Summary of Recent Round Robin Life Prediction Efforts for Crack Shape and Residual Stress Effects

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Two round-robin life prediction efforts were conducted to assess the ability to perform blind life predictions for test data obtained for corner cracks at centered and offset holes in 7075-T651 and 2024-T351 Aluminum alloys. The first round robin effort was conducted as part of a recent AFGROW Workshop focused on the ability to accurately predict crack shape evolution, and the second was conducted by the Engineered Residual Stress Initiative (ERSI) Workshop on the effect of split sleeve cold-working. The test specimen geometry used for both efforts is shown in Figure 1.

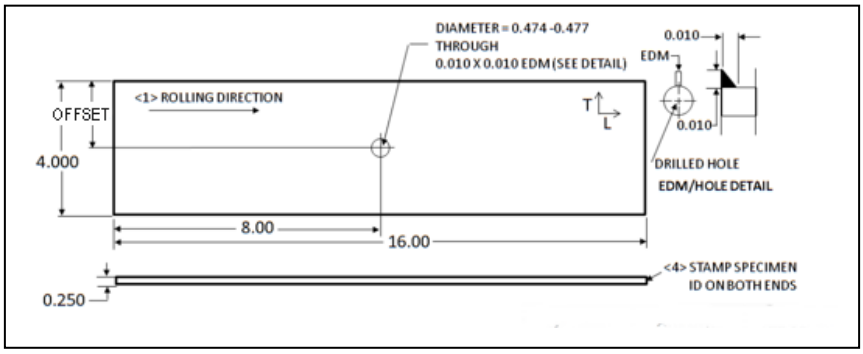

Figure 1: Specimen Geometry

The test matrix for both efforts are provided in Table 1 and Table 2.

Table 1: AFGROW Round-Robin Test Matrix

Specimen	Material	Width (in.)	Thickness (in.)	Hole Dia. (in.)	Offset (in.)	Stress Ratio	Max. Stress (Ksi)
1	7075-T651	4	0.25	0.5	2.0	0.1	12
2							
3							
4					0.6		
5							
6							9

Table 2: ERSI Round-Robin Test Matrix

Condition	Material	Width (in.)	Thickness (in.)	Hole Dia. (in.)	Offset (in.)	Stress Ratio	Max. Stress (Ksi)	Cold-worked
1	2024-T351	4	0.25	0.5	2.0	0.1	10	No
2							25	Yes
3					0.6		10	No
4							25	Yes

The AFGROW round-robin blind predictions were in very good agreement with the test results in terms of cycles to corner crack transition and total life but did not follow the crack shape trends indicated by the post-test marker band analyses. Upon further study of the test data, it was discovered that the apparent crack growth rate data were slightly different for the two, orthogonal crack directions. All blind predictions were made using crack growth rate data for the L-T orientation which was consistent with the

crack growth behavior expected for the radial direction from the open hole (c-direction). However, the marker bank data indicated a different slope in the growth rate data in the thickness direction (a-direction). Subsequent predictions were made using averaged growth rate data from the test results in each growth direction, and these predictions showed very good agreement with the test results. Although good agreement should be expected using the marker band data to predict the same result, it is significant to note that it was not possible to accurately predict the crack shape evolution seen in the test data unless predictions were made using different crack growth rate data in each direction as shown in Figure 2.

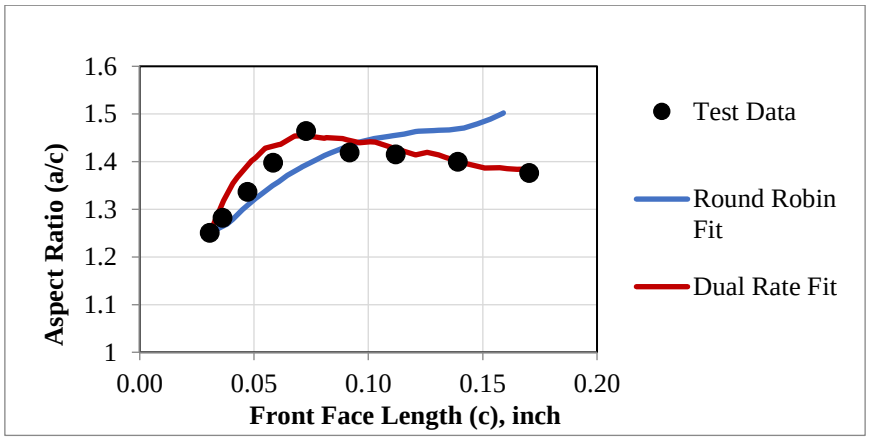

Figure 2: Crack Shape Predictions for AFGROW Round-Robin Specimen 2

The ERSI round-robin proved to be quite valuable quantifying various analysis methods and their ultimate impact on life predictions. Historically, life predictions that explicitly included residual stress have proven to be difficult and highly sensitive to analysis inputs and methods. The ERSI round-robin was completed to quantify specific sources of systematic uncertainties, with the overall goal of understanding the reproducibility uncertainty given fixed input data. A total of eight analysts participated in the round-robin, exercising various analysis methods. Specific cases including baseline (no cold-working) and cold work conditions investigating centered and offset holes. An example of the prediction results versus test data for ERSI round robin Case #4 is shown in Figure 3.

The results of these round robins will be discussed, including prediction and test result comparisons, as well as lessons learned and best practices.

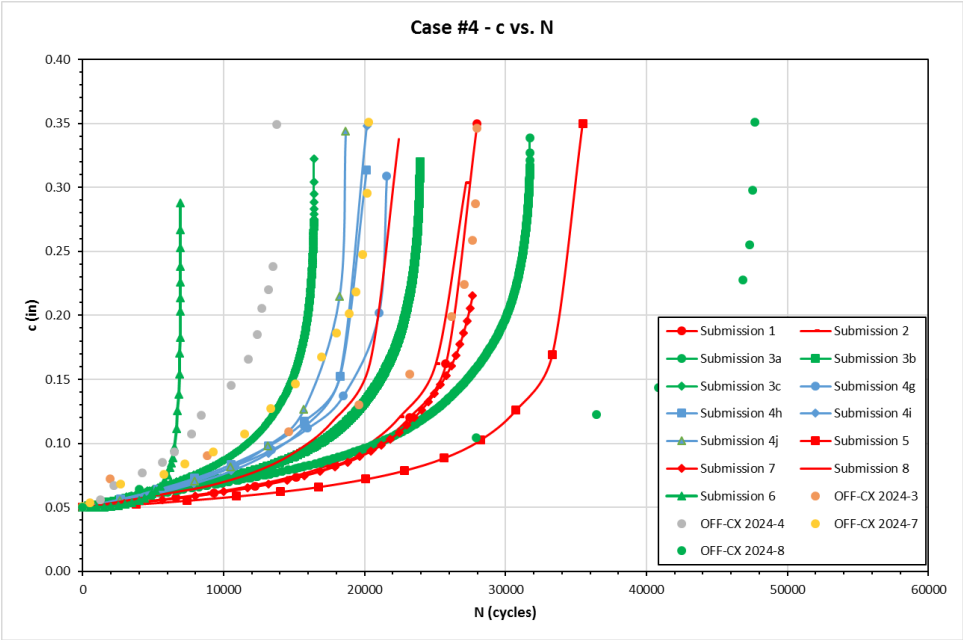

Figure 3: Surface Crack Length (c) Predictions for ERSI Round-Robin Case #4