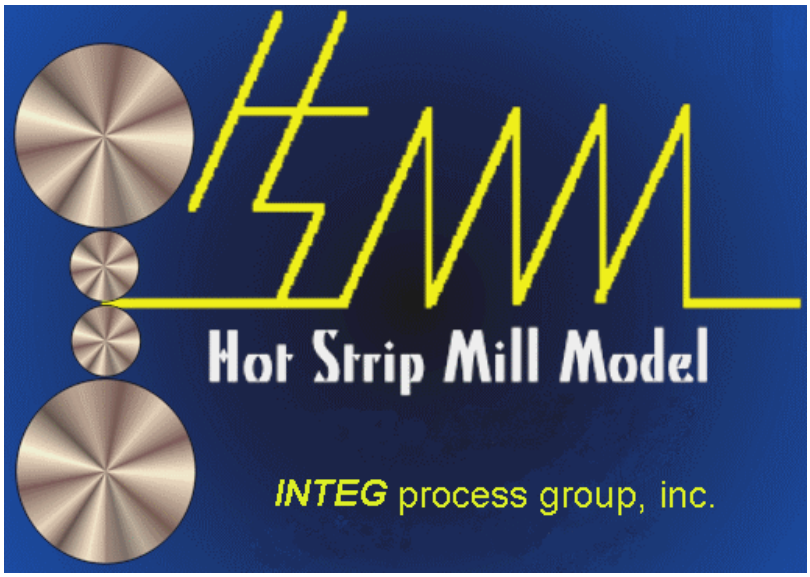
An AISI/DOE Technology

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 hsmmsupport@integpg.com

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.

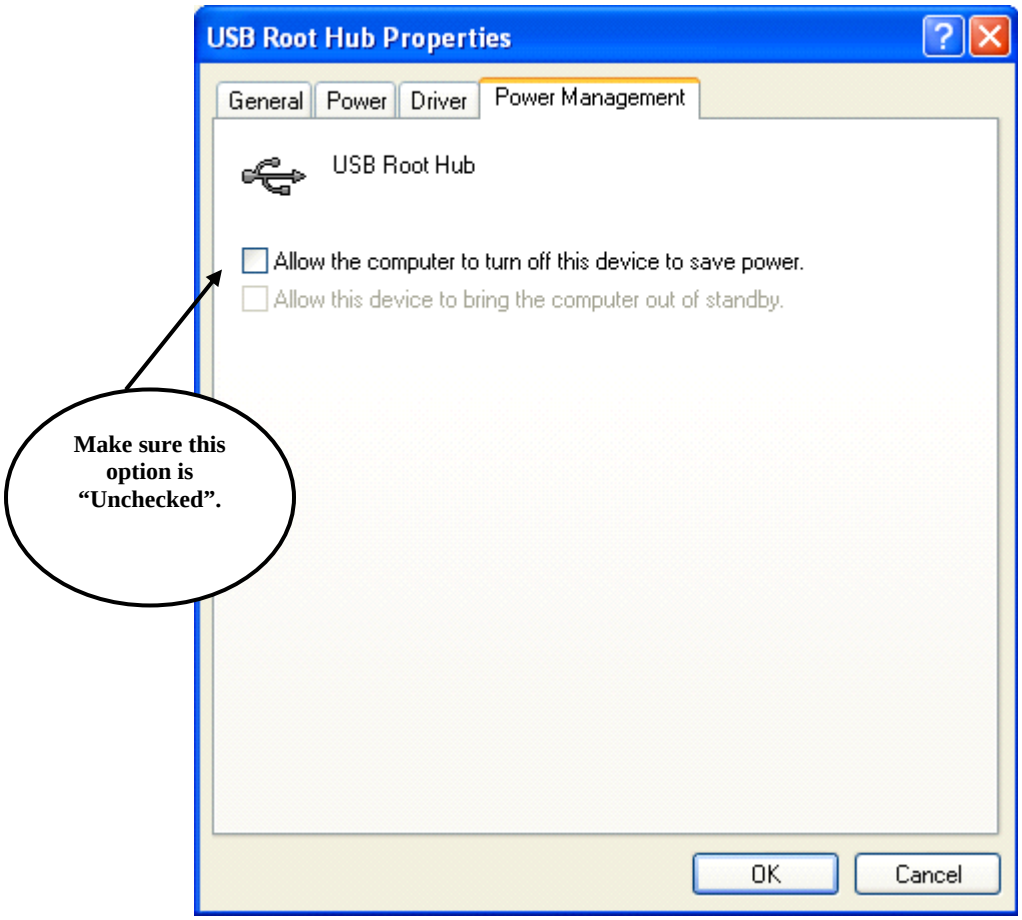
USB port security device:

- 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**.

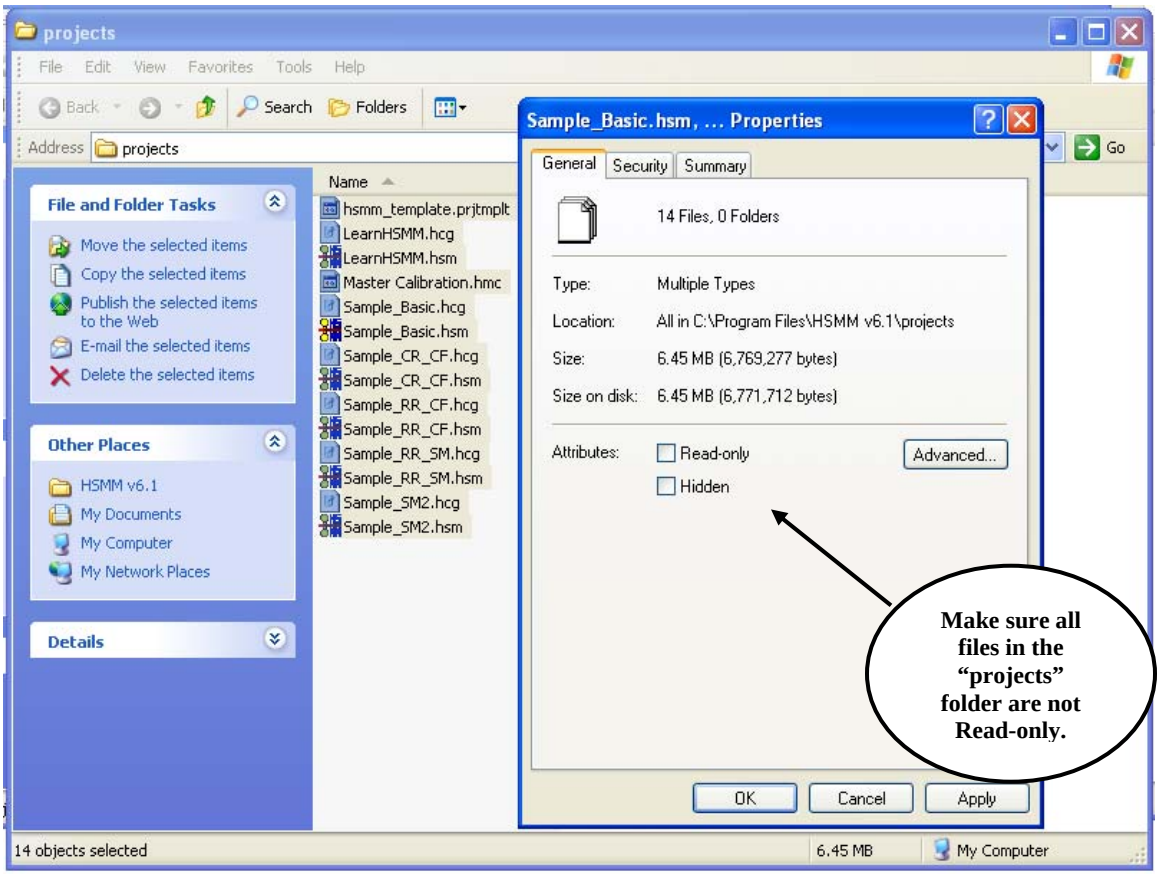


6) Start the Hot Strip Mill Model from the Windows Start Menu.

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

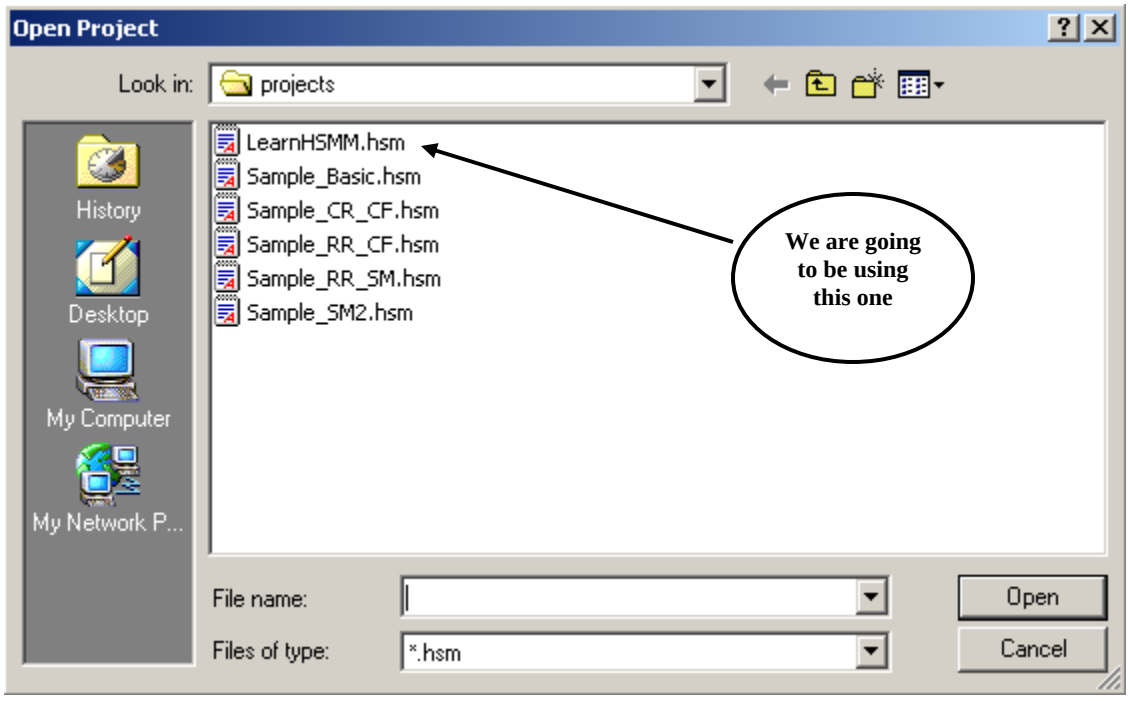
1. Overview

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 <u>Open</u> button.

