



# SORPAS® 8.0 Release notes

Date of release: 31 March 2007

We are pleased to announce the official release of **SORPAS® 8.0**. Among many new developments, this version has opened up a new area for prediction of the properties of welds after welding.

**NEWS!** It is the first time ever that you can easily use one software system to simulate and optimize the processes of resistance welding directly in correspondence to the resulted microstructures and properties of welds. This will greatly increase the effectiveness of product development, process planning and quality assurance.

The major developments and improvements in **SORPAS 8.0** have been made in the following areas:

- **Micro structures and hardness after welding**
- **Machine database and process optimizations**
- **Graphical user interface and improvements of usability and reliability**

## What's new?

### 1. Micro structures and hardness after welding

- The "Material Database" expanded with "**Metallurgy Data**"
- Distribution of **peak temperature**
- Distribution of **cooling rate at 700°C**
- Distribution of **cooling time from 800°C to 500°C**
- Distribution of **austenization volume fraction**
- Distribution of **martensite formation volume fraction**
- Distribution of **hardness after welding**

### 2. Machine database and process optimizations

- New implementation of **Machine Database**
- **Conduction angle** in AC is included in machine database as function of r.m.s. current
- **Electrode eject** and cooling of parts and electrodes separately in **Off-time**
- **Water cooling of electrodes** as function of water temperature and flow rate
- Improved criteria for **splash prediction** and graphical results showing in different colors for electrode melting and interface splash between sheets
- **New weldability lobes** showing in solid colors with nugget diameters at each point
- Optimizations with an option for targeting nugget size in **Diameter** or **Height** and also as an option for checking at **Overall max** or at the **Thinner one of the outer sheets**
- Weldability lobes and weld growth curves are saved in Ascii text files
- **Elastic loading** in addition to the plastic deformation

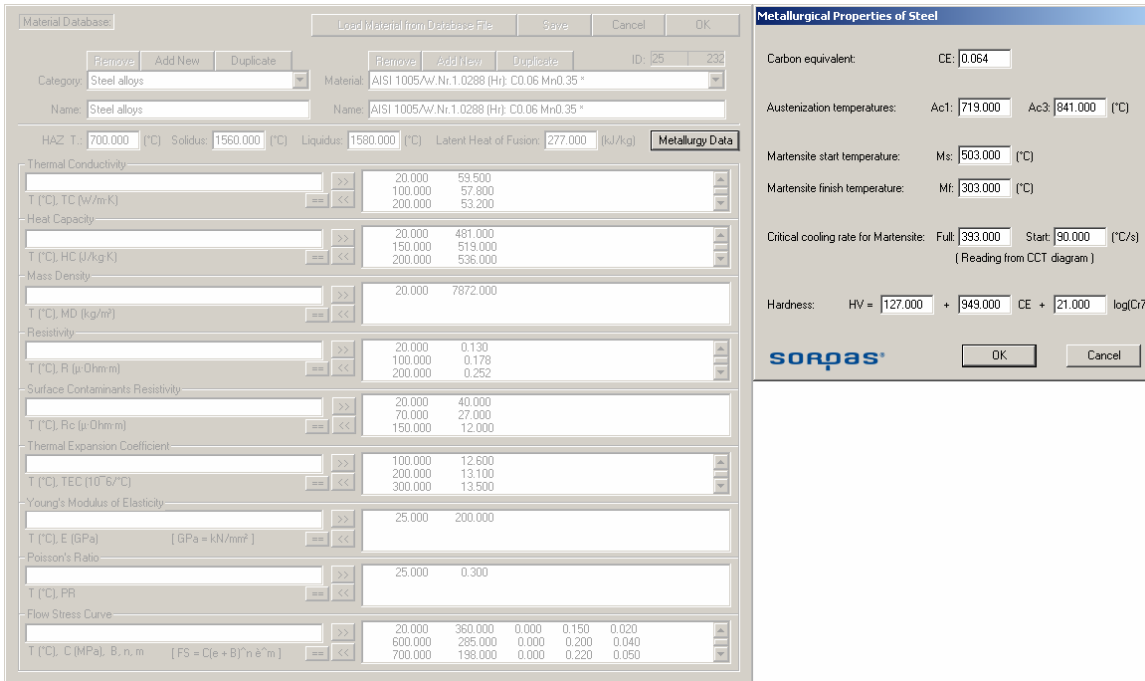
### 3. Graphical user interface and improvements of usability and reliability

