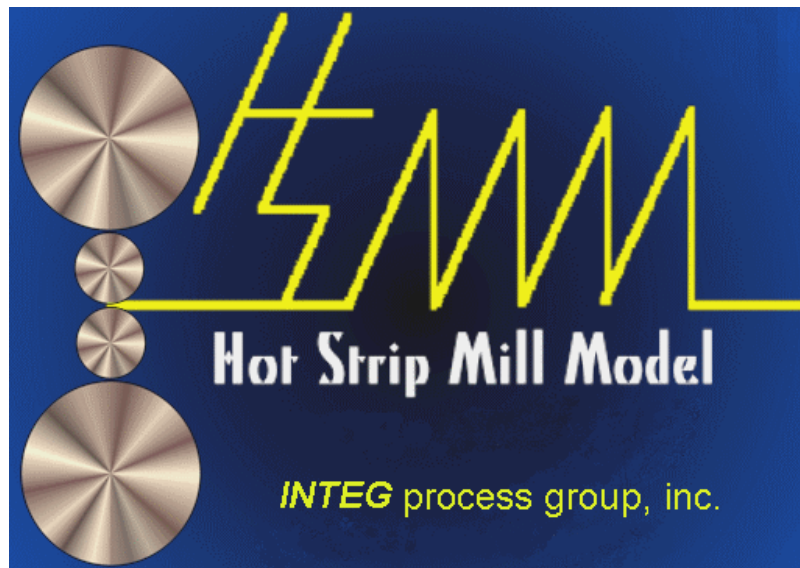




# Getting Started with HSMM v6.1

Release 2.0



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## What is HSMM?

HSMM is a **H**ot **S**trip **M**ill **M**odel PC-based computer program that performs a variety of calculations to simulate the physical process of rolling steel in a hot mill. The HSMM allows you to simulate the processing of the steel strip or plate from your reheat furnace dropout to your coiler or cooling bed. The model's tracking module tracks the head, middle and tail points along the length of the piece while calculating the temperature evolution, rolling forces, microstructure changes and final mechanical properties. Calculated results are presented to you in the form of tables, graphs, and exported files for loading into Microsoft Excel.

## Getting Started with HSMM

This document is broken down into three sections and is intended to help you get quickly oriented with the HSMM, understand how to utilize the HSMM to study and improve your mill operations and to make you aware of some of the advanced features of the HSMM.

The three sections of this document are as follows:

- Part I – Quick Tour
- Part II – Working with the HSMM

We hope that this document allows you to appreciate the HSMM. It is an advanced tool that is easy to use. The HSMM has many wonderful tools and features that will give you that extra capability in understanding your process so that you can increase your product quality, improve your process performance and save you money.

Before we get started exploring the features of the HSMM and how to use it, let's review some basic installation requirements and instructions. You should have an installation CD and a security device to install and utilize the HSMM. If not, please contact INTEG process group inc.

Should you have any questions or need any additional information, please feel free to contact us at the following:

|        |  |
|--------|--|
| Phone  | 724-933-3950 (x10 or x16 or x26)                                     |
| Fax    | 724-933-9333   |
| E-mail | <a href="mailto:hsmmsupport@integpg.com">hsmmsupport@integpg.com</a> |

## System Requirements

- Operating System (any of the following):
  - Microsoft Windows NT 4 (Workstation or Server) with Service Pack 6a
  - Microsoft Windows 2000 (Professional, Server, or Advanced Server)
  - Microsoft Windows XP (Home or Professional)
  - Microsoft Windows Server 2003 family
- 500 MHz Processor or faster
- 200 Mb of available hard disk space or more
- 256 Mb minimum of RAM or more

## Installation

- 1) If you have been supplied a USB security device, complete the Hot Strip Mill Model installation procedure before attaching the device to the USB port (this installation procedure will install the appropriate drivers for the security device).
- 2) Place the HSMM disk in the CD-ROM drive.
- 3) The installation procedure will automatically start.
- 4) Follow the instructions given by the setup procedure. When prompted, select which type of security device (either USB or LPT) will be used with this version of the model. The version of the model that is compatible with the appropriate device will be installed.
- 5) Attach hardware security key to the appropriate port (if using a USB security device, follow any instructions that may appear after attaching the device).  
Follow instructions for the security device that has been supplied to you:

### **Parallel port security device:**

- Plug the security device into the parallel port of your PC – you can go to Step 6 now.

**USB port security device:**

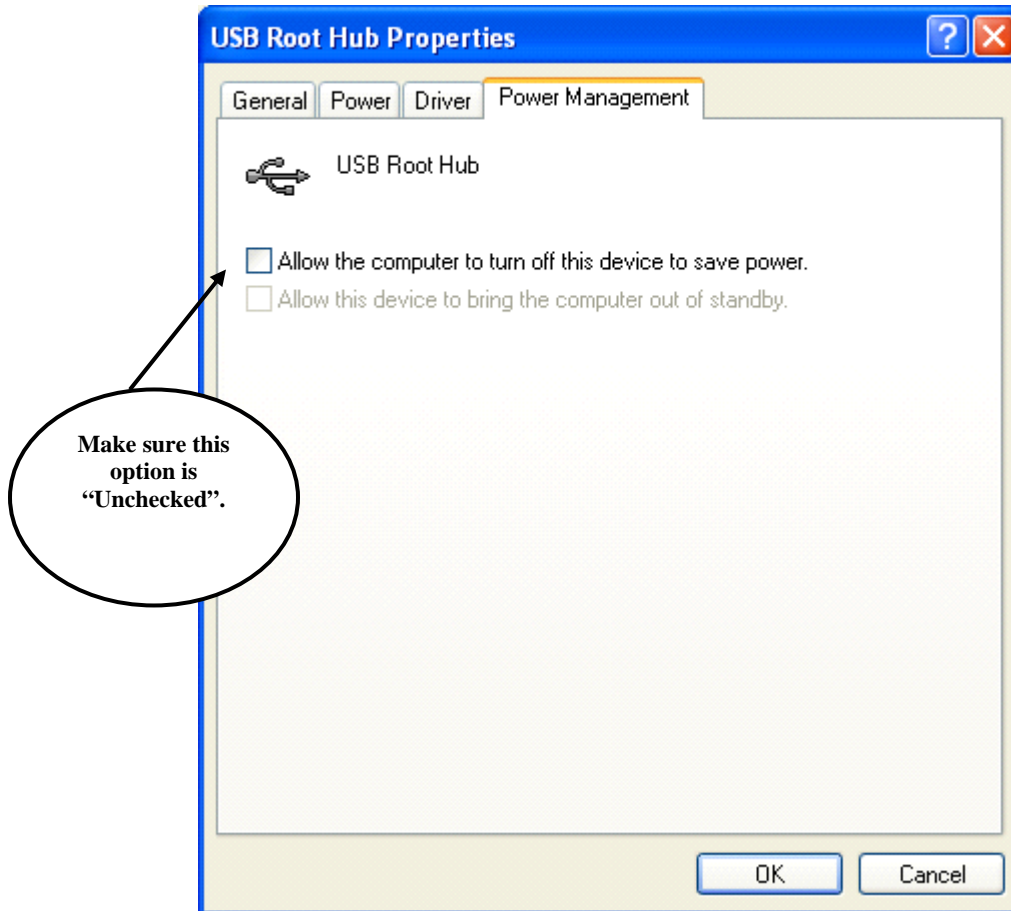
- Plug the security key into the USB port of your PC
- The Windows Hardware Wizard appears.
- Click **Next** to start the automatic driver installation.
- Windows locates the driver and installs it automatically.

**Important note for Windows XP users:**

In the Windows XP Hardware Wizard, Microsoft has added a new dialog box that may be confusing (please see picture below). Please disregard this message. Click “Continue Anyway” to proceed with the driver installation.



- On Windows XP/2000/NT4 systems, you will **not** be required to restart the computer after installation of the driver.
- Right-Click on “My Computer”. Select “Properties” – “Hardware” tab – “Device Manager”. Expand the “Universal Serial Bus Controllers” item. Double-Click on “USB Root Hub”, thus displaying the “USB Root Hub Properties” window. Click on the “Power Management” tab. Make sure the selection for “Allow the computer to turn off this device to save power” is **unchecked**.

