USE OF DEBONDABLE STRUCTURAL ADHESIVE FOR GROUND TESTING OF GAIA SEGMENTS

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ABSTRACT

In the frame of GAIA segments ground testing, a structural debondable adhesive was developed in collaboration between RESCOLL and ASTRIUM. This debonding on command is based on a process invented by RESCOLL and called INDAR INSIDE®. The SiC segments are easily debonded by hand after thermal activation and qualified part are brazed safely afterwards.

1. INTRODUCTION

Adhesives are nowadays widely used in numerous industries like automotive, aerospace, avionics or microelectronics, etc., for many reasons such as adherence in structural assemblies and in this particular case a new challenge appears: the easy dismantling of structural bonded joints. This innovative concept results from industrial constrains like maintenance or recycling needs.

Rescoll Technological Center has developed and patented a process, called INDAR INSIDE®, which offers a simple and efficient solution to the disassembling of structural bonds. Based on the use of additives activated by heating at a certain temperature, this new technology drastically reduces the dismantling time and fulfil the main characteristics required by this application, no change in processing (implementation, curing conditions, …) and no or slight modification of the mechanical properties of the adhesive.

2. CONTEXT

The primary structure of GAIA is realized by ASTRIUM. This structure is a multi segments silicon carbide (SiC) torus assembled by brazing.

Before brazing, this structure has to be mechanically qualified segments by segments. The proof test is based on the use of an Invar plate bonded to the tested part. After testing, the part has to be debonded from the testing device. The debondable adhesive used for this application exhibits then specific properties like high strength bond (high stresses applied to the part during testing), reliable and easy dismantling, easy cleaning of the part after dismantling.

3. INDAR PROCESS

INDAR, which stands for INnovative Disassembling Adhesives Research, aims to solve the problem of the irreversibility of the bonding technology without damaging substrates. Indeed, it allows reusing old substrates, for maintenance and for sorting of the materials in function of their nature for recycling.

This process is based on the incorporation, in a formulated adhesive or primer, of a specific additive called INDAR additive. In a known range of temperature the additive starts to decompose, generating gases which migrate through the adhesive and induce interfacial stresses. After a certain time, theses stresses are sufficient enough to overcome adhesion forces and the adhesive comes off the substrate, adhesive failure occurs (Fig.1).

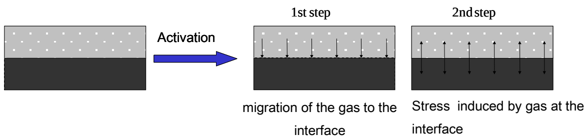

Fig.1. General working of the process

Several debonding temperatures are available, depending on the additive. Due to the kinetics of activation of this additive, it is essential to keep a margin (at least 50°C) between maximal service temperature and debonding temperature in order to avoid premature activation (Fig.2).

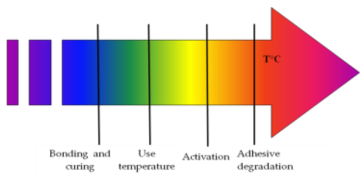

Fig.2. Temperature specifications

4. EXPERIMENTATION

The ASTRIUM specifications were the following:

- Structural bonding for SiC/Invar bonds
  - 35 MPa in pull out
  - 35 MPa in shear
- Heat curing possibility
- Debonding process in furnace until 250°C

4.1 Preliminary tests

The mechanical testing methods were developed by ASTRIUM for SiC/Invar bonds (Fig 3).

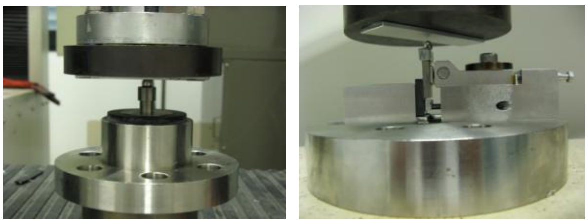

Fig. 3. Pull out tests (left picture) and shear tests (right picture) on SiC/Invar assemblies

These preliminary mechanical tests allowed identifying a suitable formulation, exhibiting high bond strength and fast curing at moderate temperature. The results obtained are detailed in the following lines.

The selected INDAR additive activates around 200°C. The decomposition temperature was chosen far beyond the curing temperature of the adhesive to avoid anticipated activation of the process.

Consequently, mechanical testing was led with this couple adhesive/additive in order to study the influence of the additive. Debonding properties were also tested on these assemblies after 10 minutes at 200°C. The efficiency of the dismantling was evaluated after cooling of the assemblies at room temperature. Typical results are presented in Figure 4.

