ISSN 1983-4764

QUICKLY AND EFFICIENTLY IDENTIFY ROLL HEATING AND COOLING PROBLEMS[1]

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Abstract

Roll heating and cooling problems such as cracks, defects and “orange peel” finish are easy to spot, but finding the source of these problems can be difficult and time-consuming. A Temperature Profile Detection system allows users to accurately identify areas of roll(s) with temperature deviations. The benefits of the system include accurate temperature measurement across the entire roll face in a few seconds allowing for quick problem identification, easier troubleshooting and maintenance, and easy operation for quick turnaround. This paper will discuss the features of the system and provide studies of installations and their use of the system to assist with process problems as well as process improvements in terms of roll cooling management.

Keywords: Roll cooling; Temperature; Measurement.

[1] *Technical contribution to the 49th Rolling Seminar – Processes, Rolled and Coated Products, October, 22nd-25th, 2012, Vila Velha, ES, Brazil.*
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ISSN 1983-4764

1 INTRODUCTION

In the rolling of metal – both hot mills and cold mills – proper roll cooling is a vital aspect in the successful delivery of top quality product. Thermal variations are often the cause and result of the interaction of equipment and product – and may be either intentionally caused or may be unintentional and unknown. Many roll performance issues are traced directly to either improper thermal characteristics or unintended force dynamics. It is the purpose of this paper to discuss useful and reasonable efforts to measure temperatures along the roll face, at known intervals, and with reliable repeatability. Further, this paper will discuss a means of storage and later retrieval of roll temperature data, while requiring very little time from mill personnel.

2 ISSUES INVOLVED WITH ROLL TEMPERATURE MEASUREMENT

Mills understand the importance of measuring temperatures. The successful measurement of roll temperatures across the roll face (called the roll thermal profile) is fundamental to knowing the performance of the roll cooling system and adequacy of the thermal model. Roll temperature and diameter are inextricably linked and interdependent. Mill personnel have used various measurement techniques in an attempt to gain usable temperatures of the mill rolls – temperatures that are as close to operating conditions as possible. The major hurdles to acquiring usable roll temperatures are:

- Time needed for measurement – With standard roll measurement techniques, roll temperature measurement is immediately compromised because of the time it takes to gain all needed measurements. The temperatures that are desired to measure are those that are occurring while the mill is operating. Because of technical challenges in obtaining this data, it is alternatively desired to measure as soon after operation as possible. Because temperatures adjust with time and trend towards thermal equilibrium, a faster measurement is a measurement that more closely approximates real-time operating conditions.
- Usefulness of data – For data to be useful, there needs to be enough of a data set to show trends over time, and to indicate or forecast temperature departure from historical norms. Further, within the entire available temperature data set, it is required to have an easy means of retrieval or search to make the data more useful.
- Ease of measurement – Because of the time demands on mill personnel and equipment, it is imperative that any useful measurement technology should be easy to use. That is – it should take a minimum of time, using a minimum of equipment, with a minimum of effort. It has been demonstrated widely through industry that only those systems that are easy to use are actually used long term.

3 TRADITIONAL ATTEMPTS FOR SOLUTION

Discussed below are several techniques that are used in the metals industry today for measurement of roll temperatures.

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3.1 Single Point Contact Method

The single point contact method most often refers to a handheld thermocouple or RTD probe. The probe is held by hand, and is intended to measure one point. In the other hand, or closely located to the probe is normally a read-out device or meter which indicates the current temperature of the sensor element at any time.
Like any system or device, there are good and bad points to it's usage for this particular application. For example, the system is lightweight and inexpensive. However, because the system uses conduction to sense temperatures, it is important that during use, the sensor is consistently held statically in contact with the sensing surface for each measurement point – usually on the order of ten to fifteen seconds for an accurate reading. With a wait time too short, the sensing element does not have time to acclimate to the heated roll surface. With wait time varying from point to point, the accuracy will vary as well from point to point.
Using this type of system for measurement of mill rolls can pose several challenges – namely:

- Time required for each measurement – 10 to 15 seconds
- Time required to record each measurement – 5 to 30 seconds (higher if the data is actually keyed into a computer for future retrieval and increased usefulness).
- Accuracy of measurement – based on operator methods and can vary. Also, points recorded later in the process are compromised through wait time because of reading other points first.