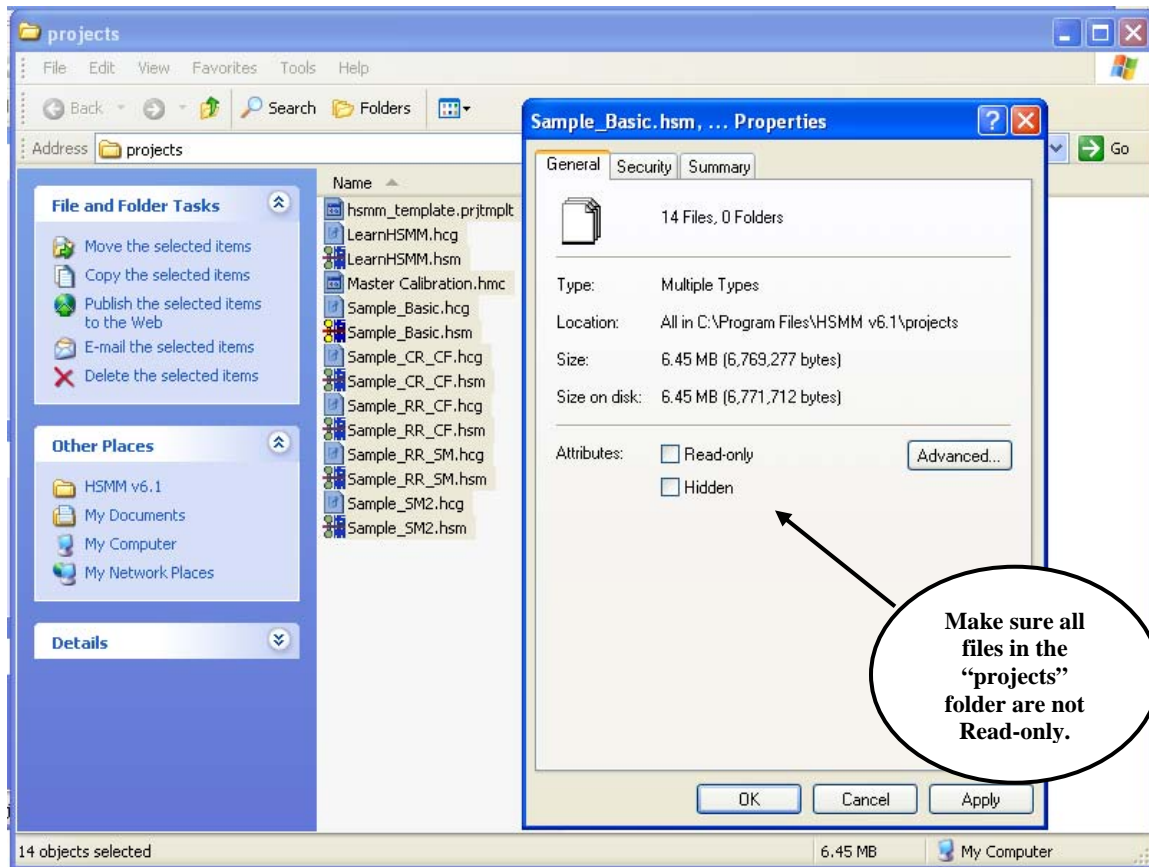


- 6) Start the Hot Strip Mill Model from the Windows Start Menu.

**Note:** If database errors occur after installing and attempting to run the model, complete the following steps:

**Step 1:**

Verify that the properties of all project files (\*.hcg, \*.hsm, \*.hcg) are not marked as read-only.



**Step 2:**

Install the following from the HSMM CD:

- If using Windows NT 4.0, open the folder labeled "sp8 98\_NT\_ME" and run the "Jet40SP8\_9xNT.exe" setup file.
- If using Windows 2000, open the folder labeled " sp8 2000 " and run the "Windows2000-KB829558-x86-ENU.exe" setup file.
- If using Windows 2003 Server, open the folder labeled "sp8 2003 server" and run the "WindowsServer2003-KB829558-x86-ENU.exe" setup file.
- If using Windows XP, open the folder labeled "sp8 XP" and run the "WindowsXP-KB829558-x86-ENU.exe" setup file.

**Step 3:**

Call or email INTEG process group inc for support.

## Part I – Quick Tour

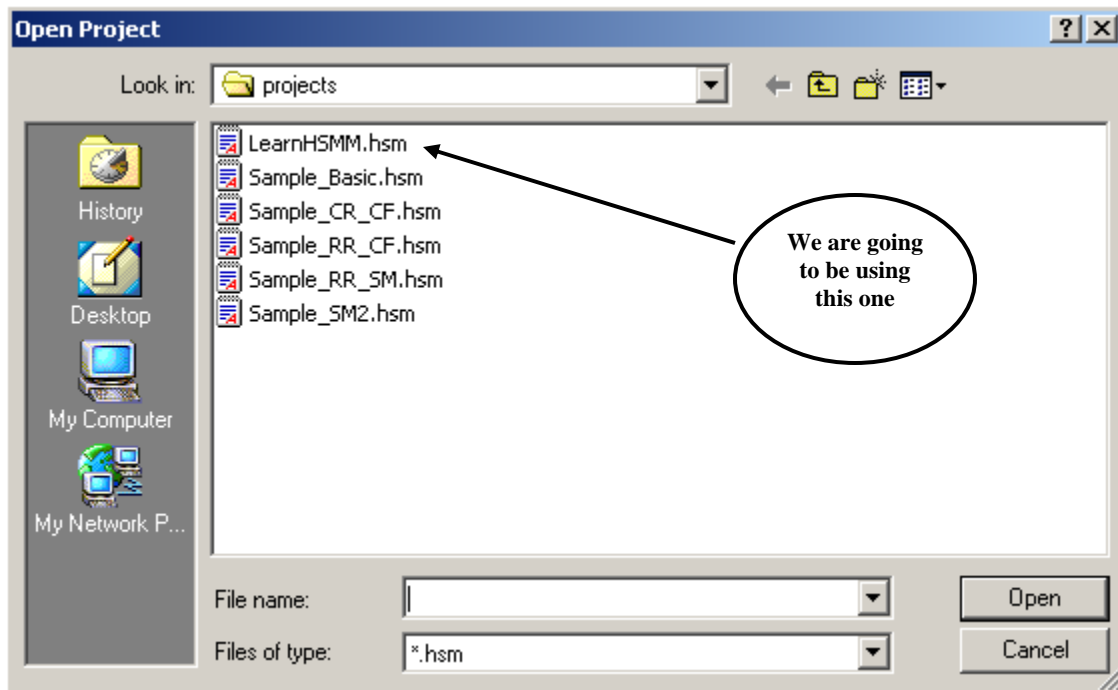
### 1. Overview

The purpose of the “Quick Tour” is to give the first time user of the HSMM a quick overview of the features of the HSMM and the capabilities of the HSMM. The “Quick Tour” will walk you through the various areas of the HSMM. Additional details about each area can be found in your HSMM User’s Manual. The HSMM User’s Manual is installed as an Adobe Acrobat PDF at the time you installed the HSMM. It can be found in the directory in which you installed the HSMM and/or under your Windows Start menu.

After completing this “Quick Tour”, please take a few minutes to browse through the User’s Manual for additional information about the operation of the HSMM and for an explanation of the theory of the HSMM.

### 2. To start the HSMM, click on Windows Start / Programs / HSMM v6.1 / HSMM v6.1

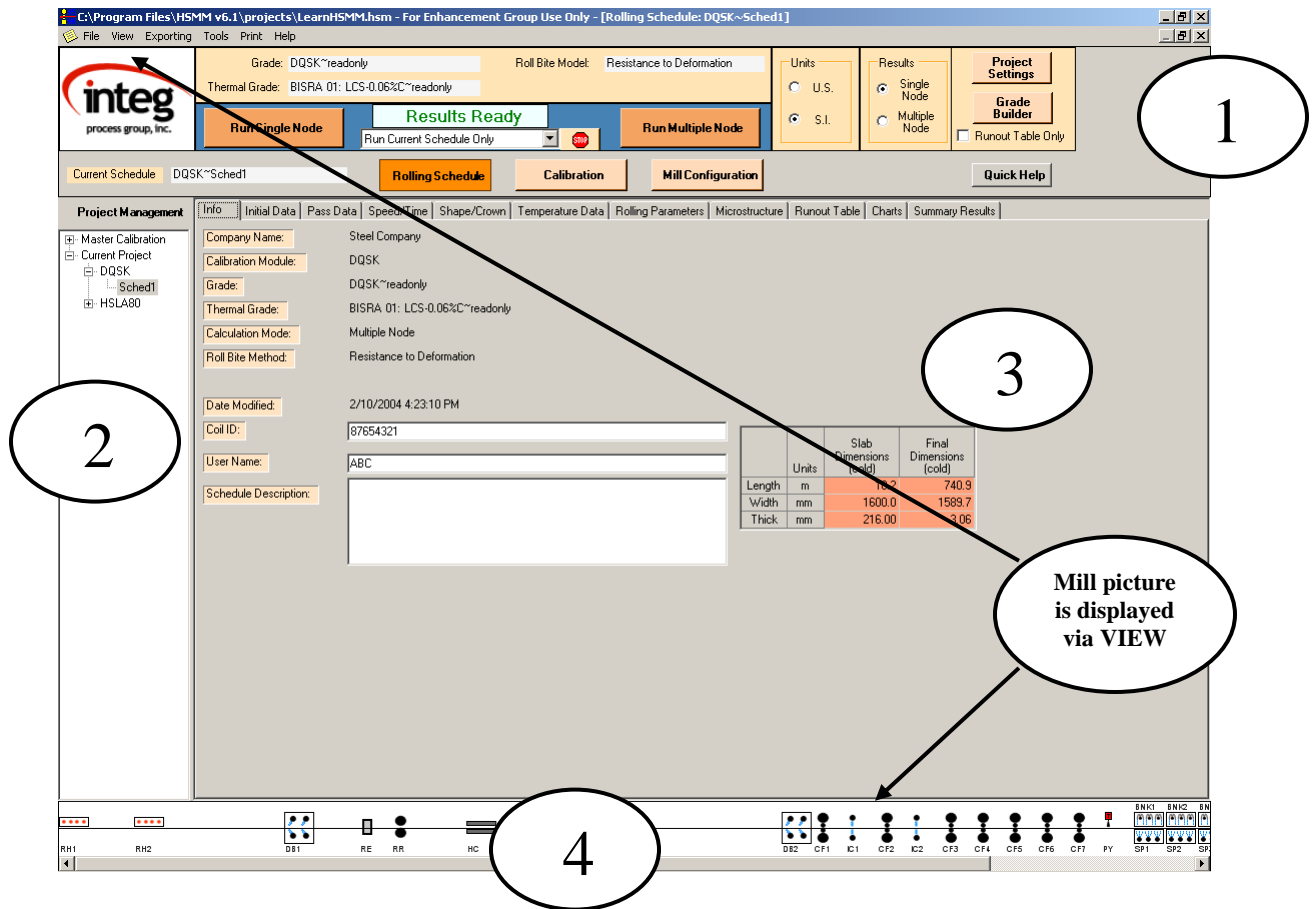
When the HSMM program is started, a splash screen with the HSMM v6.1 logo appears momentarily, followed by a standard Windows screen with a title bar indicating no project is loaded. An “Open Project” window is displayed as shown below listing the available Project files that can be loaded.



