SORPAS® 9.0 Release Notes

Date of release: 31 March 2008

We proudly announce that the new version **SORPAS® 9.0** is now released.

It is a result of over 20 years continuous research and development in resistance welding and numerical simulation, and 9 years commercial engagements on industrial applications and close collaborations with users.

This new version has included many improvements on the existing functions of previous versions based on the feedbacks and requirements of users as well as our own tests and verifications. At the same time, many new functions have been developed and implemented, e.g. **it is now possible to optimize the welding process window according to predicted weld strengths and failure modes.**

What's new?

1. Improvements on system performance

- Reducing simulation time generally by 10~40% with more efficient numerical solvers, e.g. possible for a normal spot welding simulation in less than 3 minutes on a newer PC.
- Further improvements on system stability and consistency of simulation results.
- When simulating weld growth curve and weldability lobe, a folder is automatically created for the data files and simulation results.
- Simulation progress percentage displayed with the Watcher on the Windows taskbar.
- Special function for deleting unwanted results to save disk space.
- Compatibility to previous versions, e.g. viewing simulation results of all previous versions and saving data file back to version 8.0 and version 7.0.

2. Improvements on simulation results

- Generally improved accuracy on prediction of nugget sizes and expulsion/splash limits.
- New function for manual adjustment of splash limit for individual data files or on weld growth curves and weldability lobes.
- Weld nugget diameter calculated exactly along the interface (surface of each sheet).
- Weld growth curve and weldability lobe show values at max, min. and each sheet.
- Alloying (mixing) of dissimilar steels in the weld nugget for prediction of martensite formation and hardness distribution.
- Water cooling added with electrode design in the electrode database.
- Default mesh density distribution and number of elements generally improved depending on the thickness and number of sheets and coatings.

3. Implementations of new functions

- Prediction of weld strengths (cross tension strength, shear strength and peel strength) and all presented in weld growth curves and weldability lobes.
- Prediction of failure modes in spot welds, i.e. plug failure or interface failure.
- Function for adding gap between sheets with the Input Wizard for spot welding.
- Mouse enhanced graphical user interface functions for zooming, modifying geometry and adding mesh density control points.
- Undo function at Edit data file to cancel all changes made after the last saving.
- Simulation of thermal expansion during heating (welding).
- Prediction of residual stresses after welding due to cooling and elastic unloading.
- Estimation of cracking risks due to residual stresses.

1. Weld nugget diameter calculated at interface for each sheet

The weld nugget diameters are now calculated along the weld interfaces (or surfaces of each sheet). For the upper sheet, the nugget diameter is calculated at its lower side (A as in figure). For the lower sheet, the nugget diameter is calculated at its upper side (D as in figure). For the sheet(s) in the middle, the nugget diameter is determined with the smaller one from the nugget diameters at both upper and lower sides (B as in figure). In the results the nugget diameters are displayed together with the object number indicating also where the nugget diameter is measured, for the upper side with upperscore e.g. (3⁻) and for lower side with underscore e.g. (5_).
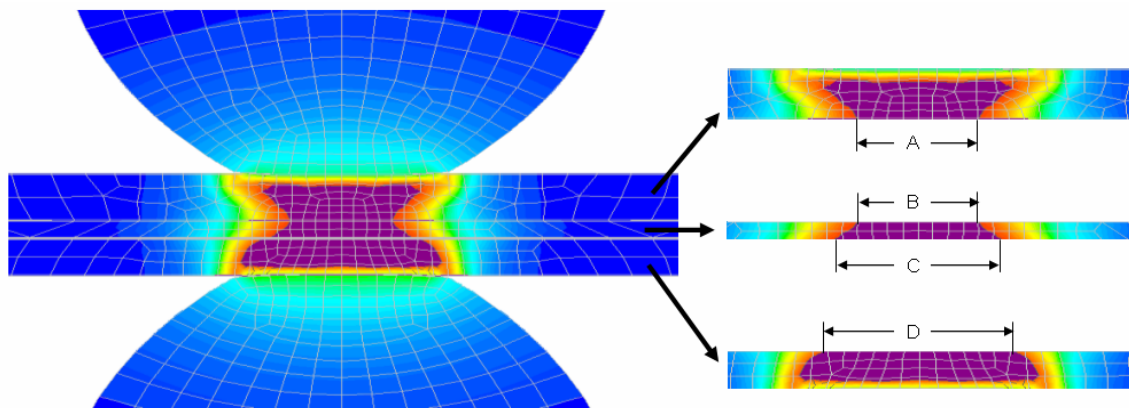

Figure 1: Positions for measurement of weld nugget diameters.

