Hybrid Composite to Metal Joining for Naval Vessels

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References

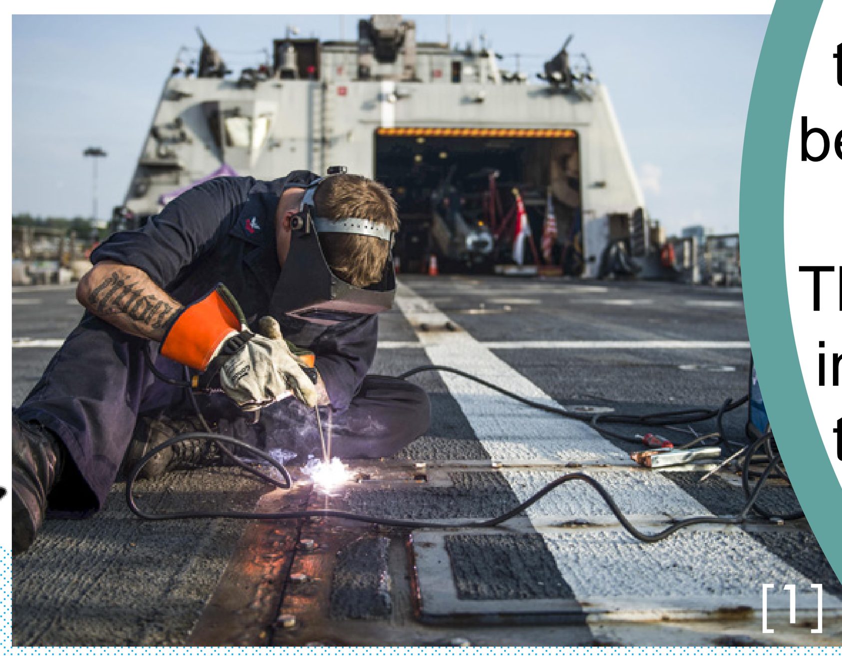
[1] Red-D-Arc, "Air Arc Gouging Saves the Navy Time and Money," Shipyard Welding Red-D-Arc Welderentals, 23 Oct 2017. [Online]. Available: https://blog.red-d-arc.com/specialty-equipment/naval-shipyard-arc-gouging/.
[2] "Development of a Thermally-Assisted Piercing (TAP) Process for Introducing Holes into Thermoplastic Composites", *Eng.D. Thesis*, University of Surrey, 2016.
[3] Dance B G I and Kellar E J C: 'Workpiece Structure Modification'. International Patent Publication Number WO 2004/028731 A1.

1) Project Aim

The aim is to design and develop a strong composite to metal joint for naval vessels. The design is based upon use of the numerical models to simulate the hybrid joining process in order to provide a strong basis for the informed decisions for the design of the metal to composite joints.

2) Why Do We Need Hybrid Joints For Naval Vessels?

It has long been a goal to produce a composite naval superstructure containing a metallic edge that can be easily welded to a metal decked vessel using conventional shipyard welding techniques such as arc welding. Our project produces the technique to effectively join metal to composite, so that the abovementioned metallic edge structure can easily be produced, and thus reduces the weight of the vessels.