3. Select the “LearnHSMM” project and click the **Open** button.

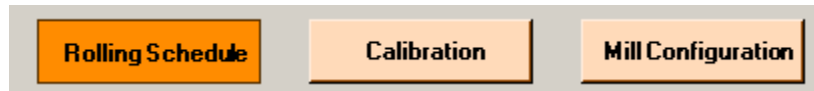
Within approximately 30 seconds the project will be loaded and the HSMM User’s Interface screen is displayed as shown below. This screen is divided into the following four main areas to display information and handle user control selections. (Please see the corresponding numbers on the graphic below.)

- 1) Project Settings and Grade Builder Shortcuts (displayed along the top of the screen)
- 2) Project Management Panel (displayed along the left side of the screen)
- 3) Data Entry and Main Display window (displayed in the center and right of the screen)
- 4) Mill Configuration Picture (optionally displayed along the bottom of the screen)





- Let's take a tour of the HSMM's three main Functional Areas (Rolling Schedule, Calibration, and Mill Configuration) by clicking on each of the appropriate function buttons in the Top Control Panel.



- Mill Configuration**

- Click on the Mill Configuration button then Finishing Area to display the following screen. You can also click on each of the mill areas tabs (Furnace Area, Roughing Area, etc) and view the equipment and associated information in each mill area. After selecting one of the mill areas, you can “right click” on the mill equipment icon (move your mouse pointer over the piece of equipment and press your right mouse button). This will display several options for adding, deleting, modifying or configuring your mill equipment. Selecting the insert option will show the available equipment for that specific mill area.

NOTE: The WHITE colored fields are for data that must be entered by the user, the SALMON colored fields represent data calculated by the HSMM and the YELLOW colored fields are for optional data (depends on the mode you use – we will discuss this in the advanced section at the end of this guide).

The screenshot shows the 'Finishing Area' configuration screen. It features a table with columns for equipment types (B2, CF1, IC1, IC2) and rows for various parameters. A context menu is open over the 'IC1' column, showing options like 'Insert', 'Delete', and 'Duplicate'. The 'Insert' option is selected, displaying a list of equipment types such as 'Continuous Finisher', 'Reversing Finisher', 'Steckel Furnace', etc.

Callouts in the image explain the data types and actions:

- Mill Areas:** Points to the top navigation tabs.
- Right click here to change equipment:** Points to the 'IC1' column header.
- Select equipment:** Points to the 'Insert' menu option.
- Data in WHITE is required:** Points to white cells in the 'IC1' column.
- Data in SALMON is calculated by the model:** Points to salmon-colored cells in the 'IC1' column.
- Data in YELLOW is optional:** Points to yellow cells in the 'IC1' column.
- Spray selection:** Points to the 'Spray Config' section at the bottom.

| Parameter                         | B2   | CF1   | IC1    | IC2 |
|-----------------------------------|------|-------|--------|-----|
| Dist to Next Station              | 5.20 |       | 1.50   |     |
| Dist Accumulated                  |      | 334.8 | 340.0  |     |
| Rated Power (KW)                  |      |       | 7500.0 |     |
| Motor Base Speed (RPM)            |      |       | 34.0   |     |
| Motor Top Speed (RPM)             |      |       | 90.0   |     |
| Gear Ratio - Reducer              |      |       | 1.000  |     |
| Rated Volts (Volts)               |      |       | 750.0  |     |
| Rated Amps (Amps)                 |      |       | 0.0    |     |
| Motor Inertia (T-m <sup>2</sup> ) |      |       | 5.0    |     |
| Mech Eff (%)                      |      |       | 95.0   |     |
| Max Load Ratio @ Base Speed       |      |       | 1.75   |     |
| Max Load Ratio @ Top Speed        |      |       | 1.60   |     |

- **Calibration**

- The Calibration section is where you tell the HSMM about the characteristics of the type of steel to be processed. **Click on the Calibration button, then the Grade Selection tab to display the following screen.** On this screen, you tell the current calibration module what grade most closely resembles the material you will be modeling (as configured in the Grade Builder Module), as well as the actual chemistry of that material. You also select whether to perform the microstructure calculations or not.

**Grade Selection:** DQSK~readonly  Enable Microstructure Calc

|                              | C %   | Mn %  | P %   | S %   | Si %  | Cu %  | Ni %  | Cr %  | Mo %  | Nb %  | V %   | Ti %  | Al %   | N %    | As %  | C %   |
|------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|--------|-------|-------|
| User Chemistry               | 0.050 | 0.280 | 0.013 | 0.012 | 0.008 | 0.055 | 0.025 | 0.005 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000  | 0.0065 | 0.047 | 0.006 |
| Grade Chemistry              | 0.038 | 0.300 | 0.010 | 0.008 | 0.008 | 0.000 | 0.000 | 0.000 | 0.005 | 0.005 | 0.002 | 0.002 | 0.040  | 0.0052 | 0.000 | 0.040 |
| Thermal Properties Chemistry | 0.060 | 0.380 | 0.017 | 0.035 | 0.008 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.0000 | 0.039  | 0.000 | 0.000 |

**Grade Selection Overview:**

**Recrystallization and Grain Growth**

Critical Strain: UBC  
 Peak Strain: UBC  
 Potential for MD Recryst: Zener-Holloman (modified)  
 Lim Potential for MD Recryst: Zener-Holloman (modified)  
 Time for 50% Recryst: Static: Avrami  
 Time for 50% Recryst: MD: Avrami  
 Fraction Recryst: Static: Avrami  
 Fraction Recryst: Meta-Dyn: Avrami  
 Recryst Grain Size: Static: UBC  
 Recryst Grain Size: Meta-Dyn: UBC  
 Grain Growth Factor: AlN Pinning  
 Grain Growth after Recryst: UBC  
 No-Recryst Temp: Manual

**Precipitation**

Austenite Precipitation  
 Precip Strengthening: AlN Precipitation  
 Transformation  
 AE3 Trans Temp: Kishida  
 Ferrite: Static (modified)

**Mechanical**

Base TS: Choquet  
 Base YS: Choquet  
 Elongation: INTEG  
 Total TS: UBC  
 Total YS: UBC  
 Transformation Strengthening: None  
 TS: NIST  
 YS: NIST

Flow Stress  
 Flow Stress: NIST

- The Calibration section is also where you select to use either the Deformation Model or Flow Stress for the roll bite calculations. It is also where you calibrate the selected method to match actual mill data for your facility and grade. **Click on Force Model Selection to display the following screen.** Curves displaying the effects of the various calculations are provided to aide in model calibration.

The screenshot shows the 'Force Model Selection' tab in the software. It features a table of calibration coefficients, a graph titled 'Resistance to Deformation', and a callout bubble with instructions.

| Description                  | Units | Value   |
|------------------------------|-------|---------|
| Resistance to Deformation    |       |         |
| Mat Normalized Resist to Def | MPa   | 122.28  |
| Mat Normalized Temp          | °C    | 1000    |
| Region 1 - Geometric Coeff B |       |         |
| Region 1 - Geometric Coeff C |       |         |
| Region 2 - Geometric Coeff A |       |         |
| Region 2 - Geometric Coeff B |       |         |
| Region 2 - Geometric Coeff C |       |         |
| Crossover Aspect Ratio       |       |         |
| Temp Effect Coeff 1          |       |         |
| Temp Effect Coeff 2          |       | 0.00185 |
| Deform Tolerance             |       | 0.0005  |
| Horiz Rolling Hard Mult      |       | 1.00    |
| Vert Flat Rolls Hard Mult    |       | 1.15    |
| Vert Grooved Rolls Hard Mult |       | 1.35    |

**Resistance to Deformation**

Aspect Ratio

**Select to use either Deformation Model or Flow Stress for roll force calculations**

Sched1

Recalculate  2nd Order  Single Line Help

- The Calibration section is also where you can adjust the tuning coefficients to improve the performance of the HSMM for a specific grade of steel. **Click on Calibration Coefficients then Single Node to display the following screen.**

Calibrate the HSMM for both Single Node and Multiple Node

The screenshot shows the 'Calibration Coefficients' window with the 'Single Node' tab selected. It contains two tables of parameters. Callouts point to specific values: 'Adjust the amount of heat lost in the roll bite' points to the 'Conduction to Work Roll (Finishing Area)' value of 12.00, and 'Adjust the amount of heat lost by the water sprays' points to the 'Descale Water Thermal Conductivity (Finishing Area)' value of 22.00.

| Description   | Units | Value |
|---|-------|-------|
| <b>Single Node Heat Transfer</b>                    |       |       |
| Radiation Effect                                    |       | 0.80  |
| Conduction to Work Roll (Roughing Area)             | W/m/C | 6.00  |
| Conduction to Work Roll (Finishing Area)            | W/m/C | 12.00 |
| Descale Water Thermal Conductivity (Roughing Area)  | W/m/C | 20.00 |
| Descale Water Thermal Conductivity (Finishing Area) | W/m/C | 22.00 |

| Description                                   | Units | Value |
|---|-------|-------|
| <b>Single Node ROT/ISC Coefficients</b>       |       |       |
| Interstand Cooling Water Thermal Conductivity | W/m/C | 5.00  |
| Runout Table Water Thermal Conductivity       | W/m/C | 13.00 |
| Runout Table Top Header Calibration Factor    |       | 1.00  |
| Runout Table Bottom Header Calibration Factor |       | 0.80  |
| Runout Table Top Header Water Effect          |       | 0.90  |
| Runout Table Top Radiation Water Effect       |       | 0.80  |
| Runout Table Leidenfrost Coefficient A        |       | 1.000 |
| Runout Table Leidenfrost Coefficient B        |       | 0.000 |
| Runout Table Leidenfrost Coefficient C        |       | 0.000 |

- **Rolling Schedule**

- The Rolling Schedule is used to set-up the specific processing parameters (temperature, speed and water use) for the rolling schedule to be modeled. The Rolling Schedule also provides you with the ability to view, chart, and export the results of the HSMM. **Click on the Rolling Schedule button for the following exercises.**
- **Click on the Initial Data tab to display the following screen.** The Initial Data tab allows you to set-up your starting parameters for slab dimensions, grain size and temperatures.