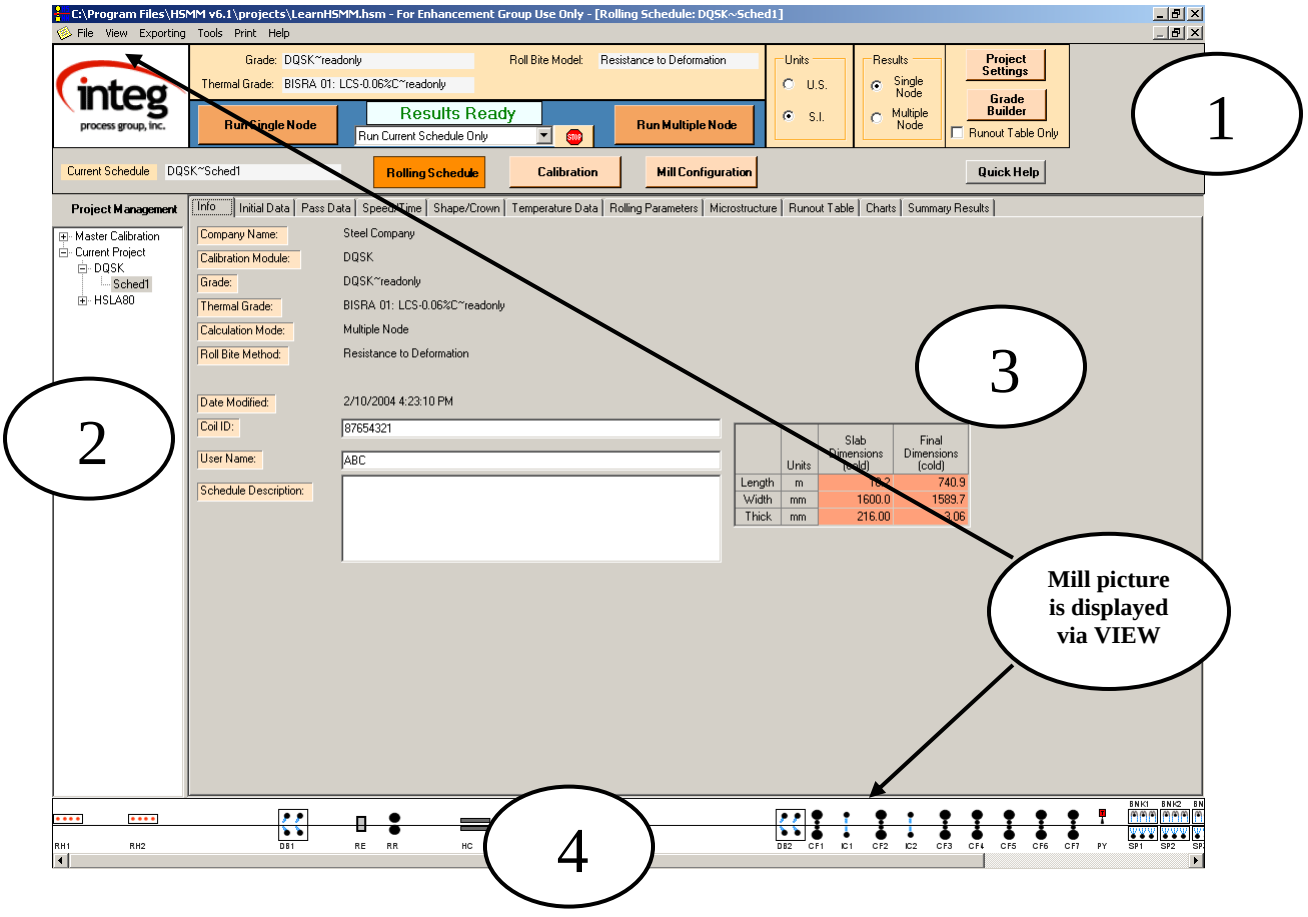
Within approximately 30 seconds the project will be loaded and the HSMM User's Interface screen is displayed as shown below. This screen is divided into the following four main areas to display information and handle user control selections. (Please see the corresponding numbers on the graphic below.)

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)

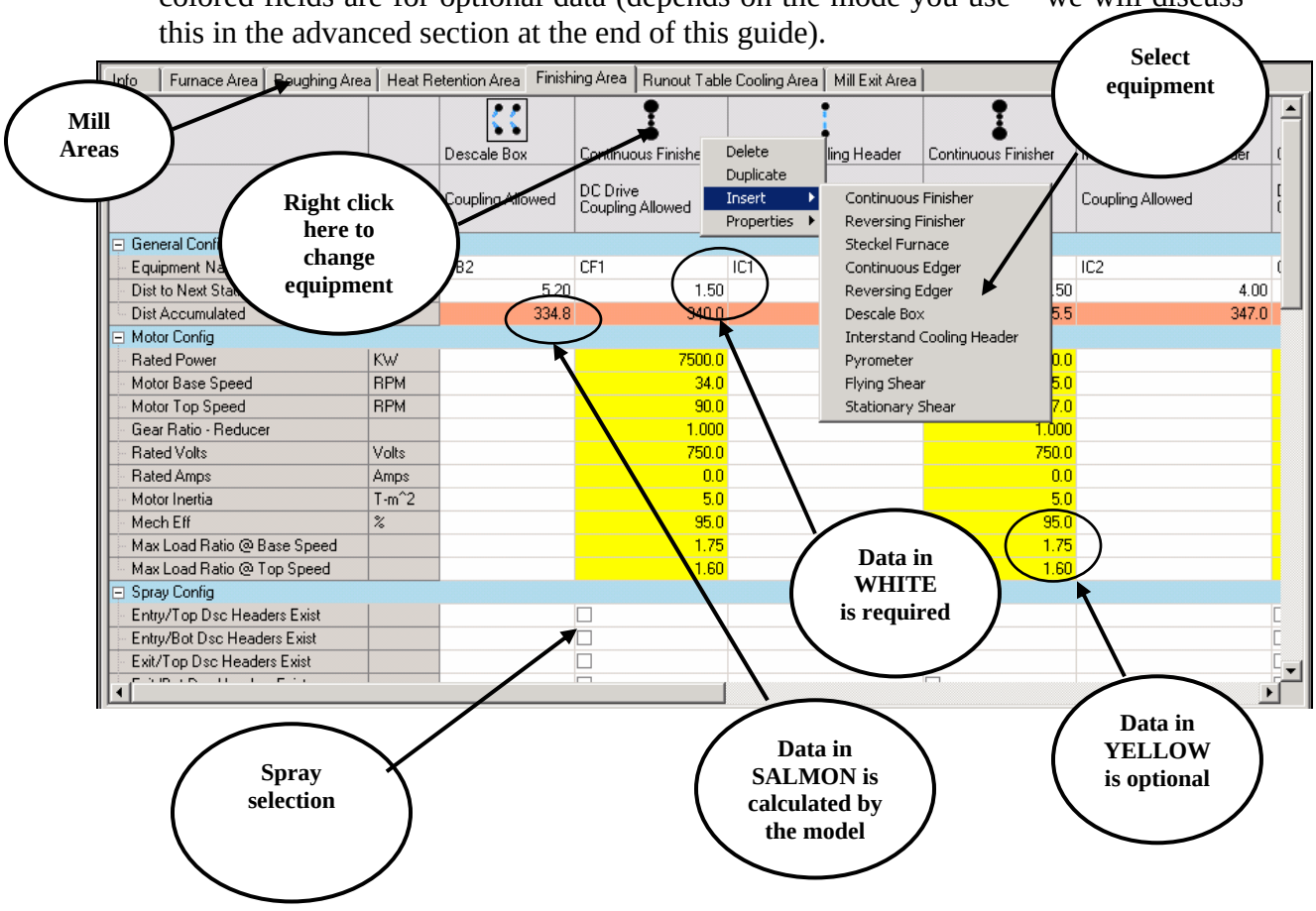


4. **Let's take a tour of the HSMM's three main Functional Areas (Rolling Schedule, Calibration, and Mill Configuration) by clicking on each of the appropriate function buttons in the Top Control Panel.**

