Embedded Inserts for Mechanical Joining of Thermoplastic and bio-Composites

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Mechanical Joining of Composites

Mechanical fasteners are vastly used in composite structures e.g. connecting parts, attaching components/equipment to panels etc.

- **Benefits**: enable assembly/disassembly of components.
- **Drawbacks**: mechanical weak point, manufacturing challenging.

Types of Mechanical fasteners

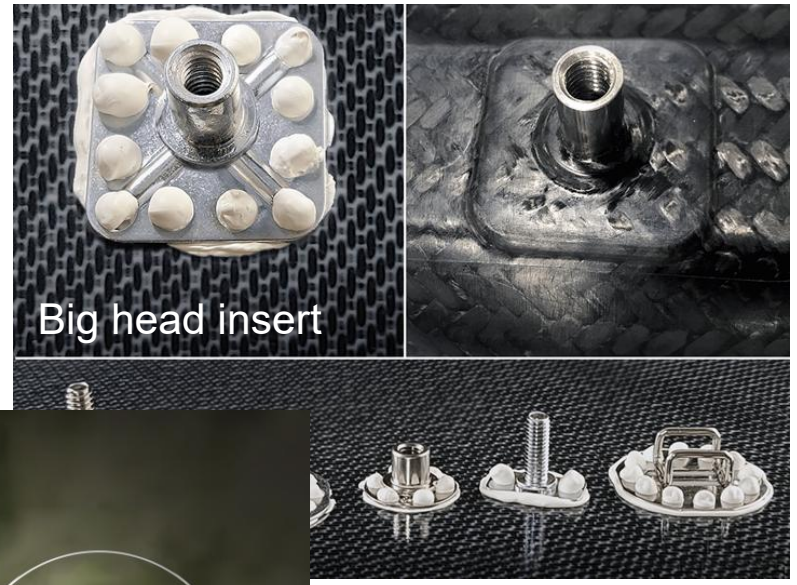
Types of fasteners for composites may be found in a vast number of materials, types, mounting process.

Types:

- Surface mounted
- Integrated into the laminate.

Mounting process.

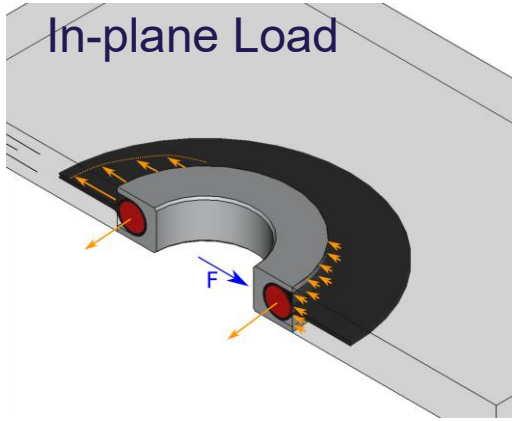
- machining -> bonding after curing.
- Embedded during composite layup process.