The screenshot shows the 'Initial Data' tab of a software interface. On the left is a table of parameters, and on the right is a chart titled 'Initial Temperature' showing a parabolic temperature distribution across the slab thickness. Three callouts provide instructions: 'Input your starting slab dimensions' points to the 'Slab Thickness Cold' field; 'Input your starting slab temperature' points to the 'Reversing Pass Thread Length' field; and 'And create a temperature distribution' points to the 'Temp Distrib. Coeff for Top' field. A fourth callout, 'Watch the temperature distribution change', points to the temperature distribution chart.

| Parameter                           | Units              | Value                               |
|-------------------------------------|--------------------|-------------------------------------|
| <b>Initial Slab Information</b>     |                    |                                     |
| Slab Thickness Cold                 | mm                 | 216.00                              |
| Slab Width Cold                     | mm                 | 1600.00                             |
| Slab Length Cold                    | m                  | 10.24                               |
| Scale Thickness                     | mm                 | 1.39                                |
| Aust Grain Size (@ 1st Horiz Stand) | µm                 | 250.0                               |
| Slab Temp Head Top                  | °C                 | 1181.0                              |
| Slab Temp Head Core                 | °C                 | 1172.0                              |
| Slab Temp Head Bottom               | °C                 | 1177.0                              |
| Slab Temp Mid Top                   | °C                 | 1181.0                              |
| Slab Temp Mid Core                  | °C                 | 1172.0                              |
| Slab Temp Mid Bottom                | °C                 | 1177.0                              |
| Slab Temp Tail Top                  | °C                 | 1181.0                              |
| Slab Temp Tail Core                 | °C                 | 1172.0                              |
| Slab Temp Tail Bottom               | °C                 | 1177.0                              |
| Temp Distrib. Coeff for Top         |                    | 2.00                                |
| Temp Distrib. Coeff for Bottom      |                    | 2.00                                |
| <b>Model Setup Information</b>      |                    |                                     |
| Dropout Furnace Number              |                    | 2                                   |
| Mill Exit Area Destination          |                    | 1                                   |
| Model Stop Temperature              | °C                 | 400.0                               |
| <b>General Mill Information</b>     |                    |                                     |
| Reversing Pass Thread Length        | m                  | 2.0                                 |
| Finishing Mill Zoom Rate            | m/sec <sup>2</sup> | 0.057                               |
| Distance Between Mills              | m                  | 0.0                                 |
| Heat Capacity                       |                    | <input checked="" type="checkbox"/> |
| Beam                                |                    | <input checked="" type="checkbox"/> |

**Initial Temperature Chart Data:**

| Location          | Temperature (°C) |
|-------------------|------------------|
| Head (Top/Bottom) | 1181.0           |
| Mid (Top/Bottom)  | 1172.0           |
| Tail (Top/Bottom) | 1177.0           |

- The Initial Data tab also allows you to set-up your starting parameters for the rolling mill, including number of reversing passes and zoom acceleration rates.

|                                       | Units              | Value                               |
|---------------------------------------|--------------------|-------------------------------------|
| <b>Initial Slab Information</b>       |                    |                                     |
| - Slab Thickness Cold                 | mm                 | 216.00                              |
| - Slab Width Cold                     | mm                 | 1600.00                             |
| - Slab Length Cold                    | m                  | 10.24                               |
| - Scale Thickness                     | mm                 | 1.39                                |
| - Aust Grain Size (@ 1st Horiz Stand) | µm                 | 250.0                               |
| - Slab Temp Head Top                  | °C                 | 1181.0                              |
| - Slab Temp Head Core                 | °C                 | 1172.0                              |
| - Slab Temp Head Bottom               | °C                 | 1177.0                              |
| - Slab Temp Mid Top                   | °C                 | 1181.0                              |
| - Slab Temp Mid Core                  | °C                 | 1172.0                              |
| - Slab Temp Mid Bottom                | °C                 | 1177.0                              |
| - Slab Temp Tail Top                  | °C                 | 1181.0                              |
| - Slab Temp Tail Core                 | °C                 | 1172.0                              |
| - Slab Temp Tail Bottom               | °C                 | 1177.0                              |
| - Temp Distrib. Coeff for Top         |                    | 2.00                                |
| - Temp Distrib. Coeff for Bottom      |                    | 2.00                                |
| <b>Model Setup Information</b>        |                    |                                     |
| - Dropout Furnace Number              |                    | 2                                   |
| - Mill Exit Area Destination          |                    | 1                                   |
| - Model Stop Temperature              | °C                 | 400.0                               |
| <b>General Mill Information</b>       |                    |                                     |
| - Reversing Pass Thread Length        | m                  | 2.0                                 |
| - Finishing Mill Zoom Rate            | m/sec <sup>2</sup> | 0.057                               |
| - Distance Before Zoom/Accel Begins   | m                  | 0.0                                 |
| - Heat Cover Bypass                   |                    | <input checked="" type="checkbox"/> |
| - Bar Head Under Heat Cover           |                    | <input checked="" type="checkbox"/> |
| <b>Steckel Mill Information</b>       |                    |                                     |
| <b>Mill Production Information</b>    |                    |                                     |
| <b>Reversing Mill Passes</b>          |                    |                                     |
| - RE-RR                               |                    | 9                                   |

Set-up a zoom rate

Set-up the number of reversing rolling passes

- Click on the **Pass Data** tab to display the following screen. The Pass Data tab allows you to set-up your pass reductions and water spray usage.

| Info                | Initial Data      | Pass Data        | Speed/Time                 | Temperature Data            | Rolling Parameters | Microstructure   | Runout Table                       | Charts                            | Summary Results |                 |                          |                        |
|---------------------|-------------------|------------------|----------------------------|-----------------------------|--------------------|------------------|------------------------------------|-----------------------------------|-----------------|-----------------|--------------------------|------------------------|
| Stand Name          | Exit Thick.<br>mm | Exit Width<br>mm | Draft Thick. / Width<br>mm | Reduct. Thick. / Width<br>% | Bite Angle<br>Deg  | Exit Length<br>m | Entry Tension<br>N/mm <sup>2</sup> | Exit Tension<br>N/mm <sup>2</sup> | Pass Spray On   | W/R Diam.<br>mm | Rotate Plate Before Pass | Roll Lube Comp. Factor |
| RE:5                | 122.60            | 1220.0           | 22.01                      | 1.77                        | 11.7               | 13.62            | 0.0                                | 0.0                               |                 | 1062.1          | <input type="checkbox"/> |                        |
| RR:5                | 102.00            | 1239.1           | 20.60                      | 16.80                       | 9.9                | 16.12            | 0.0                                | 0.0                               | None            | 1376.0          | <input type="checkbox"/> | 1.00                   |
| RR:6                | 82.00             | 1241.6           | 20.00                      | 19.61                       | 9.8                | 20.02            | 0.0                                | 0.0                               | Entry           | 1376.0          | <input type="checkbox"/> | 1.00                   |
| RE:6                | 82.15             | 1238.2           | 3.33                       | 0.27                        | 4.5                | 20.03            | 0.0                                | 0.0                               | None            |                 | <input type="checkbox"/> |                        |
| RE:7                | 83.52             | 1205.0           | 33.25                      | 2.69                        | 14.4               | 20.25            | 0.0                                | 0.0                               | None            |                 | <input type="checkbox"/> |                        |
| RR:7                | 64.00             | 1229.9           | 19.52                      | 23.37                       | 9.7                | 25.89            | 0.0                                | 0.0                               | Exit            |                 | <input type="checkbox"/> | 1.00                   |
| RR:8                | 46.00             | 1232.0           | 18.00                      | 28.13                       | 9.3                | 35.96            | 0.0                                | 0.0                               | En & Ex         |                 | <input type="checkbox"/> | 1.00                   |
| RE:8                | 46.00             | 1232.0           | 0.00                       | 0.00                        | 0.0                | 35.96            | 0.0                                | 0.0                               |                 | 1062.1          | <input type="checkbox"/> |                        |
| RE:9                | 46.46             | 1215.0           | 17.02                      |                             | 10.3               | 36.10            | 0.0                                | 0.0                               |                 | 1062.1          | <input type="checkbox"/> |                        |
| RR:9                | 33.20             | 1228.6           | 13.48                      |                             |                    | 49.96            | 0.0                                | 0.0                               | None            | 1376.0          | <input type="checkbox"/> | 1.00                   |
| Heat Retention Area |                   |                  |                            |                             |                    |                  |                                    |                                   |                 |                 |                          |                        |
| HC                  | 33.20             | 1228.6           |                            |                             |                    | 96               | 0.0                                | 0.0                               |                 |                 |                          |                        |
| Finishing Area      |                   |                  |                            |                             |                    |                  |                                    |                                   |                 |                 |                          |                        |
| DB2                 | 33.20             | 1228.6           |                            |                             |                    | 49.96            | 0.0                                | 0.0                               | 1               |                 |                          |                        |
| CF1                 | 19.72             | 1228.6           | 13.48                      |                             |                    | 84.11            | 0.0                                | 3.0                               | None            | 750.5           | <input type="checkbox"/> |                        |
| IC1                 | 19.72             | 1228.6           |                            |                             |                    | 84.11            | 3.0                                | 3.0                               | 0               |                 | <input type="checkbox"/> |                        |
| CF2                 | 12.07             | 1228.6           | 7.65                       | 38.79                       | 8.3                | 137.42           | 3.0                                | 4.0                               | None            | 750.5           | <input type="checkbox"/> |                        |
| IC2                 | 12.07             | 1228.6           |                            |                             |                    | 137.42           | 4.0                                | 4.0                               | 0               |                 | <input type="checkbox"/> |                        |
| CF3                 | 8.18              | 1228.6           | 3.89                       | 32.23                       | 5.8                | 202.76           | 4.0                                | 5.1                               | None            | 750.5           | <input type="checkbox"/> | 1.00                   |
| IC3                 | 8.18              | 1228.6           |                            |                             |                    | 202.76           | 5.1                                | 5.1                               | 0               |                 | <input type="checkbox"/> |                        |
| CF4                 | 5.98              | 1228.6           | 2.20                       | 26.89                       | 4.3                | 277.36           | 5.1                                | 6.3                               | None            | 767.9           | <input type="checkbox"/> | 1.00                   |

