

OPTimal CASTing–User Manual–2

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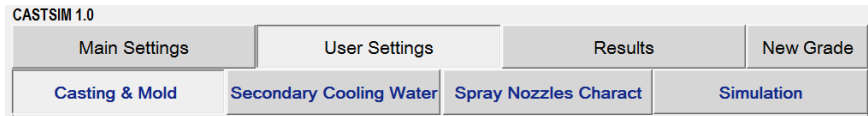
2 Results

- Line Plots
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User Settings Window

User settings option is mainly designed for advanced users who want to vary all the casting and simulation parameters.



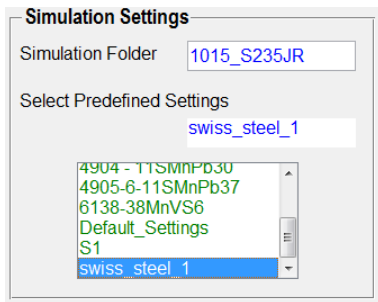
User Settings Window has 4 subtabs such as

- ❶ **Casting & Mold** – casting and mold related parameters
- ❷ **Secondary Cooling Water** – flow rate in each cooling zones
- ❸ **Spray Nozzle Characteristics** – arrangement of individual row of nozzles and related parameters
- ❹ **Simulation** – simulation related settings

User Settings Options

There are two different set of parameters displayed in parallel:

- 1 **Default** – default parameters stored in Default_Settings and also it includes grade dependent casting parameters
- 2 **User/Modify** – casting and simulation parameters stored in specified User_Settings



- In Main Setting window, what setting user have chosen is considered as User/Modify parameter. eg. `swiss_steel_1`
- Editing the user predefined values are possible
- **Default** is shown just for the guideline. Finally what is stored in **User/Modify** column is used for simulation

Switching Variables

User can edit the parameters present in **User/Modify** column. It is also possible to rivet back and request to apply default parameters. For this purpose two buttons are provided:

- 1 – **User/Modify** column is filled by default parameters
- 2 – **User/Modify** column is filled by user defined setting parameters stored in `User_Settings.mat`

default, *user*, and *present* are the 3 structures which handles the parameters. While activating the User Settings Window,

- *default* : material dependency will be switched on. `Grade_depend` is imposed on default
- *user* : `User_Settings` data will not be changed
- *present* : *user* data will be transferred to *present*. While switching and , *present* will trace the changes.

Casting & Mold Parameters

CASTSIM 1.0

Theory Manual User Manual

CASTSIM 1.0

Main Settings User Settings Results New Grade

Casting & Mold Secondary Cooling Water Spray Nozzles Charact Simulation

Steel Number 2645 Steel Type C45 Folder Fold_2645_C45 Settings swiss_steel_1

	Default	User / Modify
Casting & Mold Parameters		
Casting Speed [m/min]	2.38	2.37
Casting Temperature [degC]	1527	1532
Cooling Water Temperature [degC]	20	20
Ambient Temperature [degC]	25	25
Mold Length [mm]	870	870
Alizadeh Model		
Mold Wall Thickness [mm]	16	16
Water Temp. Rise [degC]	9.9	9.9
Mold Water Flowrate [l/min]	1564	1564

Mold Heat Transfer Model

☐ OVGU
 ☐ Brimacombe
☐ Ha et. al
 ☒ Alizadeh

Heat Flux [MW/m²]

Distance from Meniscus [mm]

Load Default Settings Load User Settings

Save Settings Run Simulation

LEHRSTUHL FÜR DYNAMISCHE VERFORMUNG UND VERGÄRUNG

SWISS STEEL Providing special steel solutions

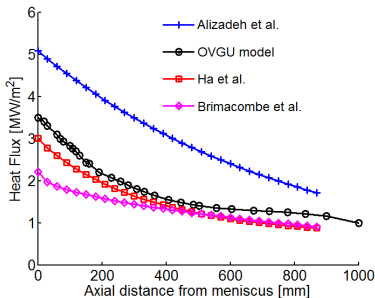
designed by Otto von Guericke University Magdeburg

- Red box shows the mold and casting related user settings
- Two blue vertical box show the default and user settings values
- Mold heat flux from the meniscus to exit is plotted
- User/Modify column is editable

Mold Boundary Model

It is possible to choose any of the 4 available mold heat flux models: OVGU, Brimacombe, Ha *et al.*, and Alizadeh. In the default settings, **Alizadeh** model which is based on the mold cooling water, has been chosen.

$$q(x, z) = A f(x) \frac{\alpha \rho_w C_{pw} Q \Delta T_w}{P_m} \frac{e^{-\alpha z}}{1 - e^{-\alpha H_m}}$$