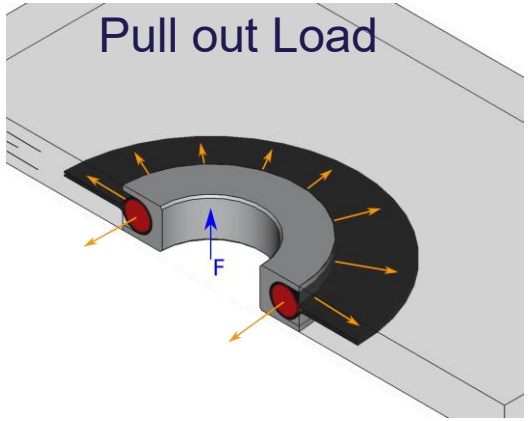


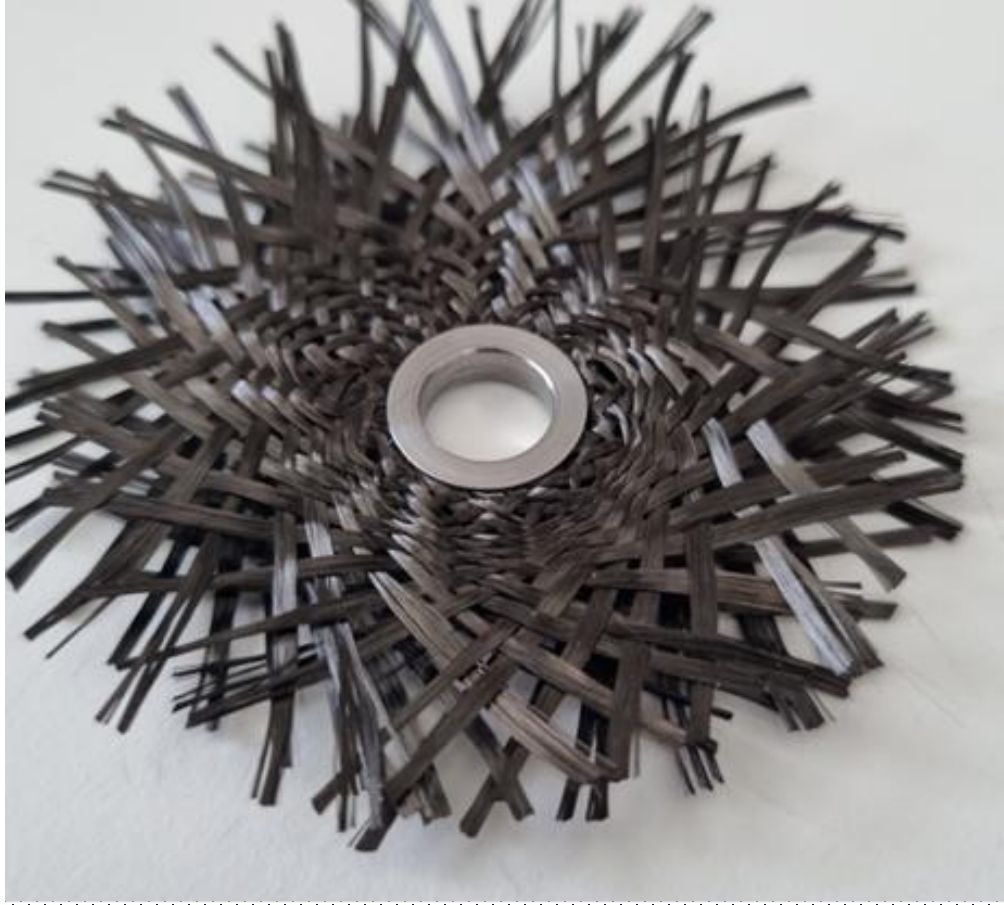
Topics

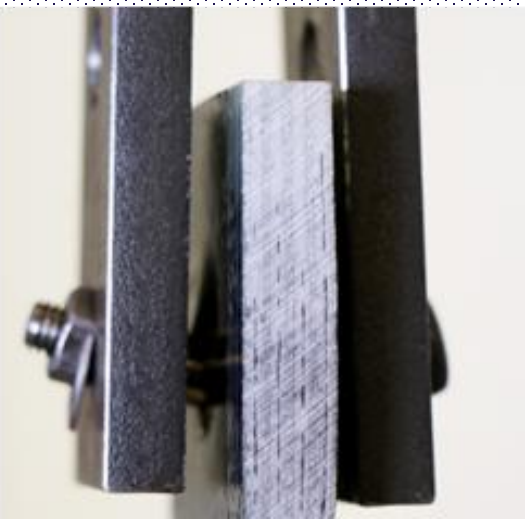
- A Fly into our Patch-technology
  - Some application examples
- Current work on thermoplastic patch integrations

