Boltless assembling Of Primary Aerospace Composite Structures

Rendicontazione

Informazioni relative al progetto

**BOPACS**

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**Stato**
Progetto concluso

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Paesi Bassi

Final Report Summary - BOPACS (Boltless assembling Of Primary Aerospace Composite Structures)

Executive Summary:

Within BOPACS work was performed that was related to the certification of bonded joints for aerospace applications. The BOPACS consortium partners performed work on the design and development of design features that are capable of arresting crack propagation in an adhesive bonded joint. A large number of these so called Disbond Stopping Features (DSF’s) were developed and tested.

To demonstrate the Crack arresting capability a test method had to be developed and established based on the Crack Lapsher Specimen (CLS). Also basic understanding of the crack mechanism under fatigue loading and crack arresting mechanism had to be established within BOPACS as the available state of the
art knowledge was very limited. A harmonized comparable test method has been established to compare the crack arresting capability of different DSF’s under Fatigue loading.

During the project execution it became clear that the originally planned aileron application only covers the so called “Low Load Transfer” joint configuration and that an additional test campaign on C-Level was needed to cover High Loaded Transfer applications. Especially the longitudinal joining of fuselage panels is a commercially very interesting application. For this type of joint the propagation of an initial damage occurs along the bond line perpendicular to the main loading direction of the joint and a large sized lap shear sample was needed to simulate the crack propagation behaviour of a such a joint.

Thanks to a project extension with 9 months it was possible to perform additional tests on these so called Wide Single Lap Shear (WSLS) specimens.

In general the “through the thickness” features like the different types of bolts are given the best results followed by the “adhesive bond line architecturing” features where locally toughened adhesives were introduced in the bond line.

Representatives of both features were tested in the aileron full scale test and due to budget and time limitations only the “through thickness feature” was tested in the WSLS test program.

The test of the aileron was stopped due to a fracture in the aileron hinge structure and the remaining part of the test program will be performed after repair of the hinge. Unfortunately the second part of the test cannot be performed within the time frame of BOPACS. However the results so far show that a crack that was starting to propagate was stopped by a toughened zone DSF and did not show any further propagation until the test was aborted.

The tests on WSLS specimen showed that bolts used as crack stoppers are capable of slowing down the crack propagation speed of an initial damage in a High Load Transfer joint. The demonstrated crack arresting capability for the tested configurations shows a very good performance which is well above the needed crack arresting capability of typical aerospace configurations in terms of number of cycles to rupture with and without crack arrestors. Also the residual strength after fatigue testing and arrested crack growth gives good confidence for LL capability after crack arresting to fulfill today’s certification requirements.

The WSLS Test campaign in BOPACS is giving good confidence for HLT application scenarios. The Specific configuration may have to be extended to be able to test larger DSF Pitches. Also the different Influences of alternative DSF, stacking Sequence and optimized joint geometry has to be investigated more deeply to enable an industrial application and certification.

Within the framework of BOPACS a model to simulate the crack growth in an adhesively bonded CFRP specimen with integrated crack stoppers was developed. With the model it was possible to closely predict the crack propagation under complex fatigue loading in a CLS specimen with a rivetless nut plate crack stopper.

Project Context and Objectives:
BOPACS is set to reduce the weight and costs of primary composite aerospace structures by enabling secondary bonding as joining technology. Until today thin walled composite structures are joined by using a large number of fasteners. Adhesively secondary bonding would considerably contribute to the weight and cost reduction but they cannot fulfill the airworthiness requirements up to now.

In order to meet airworthiness requirements for secondary bonded structures BOPACS proposes a rigorous road map to certification by developing Means of Comply based on:
Thorough research, beyond the state of the art, into the crack growth / disbond extension mechanisms in adhesively bonded joints.

- Design, analysis, testing and assessment of different categories of crack stopping design features, i.e. features that are capable of preventing cracks or disbonds from growing above a predefined acceptable size, with a joint still capable of carrying the limit load.

This topic is considered as a breakthrough technology. It secures structural integrity of the bond line throughout the entire service life. NDT and process safety are not considered to fill in this gap. Based on aerospace target applications secondary bonded joining methods will be developed that comply with the EASA airworthiness requirements. The project results and certification issues will be reviewed on a regular basis by EASA representatives through the Airbus.

Project Results:

Many disbond stopping features were developed and tested in the BOPACS project and based on the test results, it was proven that propagation of initial damage can be slowed down significantly or stopped. To demonstrate the Crack arresting capability a test method had to be developed and established based on the Crack Lapsher Specimen (CLS). Also basic understanding of the crack mechanism under fatigue loading and crack arresting mechanism had to be established within BOPACS as the available state of the art knowledge was very limited. A harmonized comparable test method has been established to compare the crack arresting capability of different DSF’s under Fatigue loading.

Due to the industrial requirements and changed way of working a dedicated TRL assessment of the individual technology approaches has not been performed. The overall approach of crack arresting for HLT Joints has been rated to be between TRL 2 and 3 within a dedicated Review at Airbus Operations. The TRL level of the individual DSF as single technology is significantly higher as for the Integration into the complex HLT configuration.

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The involvement of EASA as was initially planned was not performed. Main reason was the high costs of the EASA involvement and therefore only the certification department of Airbus was contacted. The Principle concept of crack arresting has been evaluated as “in line with current certification rules” according AC10-207B and AMC 20-29. Therefore no major concerns with regards to a serial application have been raised by the Airbus certification department.

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Potential Impact:
The main dissemination of the BOPACS work and results were presented during a two day end event organised and hosted by Airbus Operations Germany. The Symposium took place on 5th and 6th of September in Hamburg.

Overall 80 Participants participated to the symposium. 60 Participants were from outside the BOPACS Consortium. The Contribution covered 12 European Nationalities and 1 International Country (Japan). The Delegated were representing 19 Organisations / Companies outside the BOPACS Consortium.

The Planning and preparation of the Event has been performed by Airbus Operations and NLR. The Agenda covered the full perimeter of BOPACS starting with the motivation and background followed by the Feature development and related testing by all partners up to the C & D Level testing performed in BOPACS.

List of Websites:
www.bopacs.eu

contact:
Jan Halm
NLR department AVST
email: jan.halm@nlr.nl
telephone: +31 88511 4204
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