THE THERMO MECHANICAL BEHAVIOUR OF GLARE LAMINATES FOR AIRCRAFT ENGINE COWLING.

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Abstract - The main objective of this work is to design and fabricate the engine cowling system with effective composite thermal resistance coating material with low cost and high efficient. The configuration selection of cowling system and its dimensions are referred from Cessna 152 aircraft. Designing process is carried based on configuration selection using CATIA V5 R20 modelling software. After that, the computational investigation of heat transfer rate and temperature distributions of the Cessna 152 aircraft upper cowling system is carried using ANSYS 17.2 simulation software, the heat flux and heat transfer rate is found for three different materials like Aluminium Glare, Nickel Glare & Titanium Glare.

Keywords–Design, Computational Investigation, Heat Transfer, Thermal Resistance Materials

I. INTRODUCTION

The aircraft power plant system is composed of different elements working at various temperatures and in conjunction with the cowling system creates a space with high intensity of heat transfer to be covered by the ventilation or cooling systems. A cowling is the covering of a vehicle engine, most often found on automobiles and aircraft. It is a streamline metal housing or removable covering for an engine, often part or forming a continuous line with the fuselage or wing

A Cowling may be used:

- For drag reduction
- For engine cooling by directing airflow
- As an air intake for jet engines

The design and computational simulation on cowling system, surprisingly only few papers are devoted to this topic. For example, Wienczyslaw et al [2] presented the preliminary design process and numerical simulation for air intake and nacelle for I-23 aircraft. Piotr Lapka et al [3] presented the nacelle design and thermal heat transfer simulation for throughout the aircraft's flight. Additionally, the temperature and air mass flow rate inside the nacelle were determined and high temperature regions inside the nacelle were spotted. A Smaili et al [4] presented a two-dimensional axisymmetric numerical model for investigating the thermal behaviour of a wind turbine nacelle operating in a cold and in an extremely hot climate, respectively. Here, the configuration selection is done by studying Cessna 152 aircraft with FAR regulations. After that, the design work has carried out using CATIA V5. For the validation, Computational simulation is carried out using ANSYS 17.2 and its result shows, the maximum temperature spots and minimum heat transfer rate is found for three different materials like Aluminium Glare, Nickel Glare & Titanium Glare. These results may be helpful in developing new solutions for ventilation and cooling systems, which could reduce the temperature inside the cowling.

II. DESIGN OF COWLING SYSTEM

To design the cowling system, at first it is necessary to understand the aircraft configuration and its specification, the engine and its specification and the position of various accessories of engine. The cowling system is designed as per configuration of Cessna 152 aircraft

Fig 1 - Side view of Cessna 152 aircraft upper cowling

Fig 2 – Top view of Cessna 152 aircraft upper cowling

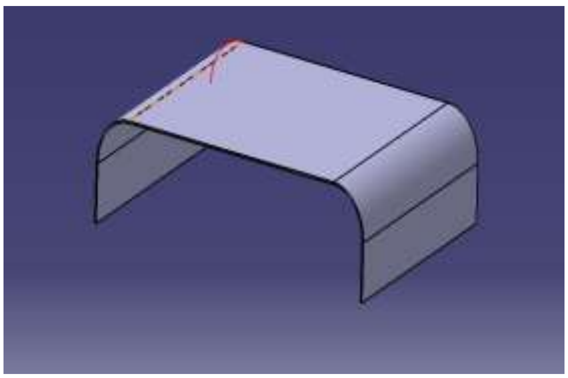

Fig 3 –Design of Cessna 152 aircraft upper cowling

III. COMPUTATIONAL INVESTIGATION

For computational study of cowling system, ANSYS 17.2. tool is used. The grid is generated using ANSYS – Workbench itself and post processing is carried in ANSYS FLUENT.
The computational study involves the following steps:

- Creating geometrical model
- Generating mesh
- Specifying the boundary conditions to the model
- Examining and visualizing results in FLUENT