Working Principle of the Patch-technology





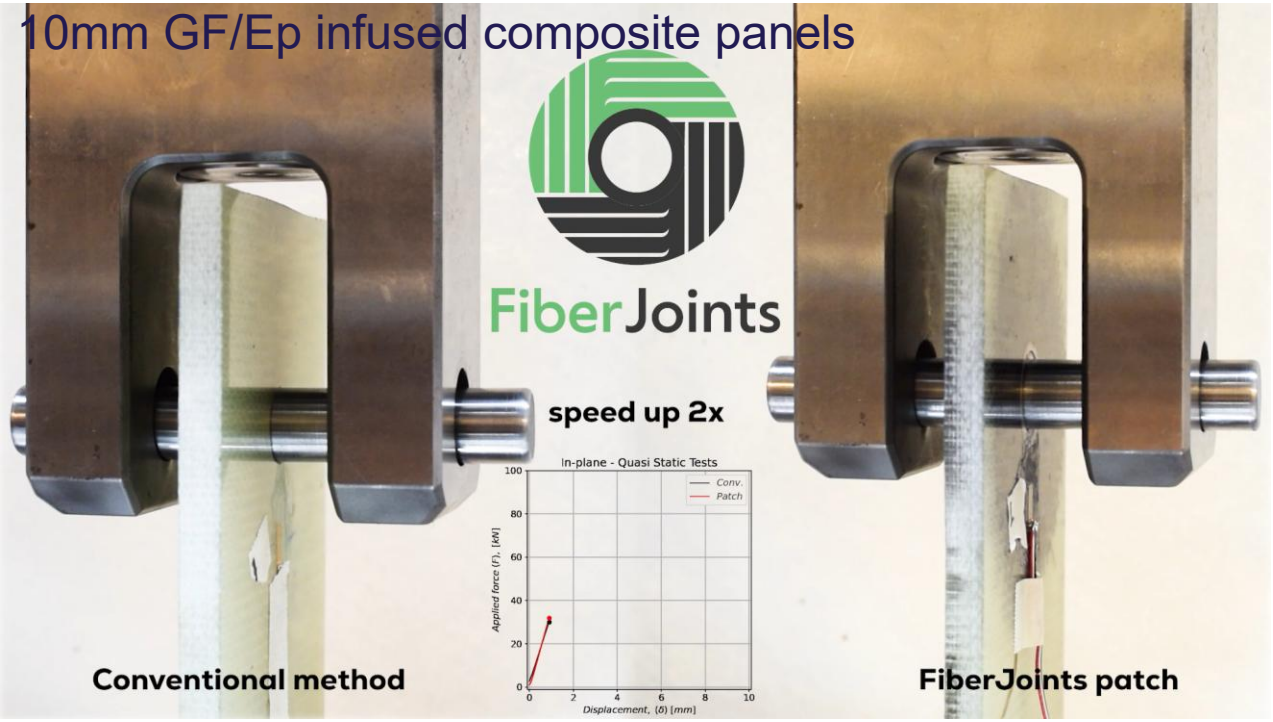




Machanical testing of Thermoset based composites with embedded Patches

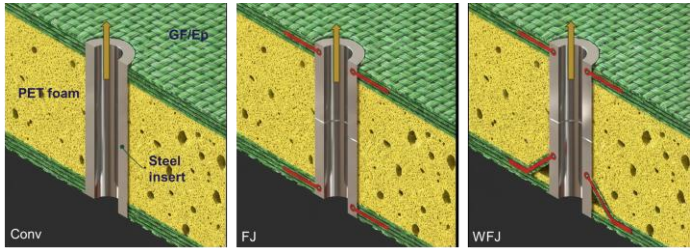
- A selection of mechanical test results.
- The effect from the patch is reflected in the mechanical performance of the joint.

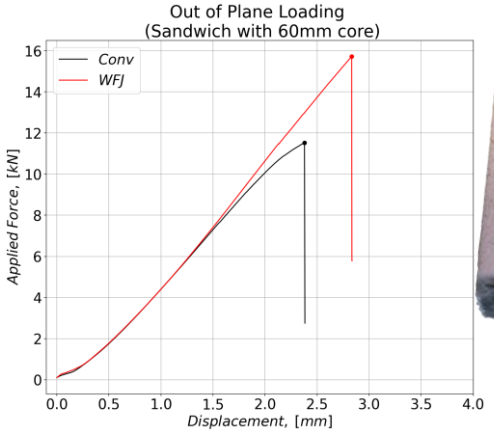
10mm GF/Ep infused composite panels

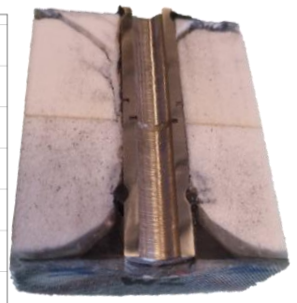


5mm CF/Ep prepreg panels loaded in-plane and out of plane to failure

65mm GF/Ep/PET core sandwich panels pull-out loaded to failure







Boss System for Pressure Vessels

Type IV pressure vessels (polymer liner + composite reinforcement.

Purpose: to storage pressurized gas

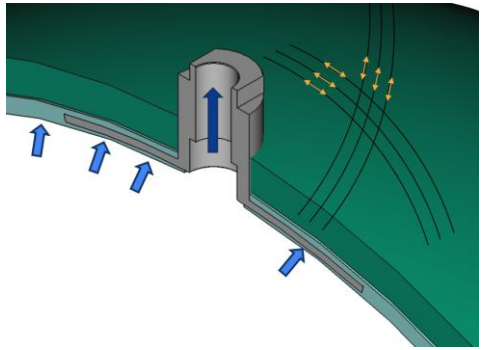
Benefits:

