College of Engineering, Design and Physical Sciences
Department of Mechanical and Aerospace Engineering

Optimization of hybrid composite-metal joints

Ruopu Bian

Supervising team: Bin Wang, Mayo Adetoro and Alireza Mousavi

Introduction

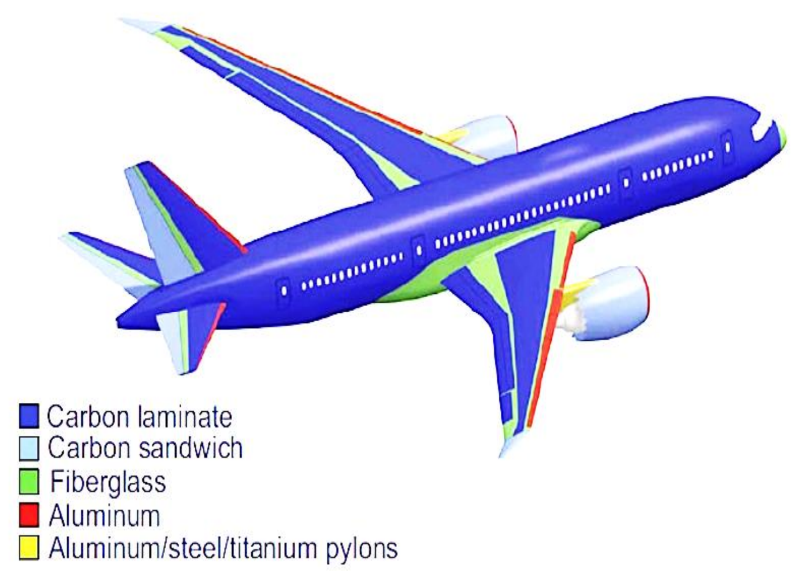

***Figure 1**: The ratio of materials used in Boeing 787[1]*

The increased use of composite and metal joints in aerospace industry has significant role in enhancing safety and reducing costs[2,3].This research focuses on new technologies of aircraft structural parts to regain their operational strength.

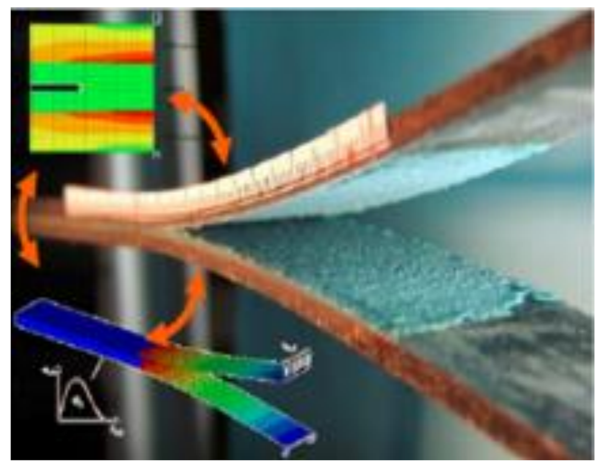

***Figure 2**: Adhesive bonding*

⇄

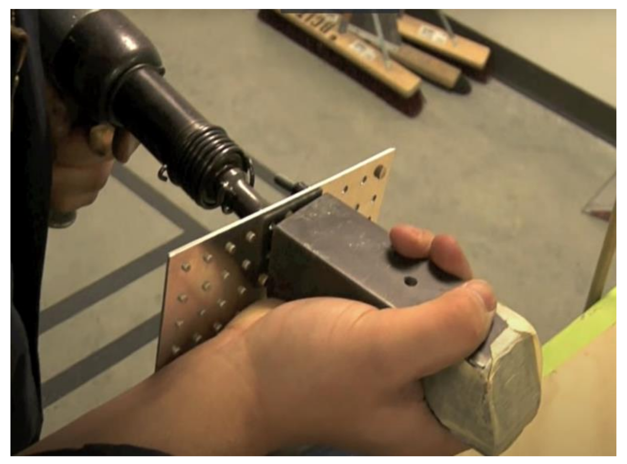

***Figure 3**: Riveting*

Adhesive bonding
- ✓ **Without any damage**
- × **Joint durability**
- × **Surface treatment**
- × **Condition requirements** (humidity and temperature)