- **Preferences** with pre-settings of materials, electrodes, machine and other parameters
- Completely revised and updated **Material database**
- Graphical instructions for defining 2.5D models with the Block Model
- Measuring scale (for example "1 mm") added on all graphs with geometry dimensions
- Full backward version compatibility
- Many other improvements for usability and reliability

## 1. Micro structures and hardness after welding

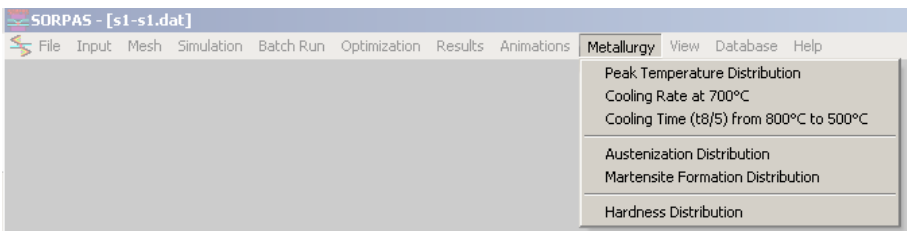
The cooling rate is essential for martensite formation and hardness distribution. Therefore, the cooling procedure with Hold-time (where electrodes in contact with sheets) and Off-time (where electrodes and sheets separated) is highly important and directly related to the resulted properties of welds. For example, longer Hold-time would have higher risk to form martensite because the cooling of sheets in contact with electrodes is much faster than that in free air.

### 1.1 Metallurgy section of the material database



The material database has been expanded with a new section for '**Metallurgy Data**', which contains information needed to calculate the microstructures and hardness development. These new data include the Carbon Equivalent (CE), austenization temperatures  $T_{Ac1}$  and  $T_{Ac3}$ , martensite start and finish temperatures  $T_{Ms}$  and  $T_{Mf}$ , critical cooling rates for start and full formation of martensite, and the functions for hardness. Most of the data can be calculated from the chemical composition with weight percentage of each element. The critical cooling rates can be obtained from the CCT diagrams of the steels. All the data are saved for each material respectively.

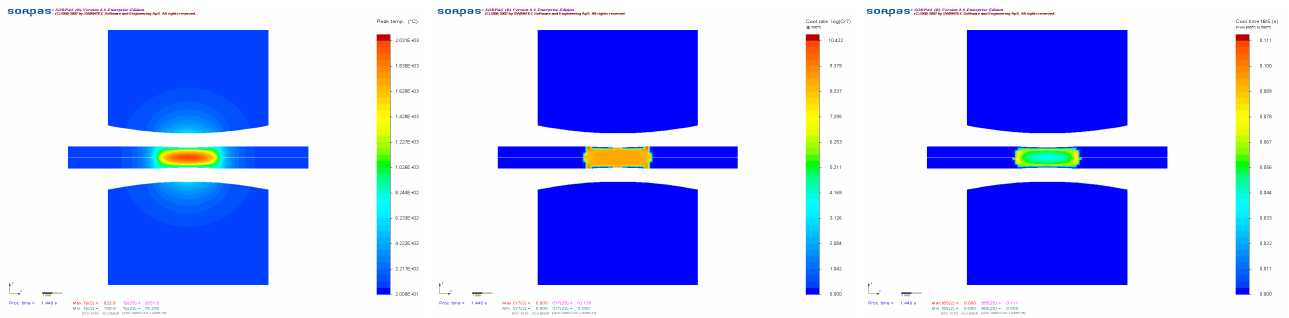
### 1.2 Menu for metallurgy results



A new menu for metallurgy results has been introduced to view the predicted metallurgy properties of welds. The metallurgical results are obtained after the simulation completed with sufficient cooling time (Hold time and Off time), especially after the peak temperatures have cooled down to below the martensite finish temperatures.