Set-up your reduction schedule

Set-up the water sprays to be used

- Click on the **Speed/Time** tab to display the following screen. The Speed/Time tab allows you to set-up your rolling speeds.

| Info                | Initial Data      | Pass Data                  | Speed/Time              | Temperature Data   | Rolling Parameters              | Microstructure                  | Runout Table | Charts               | Summary Results |                |                 |           |                    |           |
|---------------------|-------------------|----------------------------|-------------------------|--------------------|---------------------------------|---------------------------------|--------------|----------------------|-----------------|----------------|-----------------|-----------|--------------------|-----------|
| Stand Name          | Exit Thick.<br>mm | Thread Speed (Roll)<br>mps | Top Speed (Roll)<br>mps | Table Speed<br>mps | Accel. Rate<br>m/s <sup>2</sup> | Decel. Rate<br>m/s <sup>2</sup> | Forward Slip | Exit Stop Dist.<br>m | Delay Time<br>s | Roll Time<br>s | Cycle Time<br>s | Head<br>s | Rad. Time Mid<br>s | Tail<br>s |
| RR:6                | 82.00             | 2.927                      | 5.270                   |                    |                                 |                                 | 0.00         |                      |                 | 4.8            | 10.4            | 0.5       | 0.5                | 0.9       |
| RE:6                | 82.15             | 3.000                      | 5.402                   |                    | 1.30                            | 1.50                            | 0.00         | 8.00                 | 0.0             | 4.4            | 10.4            | 6.6       | 12.7               | 17.5      |
| RE:7                | 83.52             | 2.346                      | 3.346                   |                    |                                 |                                 | 0.00         |                      |                 | 6.5            | 13.1            | 1.2       | 0.8                | 1.0       |
| RR:7                | 64.00             | 3.000                      | 4.278                   |                    | 1.50                            | 1.50                            | 0.00         | 3.00                 | 0.0             | 6.4            | 13.1            | 18.6      | 11.6               | 3.6       |
| RR:8                | 46.00             | 2.891                      | 4.375                   |                    |                                 |                                 | 0.00         |                      |                 | 8.6            | 12.9            | 0.8       | 0.6                | 0.9       |
| RE:8                | 46.00             | 3.000                      | 4.540                   |                    | 1.70                            | 2.00                            | 0.00         | 2.00                 | 0.0             | 8.5            | 12.9            | 3.1       | 12.8               | 21.1      |
| RE:9                | 46.46             | 2.168                      | 4.194                   |                    |                                 |                                 | 0.00         |                      |                 | 9.5            | 11.9            | 1.2       | 0.7                | 0.7       |
| RR:9                | 33.20             | 3.000                      | 5.800                   | 5.800              | 2.00                            | 2.00                            | 0.00         | 0.00                 | 0.0             | 9.0            | 11.9            | 4.8       | 4.1                | 4.1       |
| Heat Retention Area |                   |                            |                         |                    |                                 |                                 |              |                      |                 |                |                 |           |                    |           |
| HC                  | 33.20             | 6.000                      | 6.000                   | 5.800              |                                 |                                 |              |                      |                 |                |                 | 6.1       | 31.8               | 33.6      |
| Finishing Area      |                   |                            |                         |                    |                                 |                                 |              |                      |                 |                |                 |           |                    |           |
| DB2                 | 33.20             | 0.775                      | 0.975                   |                    |                                 |                                 |              |                      |                 |                |                 |           | 5.7                | 5.1       |
| CF1                 | 19.72             | 1.305                      | 1.642                   |                    |                                 |                                 |              |                      |                 |                |                 |           | 1.0                | 0.9       |
| IC1                 | 19.72             | 1.301                      | 1.636                   |                    |                                 |                                 |              |                      |                 |                |                 |           | 2.5                | 2.3       |
| CF2                 | 12.07             | 2.126                      | 2.673                   |                    |                                 |                                 | 0.00         |                      |                 |                |                 |           | 0.6                | 0.5       |
| IC2                 | 12.07             | 2.137                      | 2.687                   |                    |                                 |                                 |              |                      |                 |                |                 |           | 1.5                | 1.4       |
| CF3                 | 8.18              | 3.153                      | 3.965                   |                    |                                 |                                 | 0.00         |                      |                 |                |                 | 0.5       | 0.4                | 0.4       |
| IC3                 | 8.18              | 3.228                      | 4.059                   |                    |                                 |                                 |              |                      |                 |                |                 | 1.2       | 1.0                | 1.0       |
| CF4                 | 5.98              | 4.415                      | 5.552                   |                    |                                 |                                 | 0.00         |                      |                 | 52.5           | 55.6            | 1.2       | 1.0                | 1.0       |
| CF5                 | 4.61              | 5.727                      | 7.202                   |                    |                                 |                                 | 0.00         |                      |                 | 52.3           | 55.6            | 0.9       | 0.8                | 0.7       |
| CF6                 | 3.72              | 7.097                      | 8.924                   |                    |                                 |                                 | 0.00         |                      |                 | 52.1           | 55.6            | 0.8       | 0.6                | 0.6       |
| CF7                 | 3.19              | 8.284                      | 10.417                  | 10.710             | 0.10                            | 2.00                            | 0.00         | 0.00                 | 0.0             | 52.0           | 55.6            | 0.0       | 0.0                | 0.0       |

Set-up the rolling speeds

Set-up any rolling delay times

- **Clicking on the Temperature Data, Rolling Parameters and Microstructure Tabs will display results from the model calculations.**
- **Click on the Runout Table tab to display the following screen.** The Runout Table tab allows you to set-up your runout table spray patterns and to view results from the model.

**Set-up and view for the head, middle or tail**

|      | H1                                  | H2                                  | H3                                  | H4                                  | H5                                  | H6                                  | H7                                  | H8                                  | H9                                  | H10                                 | H11                                 | H12                                 | Entry Temp | Exit Temp | Temp Loss | Temp Loss | Cooling | Fraction | Ferrite | Fraction of |
|------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|------------|-----------|-----------|-----------|---------|----------|---------|-------------|
|      |                                     |                                     |                                     |                                     |                                     |                                     |                                     |                                     |                                     |                                     |                                     |                                     | °C         | °C        | °C        | °C        | °C/s    | %        | µm      | %           |
| BNK1 | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | 642        | 620       | 92.8      | 150.9     | 150.9   | 0.0      | 0.0     | 0.0         |
| BNK2 | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | 642        | 620       | 73.8      | 119.7     | 119.7   | 0.0      | 0.0     | 0.0         |
| BNK3 | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | 642        | 620       | 60.1      | 97.5      | 97.5    | 0.0      | 0.0     | 0.0         |
| BNK4 | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | 642        | 620       | 5.4       | 12.4      | 12.4    | 0.0      | 0.0     | 0.0         |
| BNK5 | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | 642        | 620       | 0.0       | 3.1       | 3.1     | 0.0      | 0.0     | 0.0         |
| BNK6 | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | 642        | 620       | 0.0       | 3.1       | 3.1     | 0.0      | 0.0     | 0.0         |
| BNK7 | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | 642        | 620       | 0.0       | 3.1       | 3.1     | 0.0      | 0.0     | 0.0         |

**Turn on or off the headers to be used**

- **Click on the Charts tab to display the following screen.** The Charts tab allows you to view the results in a graphical format.