- **Mill Configuration**

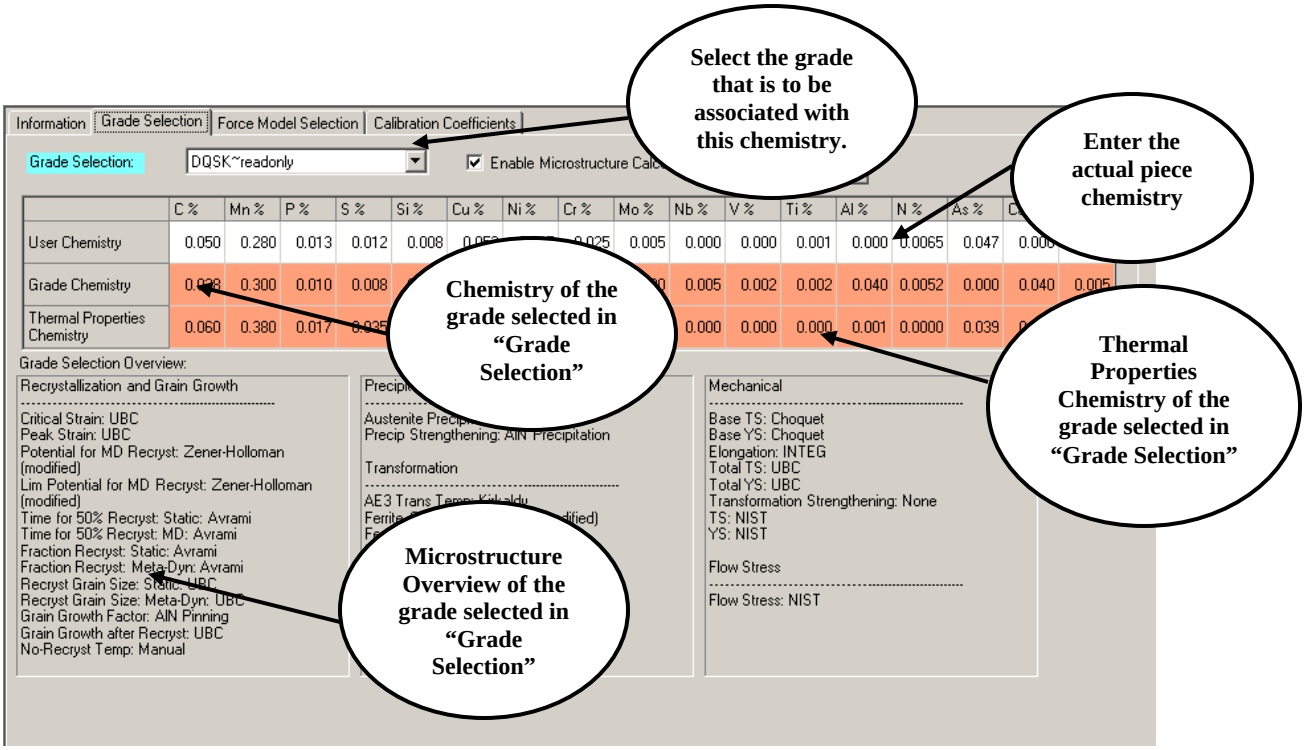
  - **Click on the Mill Configuration button then Finishing Area to display the following screen.** You can also click on each of the mill areas tabs (Furnace Area, Roughing Area, etc) and view the equipment and associated information in each mill area. After selecting one of the mill areas, you can "right 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).

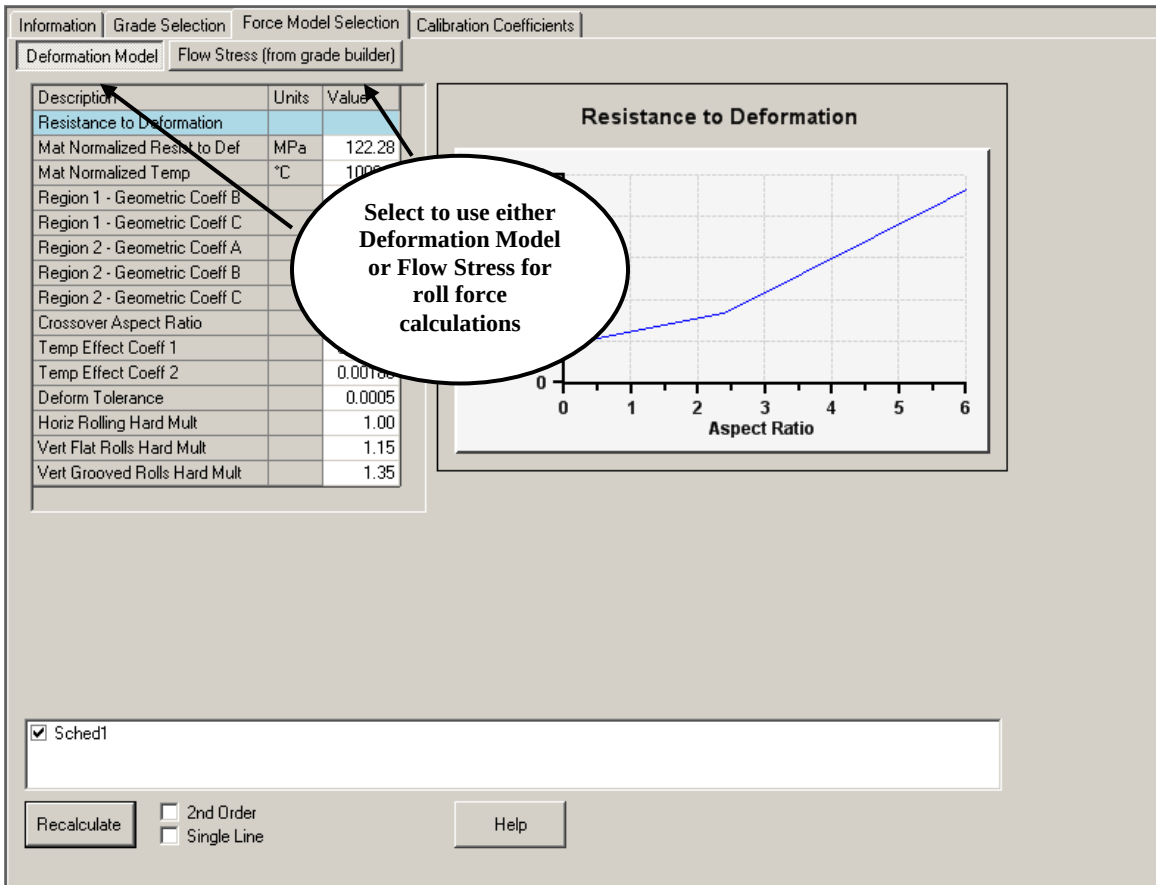


- **Calibration**

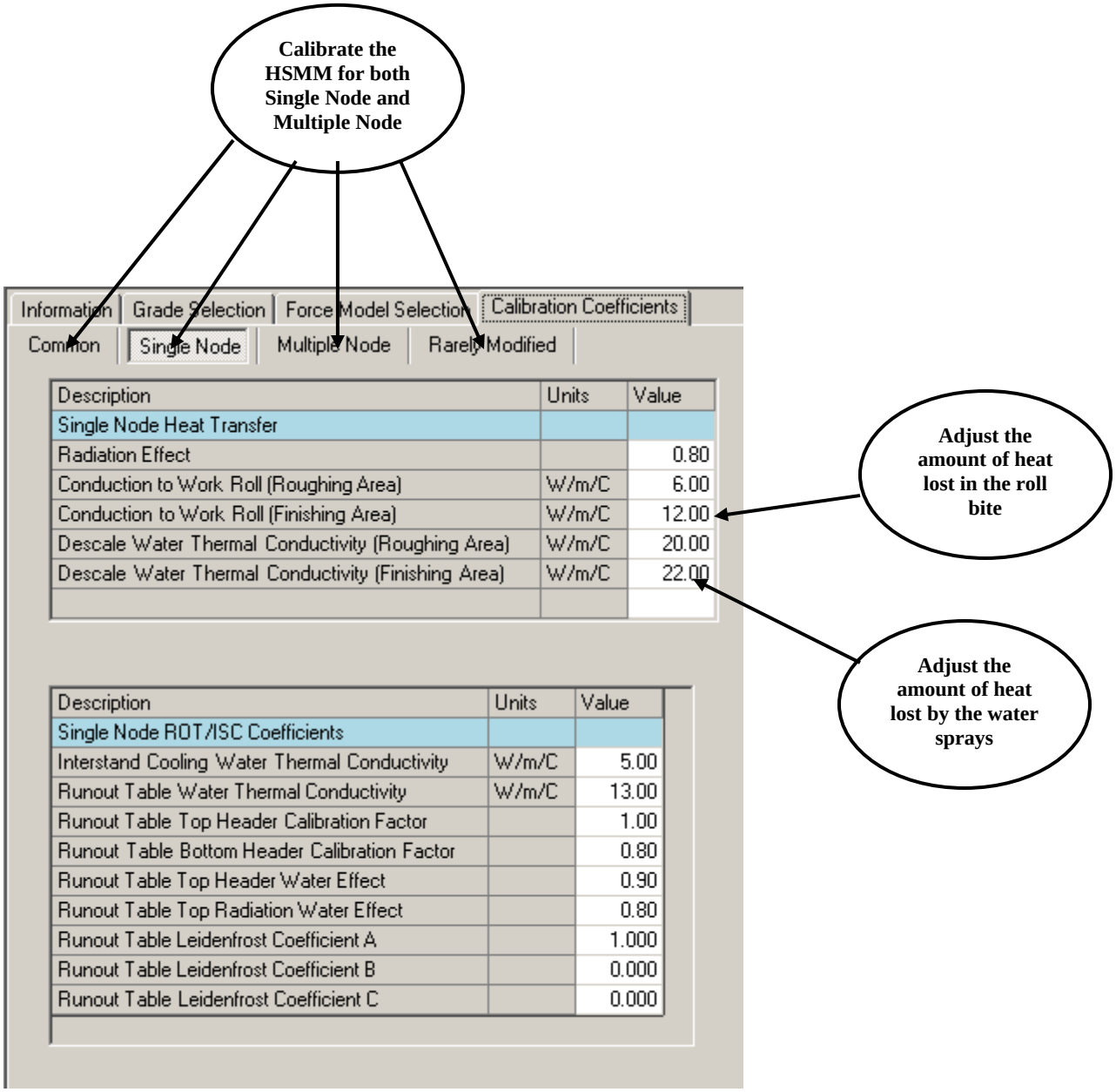
  - The Calibration section is where you tell the HSMM about the characteristics of the type of steel to be processed. **Click on the Calibration button, then the Grade Selection tab to display the following screen**. On this screen, you tell the current calibration module what grade most closely resembles 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.