- Alizadeh model considers the cooling water flow rate (Q), and its overall temperature rise ΔT_w , and mold perimeter (P_m).
- Brimacombe and Ha *et al.* models only take into account of casting speed. OVGU model is based on the thermo mechanical conditions at the interface

Secondary Cooling Water

It is possible to change the secondary cooling water flow rate in each zones. Five different kind of cooling modes are possible. Four predefined cooling modes are: ultra mild, mild, medium, and strong. Water flow rate in these four modes are independent of grades. Therefore, it is considered as factory settings. User can also input the flow rate either in Liter/meter or Liter/min.

	Default	User/Modify
Casting Speed [m/min]	2.38	2.37
Cooling Mode	Strong	Ultra Mild
Litre/m		
Zone I	50	33
Zone II	75	43
Zone III	36	13
Litre/min		
Zone I	119	78.21
Zone II	178.5	101.91
Zone III	85.68	30.81

- Default shows the cooling mode predefined by factory for the selected grade.
- User/Modify shows the cooling mode stored in `User_Settings.mat`
- When cooling mode:Others is selected, water flow rate in Zone 1,2, and 3 becomes editable. So that user can input the values.
- It is also possible to view the local impingement density and HTC distribution.

Spray Nozzle Characteristics

Individual row nozzle characteristics are displayed in matrix form. As usual, default matrix is non editable and User/Modify matrix is editable.

	ZONE	NRO	ADIST	PRDIA	COAN	DIST	WFR
1	1a	2	910.00	204.10	77	85	11.45
2	1b	1	1990.00	312.10	77	130	5.72
3	1b	1	1205.00	312.10	77	130	5.72
4	1b	1	1320.00	312.10	77	130	5.72
5	2a	1	1520.00	272.40	59	140	3.23
6	2a	1	1690.00	272.40	59	140	3.23
7	2a	1	1882.00	272.40	59	140	3.23
8	2a	1	2016.00	272.40	59	140	3.23
9	2a	1	2184.00	272.40	59	140	3.23
10	2a	1	2350.00	272.40	59	140	3.23
11	2a	1	2516.00	272.40	59	140	3.23
12	2a	1	2682.00	272.40	59	140	3.23
13	2b	1	2882.00	209.80	43	140	2.59
14	2b	1	3197.80	209.80	43	140	2.59
15	2b	1	3413.50	209.80	43	140	2.59
16	2b	1	3629.30	209.80	43	140	2.59
17	2b	1	3845.00	209.80	43	140	2.59
18	2b	1	4060.80	209.80	43	140	2.59
19	3a	1	4268.20	185.00	38	140	1.60
20	3a	1	4478.30	185.00	38	140	1.60

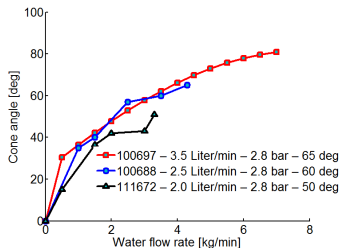
ZONE - local zone index, NRO - number of nozzles per row, ADIST - axial distance from meniscus in mm, PRDIA - print diameter in mm, COAN - nozzle cone angle in deg, DIST - nozzle distance from strand surface in mm, WFT - water flow rate in Liter/min

- Water sharing between sub zones are as follows: (a) [0.4 0.606 0.545] and (b) [0.6 0.394 0.455].
- Cone angle depends on water flow rate and nozzle type.
- It is assumed that all the four sides of the strand are cooled in the same fashion.
- At present, it is not possible to adjust the water flow rate. eg. if one nozzle row gets blocked, even though the zonal flow remains the same and its corresponding increase in flow rate of other rows occur.

Spray Nozzles

Three different nozzles are used in 6 sub zones.

- 100697 – 3.5 Liter/min – 2.8 bar – 65 deg (Zone 1a and 1b)
- 100688 – 2.5 Liter/min – 2.8 bar – 60 deg (Zone 2a)
- 111672 – 2.0 Liter/min – 2.8 bar – 50 deg (Zone 3a and 3b)



- cone angle change with flow rate is shown in figure
- cone angle at rated flow rate and pressure is considered as reference

Simulation Settings

- Billet dimensions : width and thickness can be modified
- Mesh : number of rectangular elements, order of the element, arrangement of the elements can be changed
- Simulation settings : time step size, final length, and relative tolerance can be edited.