**Select to view single and/or multiple node data**

**Select the data to be charted and up to two parameters**



- Click on the **Summary Results** tab to display the following screen. The Results tab allows you to view select summary results in a tabular format.

| Single Node Results                        |       |       |       |        | Multiple Node Results                      |       |       |       |        |
|--|-------|-------|-------|--------|--|-------|-------|-------|--------|
|  | Units | Head  | Mid   | Tail   |  | Units | Head  | Mid   | Tail   |
| <b>Final Mechanical Properties</b>         |       |       |       |        | <b>Final Mechanical Properties</b>         |       |       |       |        |
| Austenite Grain Size                       | µm    | 30.2  | 24.8  | 23.3   | Austenite Grain Size (Average)             | µm    | 27.4  | 23.7  | 24.7   |
| Ferrite Grain Size                         | µm    | 2.4   | 2.5   | 2.6    | Ferrite Grain Size (Average)               | µm    | 2.4   | 2.6   | 2.5    |
| Fraction Ferrite                           | %     | 97.2  | 97.9  | 98.8   | Fraction Ferrite (Average)                 | %     | 97.5  | 98.0  | 98.8   |
| Fraction Pearlite                          | %     | 0.0   | 0.0   | 0.0    | Fraction Pearlite (Average)                | %     | 0.0   | 0.0   | 0.0    |
| Total Yield Strength                       | MPa   | 661.9 | 643.4 | 649.6  | Total Yield Strength                       | MPa   | 653.8 | 647.1 | 655.3  |
| Total Tensile Strength                     | MPa   | 716.1 | 701.3 | 706.3  | Total Tensile Strength                     | MPa   | 709.7 | 704.3 | 710.9  |
| Total Elongation (2 inch)                  | %     | 19.2  | 19.9  | 19.7   | Total Elongation (2 inch)                  | %     | 19.5  | 19.8  | 19.5   |
| <b>Precipitation Strength Contribution</b> |       |       |       |        | <b>Precipitation Strength Contribution</b> |       |       |       |        |
| YS Component                               | MPa   | 149.8 | 153.9 | 156.2  | YS Component                               | MPa   | 155.1 | 156.9 | 158.5  |
| YS Maximum                                 | MPa   | 225.0 | 225.0 | 225.0  | YS Maximum                                 | MPa   | 225.0 | 225.0 | 225.0  |
| UTS Component                              | MPa   | 153.9 | 156.2 | 156.2  | UTS Component                              | MPa   | 156.9 | 156.9 | 158.5  |
| UTS Maximum                                | MPa   | 225.0 | 225.0 | 225.0  | UTS Maximum                                | MPa   | 225.0 | 225.0 | 225.0  |
| <b>Aging Characteristics</b>               |       |       |       |        | <b>Aging Characteristics</b>               |       |       |       |        |
| Overaged                                   |       |       |       |        | Overaged                                   |       |       |       |        |
| <b>Temperature Summary</b>                 |       |       |       |        | <b>Temperature Summary</b>                 |       |       |       |        |
| Average Initial Temperature                | °C    | 918.9 | 918.9 | 1186.9 | Average Initial Temperature                | °C    | 918.9 | 918.9 | 1186.9 |
| Average Finishing Temperature              | °C    | 933.5 | 933.5 | 933.5  | Average Finishing Temperature              | °C    | 933.5 | 933.5 | 924.2  |
| Average Coiling Temperature                | °C    | 523.6 | 523.6 | 523.6  | Average Coiling Temperature                | °C    | 523.6 | 523.6 | 527.3  |
| Average Final Temperature                  | °C    | 393.2 | 393.2 | 393.2  | Average Final Temperature                  | °C    | 393.3 | 393.3 | 393.3  |
| <b>Time Summary</b>                        |       |       |       |        | <b>Time Summary</b>                        |       |       |       |        |
| Time to Reach Final Temperature            | hours | 7.6   | 7.6   | 7.6    | Time to Reach Final Temperature            | hours | 7.4   | 7.4   | 7.4    |

5. After setting up your mill configuration, selecting the grade of steel to be rolled and entering your starting rolling parameters, the HSMM is now ready to be used to simulate the rolling process. Let's perform a calculation by clicking on one of the two Run buttons in the Top Control Panel. To save time, let's use the Run Single Node Button. (Please note as stated below that the Multiple Node calculations require a much longer time to run than the Single Node calculations.)



- **Run Single Node**
  - When we click on the Run Single Node button, the HSMM will perform calculations for the steel properties parameters such as temperature and grain size as one average value through its thickness. This calculation takes approximately 2 to 5 seconds to run and should display the results as shown above on the Summary Results tab.
- **Run Multiple Node**
  - If we click on the Run Multiple Node button, the HSMM will perform calculations for the steel properties as 101 individual values (nodes) through its thickness. This calculation can take 2 to 5 minutes depending on the mill configuration complexity and computer speed. If you have the time, click on the Run Multiple Node button and it should display the results above.

6. Please refer to the HSMM User's Manual for a detailed description of all of the available functions and data fields.

## Part II – Working with the HSMM

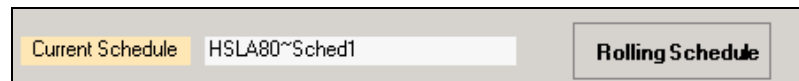
Now that we know how to set-up, configure and run the HSMM, let's understand how we can utilize the HSMM to help study various process parameters and their influence on the final product. For this demonstration, we will continue to use the LearnHSMM project and will demonstrate how the model results (temperatures and final mechanical properties) are affected by changing processing parameters such as applied water in the mill, rolling speeds, and applied Runout Table water. For quicker results, we will use only the Run Single Node calculation button. The “Summary Results History” tool will be used to keep a record of the changes in the calculated results.

Please perform the following steps:

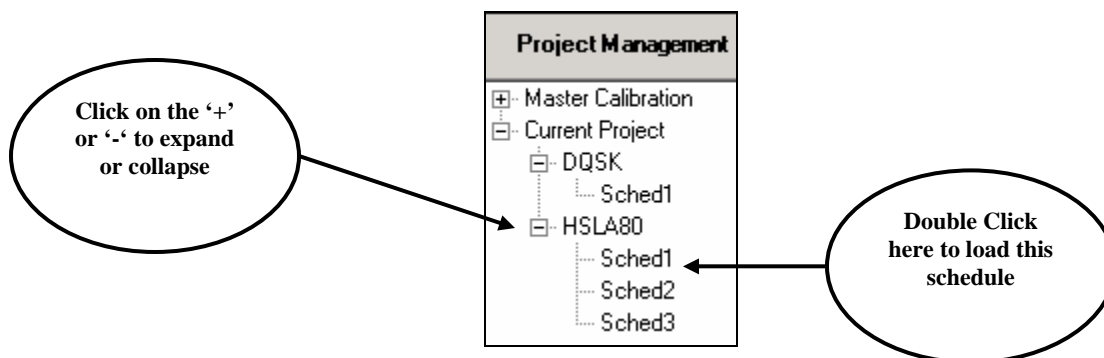
1. **Make sure you are running the Learn HSMM project as loaded in the Quick Tour. If not, click on the top menu bar, click on File \ Open Project. Click on “LearnHSMM” in the list and then on the Open button.**

NOTE: If you made any changes to the LearnHSMM project during the Quick Tour, you may want to exit the project, but DO NOT save the project. This way, you will eliminate any possible problems of accidentally entering wrong set-up information.

2. **Make sure your Current Schedule is “HSLA80~Sched1” as shown in the top Status and Control Panel.**

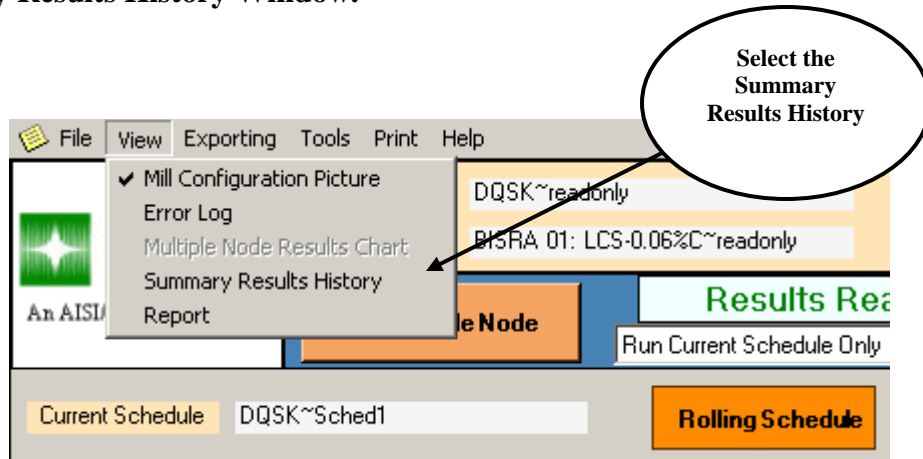


If not, select this schedule from the Project Management Panel by expanding the **Current Project** and **HSLA80** until **Sched1** is visible. Double-click on Sched1 to load it.