2. Weld growth curves and weldability lobes for weld nugget diameter and weld strengths showing curves of values at max., min. and each sheet

Based on the simulated weld nugget diameters and the generally improved prediction of hardness distribution, the weld strengths are estimated with reference to the applicable ISO standards: ISO 14272:2000 (for cross tension test), ISO 14273:2000 (for shear test) and ISO 14270:2000 (for peel test).

The weld growth curves and weldability lobes can alternatively show the following 4 kinds of weld quality measures:

- Weld nugget diameter   (mm)
- Weld cross tension strength   (kN)
- Weld shear strength   (kN)
- Weld peel strength   (kN)

The control box for managing the weld growth curves is shown in Figure 2a. Figure 2b shows the list of the weld quality measures including weld nugget diameter, cross tension strength, shear strength and peel strength. Figure 2c shows the list of positions where the weld nugget diameter is measured including "Overall min.", "Overall max." and each sheet/object. It is possible to show two weld growth curves for values at different positions on the same graph.

Figure 3 shows two examples of the weld growth curves. The three reference values (min., nom. and max.) for the weld quality range can be defined and updated on the curve. The welding process window (ΔI) defined by weld current limits corresponding to the weld quality range is indicated on the curve too. The splash limit can be adjusted manually on the curve, or for each individual data file at Edit data file under Simulation control. The preferred splash adjustment factor can be saved in the "Preferences". As shown on Figure 3b, the failure modes are also predicted with solid markers indicating "plug failure" and open markers indicating "interface failure".

The same functions with similar control box are also implemented with predicted weldability lobes.

(a)   *(b)*   *(c)*
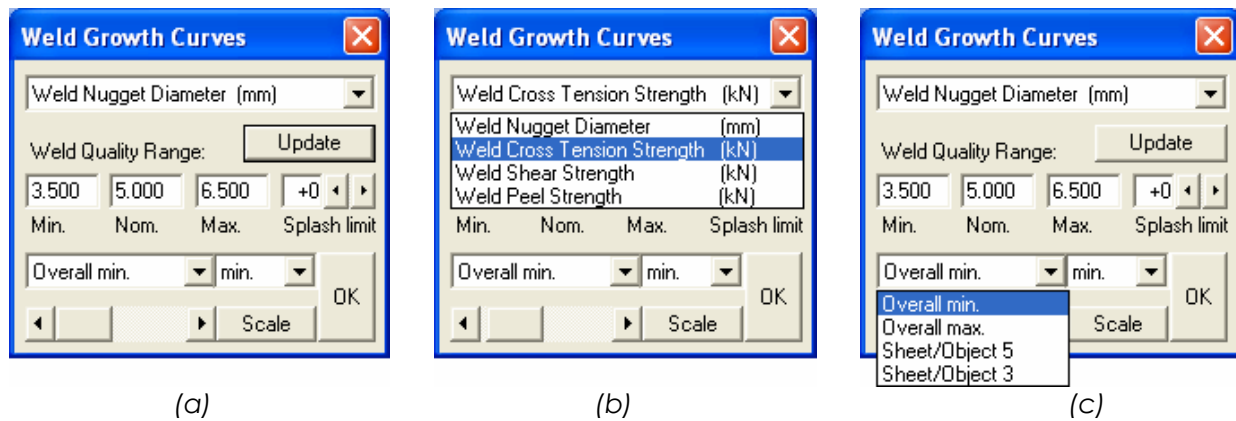
Figure 2: a) Control box with functions for weld growth curves, b) list of 4 kinds of weld quality measures, c) list of positions where the weld quality values are measured.
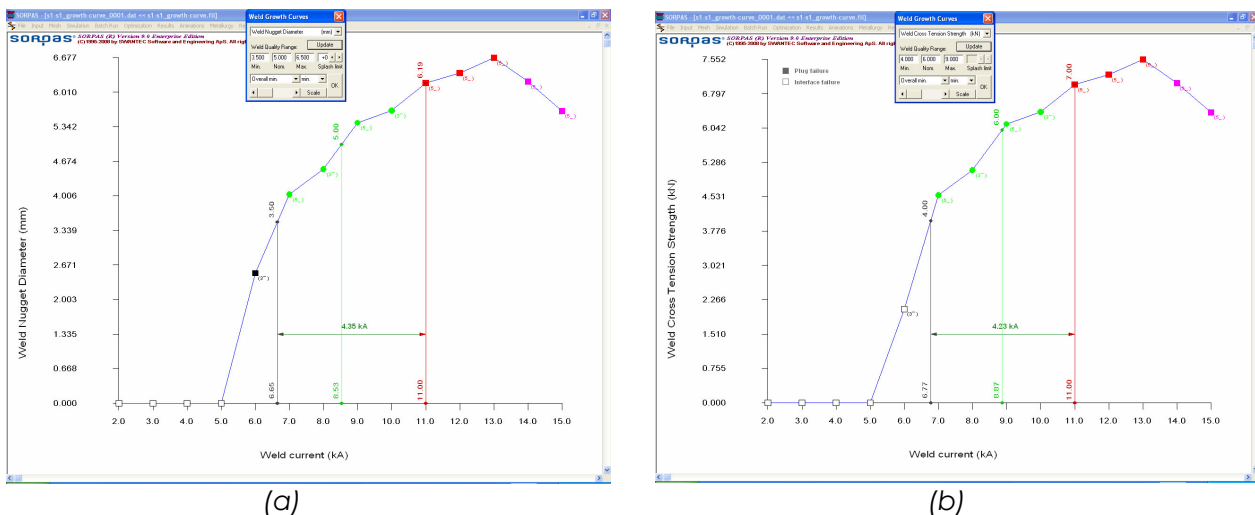