- 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.

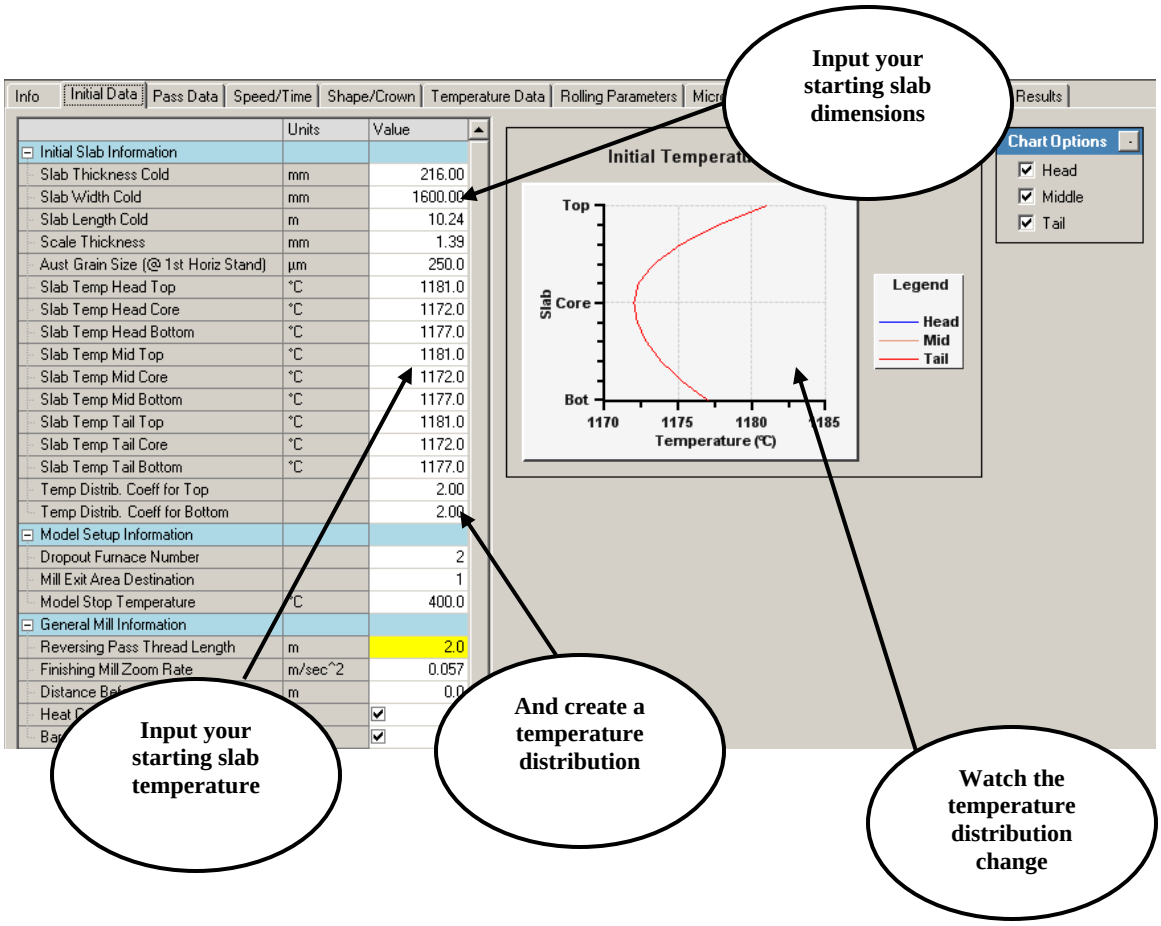


- The Calibration section is also where you can adjust the tuning coefficients to improve the performance of the HSMM for a specific grade of steel. **Click on Calibration Coefficients then Single Node to display the following screen.**