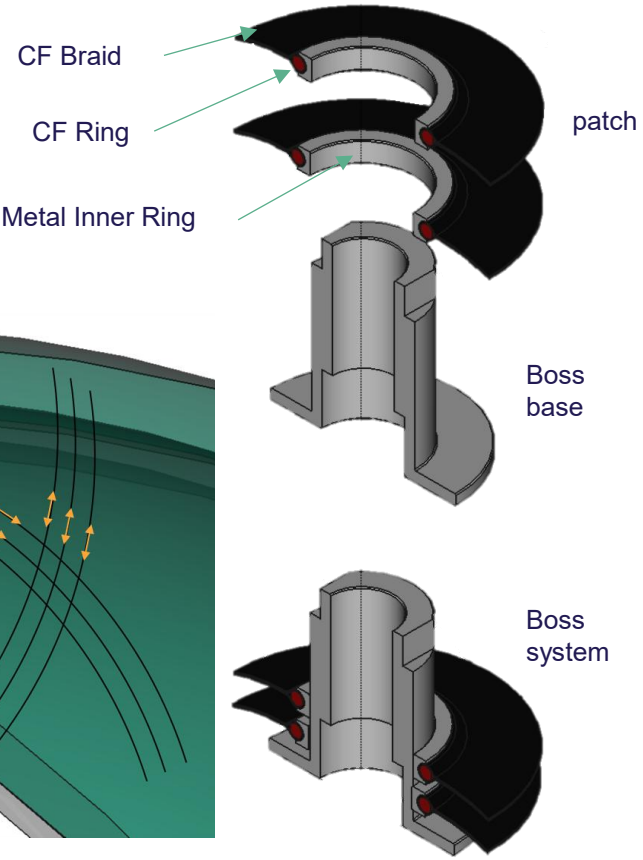
- Lightweight design
- Automated manufacturing.

Challenges:

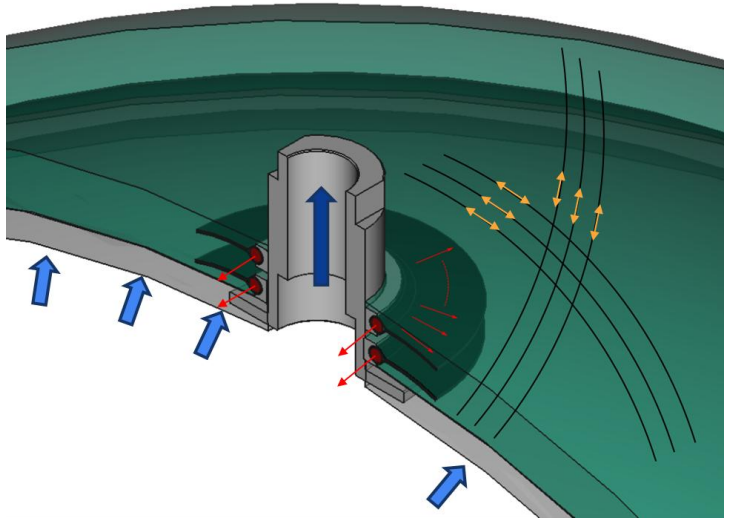
- Large heavy boss systems
- Expensive Bosses