*Note: The metallurgy data have to be added in the material database first in order to get any metallurgical result for the material to be simulated.*

### 1.3 Distributions of peak temperature, cooling rate at 700°C and cooling time from 800°C to 500°C

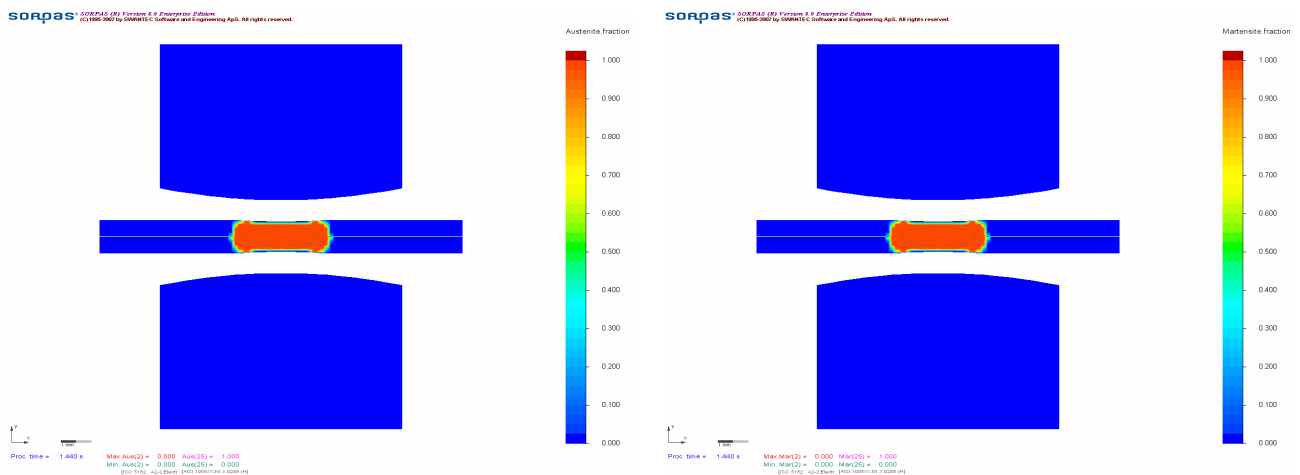


(a) Peak temperature distribution recorded throughout the entire simulation.

(b) Distribution of cooling rate recorded at 700°C.

(c) Distribution of cooling time recorded from 800°C to 500°C.

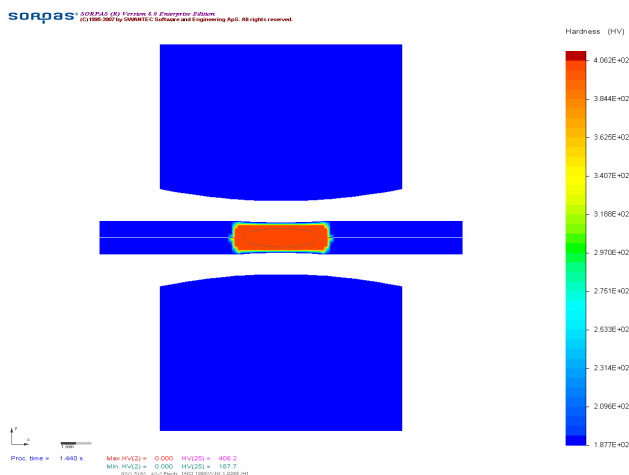
### 1.4 Volume fraction distributions of austenization and martensite formation



Distribution of austenization volume fraction resulted during heating dependent on the austenization temperatures.

Distribution of martensite volume fraction resulted during cooling dependent on the critical cooling rates and martensite start and finish temperatures.

### 1.5 The final hardness distribution



The final hardness distribution resulted after cooling dependent on the Carbon Equivalent and the cooling rate at 700°C.

## 2. Machine database and process optimizations

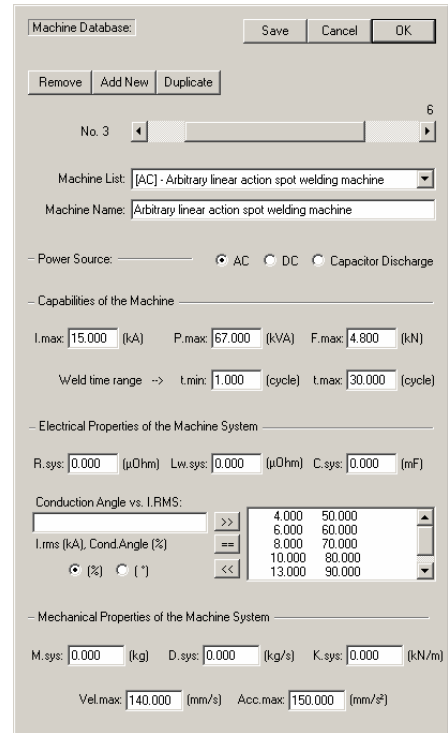
### 2.1 Machine database

The machine database has been implemented which gives the user possibilities to take into account different conditions and properties of individual welding machines in order to make more realistic simulations for practical welding processes.

