Metal Pass Software Products

Introduction

Primary software products developed by Metal Pass LLC consist of three categories:

- Roll Pass Design
- Mill Load and Power Prediction
- FDM based Temperature Profile for Rolling and Controlled Cooling

We have two sets of roll pass design programs available: AutoForm Series and FreeForm Series.

AutoForm series. With its full-automatic, easy-to-use features, you only need to fill out basic operation parameters to the web form, and the system will run the loop for trial-and-error to design every parameter for you. Our solid roll pass design knowledge and sophisticated process models make it possible for this full-automatical design. Currently this series has three programs available, for Round-Oval-Round (2 pass), Square-Diamond-Square (2 pass) and Billet-Box-Square-Oval-Round (4 pass roughing).

FreeForm series. This is a powerful series particularly designed for professional roll pass designer. It provides full freedom of trial-and-error design for the pass and groove parameters. For every trial, the system calculates spread, forward slip, roll RPM, and all other critical parameters. Applications in this FreeForm series consist of Round-Oval-Round (Up to 30 Passes) and Square-Diamond-Square (Up to 30 Passes). The FreeForm series for Round-Oval-Round pass sequence is now available for sale.

Power and Force calculation. This is a set of programs designed to calculate roll separating force and rolling torque, power. Pass sequences covered are: Round-Oval, Oval-Round, Round-Oval-Round, Square-Oval, Box-Box, Square-Diamond, Diamond-Square, Square-Diamond-Square, and General Pass.

FDM for Temperature Prediction during Rolling and Controlled Cooling. This is another powerful program, particularly developed for temperature control during rolling and controlled cooling. The application uses finite-differential method (FDM) to determine temperature field over the rod cross section during rolling, water box cooling and controlled/free air cooling. Heat transfer coefficient models are developed for rolling, controlled cooling and air cooling, etc.

Process models used for the software development. Design procedures are based on our technical development to combine recent results worldwide, primarily from Germany, Japan and USA. One of the data sources, for example, is a 10-year project in Germany in a 4-stand continuous lab mill (up to 70m/s) with controlled cooling and full measurement capabilities. Its result was recorded in various reports, which are available for Metal Pass development. Results from Japanese colleagues (e.g. Shinokura) were also employed. However, formulation from Shinokura was heavily expanded to reflect modern rolling practice such as speed (up to over 100 m/s), tension (especially in the rolling block), roll and stock materials, etc.). A great number of field data, primarily from high-speed rolling block, were evaluated and applied to our roll pass design practice.

In the following we particularly introduce two primary software programs: FDM Temperature prediction system and freeform RD-OV-RD roll pass design program.

FDM Temperature Prediction for Rolling and Controlled Cooling

Finite differential method (FDM) has advantages to be used to calculate temperature distribution during rolling and controlled cooling process such as water box temperature control process. It has been used by some mill builders for prediction temperature process during steel rod mill from rolling, interpass cooling, controlled cooling (with water box) , etc. Metal pass has developed a powerful program for the rolling and

cooling process temperature prediction. An online demo for water box temperature process is available on www.metalpass.com/cool.

Primary features

Rolling

Strain energy can either be entered by user directly, or be calculated by the program. In calculating the strain energy, strain in the height is used, together with other parameters such as flow stress. During the strain calculation, the average height is used. The average heights before and after the rolling are determined by cross section areas and widths. In case the user has difficulty to enter the widths before and after rolling of a pass, the system can estimated one pair based on known parameters and general deformation features.

The temperature increase due to the strain energy is determined based on the result of finite element analysis (FEA). FEA result shows that with total strain energy for a pass the temperature increase from the core to the surface are different. The node in the core has a higher temperature rise than in the surface. This trend is programmed into the system.

Heat transfer coefficients during rolling and interpass cooling are also well modeled based on the development in recent years from various countries. Heat transfer coefficient in the contact surface between roll and stock spans in a large range, depending on the scale formation, surface temperature, materials, roll surface cooling, etc. The system allows user to select High, Medium and Low coefficients of heat transfer if this coefficient is to be determined by system (the program). User can also enter the heat transfer coefficient directly.

Water box cooling

We have complete models on the heat transfer coefficients during water-box cooling, developed based numerous site testing and lab experiments. Heat transfer coefficient is modeled taking into account various cooling process models such as rod diameter, water flow pressure, rod surface temperature, turbulence contour, etc. The model for heat transfer coefficient has been developed based on near 10 research reports with field measurements. The measurement was done in various steel plants in USA, Canada, Australia, Germany, etc.

