Docket #: S22-031

Negative Thermal Expansion for Glueless Sleave Joints

Researchers led by Stanford University's Stephen Tsai have developed new design and manufacturing approaches for glueless/boltless joining of metallic grid and carbon composite skins.

Tight fits are achieved by leveraging differing coefficients of thermal expansion (CTE) between materials, particularly, the negative thermal expansion characteristics of [±60] carbon laminates relative to the axis of a cylinder. The shape-optimized metallic grid with carbon interior and/or exterior skin offers superior ease and speed of assembly by heating and/or chilling without bolts, welds, or adhesives.

Assembly of the joint is facilitated by the negative thermal expansion of the carbon skin in the circumferential direction with temperature modulation. Joints with external sleeves can be assembled using pre-chilled components that seal tightly when raised to ambient/operating temperature. Alternatively, joints with internal plugs can be assembled using pre-heated components that seal tightly when dropped to ambient/operating temperature. For heavily loaded structural applications, prestress can be used for assembly with no need for adhesives and the accompanying difficulty of non-destructive inspection of adhesive bonding in composite structures.

Stainless steel is a good metallic grid choice for its toughness; fatigue and corrosion resistance; chemical compatibility with carbon composites; and ease in welding and metal removal by water jet. Its thermal expansion matches well with [±60] skin in both the circumferential and longitudinal directions of a cylinder. Cylindrical shells with double skins can meet the demand of supersonic and hypersonic vehicles better than conventional frame/stringer with single skin.

This glueless joint technology is applicable to: large piping for oil, water or other industrial fluids; fuselage plugs for aircraft construction; rockets; missiles; pressure

vessels for high and cryogenic temperature applications; and structural applications.

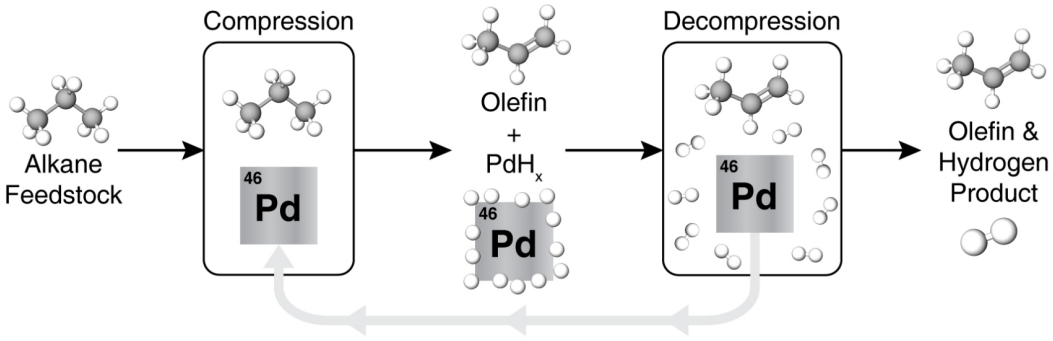


Fig. 1

Applications

- Piping for oil, water, or industrial fluids
- Fuselage plugs
- Box beams
- Landing gear
- Pressure vessels for high pressure or cryogenic applications
- Structural applications

Advantages

- Does not require welds, bolts, or adhesives
- Superior ease and speed of water jet and glueless assembly
- Assembly facilitated by temperature modulation
- Flexibility in one or two skins and different skin materials for different functions

Patents

- Published Application: 20230234325
- Issued: 12,636,853 (USA)

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