The machine database includes capabilities of the welding machine or gun such as the maximum limits of weld current, power and force; the type of power source; and the electrical and mechanical characteristics of the machine system. Some data are not yet used in the current version.

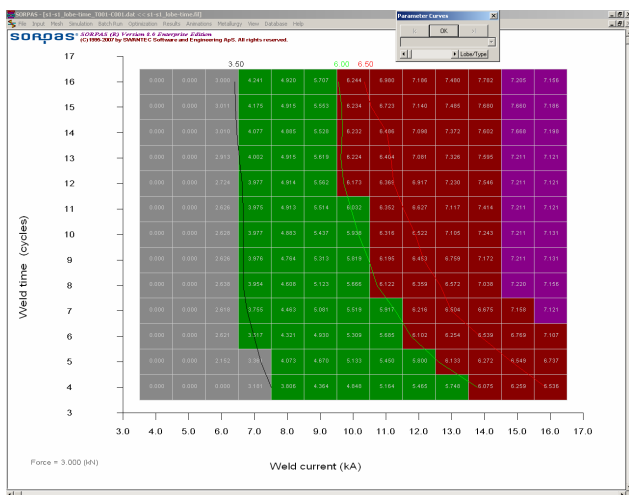
The types of power source including AC, DC and Capacitor Discharge have been moved to the machine database as they are associated with each individual machine. The power source type appears in the name of the machine as a prefix.

The conduction angle with AC machine is defined as a function of r.m.s. current in the database in a similar way as it works in the actual machine. It can be set either in Percentage or in Degree. When preparing data for simulations, the conduction angle will be automatically calculated from the functions in the Machine Database corresponding to the given r.m.s. current.

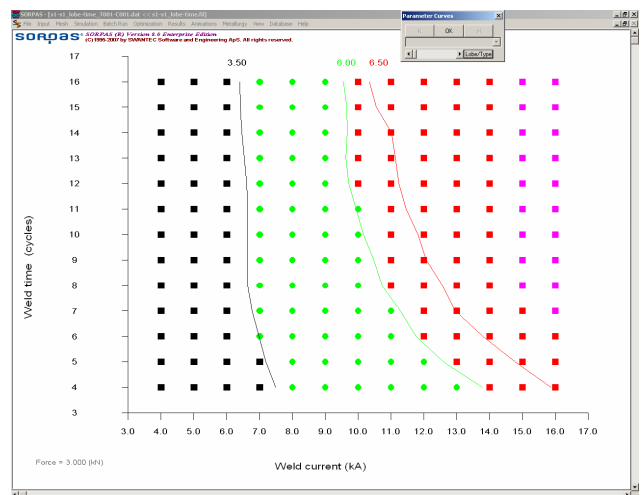


The maximum capabilities have been introduced to make sure that the welding process runs within the limits of the actual welding machines. Users can choose as an option during preparation of simulation data whether to use the machine limits or not.

### 2.2 New weldability lobe diagram



The new weldability lobe diagram (solid colors).



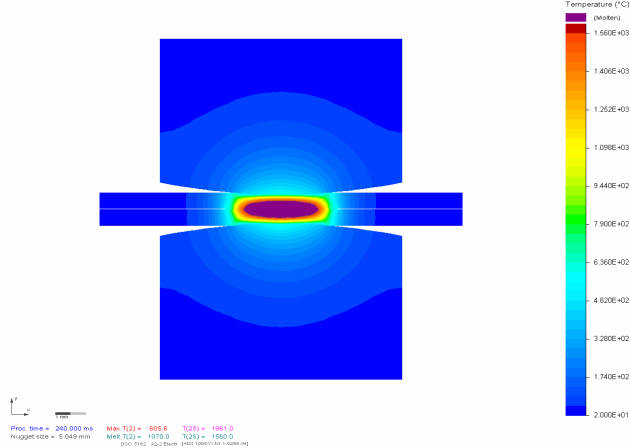
The old weldability lobe diagram (points).

