MAPLE Program Plan for generating of the material parameters for the Environmental (oxidation) damage term

ENGINEERING CENTER STEYR
GmbH & Co KG

5th FEMFAT User Meeting

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Introduction

Motivation, Tasks

- lack of material data for FEMFAT HEAT Sehitoglu
- possibility of generating the material parameters based on provided isotherm and TMF test data
- finding a general method for calculating the material parameters
- Possibility for our customers to generate their own mateial parameters based on their provided test data

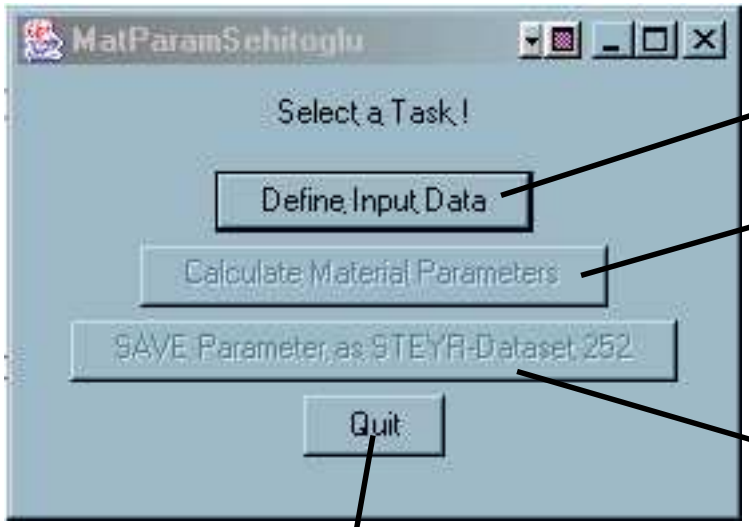
Program description

Basic functions

- Input the necessary material data and test data for the calculation of the material parameters
- Reading and writing the input data into/from a file
- Calculate the material parameters for FEMFAT HEAT – Sehitoglu analysis based on predefined boundary and initial conditions
- Output the generated material parameters into a file (either in txt-format for further use in Excel or as STEYR-Dataset 252 for the FEMFAT Calculation)
- Show the generated material parameters in a diagram (e.g.: a-β, a-Q, β-Q ... etc.)
- Show the calculated and test results in a diagram

Program description

Main program



Define input data for calculation

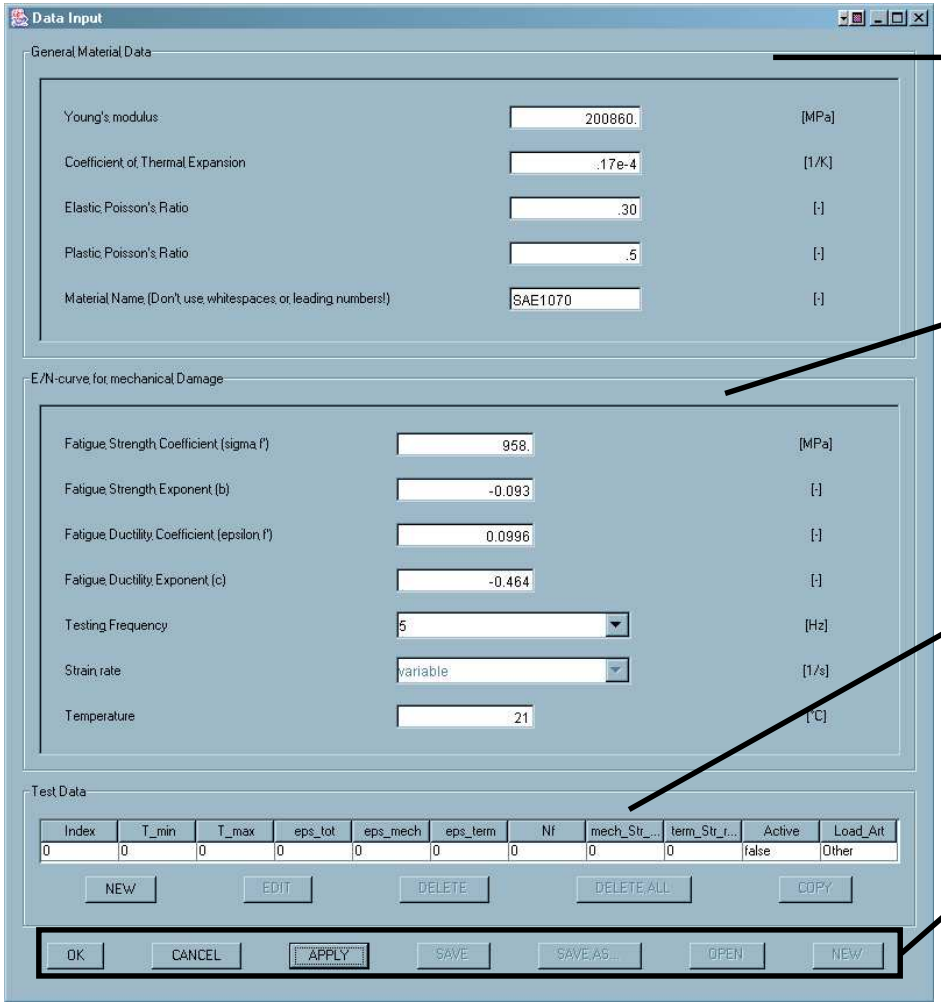
Calculation of material parameters for FEMFAT HEAT Sehitoglu Analysis – As long as there are no input data this button remains disabled