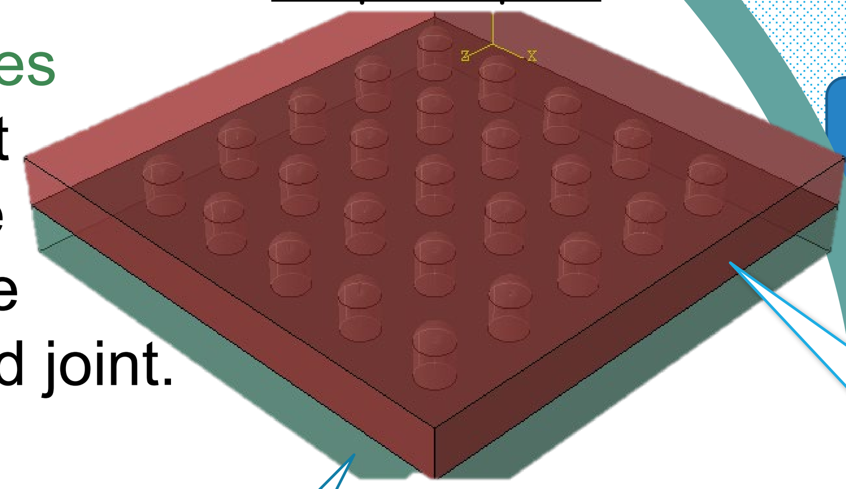
Conventional arc welding

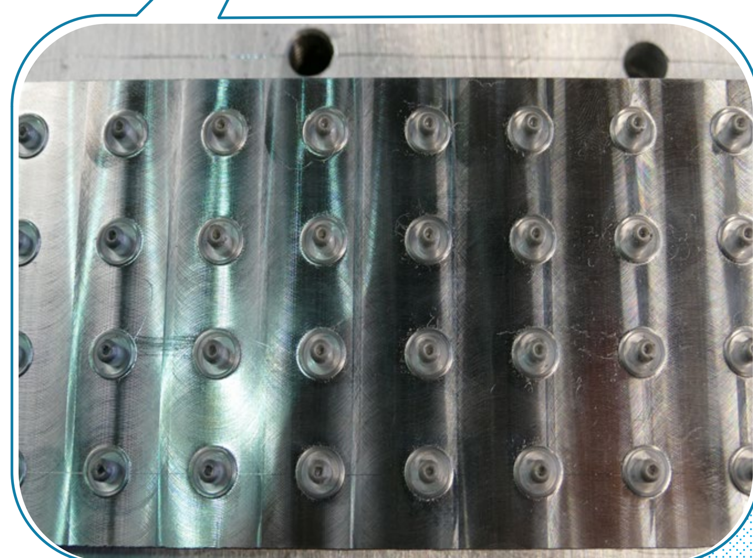
What is the hybrid composite to metal joint of interest?

The hybrid joint we have proposed re-shapes the metal base plate by protruding stud from it as shown below. The protruded metal parts are then pressed into the dry fibres of the composite before it is submerged into matrix to form a hybrid joint.

The traditional methods damage the reinforcing fibres in the composite. For this joint, it is formed before the matrix is poured. Fibres are pushed away by the protruded metal parts instead of broken by connectors, which maintain the strength of the composite, providing strong hybrid joints. Lastly, as the protruded metal parts are formed from the base metal plate, no additional weight is added to the structure.