3.2 Single Point Non-Contact Method (Infrared)

Using an infrared temperature measurement device, it is possible to measure single temperature readings quickly, through aiming the handheld device and pulling a trigger or button. These devices can be very helpful for a quick measurement of temperature. They are also lightweight and lower cost, although typically more than single point contact methods.
The challenges with this class of devices include:

- Accuracy that can be compromised through changes in "angle of incidence" measurement or surface reflectivity – a common occurrence with mill rolls.
- Measured values compromised due to emissivity changes of the roll surface. Many times, this can be circumvented through the application of paint on the roll surface so that there is a known reflectivity and emissivity.
- Time required to record each measurement – the same as the single point contact method above – between 5 and 30 seconds per data point.

As with the single point contact method, the non-contact method described here puts a high emphasis on the instrument user to achieve proper readings, and to spend quite a bit of time acquiring this data on a consistent basis.

3.3 Rolling "Trolley" Systems

For measurement of roll diameters, there are devices that can be positioned on top of the roll and pushed along the entire roll face by hand. The primary purpose of these systems is to measure roll diameter, but some systems are available with temperature measurement option. By purchasing this option, the user can position

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the trolley-mounted temperature sensor to acquire roll surface temperature as the trolley is moved.
Once again, as with the single-point temperature measurement methods outlined above, the ability of the sensor to measure the roll surface acceptably may be compromised for the same reasons already given. In the case of a trolley-mounted contact sensor, the lack of time at any one point for proper sensing is inherent (because the trolley continually moves). With the trolley-mounted infrared sensor, it may be necessary to again paint the roll surface to help mitigate reflectivity and emissivity issues.

3.4 Spraying Systems Co. Tpd (Temperature Profile Detector)

The Spraying Systems Co. Temperature Profile Detector (TPD) is constructed as a lightweight metal bar, approximately the same length as the roll face to measure. The bar has spring-loaded RTD temperature sensors positioned at specified intervals along the length of the bar – for example, every 50 mm or 75 mm. Positioned on the top of the bar is the system controller / electronics, along with handles for low-effort use of the system. Please refer to accompanying photograph 1 which shows a TPD bar with controller.

In actual use, the TPD System is very easy to use. The following are the steps required:

- Place the TPD bar on the roll surface.
- Optional magnetic mount will automatically hold the bar in place.
- Select the location of the measurement
- For example, stand F2, bottom work roll, or stand 1 bottom.
- Press the SAVE button.
    - All data points are read and transmitted wirelessly to a local PC, typically in the mill pulpit.
    - The data is stored in an industry standard SQL database.
    - Acknowledgement light is flashed on the TPD controller that the data has been received and stored.
- Measure the next roll.

Figure 1: Spraying Systems TPD assembly – Indicating bar and controller

The system has been designed so that there is no requirement of the operator to manually record temperatures. The sensors acquire the roll surface temperature through conduction. One entire roll may be measured within 20 to 30 seconds maximum, including time for sensors to acclimate to the roll surface.