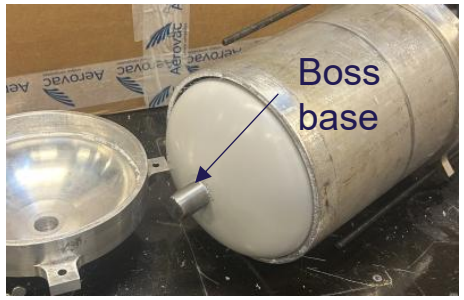
Conventional Boss





FiberJoints Boss System

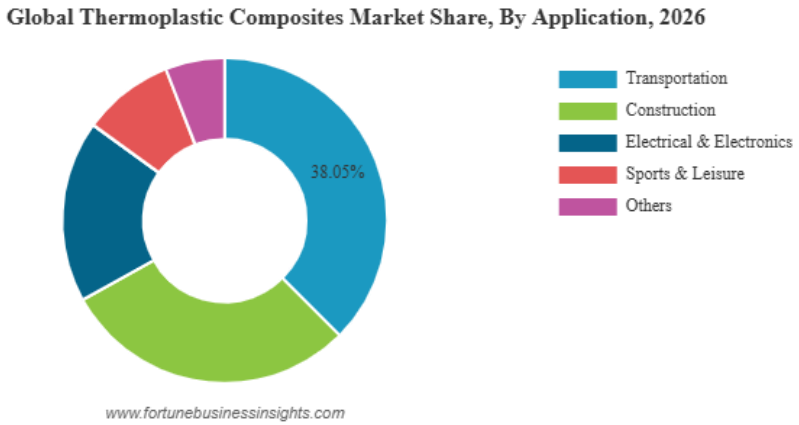




New Challenges

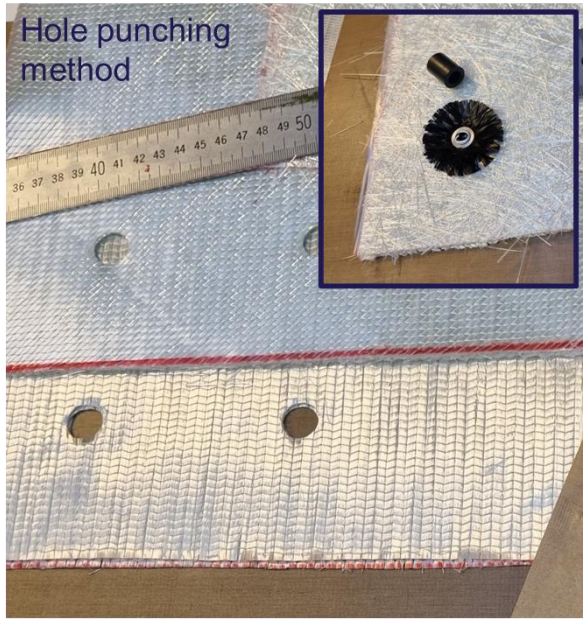
Thermo-plastic market outlook

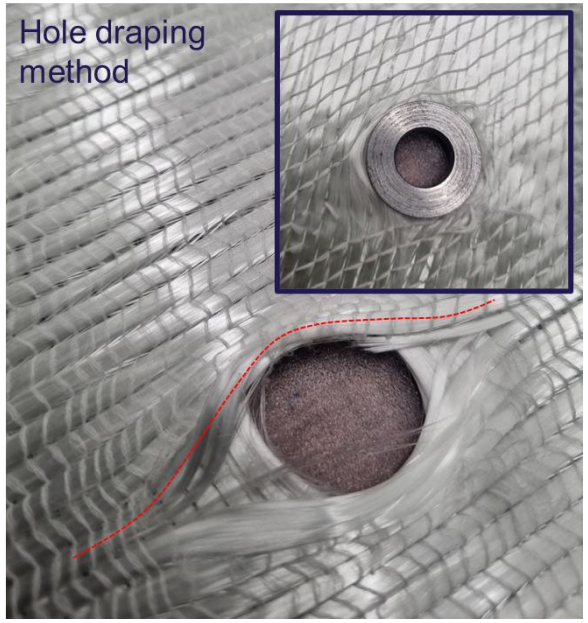
- market size was valued at USD 33.97 billion in 2025
- Expected to USD 70.94 billion by 2034, exhibiting a CAGR of 8.4%



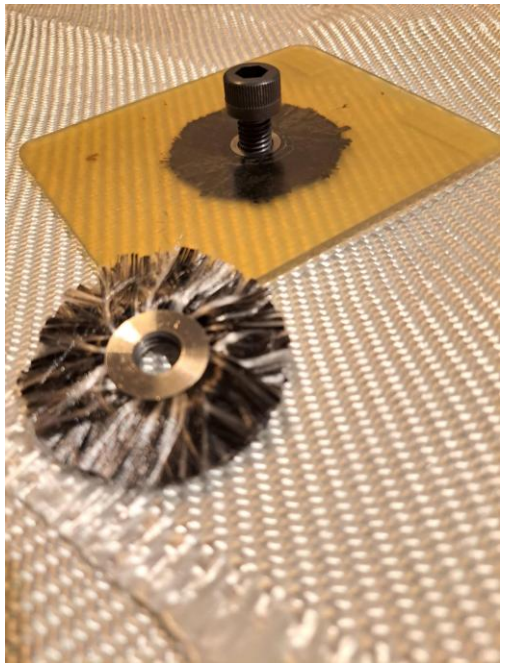
New technical challenges for the patch-technology

