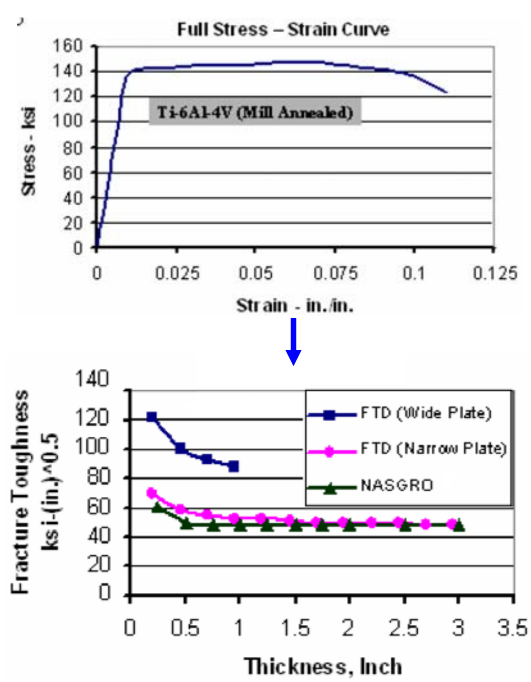
METAL FRACTURE ANALYSIS
Fracture Toughness Determination (FTD)

The design process of several components used for aerospace, automobile and electronics applications require designers/manufacturers to pre-determine their service life. Plane strain and plane stress fracture toughnesses (material properties) are key parameters that help researchers/engineers analyze such problems. Extremely expensive tests are required in order to determine these parameters that tell us when a crack will initiate in a component. Several LEFM theories have been developed in an attempt to estimate these parameters without the need for expensive tests. Among such theories is the extended Griffith theory model for ductile metals, the details can be found elsewhere[1]. Alpha Star Corporation has implemented this theory in its Metal Fracture Analysis (MFA) software as Fracture Toughness Determination (FTD) module after verifying the predictions with experimental values for several different metals and their alloys.

The FTD module requires its users to enter full engineering stress-strain curve for the material, thickness and gage length of the tensile test specimen. In addition, the user defines a thickness range of the sheet metal for which fracture toughness values are desired. Once the analysis is complete in less than a minute time, the module graphically generates the fracture toughness variation with thickness and applied stress versus crack length curves.

A databank is provided with the module that contains the stress strain curves for several metals and their alloys; for example, Aluminum 2000, 5000, 6000, 7000 series alloys, Inconel, Titanium, Steel and many others. The stress-strain data for materials in the databank have been obtained from MIL-HDBK 5.



[1] Farahmand, B., Fatigue and Fracture Mechanics of High Risk Parts, Chapman and Hall, 1997.

METAL FRACTURE ANALYSIS
Fatigue Crack Growth (FCG)

The design process of several components used for aerospace, automobile and electronics applications require designers/manufacturers to pre-determine their service life. In order to determine the remaining life of these components designers/manufacturers rely on Fatigue Crack Growth (da/dN versus ΔK) behavior of the component. Like fracture toughness tests, extremely expensive test set-up is required in order to determine the crack growth behavior of the material. Theoretically, this complete crack growth behavior is usually captured with the well known empirical Forman, Newman and Koening (FNK) equation. Several empirical and non-empirical parameters are required in order to predict the complete fatigue crack growth behavior, such as C, p, q, and n are empirical parameters, while stress ratio (R), threshold fracture toughness, plane stress fracture toughness and plane strain fracture toughness parameters among others. All these parameters are determined in MFA (Metal Fracture Analysis) without the use of any additional tests unlike NASGRO and other similar well known software. The process is based on detailed study of several metals and their alloys, the details can be found elsewhere[1]. Alpha Star Corporation has implemented this approach in its MFA software. A software as Fatigue Crack Growth (FCG) module after verifying the predictions with experimental values for several different metals and their alloys.

The FCG module requires its users to enter plane stress and strain fracture toughness values (can be obtained from Fracture Toughness Determination [FTD] module), thickness of the virtual pre-cracked panel for the material parameters, while the empirical parameters are pre-defined and remain same for a given category of the material; for example, Aluminum 2000 series. The user can vary the stress ratio, maximum applied stress and notice any shifts in the generated da/dN versus ΔK curve. FCG module is able to do so all without asking users to perform any additional tests. The FCG analysis usually takes less than a minute and graphically generates the da/dN versus ΔK curve for a given panel width and thickness, stress ratio and maximum applied stress.

A databank is provided with the module that contains the stress strain curves for several metals and their alloys; for example, Aluminum 2000, 5000, 6000, 7000 series alloys, Inconel, Titanium, Steel and many others. The databank contains the empirical parameters for several categories along with additional assumed information such as stress ratio, maximum stress and panel width. The required plane stress and strain fracture toughness values are also provided which are calculated using the FTD module.

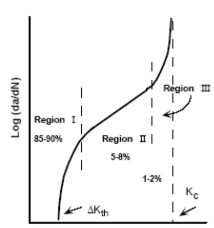


Figure 1: Typical Crack Growth Rate Versus Stress Intensity Range

---

[1] Farahmand, B., Fatigue and Fracture Mechanics of High Risk Parts, Chapman and Hall, 1997.