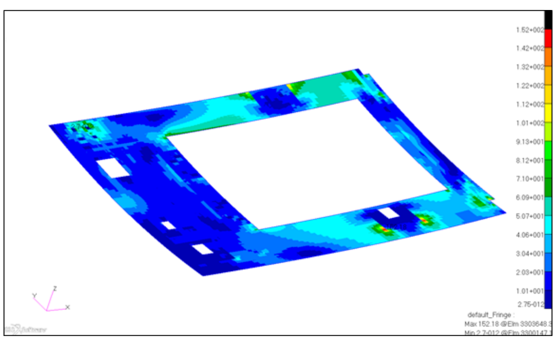

Figure 13. Fringe plot of von mises stress at Z2 – forward latch access door skin

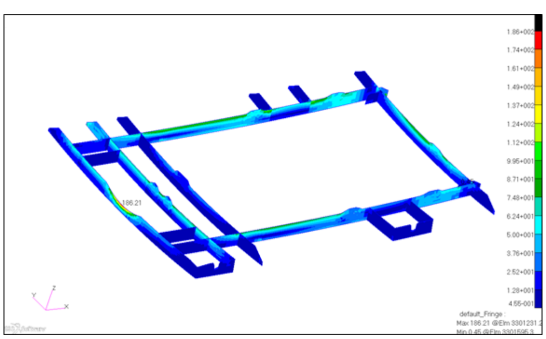

Figure 14. Fringe plot of von mises stress at Z1 – forward latch access door stiffeners

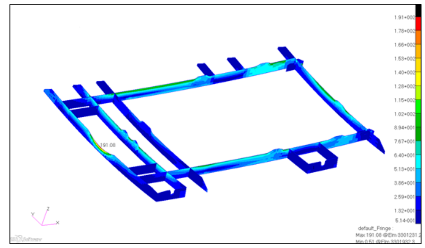

Figure 15. Fringe plot of von mises stress at Z2 – forward latch access door stiffeners

4.2 Combined Loading Strength Analysis

Von Mises (VM) stress results from the Closed LAP Assembly FEM for the Unit Burst Pressure condition for all of the Forward Latch Access Door skin and stiffener elements were surveyed to determine the most critical combined loading location. However, FEM stress results for varying thickness skin regions cannot be directly used due to the area-averaged modelled thickness for the elements (these skin regions are modelled with a constant thickness). The stresses for these areas of varying skin thickness were calculated using their shell forces and moments to more accurately account for the actual element thickness.

Both of the aforementioned methods are used for surveying Forward Latch Access Door VM stresses, but the critical stress was identified by the FEM stress survey of the stiffeners.

4.3 After Latch Access Door

The After Latch Access Doors were analysed and the resulting critical margins are presented herein for Limit and Ultimate (Critical MS for Maximum Pressure or Steady State). The critical location for the limit strength analysis of the After Latch Access Door is presented in Figures 16-20.

