CRACK PATH SELECTION IN ADHESIVELY BONDED JOINTS

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(ABSTRACT)

This dissertation is to obtain an overall understanding of the crack path selection in adhesively bonded joints. Using Dow Chemical epoxy resin DER 331® with various levels of rubber concentration as an adhesive, and aluminum 6061-T6 alloy with different surface pretreatments as the adherends, both symmetric and asymmetric double cantilever beam (DCB) specimens are prepared and tested under mixed mode fracture conditions in this study. Post-failure analyses conducted on the failure surfaces indicate that the failure tends to be more interfacial as the mode II component in the fracture increases whereas more advanced surface preparation techniques can prevent failure at the interface. Through mechanically stretching the DCB specimens uniaxially until the adherends are plastically deformed, various levels of T-stress are achieved in the specimens. Test results of the specimens with various T-stresses demonstrate that the directional stability of cracks in adhesive bonds depends on the T-stress level. Cracks tend to be directionally stable when the T-stress is compressive whereas directionally unstable when the T-stress is tensile. However, the direction of crack propagation is mostly stabilized when more than 3% mode II fracture component is present in the loading regardless of the T-stress levels in the specimens. Since the fracture sequences in adhesive bonds are closely related to the energy balance in the system, an energy balance model is developed to predict the directional stability of cracks and the results are consistent with the experimental observations. Using the finite element method, the T-stress is shown to be closely related to the specimen geometry, indicating a specimen geometry dependence of the directional stability of cracks. This prediction is verified through testing DCB specimens with various adherend and adhesives thicknesses. By testing the specimens under both quasi-static and low-speed impact conditions, and using a high-speed camera to monitor the fracture sequence, the influences of the debond rate on the locus of failure and the directional stability of cracks are investigated. Post-failure analyses suggest that the failure tends to be more interfacial when the debond rate is low and tends to be more cohesive when the debond rate is high. However, this rate dependence of the locus of failure is greatly reduced when more advanced surface preparation techniques are used in preparing the specimens. The post-failure analyses also reveal that cracks tend to be more directionally unstable as the debond rate increases. Finally, employing interface mechanics and extending the criteria for the direction of crack propagation to adhesively bonded joints, the crack trajectories for directionally unstable cracks are predicted and the results are consistent with the overall features of the crack paths observed experimentally.

ACKNOWLEDGEMENTS

The author wishes to thank the following people without whom this work would not be possible.

- Dr. David A. Dillard for his advice on my research and life, his encouragement, and most importantly, his patience over the last four years. The education, opportunities, and responsibilities that I have been given in the Adhesion Lab at Virginia Tech are greatly appreciated and will not be forgotten.
- Dr. John G. Dillard for his advice and help on the chemistry aspects of my research. Without Dr. Dillard's support, this dissertation would not be complete.
- All my other committee members Dr. Brian Love, Dr. John J. Lesko, Dr. Scott Case, and Dr. David Y. Gao for their suggestions and guidance. Their time and effort are greatly appreciated.
- My dearest friend Dr. Richard L. Clark, Jr. for his great support for this work. Without Dr. Clark's help, this work would take much longer.
- The National Science Foundation, Science and Technology Center for High Performance Polymeric Adhesives and Composites for the major support of this research.
- The Center for Adhesive and Sealant Science at Virginia Tech for partial support of this work.
- The Engineering Science and Mechanics Department at Virginia Tech for the use of various facilities.
- The Dow Chemical Company for supplying the raw materials.
- Dr. Alphonsus from 3M Company for helpful discussions.
- Bob Simonds and Shu Guo from Engineering Science and Mechanics at Virginia Tech.
- Cooper Tire and Rubber Company for providing the feelings of home and supporting the final part of this dissertation. Without the understanding and warm support from Cooper, the beginning period of my employment would not be so pleasant and the deadline of completing my dissertation would not met.
- My wife and parents for their encouragement, care, sacrifice, and understanding.

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