Air cooling

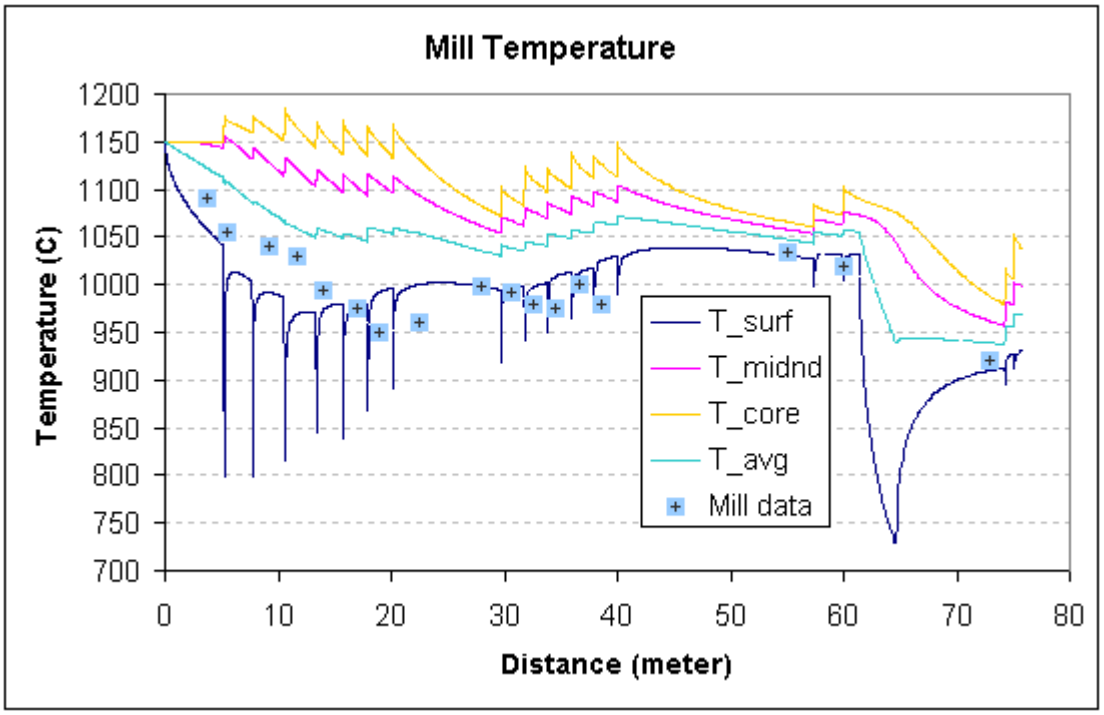
Heat transfer coefficient is modeled based on heat transfer mechanisms heat conduction, convection and radiation. Stock traveling speed, environment temperature and contact with guide, roller, etc., are considered in modeling the heat transfer coefficient.

Databank for thermal/mechanical property data

Finally, metal pass has complete databanks (some are available at www.metalpass.com) on thermal and mechanical property data ready to be served for the program package.

As one example, calculation was done with the rolling practice of former Bethlehem Steel and the predicted temperature was compared with the field measurement. The result is showed in the picture below. The calculation is very accurate (some error in the first 4 passes was because they are not round-oval pass, though they are treated as round-oval pass in this calculation).

The data for this calculation is available online. Download the reloadable file (http://www.metalpass.com/help/FDMRod_files/Cool.txt), copy the text from the file, paste it into the text box in http://www.metalpass.com/cool/inout.aspx, and click on the button "Input reloadable file".



FreeForm Series Roll Pass Design – RD-OV

This program is particularly useful to study and improve existing roll pass, in addition to designing new pass system. The program is developed based on modified Shinokura (or called Shinokura-Li spread model) to accurately determine spread during rolling. Several forward slip procedures are available for speed calculation.

The program allows user to perform RD-OV pass design pass by pass, up to dozens of passes. Besides automatic calculation of procedure parameters (spread factor, etc.), it allows user to enter those parameters directly.

A list of rolling process parameters are considered for accurately determine spread and forward slip. Those include:

- Stock material (steel grade)
- Rolling speed
- Rolling temperature
- Size
- Roll material
- Roll surface cooling and lubrication
- Roll diameter
- Inter-stand tension
- …

The user can verify several primary parameters that describe the groove shape (pass radius, groove depth, roll gap, etc.). For every set of groove parameters, near 20 calculated parameters such as fill ratio, reduction, fill ratio, aspect ratio, bite angle will be displayed to allow user to check. When a pass is designed, the exit geometry will be transferred to the next pass as entry geometry. Full report for all the primary parameters is available for every pass.

When user enter parameters for an existing pass sequence and run the calculation, he should find lots of details for improvement.

This program also allows user to study the difference among stock head, tail and middle section, by investigate tension and temperature in various region.

One pass design example and several user documents are available online at www.metalpass.com/freeform/rdov.aspx.