The **new weldability lobe** diagram shows in solid colors with nugget sizes at each point. It indicates clearly divisions between different regions by color shifting such as at splash limits. This makes it easier for users to analyze the results. As an option, it is still possible to show the old weldability lobe. Different colors are used to show different types of expulsions. The red color shows expulsions at interface between sheets and purple color shows electrode melting. The weldability lobe can be shown with respect to nugget **diameter** or **height**. The nugget size can also be measured at **overall max** or at the **thinner one of the outer sheets** that are directly in contact with the electrodes.

### 2.3 Electrode eject and cooling of parts and electrodes separately in Off-time

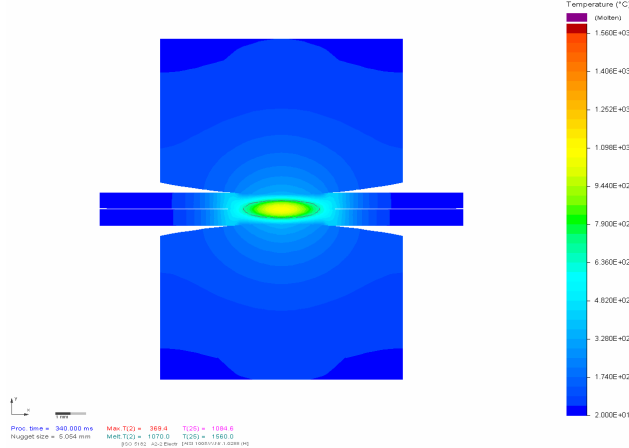
The Off-time is introduced to allow electrode eject and cooling of parts and electrodes separately. Now, the complete weld cycle for making one weld is simulated with all 4 stages (squeeze time, weld time, hold time and off time). It is ready for further developments on multiple steps welding.

SORPAS® (S) Sorpas & Engineering ApS. All rights reserved.



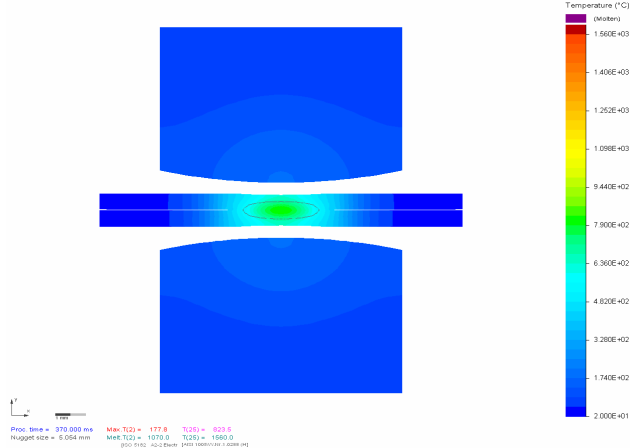
Temperature distribution at end of Weld time.

SORPAS® (S) Sorpas & Engineering ApS. All rights reserved.



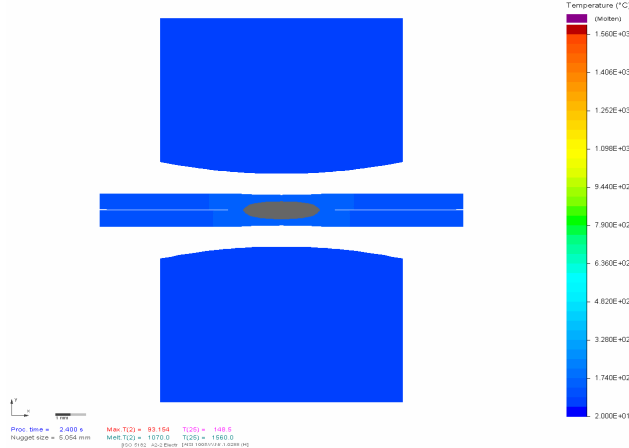
At end of Hold time before electrode eject.

SORPAS® (S) Sorpas & Engineering ApS. All rights reserved.



Electrodes eject in action.

SORPAS® (S) Sorpas & Engineering ApS. All rights reserved.



Electrodes and sheets cooling down separately after electrodes eject.