Billet Dimensions

	Default	User / Modify
Billet Width [mm]	150	<input type="text" value="150"/>
Billet Thickness [mm]	150	<input type="text" value="150"/>

Mesh Setup

Elements in Width direction	8	<input type="text" value="8"/>
Elements in Thickness direction	8	<input type="text" value="8"/>
Element Arrangements	Linear	<input type="text" value="Linear"/>
Element Order	4 nodes	<input type="text" value="4 nodes"/>

Simulation Setup

Simulation Length [mm]	5490	<input type="text" value="5490"/>
Time Step Size [sec]	1	<input type="text" value="1"/>
Relative Tolerance	0.001	<input type="text" value="0.001"/>
Geometrical Symmetry	<input type="text" value="Tway Symmetry"/>	

Loose Side Plot

Thickness direction [mm]

Fixed Side

Plot

☐ mark nodes ☐ mark elements

Load Default Settings **Load User Settings**

- Symmetry: four choices are available to choose the symmetry from two way to no symmetry
- mesh can be plotted
- possible to view node and element numbers

Save Settings

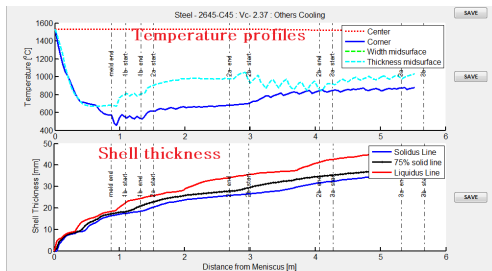
- At any stage in User settings window, it is possible to save the settings for future usage.
- Only data present in the User/Modify column will be saved.
- User needs to give appropriate name for the settings file.
- By default, the file will be saved in **Settings** folder.

Run Simulation

- At any stage in User settings window, it is possible to start the simulation.
- Simulation folder and Grade can not be changed during User settings mode.
- Simulation will consider the data present in the User/Modify column.
- It is also possible to interrupt the simulation.

Temperature Evolution

- First plot show the temperature evolution at following locations : (a) center, (b) corner, (c) width and (d) thickness midsurface
- Key locations such as mold end and secondary cooling zones are indicated by vertical lines



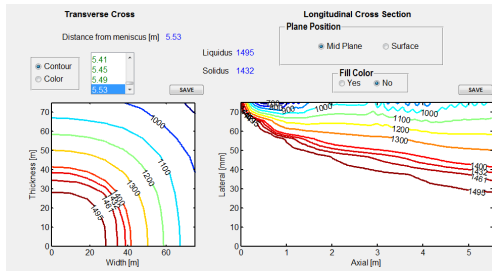
Save option allows user to save the results with default name in corresponding simulation folder

Shell Thickness

- Solidus and liquids lines are plotted
- 75% solid line is also shown
- It is possible to save individual plot or both together

Lateral Isotherms

- Based on the time step size, it is possible to plot the isotherms at different length.
- User needs to choose the distance from the list. By default final simulation length will be chosen.
- User can switch between color or line contours.



Save option allows user to save the results with default name in corresponding simulation folder

Axial Isotherms

- Surface or mid plane isotherms along the casting direction can be plotted
- Fill color is optional for the user.

New Grade

It is useful for insertion of new grade which does not exist in the software database '`\Grade Data Bank\Steel_Grade_Data.mat`'

- Steel grade number and type need to be entered
- Casting and cooling parameters has to be entered. Cooling mode can be selected from list or otherwise user can input.
- Material properties has to be given in the form of text file with 2 columns: Temperature vs. properties. It is necessary to load all 5 material properties.

Steel Grade Definition

Number: 1015
Type: S235JR
Folder: 1015_S235JR

Casting & Cooling Parameters

Casting Speed (mm/s): 2.30
Cooling Mode: Strong
Water Flow (L/m): 50
Casting Temperature (degC): 1567
Zone I: 75
Zone II: 30

Load Steel Properties

Thermal Conductivity (W/m.K): [Browse]
Density (kg/m³): [Browse]
Specific Heat (J/kg.K): [Browse]
Enthalpy (J/mol.K): [Browse]
Phases (%): [Browse]

Plot Steel Properties

Liquidus Temperature (degC)
Solidus Temperature (degC)
Latent heat (J/kg)
Thermal Conductivity (W/m.K)
Density (kg/m³)
Specific heat (J/kg.K)
Phase fraction (Liquid)
Enthalpy

Load Data Files Save New Grade

- After selecting file paths, **Load Data Files** will allow to view the plots.
- Any one of the all five properties can be selected for plotting. Scalar data will be displayed.
- **Save New Grade** permanently store the data in `Steel_Grade_Data.mat`.