# Critical Plane Selection Under Nonrelaxing Simple Tension with Strain Crystallization

Anantharaman Ramachandran*, Ross P. Wietharn, Sunil I. Mathew
Caterpillar, Peoria, IL

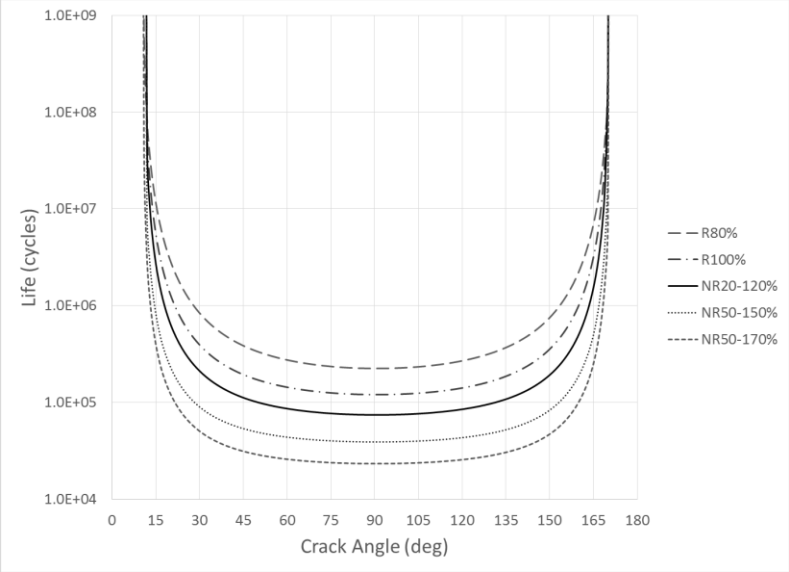
William V. Mars, Mark A. Bauman
Endurica LLC, Findlay, OH

**ABSTRACT**. The orientation of cracks initiating under cyclic loading is normally set by the maximum principal direction of the applied stress. In simple tension, this causes cracks to appear perpendicular to the tension direction. In contrast, for a strain-crystallizing natural rubber compound, we have observed an exception that occurred during nonrelaxing simple tension fatigue tests. In this case, cracks initiated in a markedly different orientation. The specimen used for experimentation was a rectangular flat dumbbell prepared according to the ASTM D4482 Standard. Critical plane analysis of this case, with and without strain crystallization, was performed with Endurica CL to predict the plane on which crack nucleation is favored. The analysis shows that the nonrelaxation ratio R, and therefore the degree of strain crystallization and associated crack growth rate, depend on plane orientation in a way that predicts the effect. This information is useful as additional validation when comparing fatigue life predictions to experiments, or as a first step towards understanding the loading experienced at the failure location. Nonrelaxing cycles in a rubber that strain crystallizes improve fatigue life, and also cause crack initiation in a direction not perpendicular to the maximum tension direction.

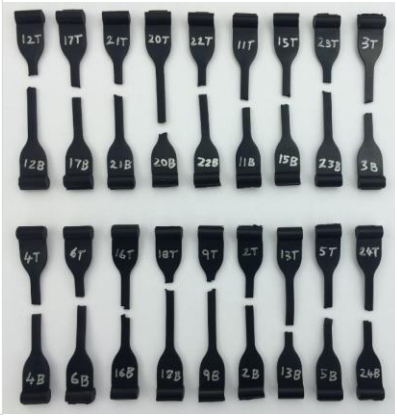
**Keywords**: Fatigue, Strain Crystallization, Durability, Natural Rubber, Damage

* Speaker

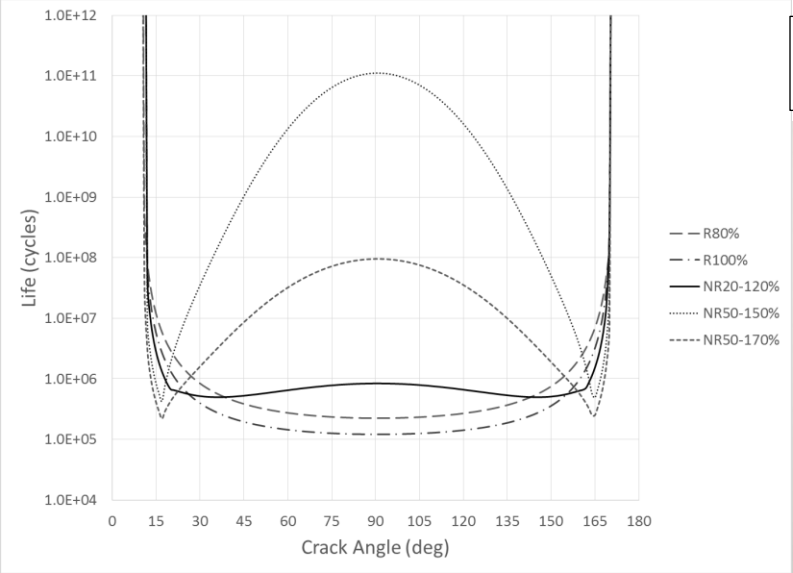
Citation: A. Ramachandran, R. P. Wietharn, S.I. Mathew, W. V. Mars, and M. A. Bauman, “Critical Plane Selection Under Nonrelaxing Simple Tension with Strain Crystallization”, Presented at the Fall 192nd Technical Meeting of the Rubber Division, ACS, Cleveland, Ohio, October 10-12, 2017 (Paper #E15).



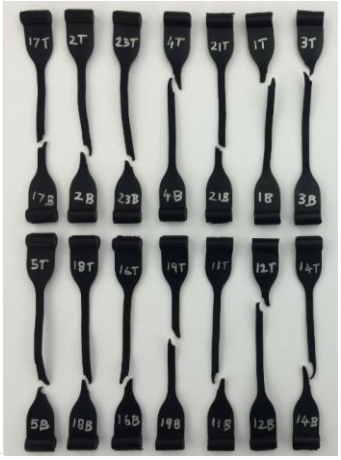

Relaxing Fatigue Specimens
R80%



Simulated fatigue life dependence on crack orientation for <u>no strain crystallization</u>




Non-Relaxing Fatigue Specimens
NR50%-170%



Simulated fatigue life dependence on crack orientation for <u>full strain crystallization</u>