Output of calculated material parameters as STEYR-dataset 252 for FEMFAT – As long as there is no result this button remains inactive

Quit from main program

Program description

Input and edit test data – by clicking on „Define Input Data“



General material data,

required for the calculation of material parameters.

Strain-life curve for calculation of the mechanical damage term

Input and editing isotherm and TMF test data

„NEW“ – always active,
the buttons „EDIT“, „DELETE“, „DELETE ALL“, „COPY“ will be only activated after the first entry of the table was input.

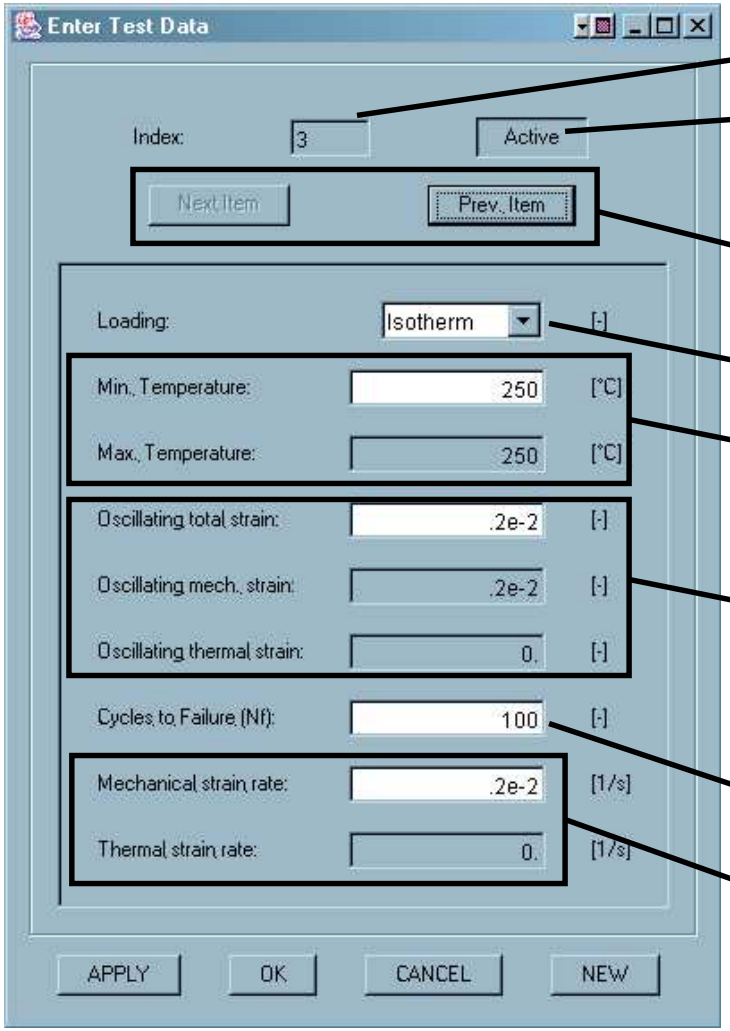
Operations, which effects every data

(OK, Cancel, Apply, Save, Save as..., Open, New)

www.magnasteyr.com

Program description

Input and edit test data – by clicking on „NEW“ or „EDIT“



Index of actual test point

Activation of actual test point
Deactivated test points will be not considered for calculation of Sehitoglu parameters

Step to next or previous test point for editing

Load (OP, IP, isothermal, others)

Maximum and minimum temperature
For isothermal load only minimum temperature can be specified, maximum temperature will be set automatically