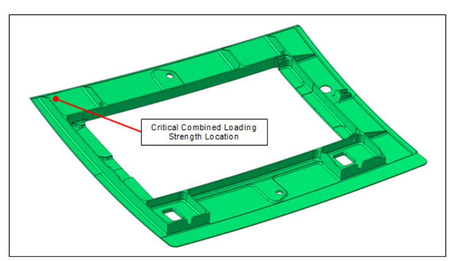

Figure 16. Critical limit analysis locations – after latch access door

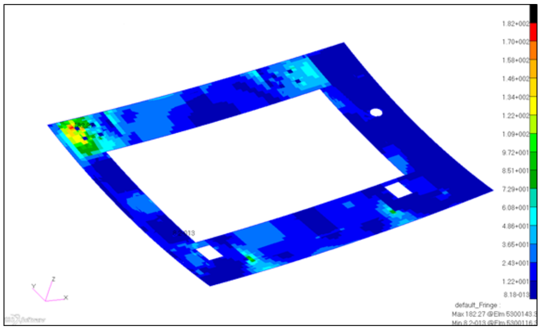

Figure17. fringe plot of von mises stress at Z1 – after latch access door skin

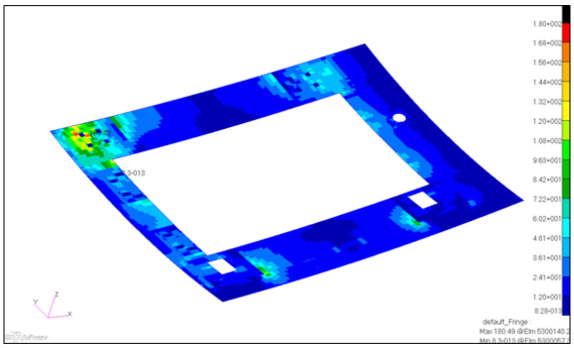

Figure 18. fringe plot of von mises stress at Z2 – after latch access door skin

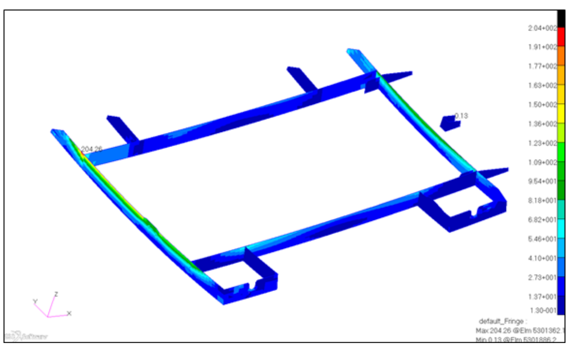

Figure 19. Fringe plot of von mises stress at Z1 – after latch access door stiffeners

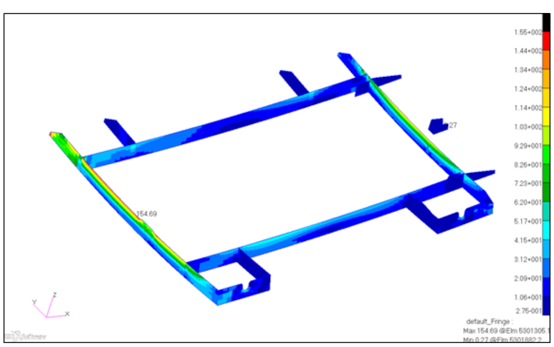

Figure 20. Fringe plot of von mises stress at Z2 – after latch access door stiffeners

4.4 Combined Loading Strength Analysis

Von Mises (VM) stress results from the Closed LAP Assembly FEM for the Unit Burst Pressure condition for all of the After Latch Access Door skin and stiffener elements were surveyed to determine the most critical combined loading. However, FEM stress results for varying thickness skin regions) cannot be directly used due to the area-averaged modelled thickness for the elements (these skin regions are modelled with a constant thickness). The stresses for these areas of varying skin thickness were calculated using their shell forces and moments to more accurately account for the actual element thickness.

Both of the aforementioned methods are used for surveying After Latch Access Door VM stresses, but the critical stress was identified by surveying the calculated VM stress results for the varying thickness skin regions.

5. Casting Converted Model

The proposal is to convert Latch Access Door (LAD) assembly from machined configuration to casting configuration. To pacify, the Latch Access Panel (LAP) and Pressure Relief Door (Pressure Relief Door) of the Latch Access Door assembly has been converted to casting configurations for investment casting with casting material Ti-6Al-4V Alloy Casting per AMS 4992.

5.1 Finite Element Model Description

The FE modelling approach for Latch Access Door assembly design with casted Latch Access Door and Pressure Relief Door is retained same as FEM approach followed for machined component. The Latch Access Door and Pressure Relief Door are meshed with new geometry and

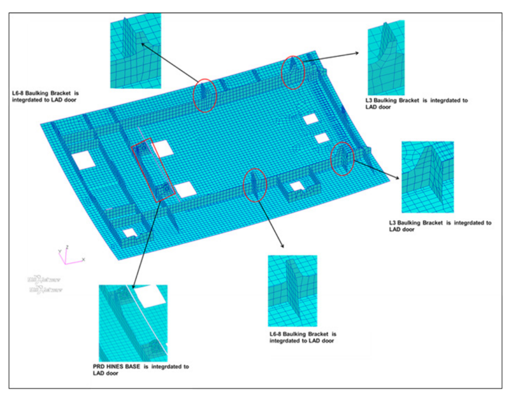

Figure 21. Forward latch access door and pressure relief door with casted parts

assembled with other Latch Access Door structure. Figure 21 shows the updated FEM model. Figure 22 shows the Forward Latch Access Door in which Pressure Relief Door hinge base, L3 baulking bracket and L6-8 baulking bracket are integrated part of Latch Access Door. Figure 22 After Latch Access Door and Pressure Relief Door with lanyard attach bracket and Pressure Relief Door hinge base is integrated to Latch Access Door and the loads remain unchanged for casting converted model.