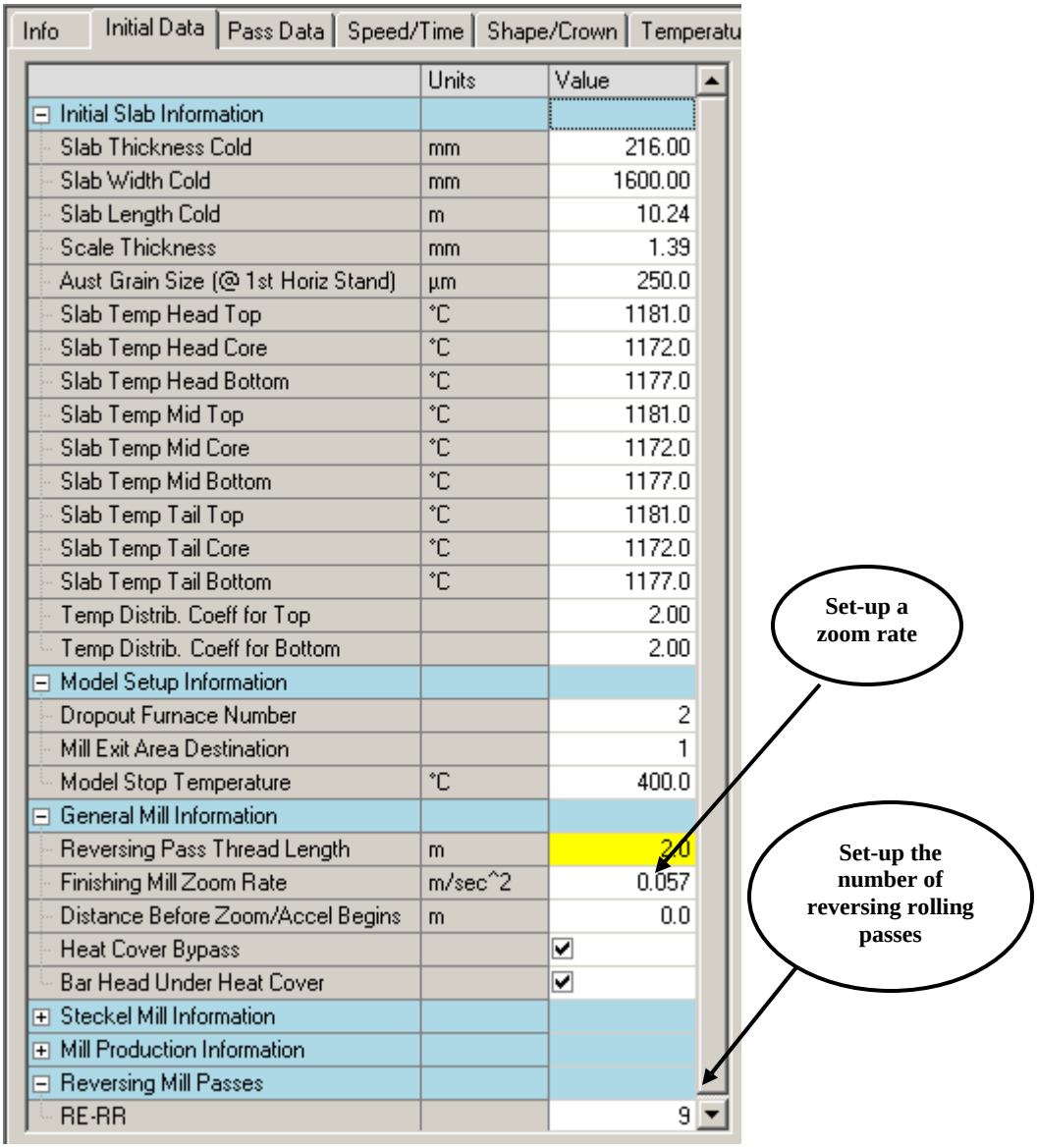


- **Rolling Schedule**

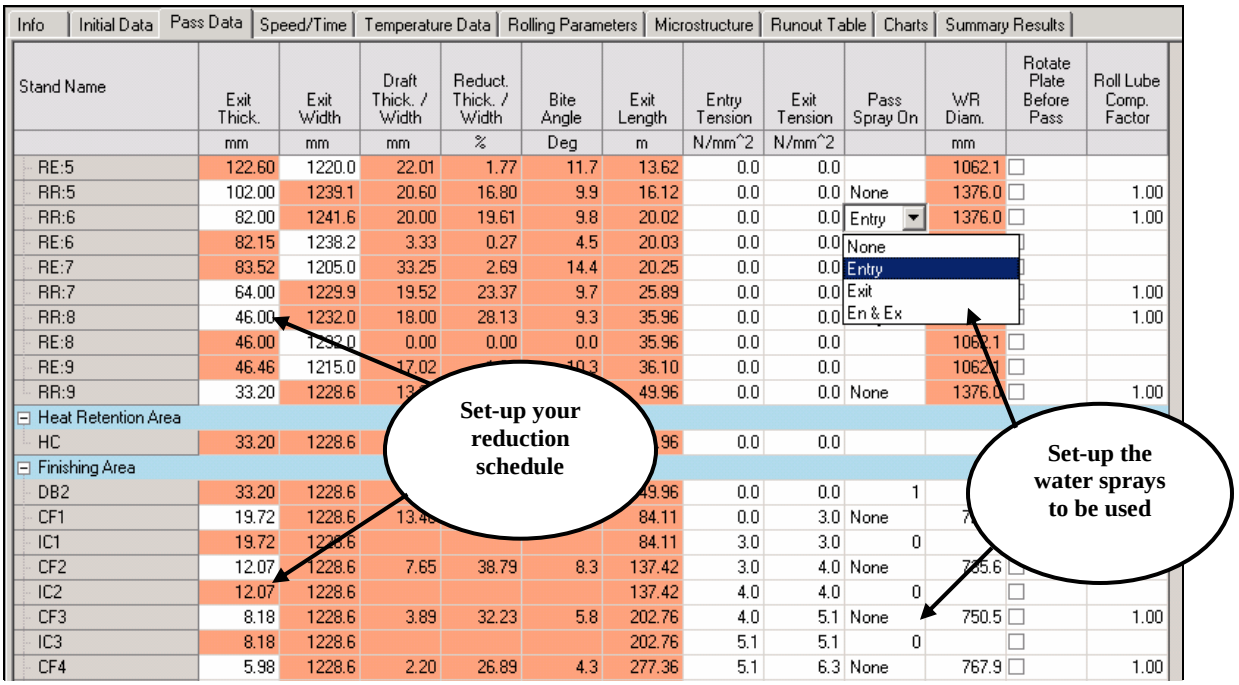
  - The Rolling Schedule is used to set-up the specific processing parameters (temperature, speed and water use) for the rolling schedule to be modeled. The Rolling Schedule also provides you with the ability to view, chart, and export the results of the HSMM. **Click on the Rolling Schedule button for 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.



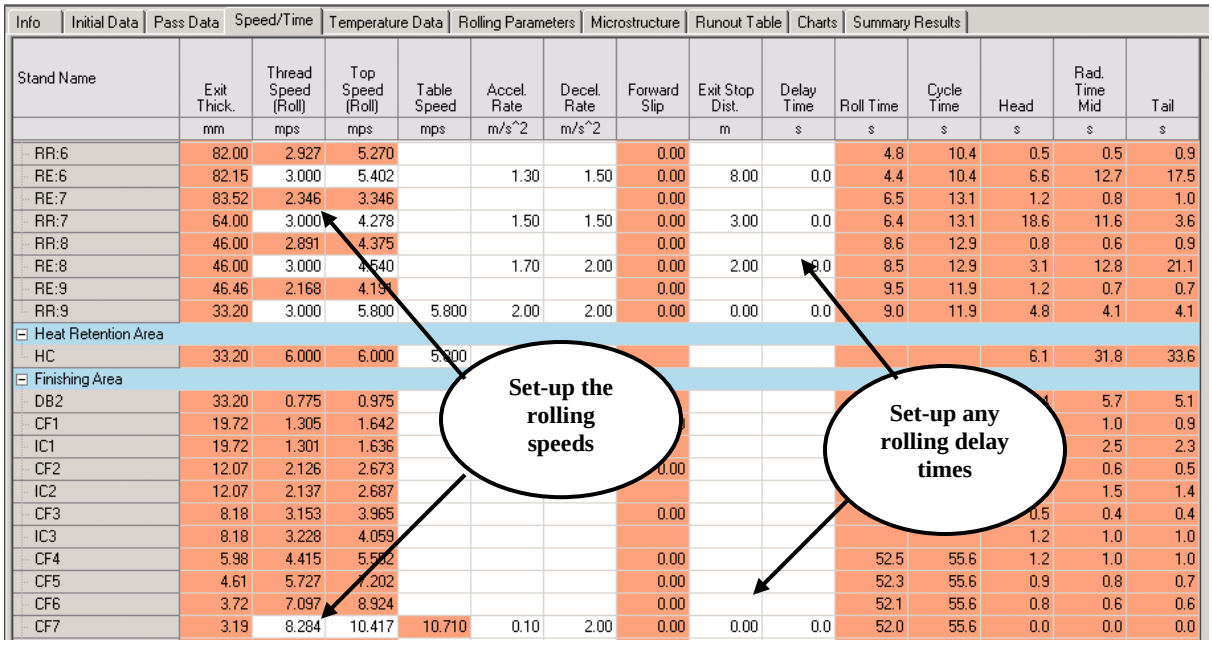
- The Initial Data tab also allows you to set-up your starting parameters for the rolling mill, including number of reversing passes and zoom acceleration rates.



- **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.

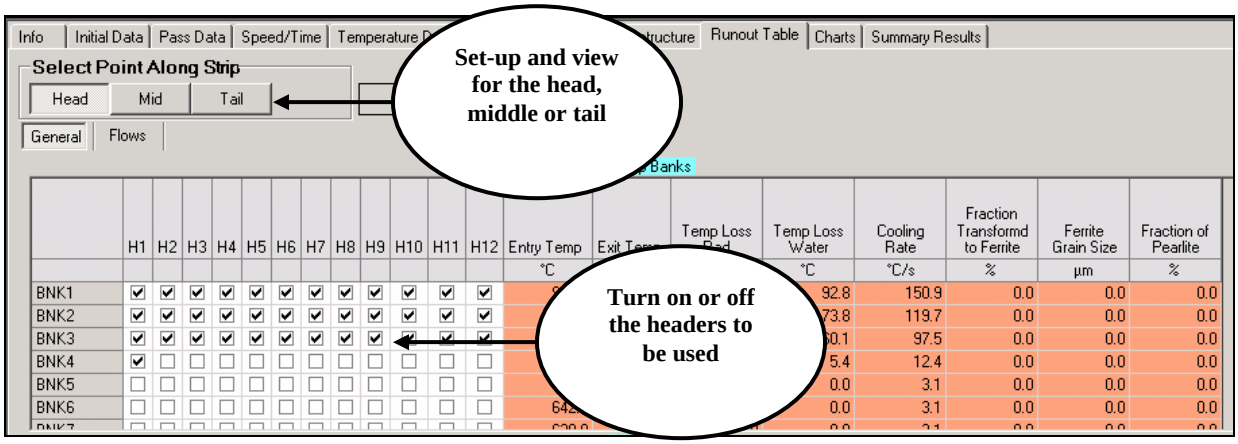


- **Click on the Speed/Time tab to display the following screen.** The Speed/Time tab allows you to set-up your rolling speeds.

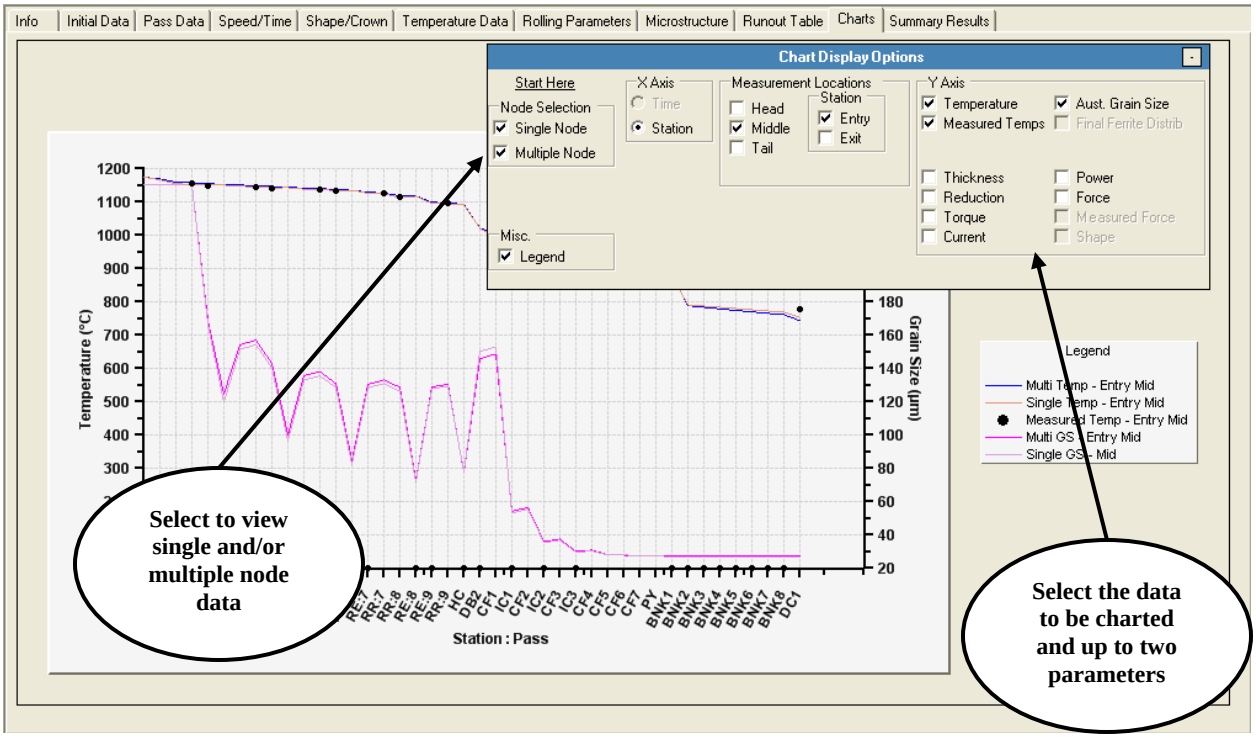


- **Clicking on the Temperature Data, Rolling Parameters and Microstructure Tabs will display results from the model calculations.**