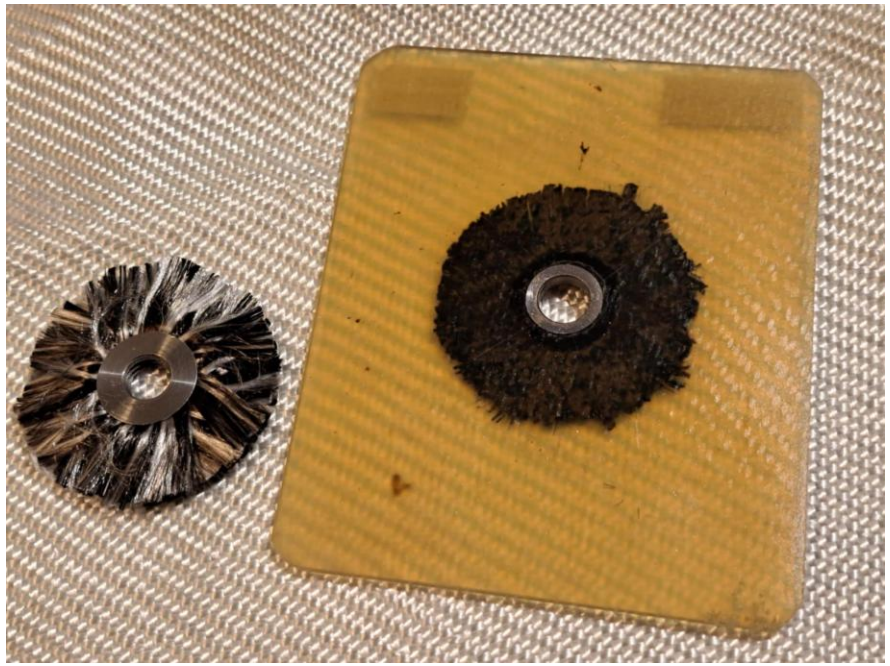
- Proof feasibility for thermo-plastic material systems
- Alternative method to hole punching (explore hole draping)



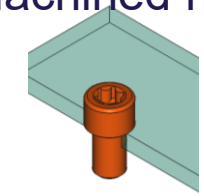


Work on Thermo- Plastic Based Patch Integration

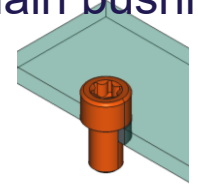




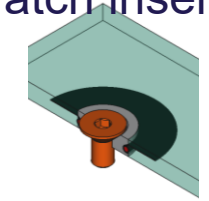
Machined hole



Plain bushing



Patch insert



A Pilot Project is carried out to investigate the applicability of the patch technology as fastener system for thermo-plastic based material systems.

Material system:

- Fabric: GF/PETG, 750g/m2, ~50% GF, weave | (Comfil)
- Patch: CF/PETG, ~3K yarn, 50% CF. co mingled w PETG fillaments | (Comfil)

Processing:

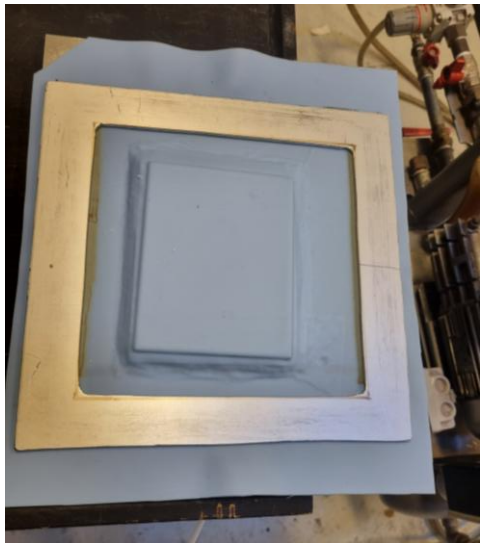
- Stacking fabrics and embedding patches [10 to 12 plies, yield 4.5 – 5.0mm consolidated laminate thickness].
- Vacuum backing
- Temperature settings
  - Drying stage @120C for 30min
  - Consolidations stage 220C for 120min

Fabricating Thermo-Plastic Based Composites

Stacking composite fabrics and topping of with a releasing layer (here a PTFE sheet)

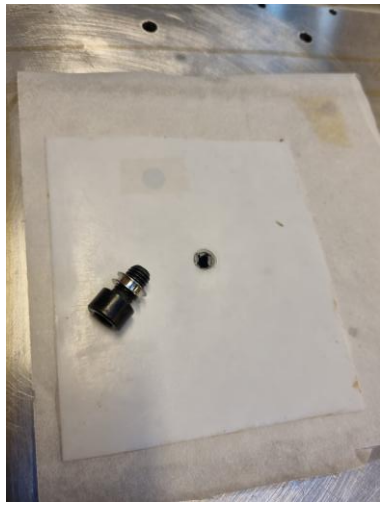
Adding a caul plate to ensure a flat-top surface.
Advise: use a breather couth inbetw. Release layer and caul plate.