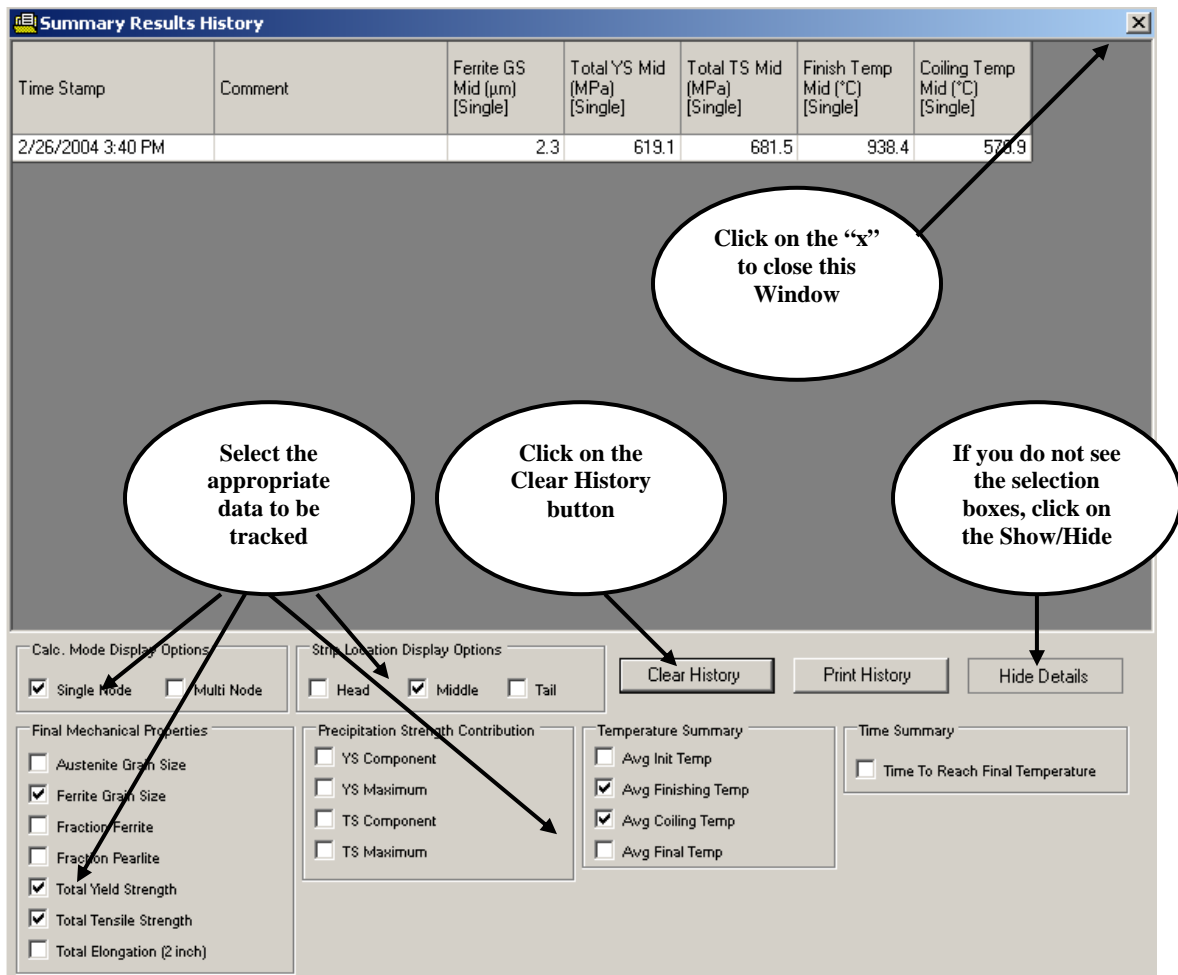


3. **Click on the Run Single Node button to run the calculations.**

- From the Top Menu bar select **View \ Summary Results History** to bring up the Summary Results History Window.



- On the Summary Results History window, click the **Clear History** button and make only the following checkbox selections:



The boxes you should have checked for the purposes of this demonstration are:

- Single Node
- Middle
- Ferrite Grain Size
- Total Yield Strength
- Total Tensile Strength
- Avg Finishing Temperature
- Avg Coiling Temperature

6. Exit the Summary Results History window by clicking on the “x” in the upper right corner.

7. We will now make several changes to the rolling mill schedule, run the Single Node model and view the changes to the final results.

8. For our first change, we will turn on the entire Finishing Mill Interstand Cooling by clicking on the Pass Data tab and scroll down to stations IC1, and IC2. In the “Pass Spray On” column, enter “111” at these 2 stations. (The “111” is the coded way to set the Interstand Cooling on for the Head, Middle, and Tail. “101” would turn on Interstand Cooling for the Head and Tail, “100” just the Head, and so on.)

| Info                | Initial Data      | Pass Data        | Speed/Time                 | Shape/Crown                 | Temperature Data  | Rolling Parameters | Microstructure                     | Runout Table                      | Charts        | Summary Result |                          |                        |
|---------------------|-------------------|------------------|----------------------------|-----------------------------|-------------------|--------------------|------------------------------------|-----------------------------------|---------------|----------------|--------------------------|------------------------|
| Stand Name          | Exit Thick.<br>mm | Exit Width<br>mm | Draft Thick. / Width<br>mm | Reduct. Thick. / Width<br>% | Bite Angle<br>Deg | Exit Length<br>m   | Entry Tension<br>N/mm <sup>2</sup> | Exit Tension<br>N/mm <sup>2</sup> | Pass Spray On | WR Diam.<br>mm | Rotate Plate Before Pass | Roll Lube Comp. Factor |
| RR:3                | 145.00            | 1243.5           | 24.95                      | 14.68                       | 10.9              | 11.29              |                                    |                                   | None          | 1376.0         | <input type="checkbox"/> | 1.00                   |
| RR:4                | 121.00            | 1247.2           | 24.00                      | 16.55                       | 10.7              | 13.49              |                                    |                                   | None          | 1376.0         | <input type="checkbox"/> | 1.00                   |
| RE:4                | 121.32            | 1242.0           | 5.15                       | 0.41                        | 5.6               | 13.51              |                                    |                                   |               | 1062.1         | <input type="checkbox"/> |                        |
| RE:5                | 122.59            | 1220.0           | 22.01                      | 1.77                        | 11.7              | 13.61              |                                    |                                   |               | 1062.1         | <input type="checkbox"/> |                        |
| RR:5                | 102.00            | 1239.1           | 20.59                      | 16.80                       | 9.9               | 16.11              |                                    |                                   | None          | 1376.0         | <input type="checkbox"/> | 1.00                   |
| RR:6                | 82.00             | 1241.6           | 20.00                      | 19.61                       | 9.8               | 20.00              |                                    |                                   | Entry         | 1376.0         | <input type="checkbox"/> | 1.00                   |
| RE:6                | 82.15             | 1238.2           | 3.28                       | 0.26                        | 4.5               | 20.02              |                                    |                                   |               | 1062.1         | <input type="checkbox"/> |                        |
| RE:7                | 83.52             | 1205.0           | 33.25                      | 2.69                        | 14.4              | 20.23              |                                    |                                   |               | 1062.1         | <input type="checkbox"/> |                        |
| RR:7                | 64.00             | 1229.9           | 19.52                      | 23.37                       | 9.7               | 25.87              |                                    |                                   | None          | 1376.0         | <input type="checkbox"/> | 1.00                   |
| RR:8                | 46.00             | 1232.1           | 18.00                      | 28.13                       | 9.3               | 35.92              |                                    |                                   | Entry         | 1376.0         | <input type="checkbox"/> | 1.00                   |
| RE:8                | 46.00             | 1232.0           | 0.00                       | 0.00                        | 0.0               | 35.93              |                                    |                                   |               | 1062.1         | <input type="checkbox"/> |                        |
| RE:9                | 46.46             | 1215.0           | 16.98                      | 1.38                        | 10.3              | 36.07              |                                    |                                   |               | 1062.1         | <input type="checkbox"/> |                        |
| RR:9                | 33.20             | 1228.8           | 13.26                      | 28.54                       | 8.0               | 49.91              |                                    |                                   | None          | 1376.0         | <input type="checkbox"/> | 1.00                   |
| Heat Retention Area |                   |                  |                            |                             |                   |                    |                                    |                                   |               |                |                          |                        |
| HC                  | 33.20             | 1228.8           |                            |                             |                   | 49.91              |                                    |                                   |               |                | <input type="checkbox"/> |                        |
| Finishing Area      |                   |                  |                            |                             |                   |                    |                                    |                                   |               |                |                          |                        |
| DB2                 | 33.20             | 1228.6           |                            |                             |                   |                    |                                    |                                   | 1             |                | <input type="checkbox"/> |                        |
| CF1                 | 19.72             | 1228.6           | 13.26                      | 28.54                       | 8.0               |                    | 0.0                                | 3.0                               | None          | 725.3          | <input type="checkbox"/> | 1.00                   |
| IC1                 | 19.72             | 1228.6           |                            |                             |                   |                    |                                    |                                   | 111           |                | <input type="checkbox"/> |                        |
| CF2                 | 12.07             | 1228.6           | 7.62                       | 32.22                       | 10.0              |                    | 3.0                                | 4.0                               | None          | 735.6          | <input type="checkbox"/> | 1.00                   |
| IC2                 | 12.07             | 1228.6           |                            |                             |                   |                    |                                    |                                   | 111           |                | <input type="checkbox"/> |                        |
| CF3                 | 8.18              | 1228.6           | 3.89                       | 32.22                       | 10.0              |                    | 4.0                                | 5.1                               | None          | 750.5          | <input type="checkbox"/> | 1.00                   |
| CF4                 | 5.98              | 1228.6           | 2.20                       | 26.89                       | 4.3               | 277.12             | 5.1                                | 6.3                               | None          | 767.9          | <input type="checkbox"/> | 1.00                   |
| CF5                 | 4.61              | 1228.6           | 1.37                       | 22.91                       | 3.4               | 359.48             | 6.3                                | 7.2                               | None          | 761.3          | <input type="checkbox"/> | 1.00                   |
| CF6                 | 3.72              | 1228.6           | 0.89                       | 19.31                       | 2.9               | 445.49             | 7.2                                | 8.1                               | None          | 710.1          | <input type="checkbox"/> | 1.00                   |
| CF7                 | 3.19              | 1228.6           | 0.53                       | 14.33                       | 2.1               | 519.99             | 8.1                                | 8.8                               | None          | 773.9          | <input type="checkbox"/> | 1.00                   |
| PY                  | 3.19              | 1228.6           |                            |                             |                   | 519.99             |                                    |                                   |               |                | <input type="checkbox"/> |                        |