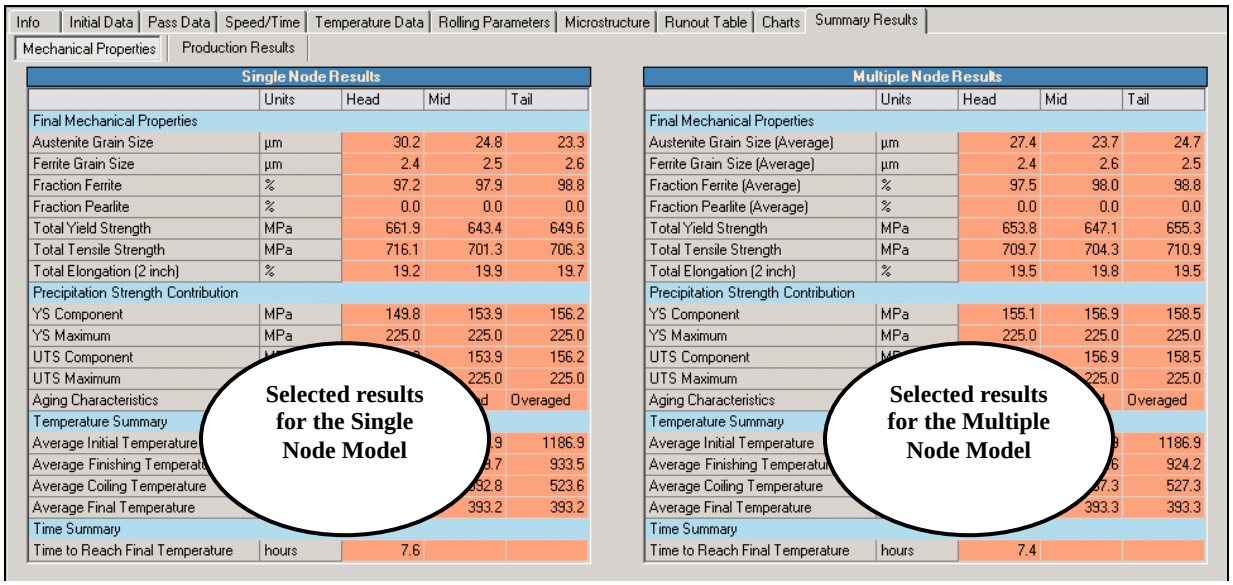
- **Click on the Runout Table tab to display the following screen.** The Runout Table tab allows you to set-up your runout table spray patterns and to view results from the model.



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



- **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	Units	Head	Mid	Tail
Final Mechanical Properties				
Austenite Grain Size	µm	30.2	24.8	23.3
Ferrite Grain Size	µm	2.4	2.5	2.6
Fraction Ferrite	%	97.2	97.9	98.8
Fraction Pearlite	%	0.0	0.0	0.0
Total Yield Strength	MPa	661.9	643.4	649.6
Total Tensile Strength	MPa	716.1	701.3	706.3
Total Elongation (2 inch)	%	19.2	19.9	19.7
Precipitation Strength Contribution				
YS Component	MPa	149.8	153.9	156.2
YS Maximum	MPa	225.0	225.0	225.0
UTS Component			153.9	156.2
UTS Maximum			225.0	225.0
Aging Characteristics			d	Overaged
Temperature Summary				
Average Initial Temperature			.9	1186.9
Average Finishing Temperat			8.7	933.5
Average Coiling Temperature			592.8	523.6
Average Final Temperature			393.2	393.2
Time Summary				
Time to Reach Final Temperature	hours	7.6		

Multiple Node Results	Units	Head	Mid	Tail
Final Mechanical Properties				
Austenite Grain Size (Average)	µm	27.4	23.7	24.7
Ferrite Grain Size (Average)	µm	2.4	2.6	2.5
Fraction Ferrite (Average)	%	97.5	98.0	98.8
Fraction Pearlite (Average)	%	0.0	0.0	0.0
Total Yield Strength	MPa	653.8	647.1	655.3
Total Tensile Strength	MPa	709.7	704.3	710.9
Total Elongation (2 inch)	%	19.5	19.8	19.5
Precipitation Strength Contribution				
YS Component	MPa	155.1	156.9	158.5
YS Maximum	MPa	225.0	225.0	225.0
UTS Component			156.9	158.5
UTS Maximum			225.0	225.0
Aging Characteristics			d	Overaged
Temperature Summary				
Average Initial Temperature			8	1186.9
Average Finishing Temperatu			6	924.2
Average Coiling Temperature			7.3	527.3
Average Final Temperature			393.3	393.3
Time Summary				
Time to Reach Final Temperature	hours	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

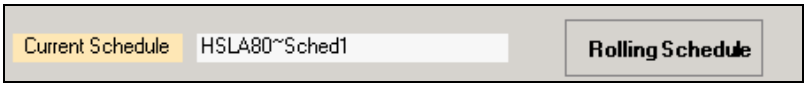
Now that we know how to set-up, configure and run the HSMM, let's understand how we can utilize the HSMM to help study various process parameters and their influence on the final product. For this demonstration, we will continue to use the LearnHSMM project and will demonstrate how the model results (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:

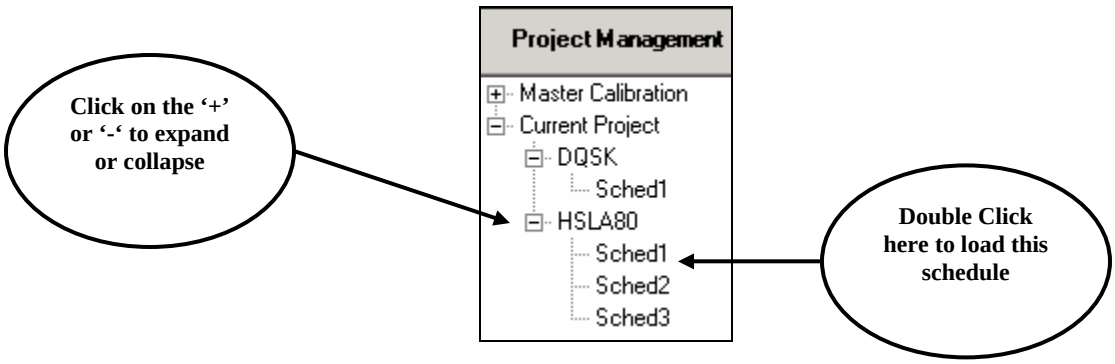
1. **Make sure you are running the Learn HSMM project as loaded in the Quick Tour. If not, click on the top menu bar, click on File \ Open Project. Click on "LearnHSMM" in the list and then on the Open button.**

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.**

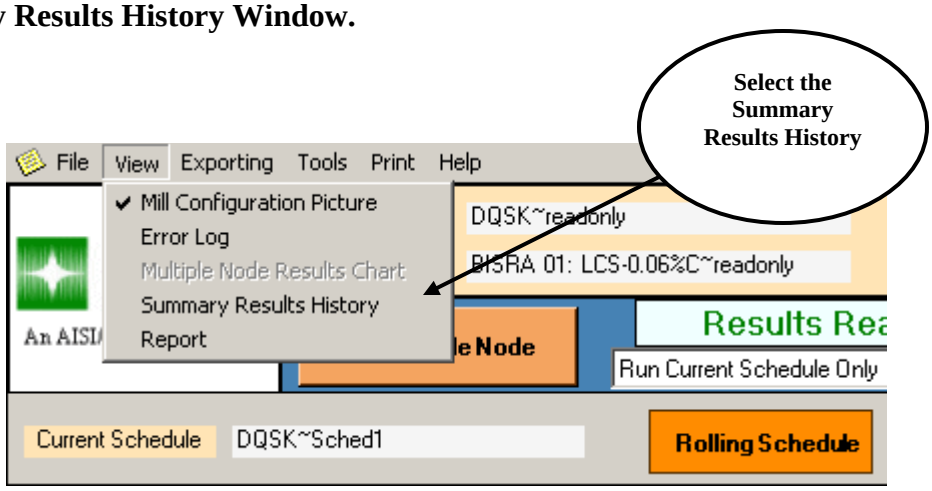


If not, select this schedule from the Project Management Panel by expanding the **Current Project** and **HSLA80** until **Sched1** is visible. Double-click on Sched1 to load it.