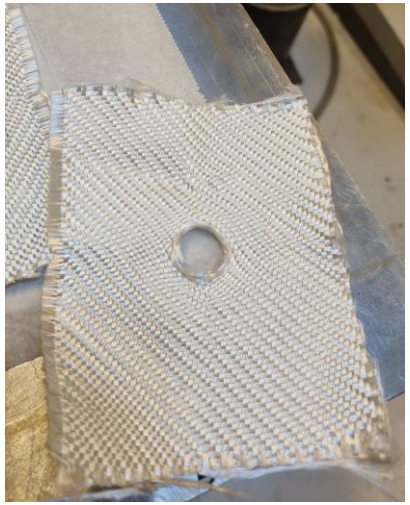
Seal the stack with a vacuum film (here a silicone mat) and draw vacuum.
Check for air tightness.

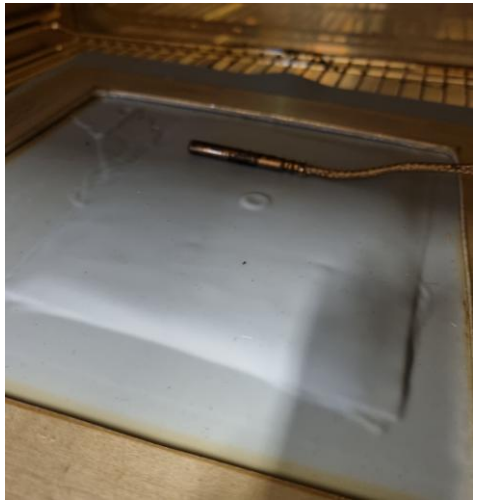


Consolidate the composite during vacuum and heat.
Process:
Drying stage: 30min @ 120C
Consolidation 120min @220C

Work on Thermo- Plastic Based Patch Integration







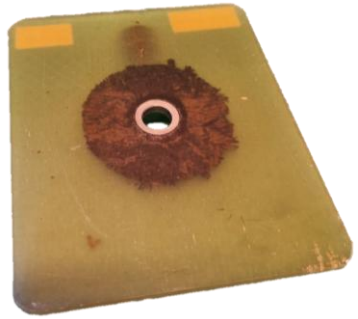
Many of the same process steps are repeated when integrating inserts or patches

A spike have shown very handy in forming a hole in the fabric.