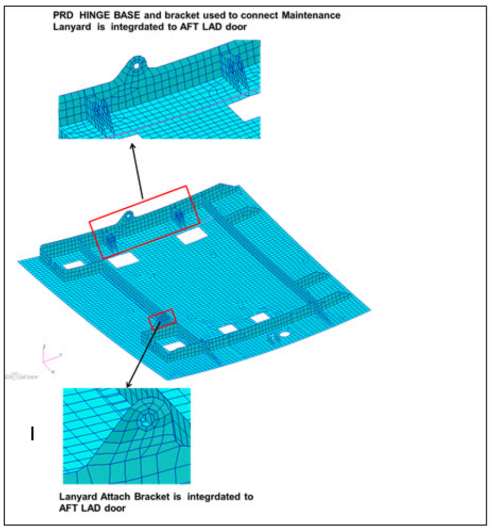

Figure 22. After latch access door and pressure relief door with casted parts

6. Results and Discussions

6.1 Static Analysis

The Forward and After Latch Access Doors were analysed using the same methodologies. The details of the analysis and sample calculations are given except for an additional factor for casting material will be used CF=1.5. Therefore only the resulting critical margins are presented herein for Limit and Ultimate (Critical MS for Maximum Pressure or Steady State).

6.2 After Latch Access Door

Load consistent Temperature for Max Burst Duct Pressure Case of 86.1°C is used in the combined loading strength analysis for skin to obtain positive MS in the critical Location. The critical location for the limit strength analysis of the After Latch Access Door is presented in Figure 23.

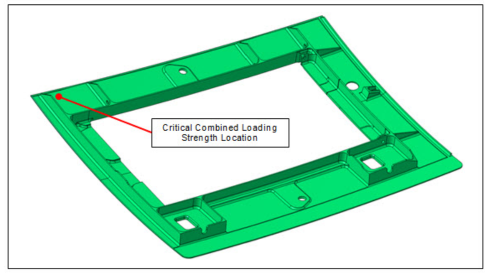

Figure 23. Critical limit analysis locations – after latch access door

6.3 Combined Loading Strength Analysis

Von Mises (VM) stress results from the Closed LAP Assembly FEM for the Unit Burst Pressure condition for all of the Forward Latch Access Door skin and stiffener elements were surveyed, but the critical stress was identified by the FEM stress survey of the stiffeners Figure 24.

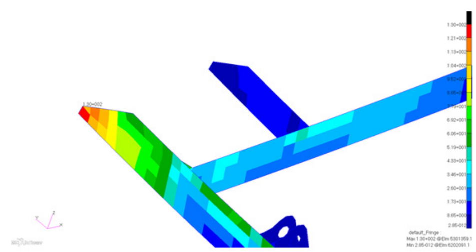

Figure 24. Fringe plot of von mises stress – after latch access door stiffener

6.4 Forward Latch Access Door

The Forward Latch Access Doors were analysed and the resulting critical margins are presented herein for Limit and Ultimate (Critical MS for Maximum Pressure or Steady State). The critical location for the limit strength analysis of the Forward Latch Access Door is presented in Figures 25-26.

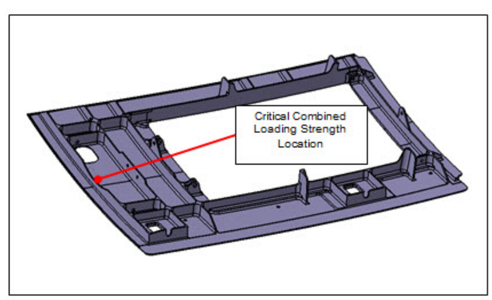

Figure 25. Critical limit analysis locations – forward latch access door

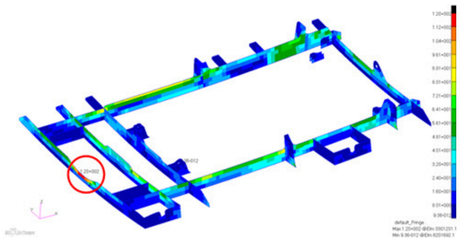

Figure 26. Fringe plot of von mises stress – forward latch access door stiffener

7. Conclusion

Based on the FEM static analysis results it is clearly shown that there is no critical condition in integrated portions of Latch Access Door panel stiffeners. The load acting on the Latch Access Door panel stiffener causes critical condition only on the predefined locations similar to the conventional model, and not affecting any integrated portions in Latch Access door panel stiffeners. So it is possible to conclude that the modified design is valid and can be proceed for further manufacturing in order to attain cost effectiveness.

8. References

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