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MOTIVATIONS

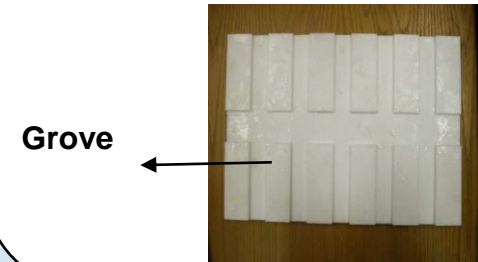
- ◆ Titanium alloys have exceptional high strength-to-weight ratio and resistant to corrosion. However, the durability of these joints against extreme environmental conditions is a concern.
- ◆ Traditional surface treatments for titanium joints are not practical for large structures.
- ◆ The alternative method can a sol-gel surface treatment: It is water based system and low cost and simple. Thus, it is practical for large structures.
- ◆ The main goal of this work is to evaluate the bond strength and the durability of adhesively bonded titanium joints under different environmental conditions (such as RT/dry, hot/dry, low/dry hot/wet and RT/wet), using TP-8 as the adhesive material and sol-gel as adhesion promoter.

MATERIALS

- Titanium Alloy of Ti-6AL-4V used as adehrends.
- Sol-Gel (AC@-130)
 - It is a waterborne system.
 - it is a mixture of a silane coupling agent and zirconium (Zr) isopropoxide in water.
 - Used as adhesion promoter.
 - A mix ratio of 30A:1B was applied.
- TP-8 Resin Materials.
 - It is type of toughened epoxy material.
 - Used as adhesive materials
 - It consists of two parts (3A:1B mix ratio was applied).

MATERIALS AND PREPARATION OF TITANIUM PIECES

- Titanium pieces were treated with sol-gel solution.
- Stainless shims were used to obtain a 0.254 mm bond line thickness.
- Alignment fixture (as shown below) was made to maintain the alignment of the samples during curing process.



SPECIMEN PREPARATION

- Using TP-8, the were bonded in a double lap-shear configuration sample according to ASTM D3165-00.
- Applying to assembly the curing cycle: Cure at 60 °C for 1.5 hrs and post-cure at 104.4 °C for 2 hrs.

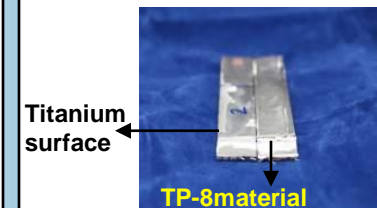
Double-LAP-SHEAR TEST

- Test Conditions:
 - ❖ ASTM D3165-00
 - ❖ A gage length was 139.7 mm.
 - ❖ Cross-head speed was 1.27 mm/min.
- Batch Repeatability:
 - ❖ Two samples were tested at RT to show equivalency between each batch of samples prepared for low/dry, hot/dry, hot/wet and wet/RT/ tests

ENVIRONMENTAL CONDITIONS

- Untreated samples:
 - At RT/dry (RT/0% RH)
 - At RT/dry (RT/0% RH)
- tests on treated samples:
 - At hot/dry (at 60°C/0% RH)
 - At low/dry (at -40°F and 0%RH)
- Treated samples and preconditioned in water at 71C for 14 days:
 - At how/wet (71C/90% RH)
 - At wet/RT (RT/90%RH)

UNTREATED SAMPLES AT RT/DRY

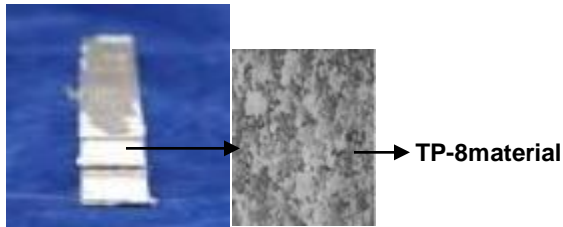


- 100% adhesive failure with TP-8
- 23 MPa average bond strength
- No indication of plastic deformation of the adhesive material

BOND STRENGTH AND DURABILITY OF TITANIUM JOINTS USING TP-8 ADHESIVE UNDER DIFFERENT ENVIRONMENTAL CONDITIONS

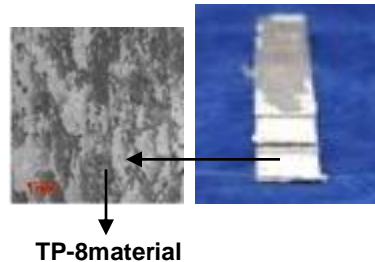
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TREATED SAMPLES AT RT CONDITIONS



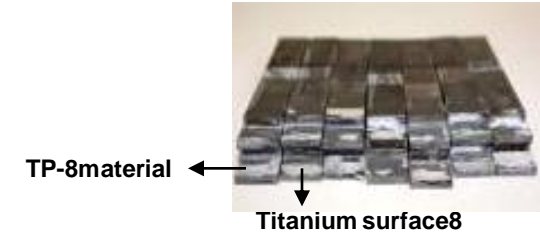
- 100% cohesive failure
- 32 MPa average bond strength
- TP-8 experienced a large degree of ductility.
- Sol-gel treatment increased significantly the adhesion between titanium and TP-8 resin.

TREATED SAMPLES AT HOT/DRY CONDITIONS



- A reduction of ~33% in bond strength and a cohesive failure of TP-8 material were obtained.
- Compared to RT test, TP-8 failed on larger size scale. This may indicate a larger degree of plastic deformation occurred in the adhesive material at 60°C than at RT.

TREATED SAMPLES AT LOW/DRY CONDITIONS



- Mixed cohesive/adhesive failure mode of TP-8 material.
- 31.5 MPa average bond strength (100% retention)
- Results indicate a high thermal resistance of the joints against low environments.

TREATED SAMPLES AT HOT/WET CONDITIONS



- 90-100% cohesive failure
- 19 MPa average bond strength
- 60% retention in strength
- Results indicate a high thermal stability of the interfacial regions.

TREATED SAMPLES AT WET/RT CONDITIONS



- 90-100% cohesive failure
- 27 MPa average bond strength
- 84% retention in strength

CONCLUSIONS

- AC-130 sol-gel increased significantly the adhesion between titanium surface and TP-8 and the durability of the interfacial regions.
- Wet sample showed a strength retention of 60% and 80% under hot/wet and wet/RT conditions, respectively.
- All samples tested under conditions of RT/dry, hot/dry, hot/wet and RT/wet exhibited predominantly cohesive failure.

ACKNOWLEDGEMENTS

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