### 2.4 Water cooling

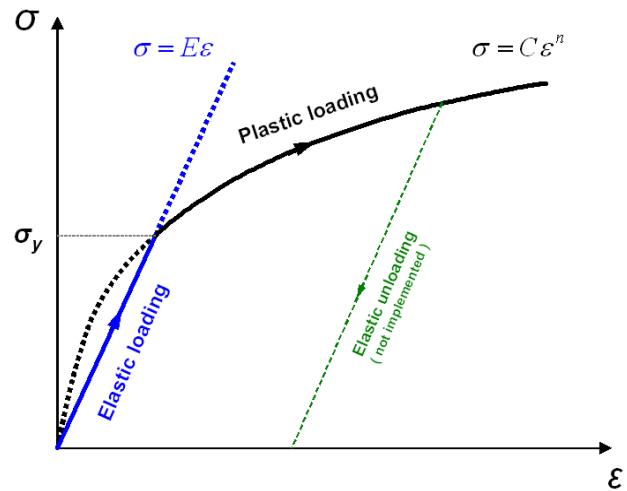
A new function for water cooling has been developed to simulate water cooling in electrodes as function of water temperature and flow rate (liter/minute). The water cooling is added by inserting a special Tool block fitting exactly the water cooling cavity in the electrodes. Tools no.1 and no.2 are reserved for electrical connections, so the Tools used for water cooling can only start from no. 3. When the check box "Water cooling" is checked, the Tool block for water cooling will change its color to light blue indicating it is now set as water cooling.

The screenshot shows the SORPAS software interface with the 'Watercooling' settings panel on the left and a graph on the right. The settings panel includes fields for 'Process Time', 'Squeeze', 'Weld', 'Hold', 'Date', 'Size', 'Move', 'Tool', 'Security of the Current Tool', 'Mechanical Control', and 'Electrical Control'. The 'Water cooling' checkbox is checked. The graph shows 'Current (kA)' on the left y-axis and 'Force (kN)' on the right y-axis, both plotted against 'Process time (ms)' on the x-axis. The current shows a series of pulses, and the force shows a steady increase over time.

### 2.5 Elastic loading

In this new version, the elastic loading (as shown with the blue line in the figure to the right) has been implemented as an option to combine with the plastic deformation that have been modeled with the flow stress (stress-strain) curve.

As illustrated in the figure, the elastic loading presents only at very low strain, thus gives minimal effect on large scale welding. It will be more important for examples with less overall deformation especially in micro welding applications. The elastic unloading (eventually resulting in the residual stresses) has not been implemented in the current version.



## 3. Graphical user interface and Improvements on usability and reliability

### 3.1 Preferences

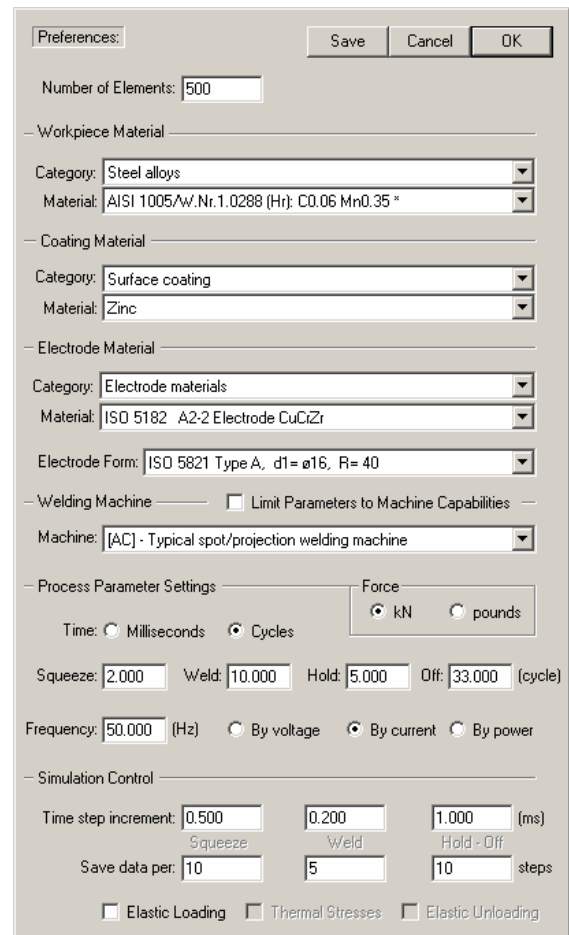
A database with Preferences has been implemented to allow users to set up the default settings (pre-settings) to be used for making new simulations.