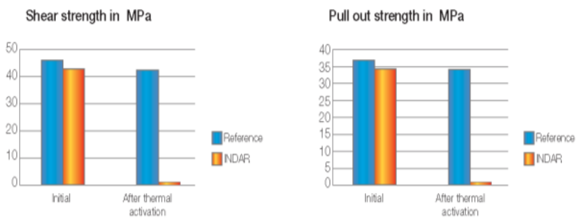

Fig. 4: Results of mechanical testing on SiC/Invar bondings

The results show that the adhesive has excellent properties in shear test (45 MPa) and in pull out test (36 MPa) with in all cases cohesive failures. Both values are superior to specifications.

With the incorporation of the additive, slight decrease of mechanical properties was observed but the adhesive properties are still compliant with specifications.

After 10 minutes at 200°C, a slight decrease of mechanical properties was observed from 45 MPa to 40 MPa for bondings without INDAR additive. Whereas for samples with INDAR, there was a drastic loss of mechanical properties and manual disassembling is possible with adhesive failure on the adhesive/Invar interface. Residual adhesive was observed on the SiC part. These experiments show the efficiency of debonding with INDAR process.

In a second step, the INDAR process was tested on semi industrial bonding to assess the efficiency on upper-scale samples and train ASTRIUM staff with the bonding and debonding operations.

4.2 Semi industrial bonding

During the preliminary tests experiments were made on samples with low bonding surfaces, which is not very representative of the final application.

During this step, only debonding process was tested. Sic pieces were bonded on an Invar crown. Bonding was realized in order to have 100µm thickness for the glue line; calibration was done by micro glass beads.

For the debonding step, temperature on the crown was followed by thermocouple. After 10 minutes at 200°C on the substrate surfaces, debonding occured very easily even without mechanical solicitations with a perfect adhesive failure on the interface adhesive /Invar as shown in Figure 5.

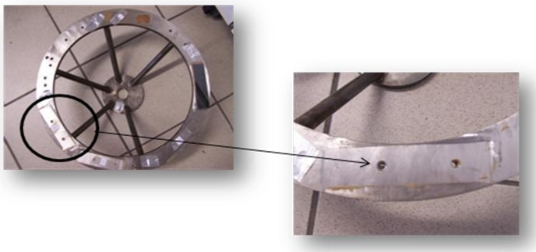

Fig.5. Debonding with adhesive failure of SiC pieces bonded on Invar crown

Residual adhesive was observed on SiC substrates, which implied further cleaning of the part before brazing. A stripping solvent was used to clean the surfaces. After several hours, adhesive was cleanly removed and analyses (IR spectroscopy) were made in order to check pollution traces. Comparison between a clean SiC surface and a SiC sample after solvent action showed no pollution.

4.3 Industrial phase

After the validation of this intermediate phase, ASTRIUM bonding operators and engineers were formed by RESCOLL to INDAR bonding and debonding processes.

The debondable adhesive was successfully used on Gaia for all flight parts (the 17 segments and the two mirror brackets) without any problem on the glued interfaces. Loads of several KN applied on the adhesive parts allowed to create stress higher than the satellite launch mechanical environments.

Figure 7 shows no residue on SiC surface, consequently, the parts are ready to braze.

The pictures in Figure 6&7 are views of the final assembly during testing and after debonding.

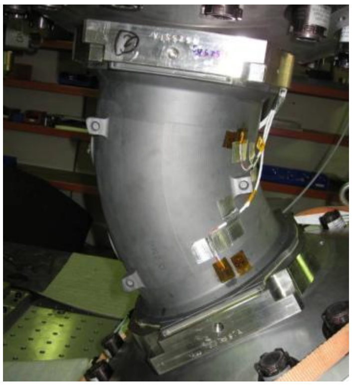

Fig.6. Proof test of structural Gaia torus Part.

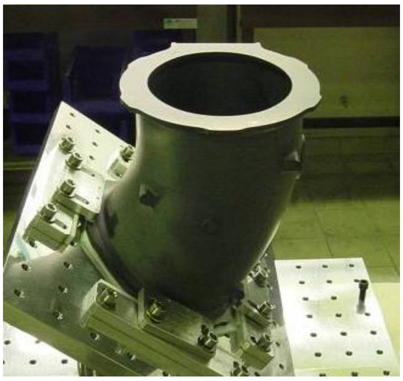

Fig.7. Structural Gaia torus Part after debonding

5. CONCLUSION

The INDAR process developed by RESCOLL is an interesting method for debonding on command structural bonds.

In this paper, SiC/Invar bonds were studied with high mechanical properties and good disassembling properties. After lab scale, a semi industrial bonding was realized and manual debonding was observed. The elimination of adhesive on SiC substrates was achieved easily with a stripping formulation.

The debondable adhesive was successfully used on the GAIA segments. The bonding-debonding process has been implemented several times with reliability and easy dismantling of the parts. Final brazing of the segments has returned no specific issue. Thus the debondable adhesive allowed carrying out safe proof tests of the part with a very representative interface (bonding compare to brazing).