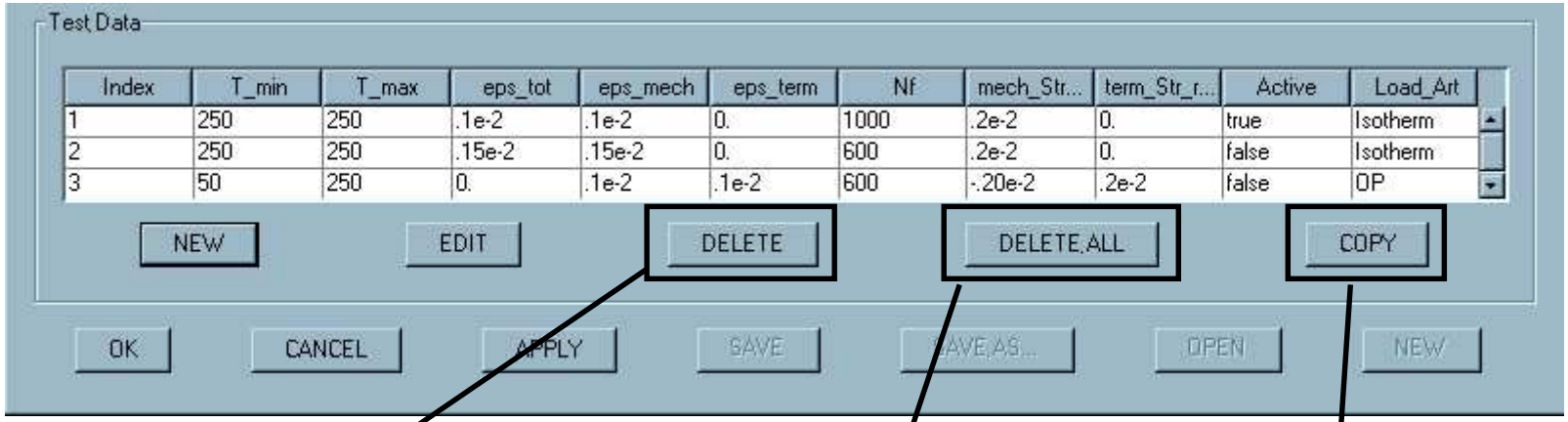
Strain amplitudes
Some of them will be set automatically depending on load – e.g.: for isothermal load
thermal strain amplitude = 0,
mechanical strain amplitude = total strain amplitude

Cycles to failure

Strain rates
For isothermal load thermal strain rate will be set automatically to 0 –
for OP or IP load only one strain rate can be defined, the other one will be set automatically

Program description

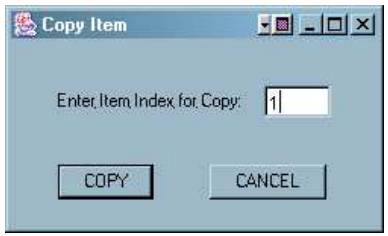
Delete and Copy Test Data



Delete one test point
The specified test point will be deleted.

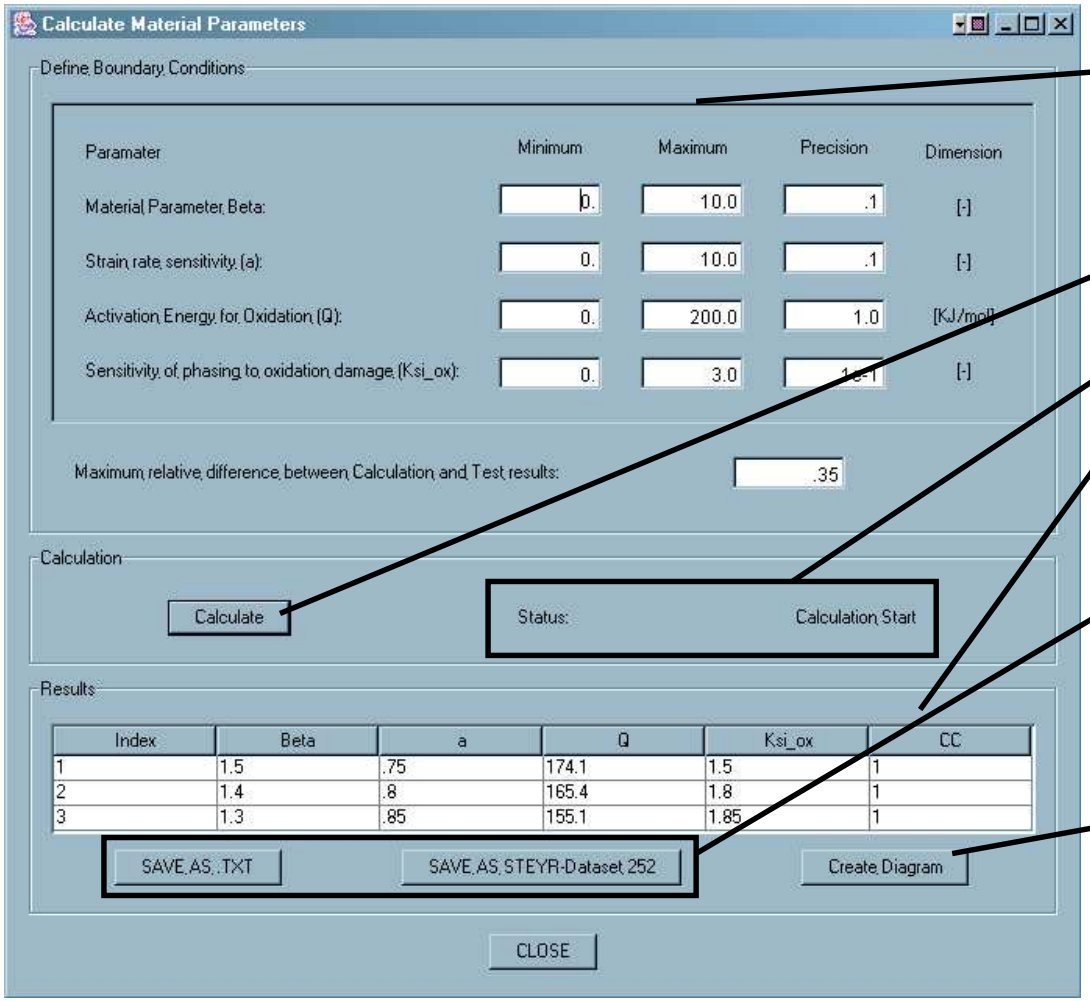
Delete all test points
After confirmation all test points will be deleted.

