Deutsches Zentrum
für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

Master Thesis / Masterarbeit

Begin
From 09/2023 or later

Topic: Analytical solution of a 2D heat flux distribution in a glued single-lap joint

Background

As seen in DLR space projects – such as the compact satellite Eu:CROPIS or the small asteroid lander MASCOT – with very lightweight composite structures, the thermal sub-systems participate with a significant portion to the total mass. Also, the structural design itself is highly influenced by the need for additional thermal sub-systems.

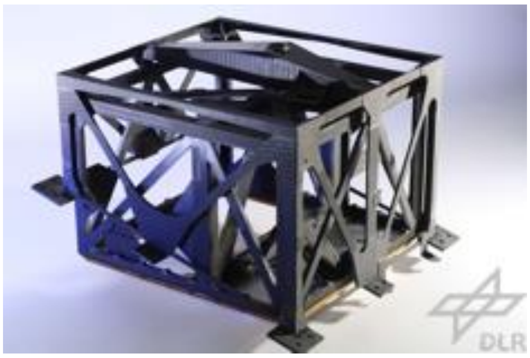

Figure 1: MASCOT primary structure

Thus, we investigate experimentally, numerically and analytically the effective thermal conductivity in primary structures with a special focus on glued joints. Once this will be completed a corresponding numerical simulation can be set up with improved parameters, which will help to consolidate the prediction of the structure's heat conduction capability.

Task

In previous work a single-lap joint was analysed numerically (cf Figure 2). This joint consists of two carbon-fibre reinforced plastic rods (thickness t_{lam}) that are glued over a length L_j with a glue of thickness ta. Applying a thermal flux Q at one end and holding the temperature T_{sink} at the other, results in a certain heat flux distribution in the glued joint (highlighted pink box). Next to the numerical solution, an analytical solution with simple boundary conditions is for this two-dimensional area in existence.

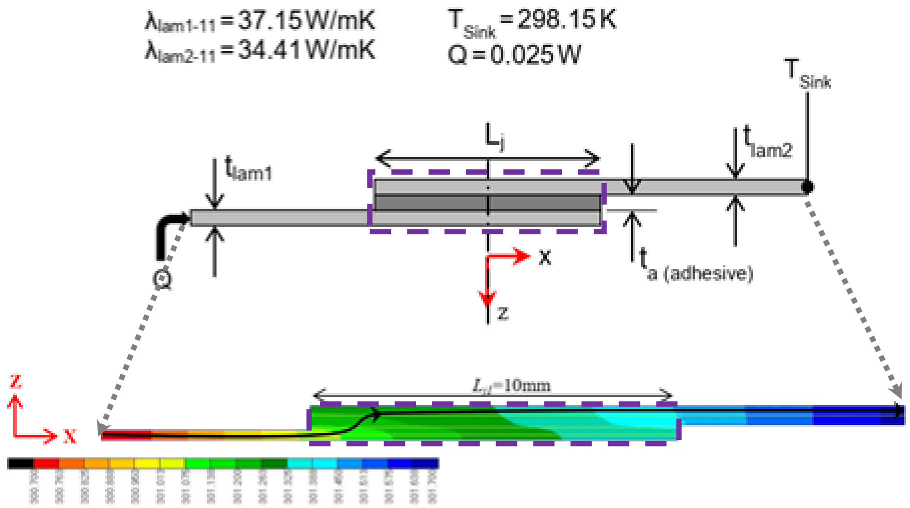

Figure 2: Definition of a single-lap joint and boundary condition, top. Simulation results of a temperature distribution in the single lap joint, bottom. The lilac highlighted box defines the area of interest for an analytical solution.

In a next step, and this is the goal of the thesis, the problem needs to be solved with more refined boundary conditions. This involves an existing Python program that supports in applying a Fourier series as boundary condition and plotting the resulting temperature fields in the jointed area as well as the corresponding heat flux distribution.

Steps

Specifically, the following points shall to be fulfilled:

- Getting familiar with the theoretical background of formulating and solving the partial differential equation for such a problem (2D Laplace)
- Formulating the Laplace equation and boundary condition for the single lap joint (neglecting the glue layer)
- Solving the Laplace equation
- Optional: Including the glue layer in the problem
- Summary and documentation of all results (English or German) and presentation of results at the Institute of Lightweight Systems/Institute for Partial Differential Equations

Qualifications

- Bachelor in mathematics/mechanical engineering/CES/physics or comparable
- Ability to work independently
- Basic knowledge in Python, but not mandatory
- Basic knowledge in partial differential equations

The Master Thesis will be conducted at the German Aerospace Centre (DLR), Institute of Lightweight Systems, Braunschweig and mentored by Dipl.-Ing. Michael Lange, Institute of Lightweight Systems as well as Prof. Dr. Dirk Langemann, TU Braunschweig, Institute for Partial Differential Equations.

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