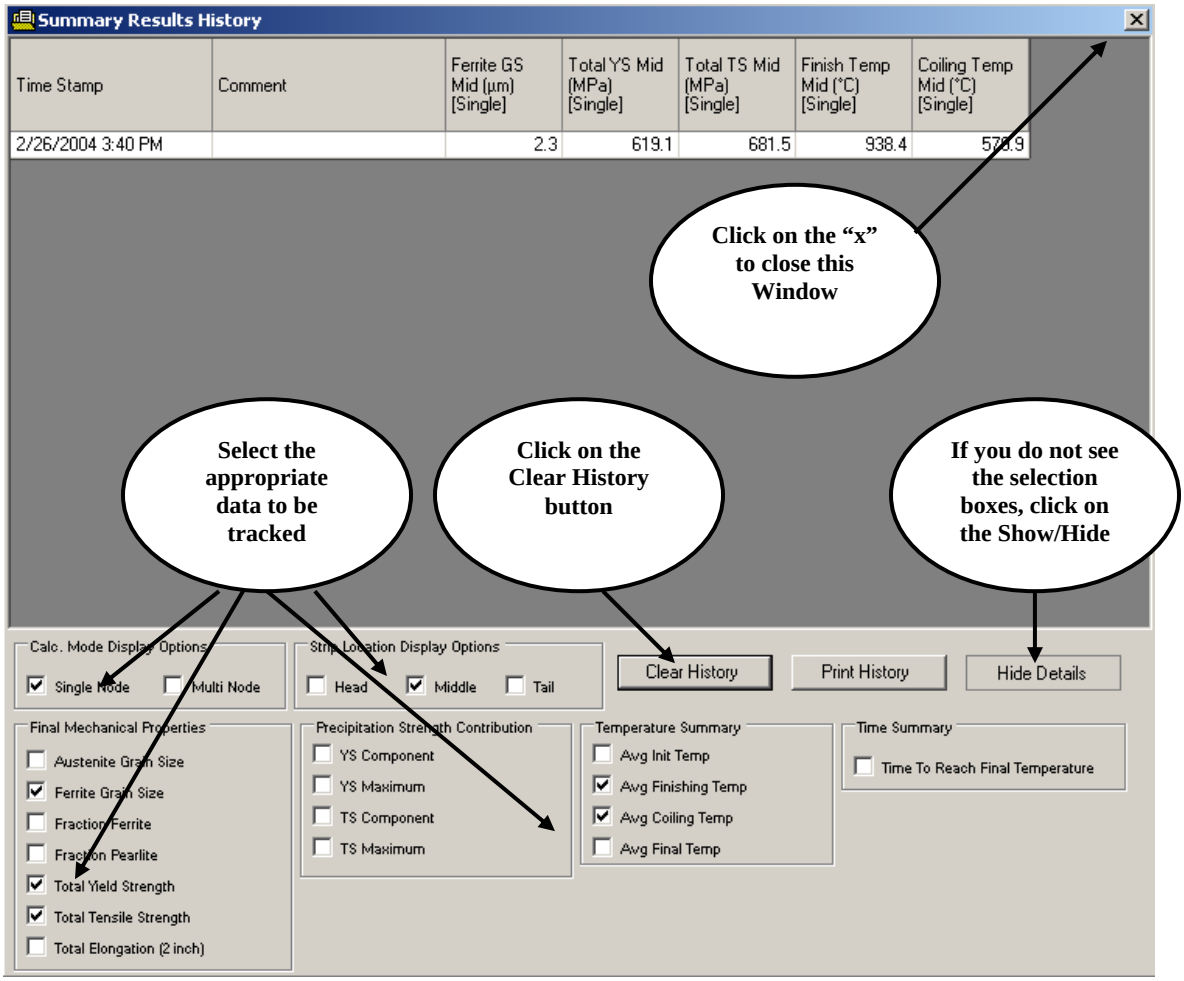


3. **Click on the Run Single Node button to run the calculations.**

4. **From the Top Menu bar select <u>View \ Summary Results History</u> to bring up the Summary Results History Window.**



5. **On the Summary Results History window, click the <u>Clear History</u> button and make only the following checkbox selections:**



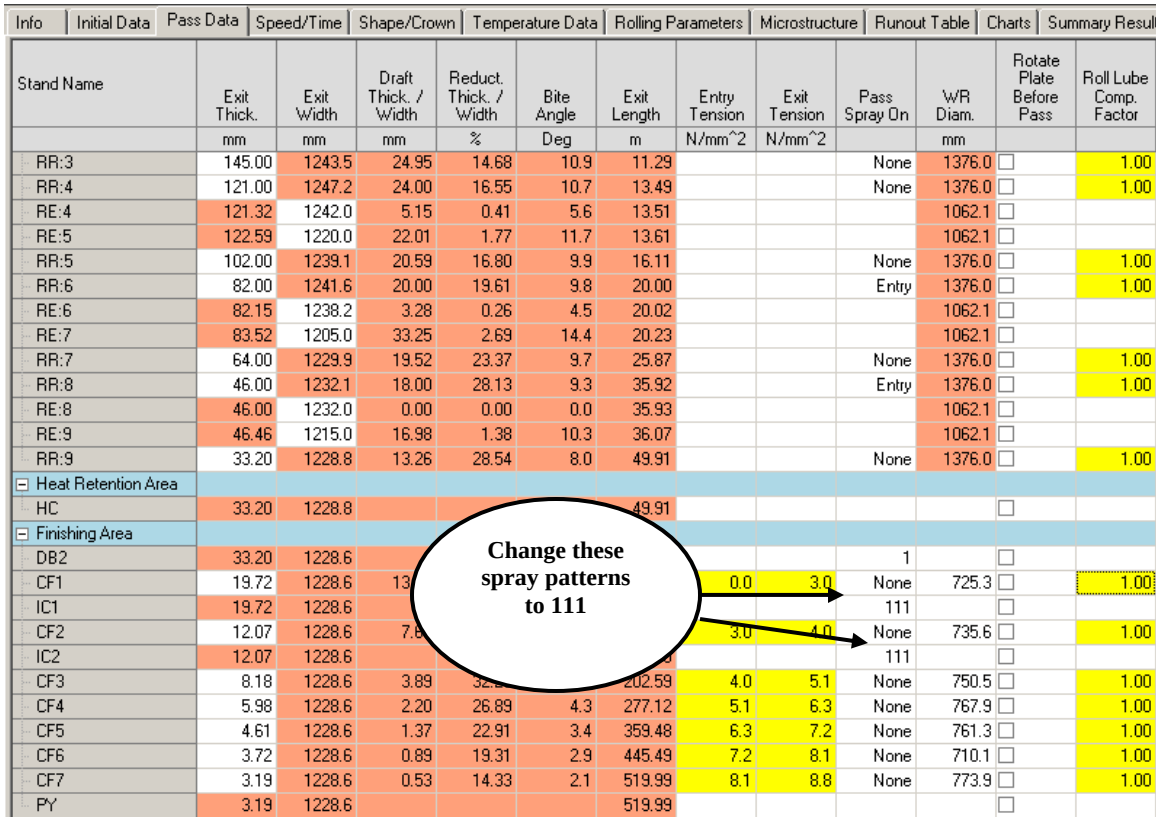
The boxes you should have checked for the purposes of this demonstration are:

- 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.

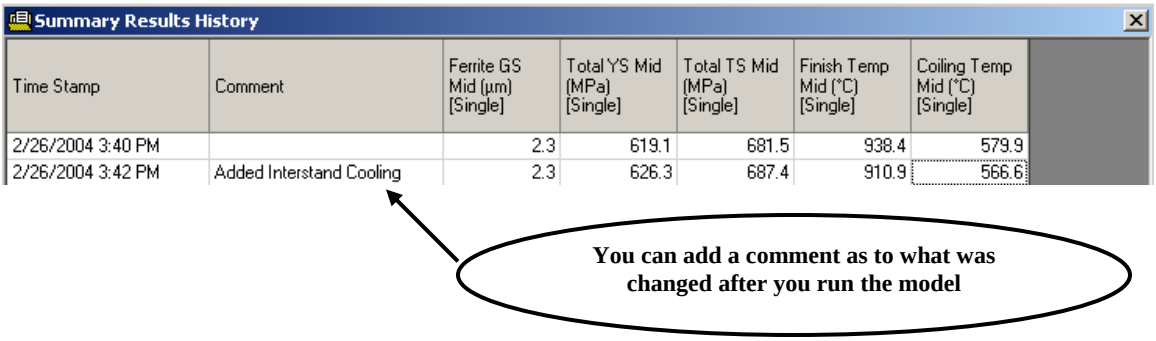
7. We will now make several changes to the rolling mill schedule, run the Single Node model and view the changes to the final results.

8. For our first change, we will turn on the entire Finishing Mill Interstand Cooling by clicking on the <u>Pass Data</u> 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.)