Copy of one test point
A new test point will be generated as copy of the specified one.



Program description

Calculate Material Parameter



Definition of limits for some Sehitoglu parameters

Start calculation

Status of calculation

Calculation results
Output of all parameter combinations, which fulfill the specified conditions.

Save results
as txt format for further usage e.g. in Excel or as STEYR dataset 252 for FEMFAT HEAT analysis

Result visualization
Combinations of calculated Sehitoglu material parameters can be visualized in 2D diagrams in pairs (e.g.: a-β, a-Q, β-Q, etc.)

Calculation of material parameters for the oxidation term

- **Necessary test data**
  - **Strain life curve at RT for calculating the mechanical damage**
  - **Isotherm strain life curves at higher temperatures (at least two temperature level – alu.: 150-350 °C, steel: 250-600 °C) at different constant strain rate, without mean strain and without dwell time**
  - **OP test data (fully constraint)**
  - **The oxidation and mechanical damage terms should be dominant at these test data**
- **Simplifications, presumptions**
  - **At RT only mechanical damage occurs (dominant)**
  - **Creep damage at the isotherm and OP test is neglectable – or known (can be defined by isotherm test at higher temperatures in neutral gas eg. helium)**

Calculation of material parameters for the oxidation term

- **Simplifications, presumptions**

$$\frac{1}{N_f^{ox}} = \left(\frac{h_{cr}\ \delta_o}{B\Phi^{ox}\ K_{peff}}\right)^{-\frac{1}{\beta}} \quad \frac{2\left[\Delta\varepsilon_{mech}^{ox}\right]^{\frac{2}{\beta}+1}}{\left(\dot{\varepsilon}\right)^{(1-a'/\beta)}}$$

$$K_p^{eff} = \frac{1}{t_c}\int_0^{t_c} D_0 \exp\left(\frac{-Q}{RT(t)}\right)dt$$

$$\Phi_{ox} = \frac{1}{t_c}\int_0^{t_c} \exp\left[-\frac{1}{2}\left(\frac{\left(\dot{\varepsilon}_{th}/\dot{\varepsilon}_{mech}\right)+1}{\xi^{ox}}\right)^2\right]dt$$

$$CC = \frac{h_{cr}\cdot\delta_0}{B\cdot D_0}$$

$$\Phi_2^{ox} = \Phi_1^{ox}\cdot\left(\frac{N_{f1}^{ox}}{N_{f2}^{of}}\right)^{\beta}\cdot\left(\frac{K_{p1}^{eff}}{K_{p2}^{eff}}\right)\cdot\left(\frac{\dot{\varepsilon}_2}{\dot{\varepsilon}_1}\right)^{\beta-a}\cdot\left(\frac{\Delta\varepsilon_{mech1}}{\Delta\varepsilon_{mech2}}\right)^{2+\beta}$$

Summary, Outlook

- **Calculation of material parameters of environmental damage for FEMFAT HEAT - Sehitoglu Analysis by using parameter optimization methods**
- **diplom work for finding the most suitable parameter optimization algorythm for the program (deterministic and stochastic methods like simple gradient method, Levenberg-Marquardt method, evolution strategy etc.)**
- **working on a solution for calculation of material parameters of creep damage term, which should be implemented in the program as well**
- **after finishing of the current project, the program should be available for our customers as well (at this time available only for internal use)**

THANK YOU FOR YOUR ATTENTION !