On The Analysis of a Contact Friction Composite-To-Metal Joint

Costache, Andrei; Anyfantis, K. N.; Berggreen, Christian

Publication date:
2015

On The Analysis of a Contact Friction Composite-To-Metal Joint

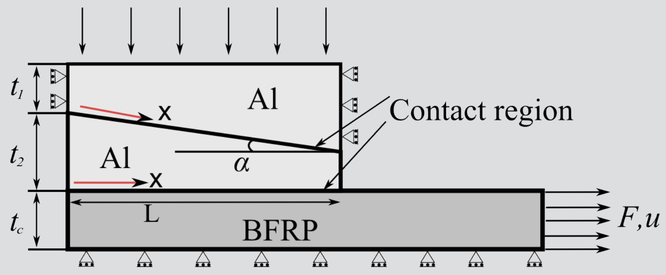
{A.Costache, K.N.Anyfantis, C.Berggreen}
{DTU Mechanical Engineering}@DTU.dk

Contribution

We introduce a method to anchor fiber reinforced composites with a rectangular profile in a friction-type wedge. The challenge is to obtain sufficient pullout force without the use of crimping. A FEM model has been used to perform geometrical parameter analysis, resulting in an optimal wedge geometry.
This anchoring system is applicable to any kind of FRP material and has been evaluated numerically and with actual pullout tests.

Model

The model consists of two aluminum wedges placed on each side of the FRP material. Initial external pressure is applied with the help of an outer case. Boundary conditions allow for the vertical displacement of the top wedge and the horizontal movement of the FRP strip. The tilt angle influences the pressure distribution in the Al/FRP interface.



By optimizing the geometry it is possible to achieve as uniform as possible pressure distribution, while at the same time allowing the wedges to further slide and increase pullout force.

FE analysis

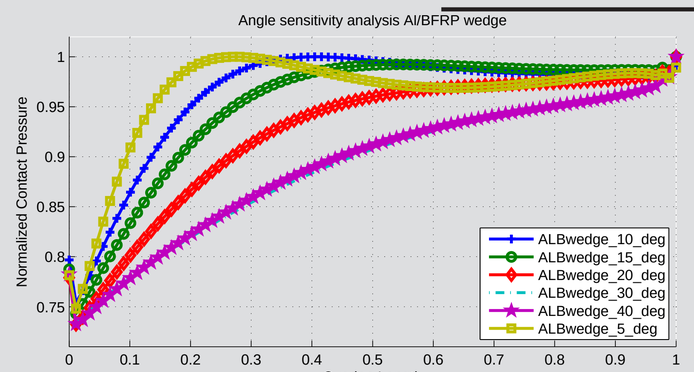
FE analysis has focused on investigating the effect of tilt angle, overlap length and response of the model. The resulting geometry dimensions have been used to analyze the pressure distribution in the interface during pullout.

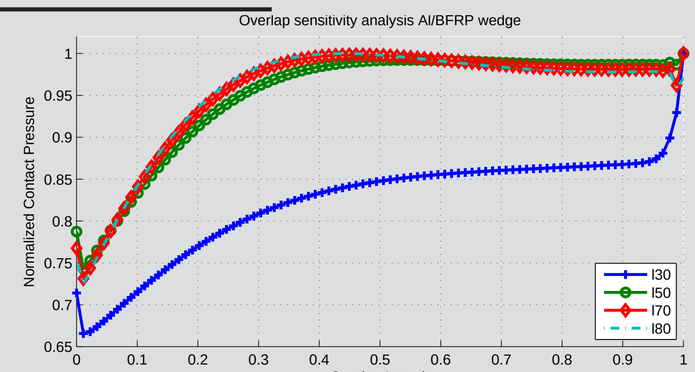
References

[1] A. Prenleloup, T. Gmur, J. Botsis, et.al. Acoustic emission study and strength analysis of crimped steel-composite joints under traction. *Composite Structures*, Vol. 74, No. 3, pp 370-378, 2006.
[2] A. Al-Mayah, K. Soudki, and A. Plumtree. FEM and mathematical models of the interfacial contact behaviour of CFRP-metal couples. *Composite Structures*, 73(1), pp. 33-40, 2006.