Riveting
- ✓ **low cost**
- × **High stress concentrations**
- × **Low tensile and fatigue strength**

Methodology

- 1.FE analysis of metal to composite joints involving single and multi-pin matrix model with adhesive bonding.
- 2.Experimental study, e.g. 3D printing of structures and mechanical testings using advanced condition monitoring technologies. Focus will be on the failure mechanisms of such joints under various design and loading scenarios. (Next step)

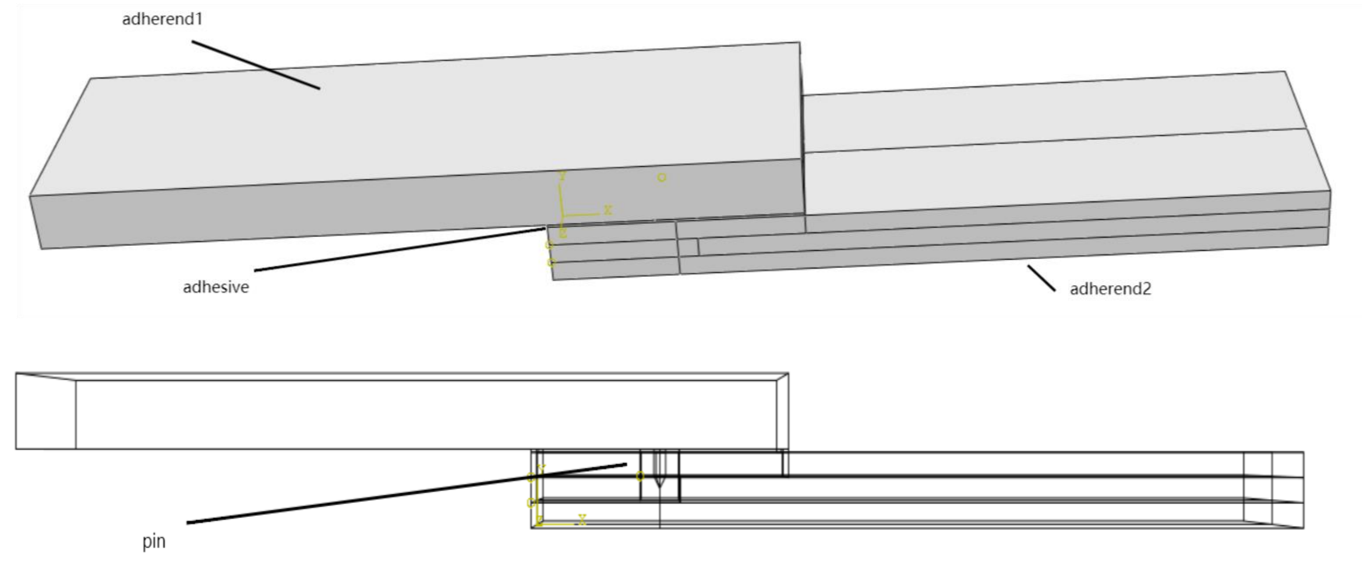

***Figure 4**: Model of metal(adherend1) and composite(adherend2) joints with 1 pin and adhesive bonding*

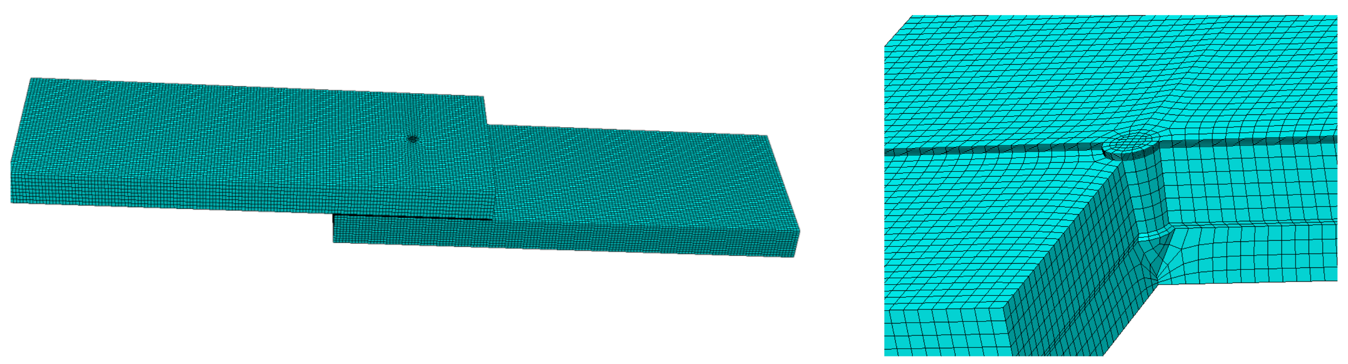

***Figure 5**: Mesh of the Model*

Results

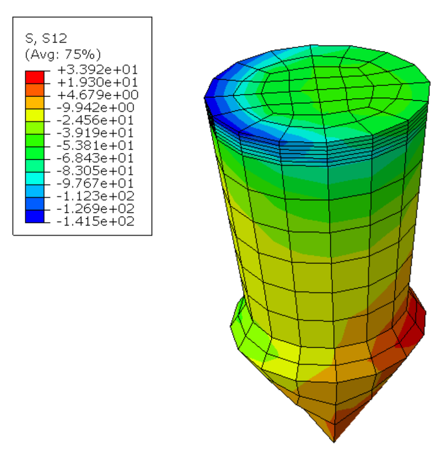

***Figure 6**: Shear stress of the pin*

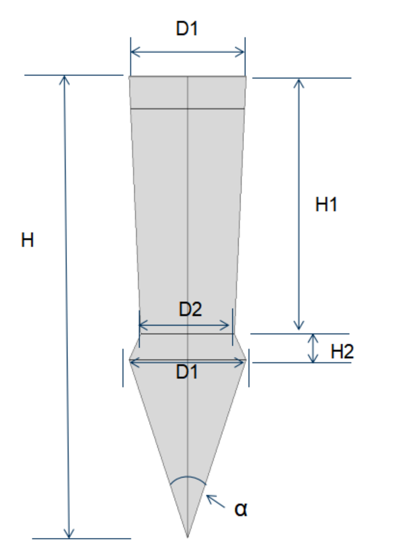

***Figure 7**: Parameters of 1 pin*

***Table1:** Sensitivity study of 1 shape pin 1 pin*

Sensitivity study(%) (Smax-Smin)/Smax*100%					
	D1	D2	H1	H2	H
ΔS12/S12Max	4.33	4.86	5.70	4.75	11.93
ΔS22Tensile /S22Max	2.13	2.90	2.46	2.20	3.07

***Table2:** Optimization of 1 pin*

Combined S12 and S22	Angle(°)	D1(mm)	D2(mm)	H1(mm)	H2(mm)	H(mm)
Best pin	60	2	1.6	1.5	0.2	3.43

- 1.The largest shear stress in the pin is at the cross section between the bottom of the pin and the metal plate.
- 2. The total height of pin has great influence on the shear stress(S12) in pin and S12 decreases with the increase of the height. For axial stress(S22), the shape of pin (especially the angle) has a greater effect on it.
- 3. By optimizing the shape of pin, the shear stress and axial stress are reduced.

Future work

- 1.The future work will be multiple pins in rows and matrix for joint design optimization involving aluminum and titanium alloys and carbon fibre reinforced composites.
- 2. Experimental study using additively manufactured pins will also be conducted.

References

- [1] Gohardani AS, Doulgeris, Singh R. Challenges of future aircraft propulsion: A review of distributed propulsion technology and its potential application for the all electric commercial aircraft. Progress in Aerospace Sciences 2011; 47(1): 369-391.
- [2] Huang, Y., Wang, J., Wan, L., Meng, X., Liu, H., & Li, H. (2016). Self-riveting friction stir lap welding of aluminium alloy to steel. Materials Letters, 185, 181-184.
- [3] Wang, H., Yuan, X., Li, T., Wu, K., Sun, Y., & Xu, C. (2018). TIG welding-brazing of Ti6Al4V and Al5052 in overlap configuration with assistance of zinc foil. Journal of Materials Processing Technology, 251, 26-36.

Email: ruopu.bian@brunel.ac.uk