(a)   *(b)*

Figure 3: Weld growth curves showing the weld quality range and welding process window (ΔI). a) weld nugget diameter, b) weld cross tension strength where the failure modes are also predicted with solid markers indicating "plug failure" and open markers indicating "interface failure".

3. Alloying (mixing) of dissimilar steels inside the weld nugget for prediction of martensite formation and hardness distribution

When dissimilar steels are welded, the steels inside the weld nugget will be alloyed or mixed after melting. This effect has been implemented in the calculations for martensite formation and hardness distribution inside the weld nugget. Figure 4 shows an example of the hardness distribution after alloying/mixing in the weld nugget for spot welding of DP600 and DC06. The alloying effect has resulted in a uniform hardness in the weld nugget slightly lower than that in the HAZ of DP600.
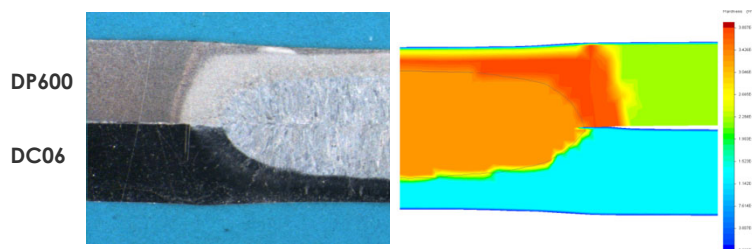

Figure 4: Hardness distribution with alloying in the weld nugget for spot welding of DP600 and DC06.

4. Adding gap between sheets with the Input Wizard for spot welding

A gap of any size (mm) can be added with the Input Wizard for preparation of the sheet combination. The size of the gap can be set individually at each interface or equally at all interfaces. Figure 5 shows an illustration of the gaps added differently in a 3-sheet combination.
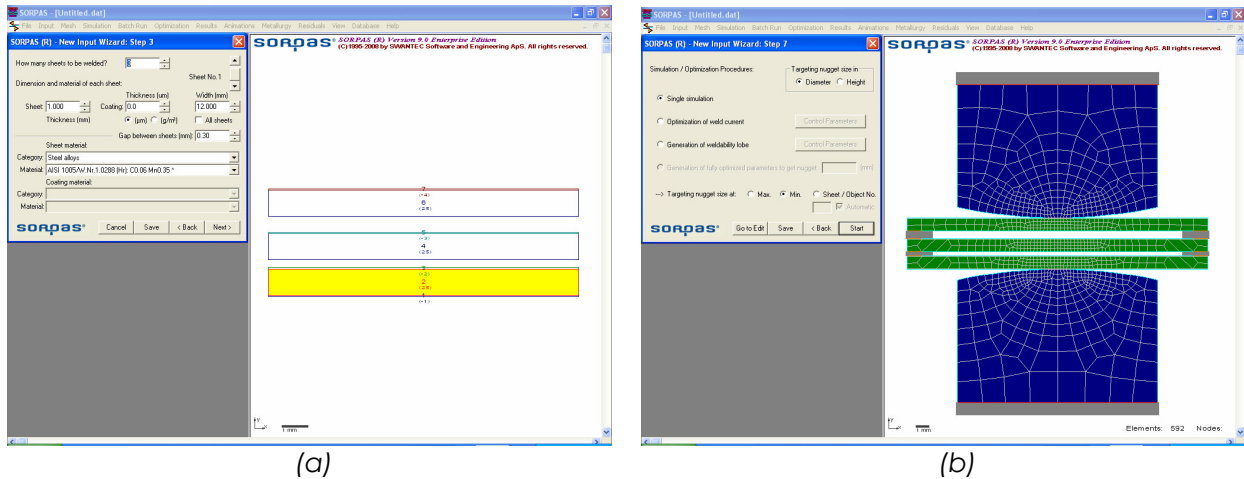

(a)   *(b)*

Figure 5: Adding gap between sheets with the Input Wizard. a) Adding gap when preparing the sheet combination, b) the stack-up after automatic mesh generation.