Composite plate

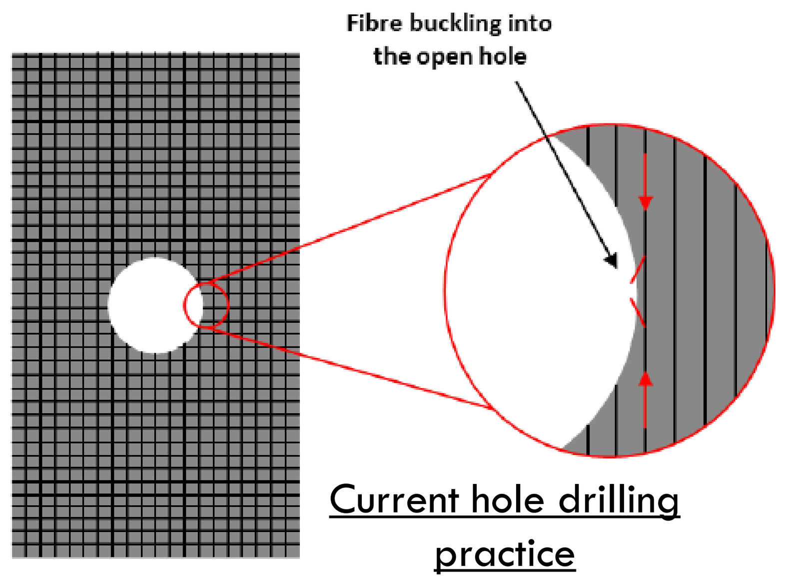




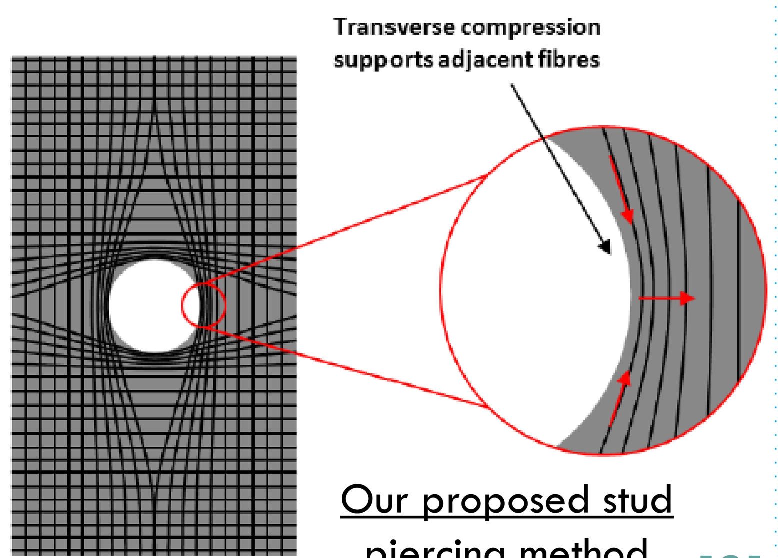
Metal plate with RFSSW studs

3) Current Industrial Practice

Traditional metal to composite joining methods, such as bolted and riveted joints, introduce additional weight to the structures. To use those connectors, holes are formed in composite, which breaks the load carrying reinforcing fibres and weakens the area.



