Structural Design of Wing for Long Endurance Surveillance Plane

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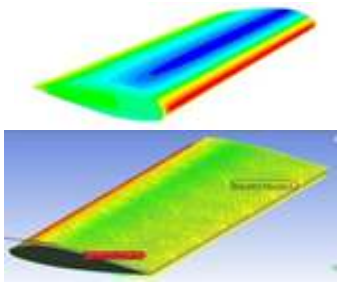
Abstract:

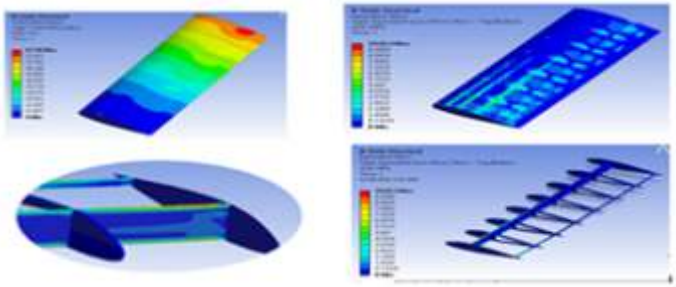
Wing which is the main lifting surface in aircraft is a complex arrangement of different structural members like wing spar, ribs and stringers. Designing the aircraft wing involves determining the loads, external shape, material selection, shaping, sizing and optimization of structure. Loads generated on wing are transformed to interior structure comprising of ribs and spars. These are designed based on the loads acting on a wing. In preliminary stage of design loads acting on wing are approximated as geometry would still be evolving. CFD computation and wind tunnel testing are used to generate actual loads only when the geometry is known to a degree of accuracy. Since maximum loads are generated at high angles of attack, wing structure behaviour at such angles of attack need to be studied.

The present work is on structural design of wing of long endurance surveillance plane. Loads acting on the wing were calculated based on estimated V-n diagram. In order to design the structural members, shear force and bending moment of wing are required and these were drawn. Ribs and spar were designed with analytical methods like wing idealisation and shear gradient methods respectively. CFD computation was done on wing at minimum and maximum angle of attacks and generated pressure loads were mapped on to the structure. Geometry was created in CATIA V5, meshing was done in ICEMCFD. Computations were done in Fluent and the generated pressure field was mapped on to the structure using ANSYS workbench. Balsa wood material properties were applied for wing.

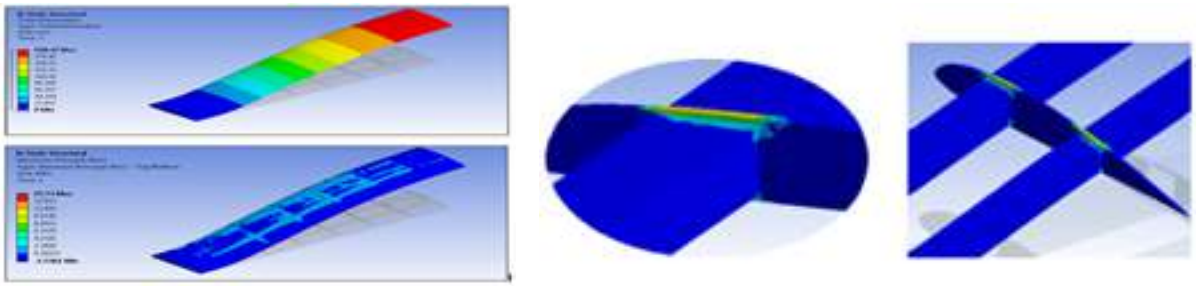
Grid independence study was done to choose an adequate grid for further computations. Pressure coefficient (Cp) distributions across the chord at different location on span were computed at different angle of attacks. Results from the numerical analysis were found to be accurate enough given the computational limitations. Deflection of wing at zero degree angle of attack is around 1.5% length of half span wing and at maximum angle of attack are around 19.8. In real aircrafts this value is around 26% length of half span of wing. Principal stresses acting on the structure were within the allowable limit. Stress concentration was observed at the joints of ribs and spar as expected.



CFD and transformation



Deformation and stress concentration in baseline model



Deformation and stress concentration in actual model