5. Mouse enhanced graphical user interface functions for zooming, modifying geometry and adding mesh density control points

The function for zooming by mouse clicks is implemented. The zoom area can be defined by clicking 2 points crossing the desired area. The two corner points of the zoom area (after correction to the aspect ratio) are displayed in the edit window bars. The two pints can be modified and then the zoom can be set manually. This makes it possible to define exactly the same zoom by copying the coordinates of the zoom area corner points from one example to another.
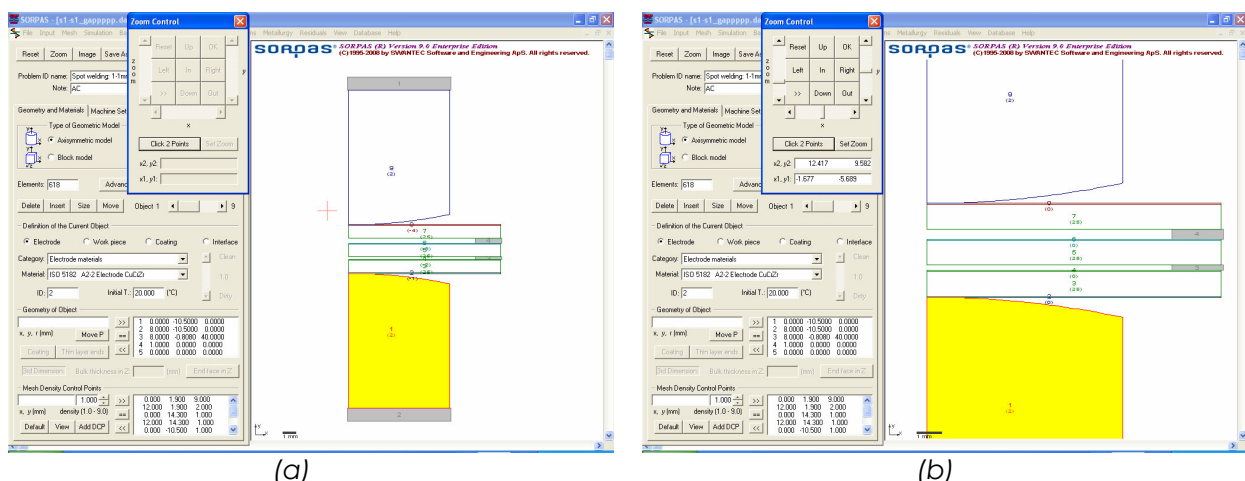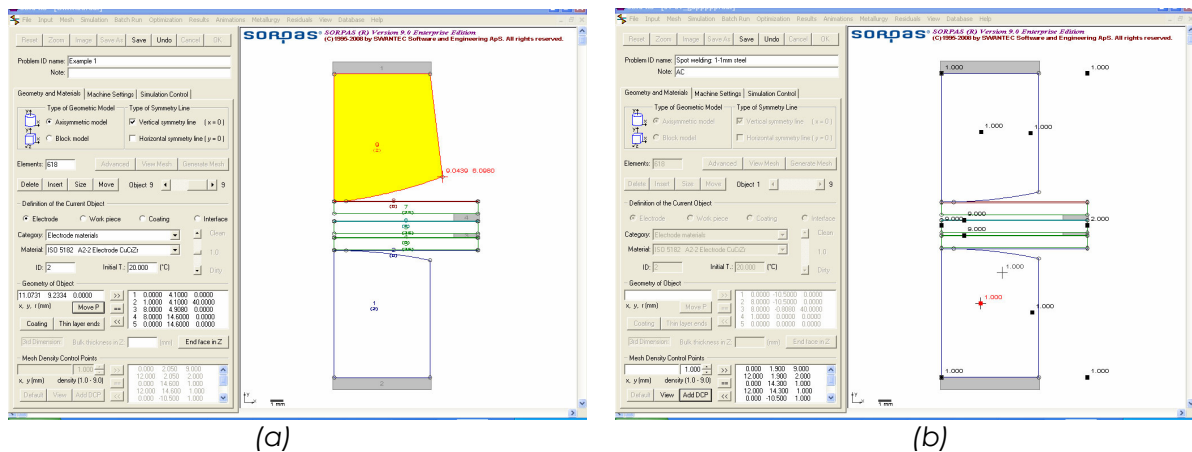

(a)   *(b)*

Figure 6: Zooming by mouse clicking 2 points or setting zoom by typing coordinates of 2 points.