Stand Name	Exit Thick.	Exit Width	Draft Thick. / Width	Reduct. Thick. / Width	Bite Angle	Exit Length	Entry Tension	Exit Tension	Pass Spray On	WR Diam.	Rotate Plate Before Pass	Roll Lube Comp. Factor
	mm	mm	mm	%	Deg	m	N/mm^2	N/mm^2		mm		
RR:3	145.00	1243.5	24.95	14.68	10.9	11.29			None	1376.0	☐	1.00
RR:4	121.00	1247.2	24.00	16.55	10.7	13.49			None	1376.0	☐	1.00
RE:4	121.32	1242.0	5.15	0.41	5.6	13.51				1062.1	☐	
RE:5	122.59	1220.0	22.01	1.77	11.7	13.61				1062.1	☐	
RR:5	102.00	1239.1	20.59	16.80	9.9	16.11			None	1376.0	☐	1.00
RR:6	82.00	1241.6	20.00	19.61	9.8	20.00			Entry	1376.0	☐	1.00
RE:6	82.15	1238.2	3.28	0.26	4.5	20.02				1062.1	☐	
RE:7	83.52	1205.0	33.25	2.69	14.4	20.23				1062.1	☐	
RR:7	64.00	1229.9	19.52	23.37	9.7	25.87			None	1376.0	☐	1.00
RR:8	46.00	1232.1	18.00	28.13	9.3	35.92			Entry	1376.0	☐	1.00
RE:8	46.00	1232.0	0.00	0.00	0.0	35.93				1062.1	☐	
RE:9	46.46	1215.0	16.98	1.38	10.3	36.07				1062.1	☐	
RR:9	33.20	1228.8	13.26	28.54	8.0	49.91			None	1376.0	☐	1.00
Heat Retention Area												
HC	33.20	1228.8				49.91					☐	
Finishing Area												
DB2	33.20	1228.6							1		☐	
CF1	19.72	1228.6	13				0.0	3.0	None	725.3	☐	1.00
IC1	19.72	1228.6							111		☐	
CF2	12.07	1228.6	7.6				3.0	4.0	None	735.6	☐	1.00
IC2	12.07	1228.6							111		☐	
CF3	8.18	1228.6	3.89	32.		202.59	4.0	5.1	None	750.5	☐	1.00
CF4	5.98	1228.6	2.20	26.89	4.3	277.12	5.1	6.3	None	767.9	☐	1.00
CF5	4.61	1228.6	1.37	22.91	3.4	359.48	6.3	7.2	None	761.3	☐	1.00
CF6	3.72	1228.6	0.89	19.31	2.9	445.49	7.2	8.1	None	710.1	☐	1.00
CF7	3.19	1228.6	0.53	14.33	2.1	519.99	8.1	8.8	None	773.9	☐	1.00
PY	3.19	1228.6				519.99					☐	

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



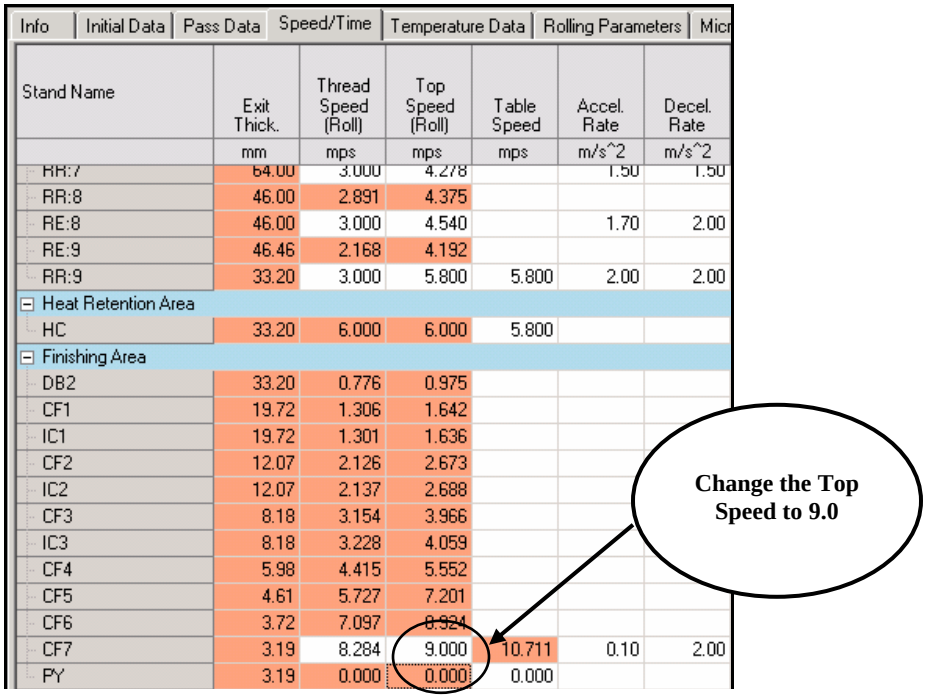
Summary Results History

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

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.

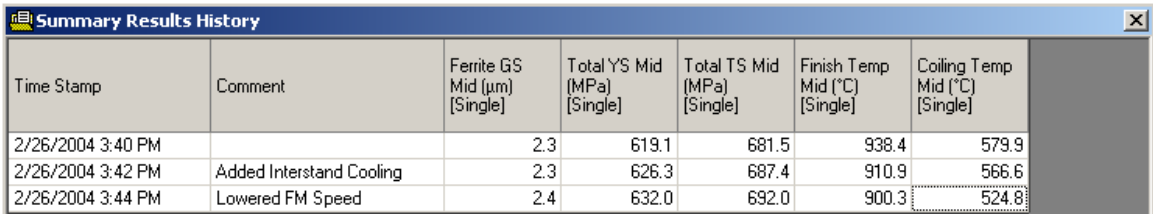
10. **For our second change, we will lower the Finishing Mill top speed by clicking on the <u>Speed/Time</u> tab and scrolling down to the CF7 stand. Lower the speed value in the "Top Speed (Roll)" column from 10.417 down to 9.0.**



Info | Initial Data | Pass Data | Speed/Time | Temperature Data | Rolling Parameters | Micr

Stand Name	Exit Thick.	Thread Speed (Roll)	Top Speed (Roll)	Table Speed	Accel. Rate	Decel. Rate
	mm	mps	mps	mps	m/s^2	m/s^2
RR:7	64.00	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		

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



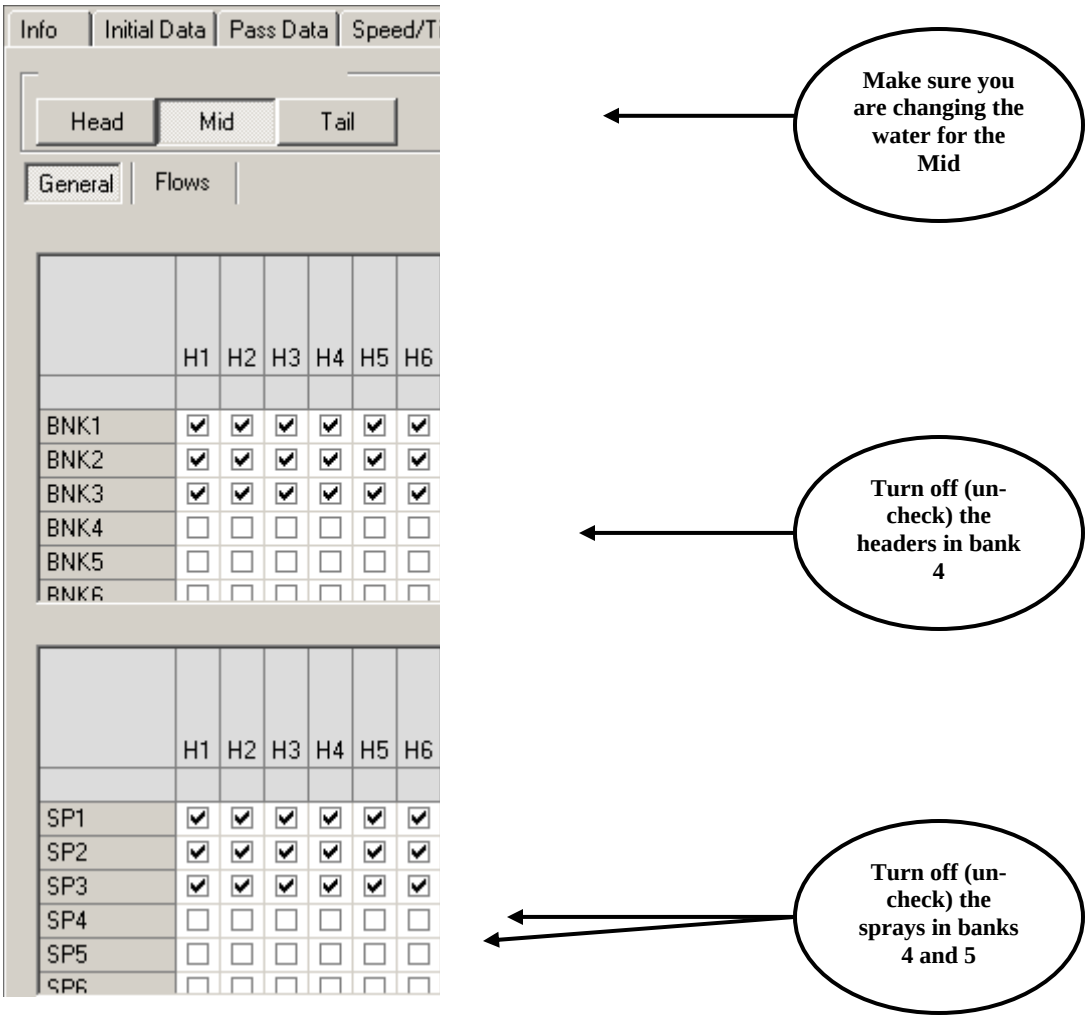
Summary Results History

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

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 <u>Runout Table</u> tab and also on the <u>Mid</u> 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.



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 <u>Run Single Node</u> button again to run the calculations. When the Results are Ready, open the View \ Summary Results History screen again.

Summary Results History

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:

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