Work on Thermo- Plastic Based Patch Integration

A

B

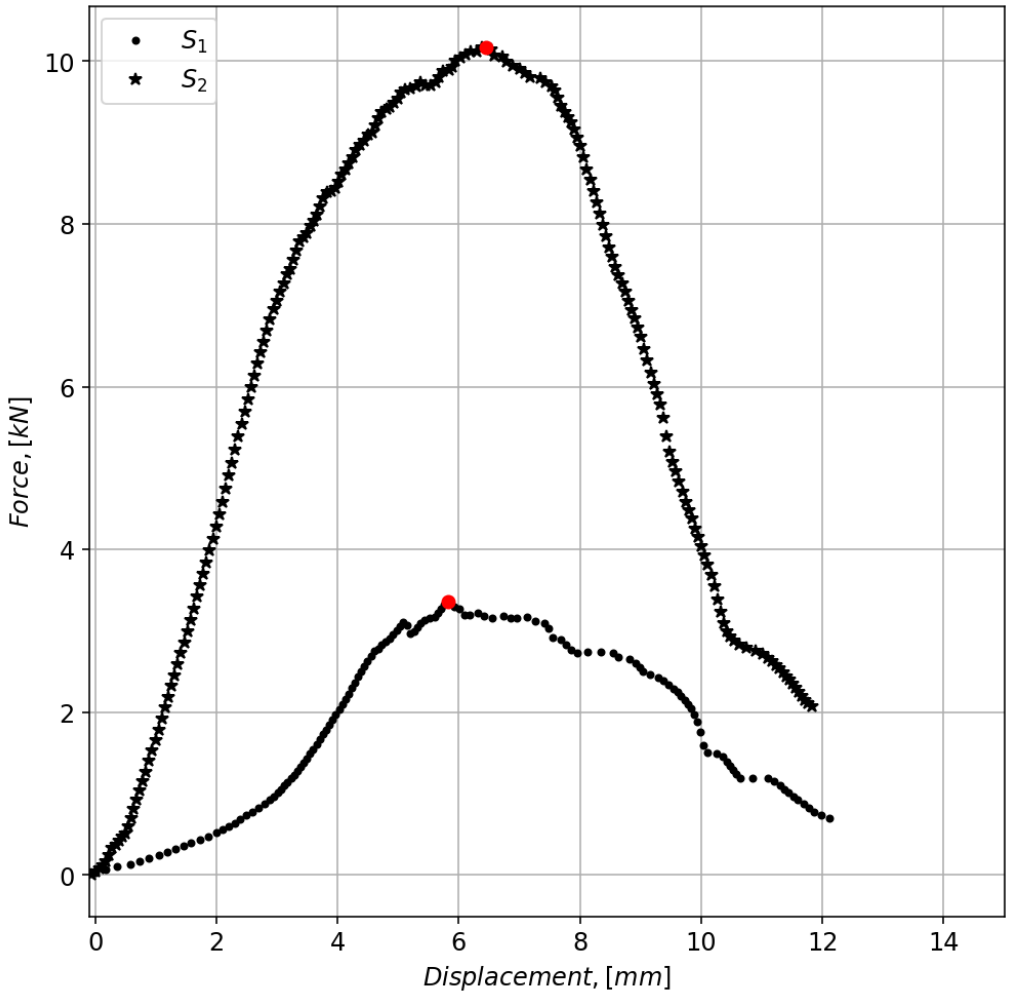


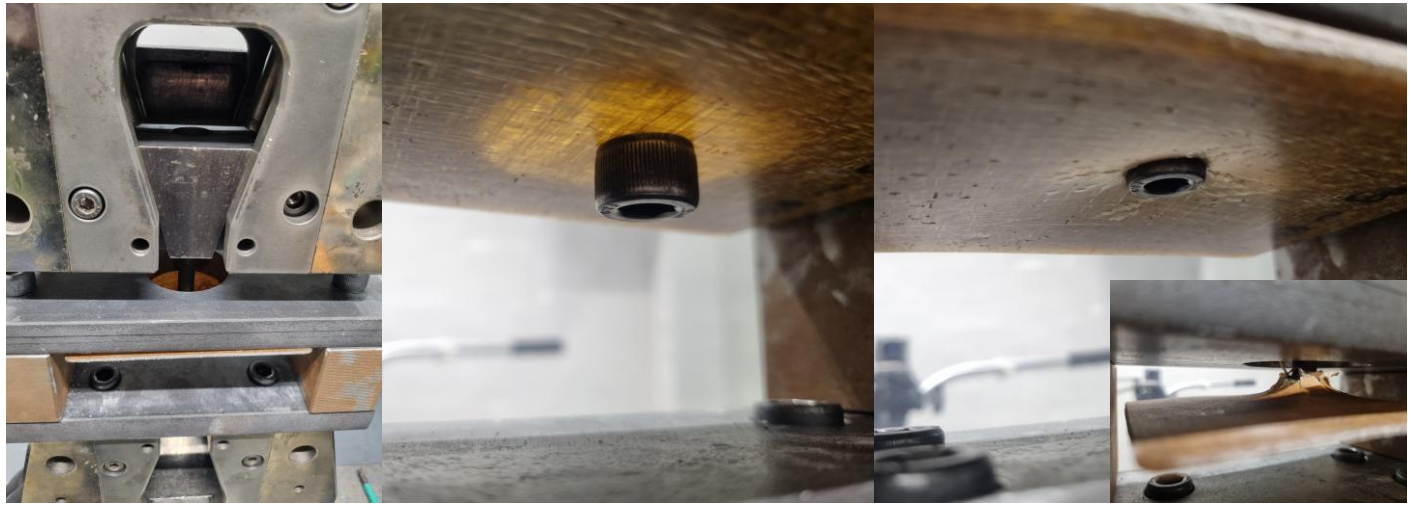
If care is not taken during fabrication poor result can easily manifests themselves.

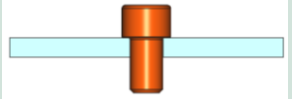
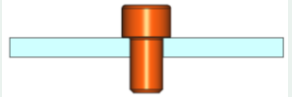
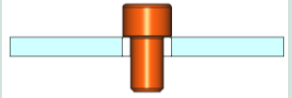
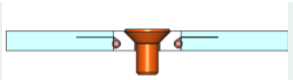
A. Insufficient compaction in vicinity of the insert (caused by too flexible caul plate).

B. Insufficient vacuum during the drying- and consolidation stage.

Pull-out Testing





Sample	Thick. [mm]	Fmax [kN]	Joining type	
S1	1.7	3.4		Bolt size: M10
S2	4.8	10.2		Bolt size: M10
S3				
S4				

Summary

- Trials on how to integrate patches into GF/PETG fabrics are in progress.
  - An alternative method for preparing holes in the fabric is being tested. The technique seem promising but its effect on the mechanical strength is being evaluated.
  - Processing induced flaws may rise from insufficient vacuum and –compaction near the insert.
- Mechanical testing.
  - Only machined hole samples have been tested for their pull-out strength. Pull-out strength scales with sample thickness as expected.