Figure 7 shows two other new functions with mouse clicks: a) moving a point in any object, or catching the coordinates of any position; b) adding mesh density control points with specified mesh density scale.

(a)   *(b)*

Figure 7: Functions for moving point/catching coordinates and adding mesh density control points.

## 6. Thermal expansion due to heating during welding

The thermal expansion due to heating during welding
has been implemented. Figure 8 shows an example
of the simulated tool displacement curve. A negative
movement occurred due to thermal expansion of
sheets/objects and electrodes. The first positive
displacement was during squeezing. The negative
movement started due to heating and then further
deformation of materials took over movement again.

*Figure 8: Tool displacement curve with
negative movement due to thermal
expansion of sheets and electrodes.*
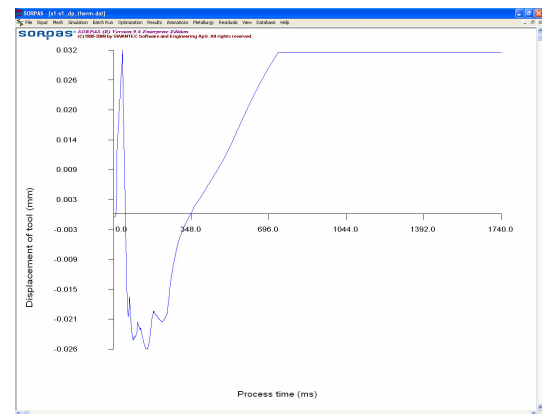
7. Residual stresses and cracking risks

Functions for simulating residual stresses and cracking risks after welding have been implemented.
The residual stresses have been calculated based on elastic unloading, cooling shrinkage and
phase transformations. Figure 9 shows example of the residual stresses and the cracking risks.
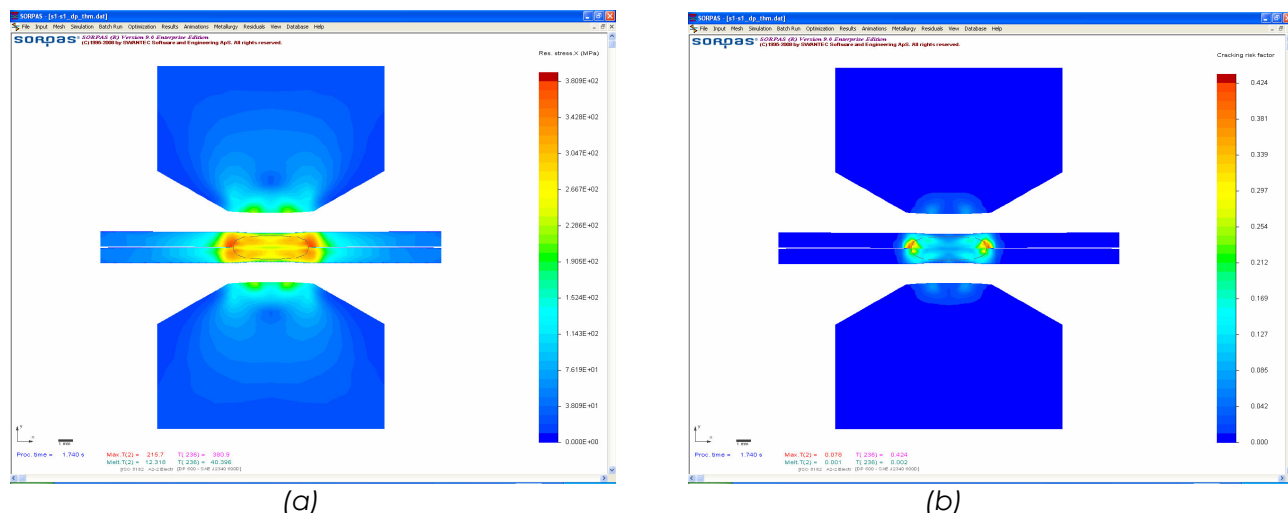
(a)   *(b)*

Figure 9: a) residual stresses in radial direction, b) the cracking risks and potential crack location.