Change these spray patterns to 111

- Now let's run the HSMM to see the effect of adding the water. Click on the **Run Single Node** button to run the calculations. When the Results are Ready, open the View \ **Summary Results History** screen again.

| Time Stamp        | Comment                  | Ferrite GS Mid (µm) [Single] | Total YS Mid (MPa) [Single] | Total TS Mid (MPa) [Single] | Finish Temp Mid (°C) [Single] | Coiling Temp Mid (°C) [Single] |
|-------------------|--------------------------|------------------------------|-----------------------------|-----------------------------|-------------------------------|--------------------------------|
| 2/26/2004 3:40 PM |                          | 2.3                          | 619.1                       | 681.5                       | 938.4                         | 579.9                          |
| 2/26/2004 3:42 PM | Added Interstand Cooling | 2.3                          | 626.3                       | 687.4                       | 910.9                         | 566.6                          |

You can add a comment as to what was changed after you run the model

Upon examination and comparison of the latest model run with the previous model run, when we add Interstand water in the finishing mill, we can observe the following:

- The finishing temperature has DECREASED, as expected, because of the additional water.
- The coiling temperature has also DECREASED, as expected, because we entered the runout table at a lower temperature and maintained the same amount of water on the runout table.
- The Yield Strength and Tensile Strength have both INCREASED, as expected.

- For our second change, we will lower the Finishing Mill top speed by clicking on the **Speed/Time** tab and scrolling down to the CF7 stand. Lower the speed value in the "Top Speed (Roll)" column from 10.417 down to 9.0.

| Info                | Initial Data | Pass Data           | Speed/Time       | Temperature Data | Rolling Parameters | Micro            |
|---------------------|--------------|---------------------|------------------|------------------|--------------------|------------------|
| Stand Name          | Exit Thick.  | Thread Speed (Roll) | Top Speed (Roll) | Table Speed      | Accel. Rate        | Decel. Rate      |
|                     | mm           | mps                 | mps              | mps              | m/s <sup>2</sup>   | m/s <sup>2</sup> |
| RR:7                | 54.00        | 3.000               | 4.278            |                  | 1.50               | 1.50             |
| RR:8                | 46.00        | 2.891               | 4.375            |                  |                    |                  |
| RE:8                | 46.00        | 3.000               | 4.540            |                  | 1.70               | 2.00             |
| RE:9                | 46.46        | 2.168               | 4.192            |                  |                    |                  |
| RR:9                | 33.20        | 3.000               | 5.800            | 5.800            | 2.00               | 2.00             |
| Heat Retention Area |              |                     |                  |                  |                    |                  |
| HC                  | 33.20        | 6.000               | 6.000            | 5.800            |                    |                  |
| Finishing Area      |              |                     |                  |                  |                    |                  |
| DB2                 | 33.20        | 0.776               | 0.975            |                  |                    |                  |
| CF1                 | 19.72        | 1.306               | 1.642            |                  |                    |                  |
| IC1                 | 19.72        | 1.301               | 1.636            |                  |                    |                  |
| CF2                 | 12.07        | 2.126               | 2.673            |                  |                    |                  |
| IC2                 | 12.07        | 2.137               | 2.688            |                  |                    |                  |
| CF3                 | 8.18         | 3.154               | 3.966            |                  |                    |                  |
| IC3                 | 8.18         | 3.228               | 4.059            |                  |                    |                  |
| CF4                 | 5.98         | 4.415               | 5.552            |                  |                    |                  |
| CF5                 | 4.61         | 5.727               | 7.201            |                  |                    |                  |
| CF6                 | 3.72         | 7.097               | 8.924            |                  |                    |                  |
| CF7                 | 3.19         | 8.284               | 9.000            | 10.711           | 0.10               | 2.00             |
| PY                  | 3.19         | 0.000               | 0.000            | 0.000            |                    |                  |

Change the Top Speed to 9.0

11. Now let's run the HSMM to see the effect of lowering the top speed. Click on the **Run Single Node** button again to run the calculations. When the Results are Ready, open the **View \ Summary Results History** screen again.

| Time Stamp        | Comment                  | Ferrite GS Mid ( $\mu\text{m}$ ) [Single] | Total YS Mid (MPa) [Single] | Total TS Mid (MPa) [Single] | Finish Temp Mid ( $^{\circ}\text{C}$ ) [Single] | Coiling Temp Mid ( $^{\circ}\text{C}$ ) [Single] |
|-------------------|--------------------------|---|-----------------------------|-----------------------------|---|--|
| 2/26/2004 3:40 PM |                          | 2.3                                       | 619.1                       | 681.5                       | 938.4   | 579.9  |
| 2/26/2004 3:42 PM | Added Interstand Cooling | 2.3                                       | 626.3                       | 687.4                       | 910.9   | 566.6  |
| 2/26/2004 3:44 PM | Lowered FM Speed         | 2.4                                       | 632.0                       | 692.0                       | 900.3   | 524.8  |

Upon examination and comparison of the latest model run with the previous model run, when we lower the top speed in the finishing mill, we can observe the following:

- The finishing temperature has DECREASED, as expected, because of the lower speed.
- The coiling temperature has also DECREASED, as expected, because we entered the runout table at a lower temperature, ran at a lower speed and maintained the same amount of water on the runout table.
- The Yield Strength and Tensile Strength have both INCREASED, as expected.

12. For our third change, we will turn off the Runout Table water at bank 4 for just the middle by clicking on the **Runout Table** tab and also on the **Mid** button. Un-check all the checkboxes in the top banks BNK4 and the bottom banks SP4 and SP5. Note: A shortcut to turning all the headers in a bank on or off is to click in the bank name column to select the entire bank and then press the spacebar or enter key.

Info | Initial Data | Pass Data | Speed/T

Head | Mid | Tail

General | Flows

|      | H1                                  | H2                                  | H3                                  | H4                                  | H5                                  | H6                                  |
|------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| BNK1 | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| BNK2 | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| BNK3 | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| BNK4 | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            |
| BNK5 | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            |
| BNK6 | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            |

|     | H1                                  | H2                                  | H3                                  | H4                                  | H5                                  | H6                                  |
|-----|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| SP1 | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| SP2 | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| SP3 | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| SP4 | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            |
| SP5 | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            |
| SP6 | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            | <input type="checkbox"/>            |

Make sure you are changing the water for the Mid

Turn off (un-check) the headers in bank 4

Turn off (un-check) the sprays in banks 4 and 5

13. Now let's run the HSMM to see the effect of removing some water from the runout table on the tail end of the strip. Click on the Run Single Node button again to run the calculations. When the Results are Ready, open the View \ Summary Results History screen again.

| Time Stamp        | Comment                  | Ferrite GS Mid (µm) [Single] | Total YS Mid (MPa) [Single] | Total TS Mid (MPa) [Single] | Finish Temp Mid (°C) [Single] | Coiling Temp Mid (°C) [Single] |
|-------------------|--------------------------|------------------------------|-----------------------------|-----------------------------|-------------------------------|--------------------------------|
| 2/26/2004 3:40 PM |                          | 2.3                          | 619.1                       | 681.5                       | 938.4                         | 579.9                          |
| 2/26/2004 3:42 PM | Added Interstand Cooling | 2.3                          | 626.3                       | 687.4                       | 910.9                         | 566.6                          |
| 2/26/2004 3:44 PM | Lowered FM Speed         | 2.4                          | 632.0                       | 692.0                       | 900.3                         | 524.8                          |
| 2/26/2004 3:45 PM | Removed Mid ROT Cooling  | 2.4                          | 622.8                       | 684.6                       | 900.3                         | 607.2                          |

Upon examination and comparison of the latest model run with the previous model run, when we remove some water from the runout table, we can observe the following:

- The finishing temperature has STAYED the SAME, as expected.
- The coiling temperature has INCREASED, as expected, because we maintained the same speed, but with less water on the runout table

- The Yield Strength and Tensile Strength have both DECREASED, as expected.

**14. For ease of comparison, we can study the results of four calculation runs in one table of data. As described previously, note how the HSMM results were affected by the process changes.**

| Run Number | Process Parameters                            | Middle Temperature Changes   | Mechanical Props Changes |
|------------|---|------------------------------|--------------------------|
| Original   | No IC, normal FM speed and normal ROT water   |                              |                          |
| 1          | IC on   | Finishing and Coiling: Lower | YS and TS: Higher        |
| 2          | IC on, FM speed lower                         | Finishing and Coiling: Lower | YS and TS: Higher        |
| 3          | IC on, FM speed lower, less ROT water on tail | Coiling: Higher              | YS and TS: Lower         |

15. As we have just done, continue to make other adjustments to the process inputs as you desire and observe the changes to the results in the data tables, Summary Results History, and charts.

## Summary

Thank you for taking the time to complete this “Quick Tour” of the Hot Strip Mill Model (HSMM). Hopefully this tour gave you an idea of how simple, yet complex the HSMM can be. The HSMM has many wonderful tools and features that will give you that extra capability in understanding your process so that you can increase your product quality, improve your process performance and save you money.

Please do not hesitate to contact our HSMM team at INTEG process group. We can be reached via phone, fax or e-mail as follows:

Phone        724-933-3950 (x10 or x16 or x26)

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