When preparing new simulations with the Wizard or the data file Editor, the default values will be taken from the preferences and used for preparing the simulation data.

It will be still possible to change the values after they are loaded into the Wizard or the data file Editor. All simulations will run only according to the data that are finally defined and saved in the data file.

The new feature for *elastic loading* can be set here in the Preferences as an option to include in the simulations or not. It can also be changed in the data file Editor under Simulation Controls.

Some modifications have been made in the data input windows in the Wizard and the data file Editor in order to synchronize with and make use of the data in the Preferences and the Machine Database.



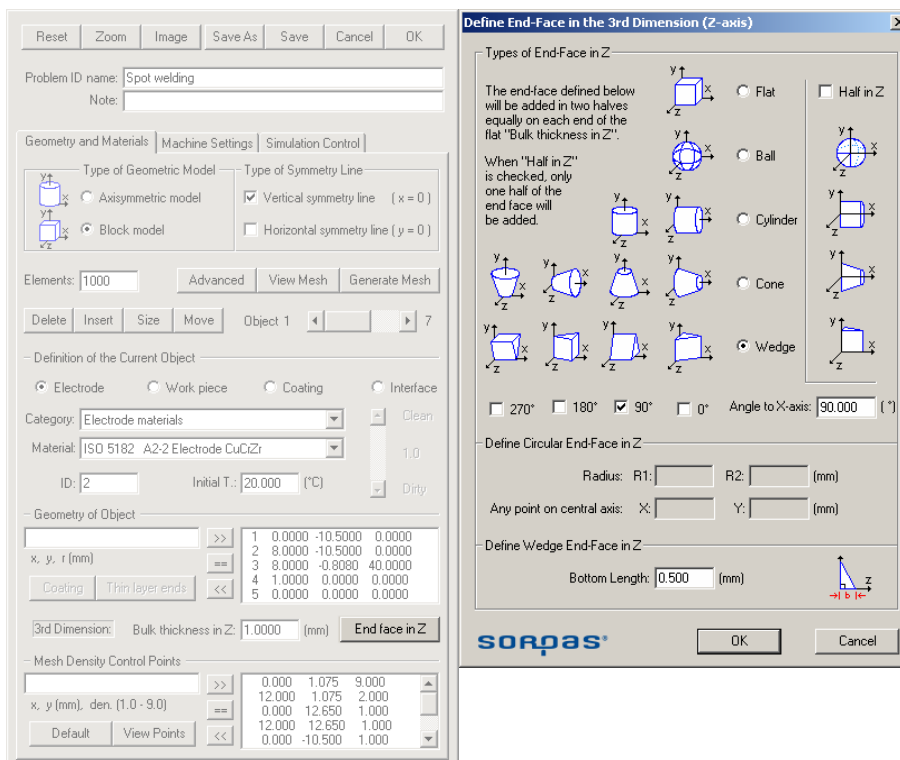
### 3.2 Graphical instructions for modeling in Block Model

As graphical instructions, small picture icons have been introduced to the data input window for setting up the “**End Face in Z**” when defining the 2.5D models with the Block Model.

The most commonly used orientations for different types of the End Face in Z have been pre-defined and shown in pictures. They can be selected by simply clicking on the corresponding check box. Any irregular angles for special orientations to the x-axis can be set in the input box.

The defined **End Face in Z** is only the ending shape in the 3<sup>rd</sup> dimension, which will be added in two halves equally to each end of the flat “**Bulk thickness in Z**” that was set in the data input window for “Geometry and Materials”. The bottom length is only used for defining a wedge as illustrated.

When “**Half in Z**” is checked, only one half of the ending shape defined by the End Face in Z will be added to the Bulk thickness in Z.



### 3.3 Full backward version compatibility.

The old data files from earlier version can be opened as read-only to show the simulation results. The user can then decide as an option whether to update the data file to take advantages of the new version SORPAS 8.0 or just continue as read-only to view data in the old version Data File Editor.

It is recommended to use the “**Save as**” function to convert the old version data files to the new version.

It is also possible to save the new version data file backward to version 7.0, but all the new features for the new version will be missed.