



Fig. 28 Maximum Equivalent Stress at the Critical Time(@6.2ms)

5. CONCLUSIONS

This study presented an FSI analysis based on SPH simulating bullet impacts with a full-scale fuel cell assembly. The validity of the commercial software (LS-DYNA) for the application was demonstrated through numerical example. The behavior of the bullet was investigated by numerical results and the fluid pressure caused by the bullet impact and trajectory was calculated. Moreover, the maximum stress value was calculated and based on that data, vulnerable areas were estimated in each fuel cell.

Numerical analysis was performed for two cases, where the bullet impacted the fuel assembly perpendicular to its side, and from a 45 deg. angle. In both cases, the portion of the fuel cell where the bullet exited was severely damaged because the bullet was overturned in the process of penetrating the internal fluid. In the simulation result, it was estimated that the bullet could not penetrate the internal fuel cell skin to exit if its kinetic energy was reduced under 500J. Due to the creation of a hydraulic ram, the maximum stress primarily occurred on the top metal fittings. In detail, the maximum equivalent stress was calculated to be 321MPa in a side impact of the FT1 and 238MPa for the FWD. The maximum equivalent stress of the skin occurred around the top metal fitting of the FWD and its value was calculated to be 73MPa. Considering the results of the specimen test, it was estimated that the fuel cell skin was not damaged as a result of the bullet impact because it was capable of surviving twice that impact, i.e., that was its safety factor.

This study only performed numerical simulations considering a bullet impact to the side of the FWD and FT1 in the fuel cell assembly, and considering only bulkhead and fuel cells. However, there could be a much more severe case involving a bullet impact in the fuel cell assembly. Therefore, to improve the crew's survivability, various additional critical conditions need to be considered in the design of the fuel cell assembly. This study shows that there are various design parameters which can affect the bullet resistance capability of fuel cells. In the future, the reliability of the numerical simulations acquired in this study should be verified and, if necessary, the data correlation approach between the numerical simulation and actual test should be conducted. Moreover, this study will be extended to include estimations of bullet impact to a full-scale airframe coupled with an internal LRU and surrounding components.

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