Current hole drilling practice

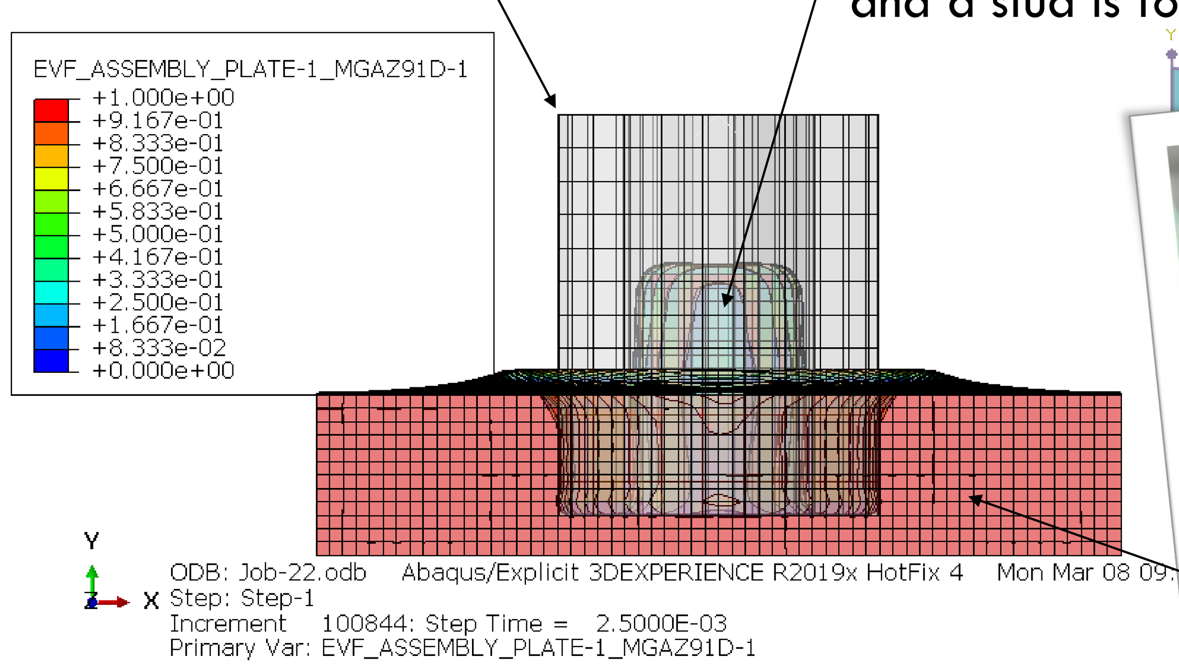


Our proposed stud piercing method

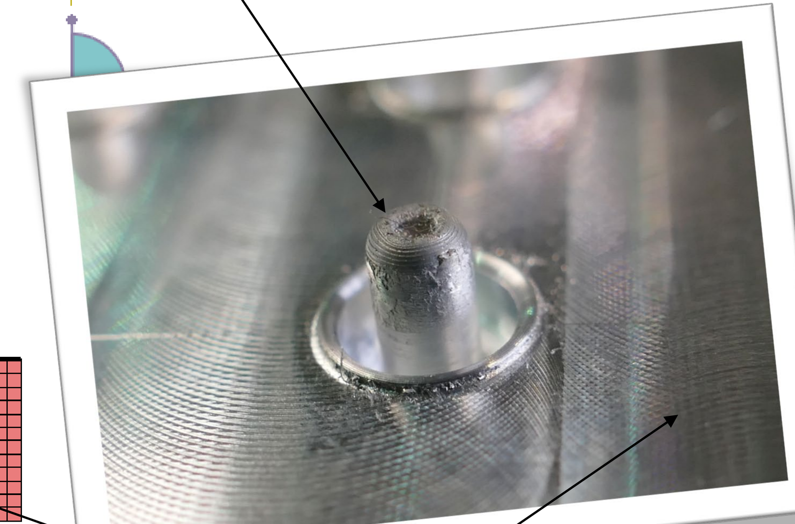
[2]

4) Metal Stud Simulation

The metal protrusion process is simulated using Coupled Eulerian Lagrange model. Pictures on the right show the process and its simulation. As the sleeve rotates downwards into the base plate, the metal is molten and pushed upwards inside the sleeve, forming a metal stud when it cools down. The stud is then pushed into the reinforcing fibres, forming a hybrid joint.

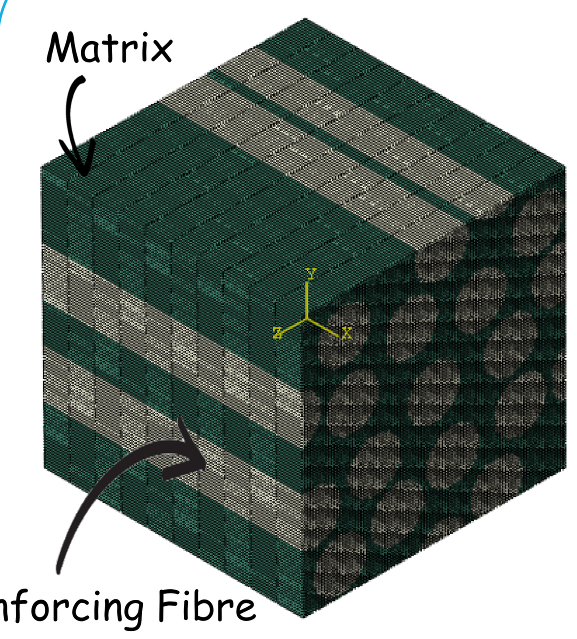


Numerical model simulation the metal stud forming process



Metal stud forming process

5) Fibre Reinforced Composite Simulation



Numerical model of the microstructure of the fibre reinforced composite

The strength of composites is largely dependent on the arrangement of their reinforcing fibres, which can be simulated using Unit Cell Model. Thus, we can quickly and easily obtain the mechanical response of the composite to the intrusion of the metal studs and the overall strength of the hybrid joint.

6) Conclusion

The preliminary simulation results indicate a promising potential of the stud forming technique to join metal to composite, which provides good information to fulfill the industry's growing interest in hybrid joining. The following work will focus on the investigation of the influence of the metal studs on the fiber volume and distribution.

Cross section of a Comeld™ joint

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