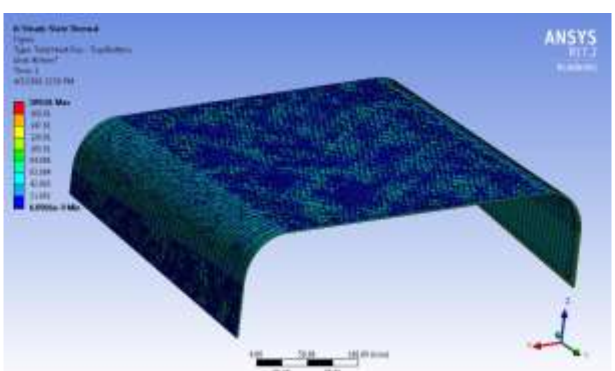

Fig 4: Temperature variation for Al – Glare Combination

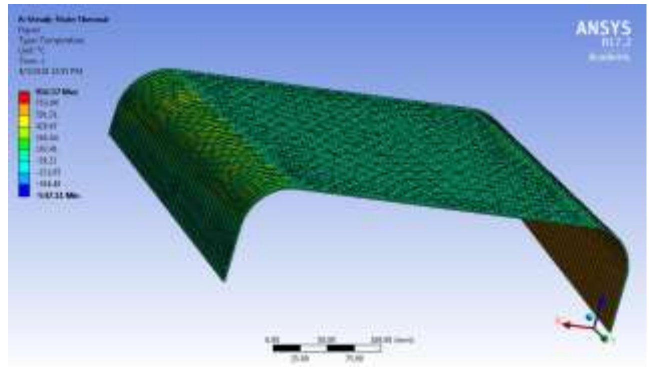

Fig 5: Temperature variation for Ni – Glare Combination

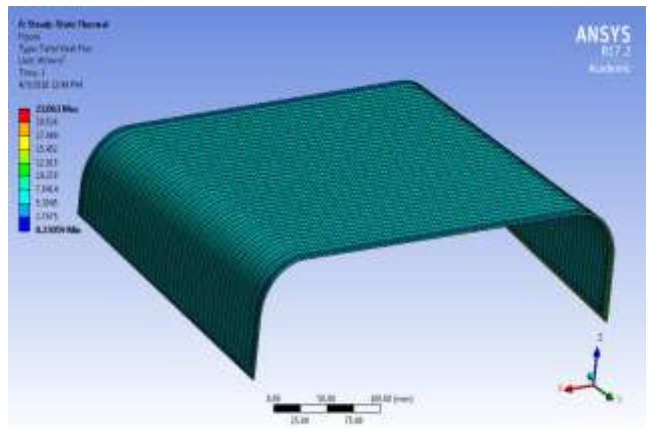

Fig 6: Temperature variation for Ti – Glare Combination

IV. Materials & Methods

Aluminium alloys have been used in many applications where structural lightness and corrosion resistance are important. They are also extremely good conductors of electricity but have a high coefficient of thermal expansion that makes them unsuitable for high temperature applications (example – Outer skin of high speed aircraft and engine components)

GLARE (glass-reinforced aluminium laminate) is a new class of fibre metal laminates for advanced aerospace structural applications. It consists of thin aluminium sheets bonded together with unidirectional or biaxial reinforced adhesive prepare of high-strength glass fibres. GLARE laminates offer a unique combination of properties such as outstanding fatigue resistance, high specific static properties, excellent impact resistance, good residual and blunt notch strength, flame resistance and corrosion properties, and ease of manufacture and repair. Fiber-reinforced metal laminates (FML) are hybrid composites consisting of alternating thin layers of metal sheets and fibre-reinforced epoxy prepreg. The most commonly used metal for FML is aluminium, and the fibres can be Kevlar or glass.

Another fiber-metal laminate is based on the combination of titanium and Nickel fiber/polymer composites (TiGr) & (NiGr) These laminates possess excellent properties of both metals and fibrous composite materials.

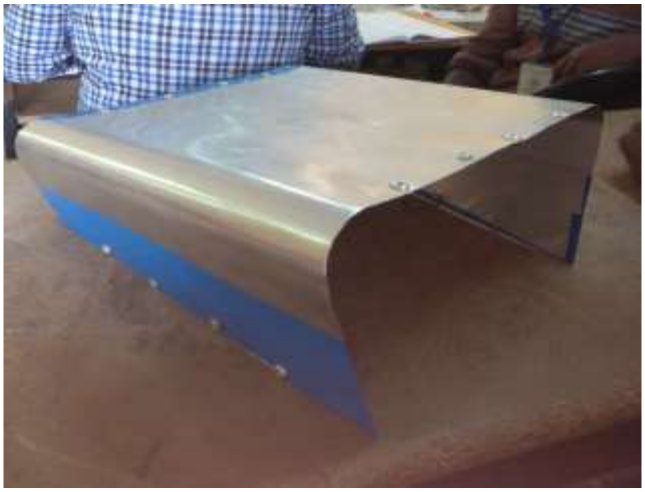

Fig 7: Fabrication of Cessna 152 aircraft upper cowling

Fig 8: Cessna 152 aircraft upper cowling with GLARE Coating

Heat Flux sensors HFP01 measures heat flux through the object in which it is incorporated or on which it is mounted, in W/m². The sensor in HFP01 is a thermopile. This thermopile measures the temperature difference across the ceramics-plastic composite body of HFP01. A thermopile is a passive sensor; it does not require power. It can be connected directly to commonly used data logging systems. A Heat flux sensor is a transducer that generates an electrical signal proportional to total heat rate applied to the surface of the sensor. The measured heat rate is divided by the surface area of the sensor to determine the heat flux.

Fig 9: Heat flux sensor - HFP01

V. Conclusion

s.no	case	Heat flex w/mm^2
1	Aluminum Glare	189.01
2	Titanium Glare	23.06
3	Nickel Glare	97.785

Configuration selection of cowling system:

- The configuration selection of cowling system is made by referring Cessna 152 aircraft.
- For proposed aircraft, the cowling parts like radiators position, cowl air intake and exit sizing were decided

Design of cowling system:

- The design work is carried as per configuration selection using CATIA V5 R20 modelling software.

Computational investigation on cowling system:

- The computational investigation of fluid flow and heat transfer in the engine upper cowling of the aircraft were performed in this work using ANSYS 17.2 simulation software.
- The geometrical model is discretised using ANSYS WORKBENCH solved using FLUENT tool.
- The total three cases with different material composition is simulated and it is observed that, the maximum Heat flux is 189.01 W/mm^2 over the upper surface of the engine cowling.
- This results shows that, the maximum heat flux rate of aluminium glare material is high compared to other two materials. Due to the high heat flux rate the high values of convective heat transfer over an upper cowling surface were also attained.

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