MPM Technologies, Inc.

Charpy Data Fitting

INTRODUCTION

Charpy curve fitting is a challenging task because, for most applications, there are relatively few data points. An example is in the nuclear industry where surveillance capsules are periodically pulled and tested. In this application, there may be as few as 12 to 15 data points available to characterize the entire transition region and upper shelf. MPM has addressed this challenge by developing an advanced Charpy curve fitting software package (Charpy Fit™ v1.0).

The curve fitting results are given in terms of plots of Charpy energy, lateral expansion, and fracture appearance (percent shear) as functions of temperature. These plots show the data points as well as the best fit trends. Four definitions of transition temperature are typically applied to the fitted data. The four transition temperature definitions, referred to as the Charpy indices, are:

- 30 ft-lb Charpy energy
- 50 ft-lb Charpy energy
- 35 mil lateral expansion
- Fracture appearance (50% shear)

In addition, upper shelf Charpy energy and upper shelf lateral expansion can be determined.

FITTING METHOD

The Charpy Fit™ v1.0 software allows data to be fit as a function of temperature using either of two functions. One function is the hyperbolic tangent function. The other is a second order polynomial. The function form for the hyperbolic tangent function is given below:

$$y = \frac{a_1}{2}\left[1 - \tanh\left(\frac{T - a_3}{a_4}\right)\right] + \frac{a_2}{2}\left[1 + \tanh\left(\frac{T - a_3}{a_4}\right)\right]$$

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where *y* is Charpy energy, T is temperature, and a_i are the model parameters to be determined by fitting. The parameters can be interpreted as follows: a_1 is the lower shelf value of *y*; a_2 is the upper shelf value of *y*; a_3 is the temperature at which the hyperbolic tangent function has its inflection point; and a_4 is a measure of the temperature range over which the transitional behavior occurs.

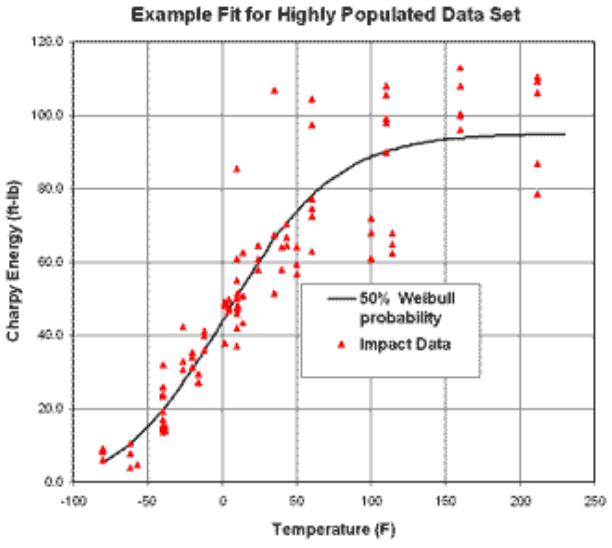
For each function, the user has the option of fitting a median trend for the data or fitting both a median trend and a statistical distribution trend. The statistical distribution is a three parameter Weibull type distribution for both functions. This distribution was selected because of its applicability to the physics of fracture in ferritic steels which exhibit brittle fracture in the transition region.

If a Weibull statistical fit is specified, then the variance from the Weibull fit is used as a weight function in the least squares fitting of the median trend. If a "median only" fit is specified, the least squares weighting of the data points assumes that the variance is proportional to the magnitude of the median at that temperature. This default weighting for a "median only" fit can be circumvented by doing a "median and Weibull" fit while fully (or partially) specifying the Weibull distribution parameters. The accuracy of the fitting algorithm was verified for each of the two fitting functions. Also, each fitting function was verified in both the "median only" and the "median and Weibull" modes.

In order to improve the fitting results for sparse data sets, several of the model parameters can be specified prior to fitting based on physics and the MPM fitting data base. The fitting data base is included with the package and is applicable to many materials. The data base was developed by fitting large populations and doing sensitivity studies.

EXAMPLE FIT

The figure shown to the right is an example fit of a highly populated data set. The data set is representative of reactor pressure vessel steels. The software allows random selection of subsets of the data set to test the Weibull parameters determined from fitting small populations of data. In cases where the Weibull parameters cannot



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be accurately determined from a small data set, the large population data set can be used to accurately set the parameters.

FOR MORE INFORMATION

If you would like a price quotation or additional information concerning MPM's services or products, please contact us at the below listed address:

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