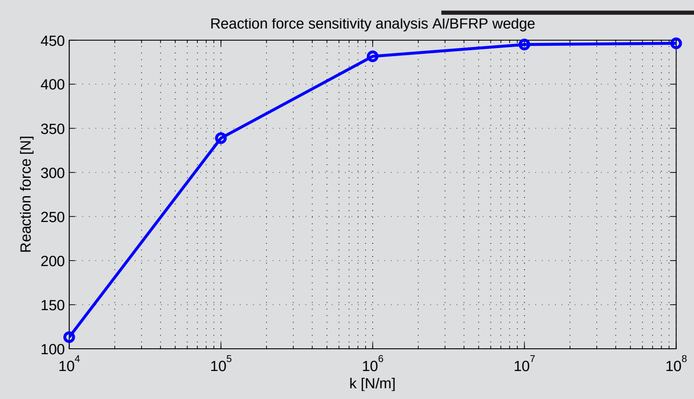
Results

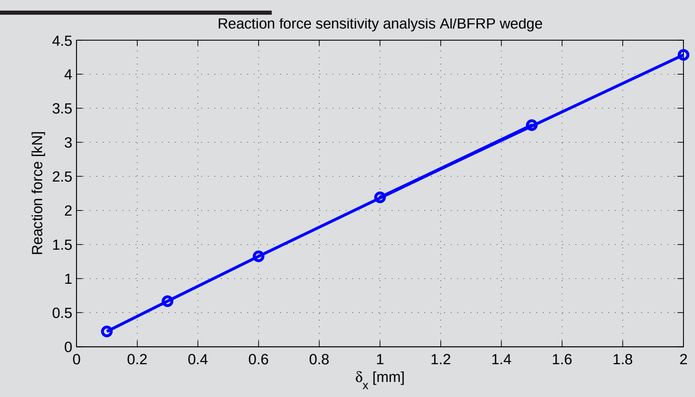
Parameter screening has been done with regard to the effect of the pressure distribution in the Al/FRP interface. This interfacial pressure distribution shows great sensitivity for the tilt angle. The joint shows less sensitivity with regard to overlap length, at an optimal tilt angle of 15°.



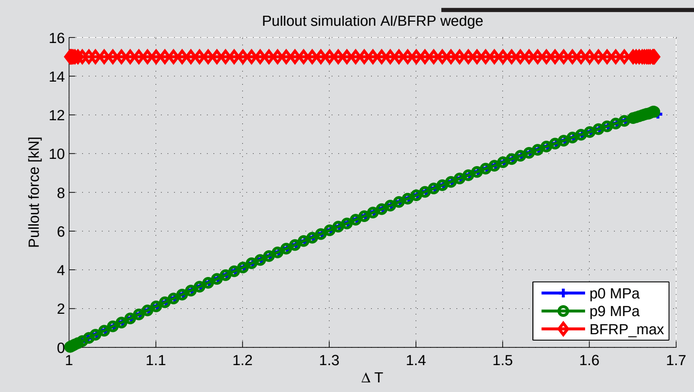


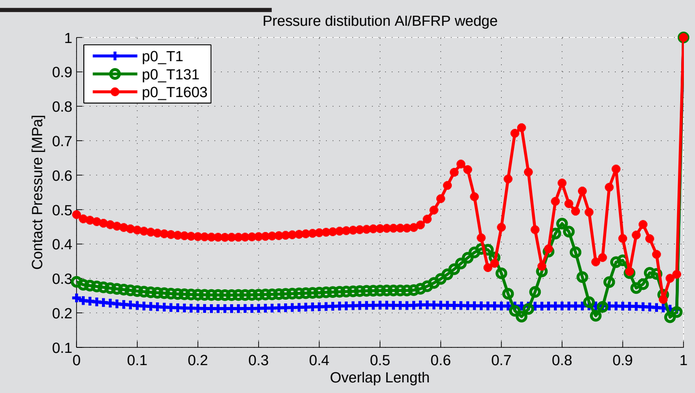
Pullout tests have been used to estimate the necessary stiffness of the outer case. The increase in pullout force is linear with regard to applied displacement.





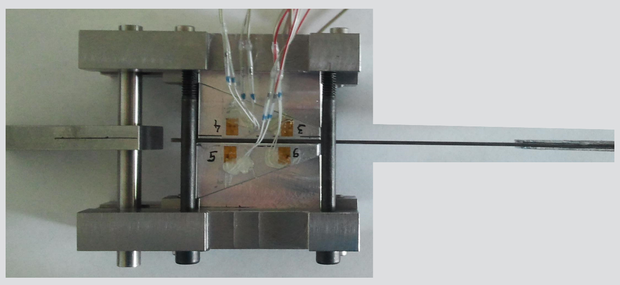
Several tests have proved that in ideal conditions pre-clamping pressure does not influence the strength of the anchor.





During pullout the FRP strips will start to slip out of the anchor. The area in which this this takes place can be estimated by looking at the interfacial pressure over several time steps.

Test Setup



A test rig is used for model validation. Several wedge configurations can be tested and compared compared to numerical results. Pre-clamping pressure and strain levels can be monitored during the test. Preliminary test results have achieved pullout values lower the ones estimated with the FE model.

Future Work

- Use experimental methods to evaluate assumed material properties.
- Match FE results and experimental ones.
- Expand to a 3D modell to check through thickness stresses.
- Use DIC to evaluate wedge displacement and stress in the FRP strips.
- Expand to fatigue testing.

Contact Information

Andrei Costache
DTU Mechanical Engineering
+45 45251391 // ancos@mek.dtu.dk

Acknowledgment

The guidance and support from Kristian Glejbøl, from National Oilwell Varco Denmark I/S, Floating Production | Flexibles, as well as the economic support from the Danish Agency for Science, Technology and Innovation are gratefully acknowledged.