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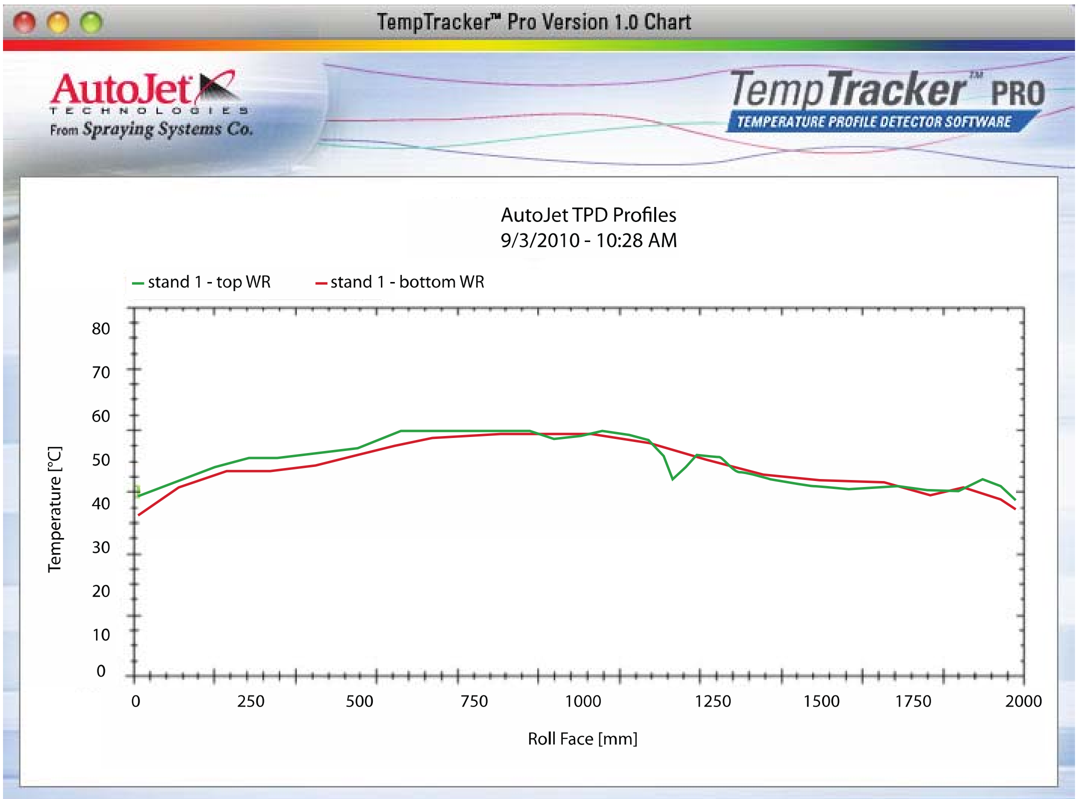

Figure 2: TPD measured temperature data plotted as a function of horizontal roll face distance. Two curves overlaid for comparison.

Because the data is stored in industry standard SQL, further access to the data is not limited. Within the control program for the system, the data may be queried and viewed as needed. Multiple records may be exported as CSV for further use in Excel, and graphs may be shared as needed subject only to IT department restrictions.

A data search (query) may be specified based on location, date range, optional comment field, or combination of these values.

Please refer to photograph 2 that illustrates two overlapping roll temperature curves. On this photograph, roll surface temperature has been measured by a TPD system, and is plotted as a function of horizontal distance along the roll face. By superimposing more than one curve, it is possible to easily compare or contrast data.

4 RESULTS AND DISCUSSION

Through data received from several major steel suppliers in the US Midwest region as well as engineering and research centers, the following have been found to be benefits of using the TPD system data and incorporating it into thermal models and operating practice:

1. Better strip shape control. Roll temperature related shape issues are estimated to be reduced significantly, with maximum deviation of shape reduced by up to 95%.
2. Better strip surface quality. Increased related issues by 10 to 15%, by providing critical data to fine-tune thermal models and create the proper oxide layer on the mill rolls. Since each roll chemistry has a unique target range of operating temperature, this target range will necessarily be selected

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by the mill control system based on roll chemistry, but is fine-tuned through data from the TPD.

3. Shorter maintenance time. By having temperature data available as a function of distance across the roll face, taken for each roll on a continual basis, it is easy to spot temperature trends that are departing from historical norms. A data point that increases over time indicates nozzle plugging may be occurring. Conversely, if a data point is decreasing over time, it signifies higher cooling rates and can indicate nozzle wear. In addition, the location of these thermal issues is seen automatically through simply viewing the resulting graph of temperatures as a function of distance. Knowing the location to check for nozzle issues reduces maintenance time.
4. Cobble reduction and associated delays with clearing the mill. Because of the availability of proper temperature data and the ability to fine-tune the thermal model for a variety of schedules, cobbles have been almost complete eliminated at some facilities. This has been attributed to a reduction in improper bending and shifting references that cause abnormal shape variations in the finishing stands.
5. Easier roll cooling header upgrades / modifications. Prior to any roll cooling modifications, existing roll thermal profiles should be taken, to quantify the existing thermal nature of the mill. Then, after header modifications or replacement, acquiring the new temperature profiles can provide valuable data to thermal model tuning. Typical ramp-up time after header modifications is cut by a factor of four.
6. Extended roll life. After the consistent use of the TPD and making associated thermal model changes, roll life has been increased up to 20% in some installations. Because roll costs are a significant part of any mill budget, this amount of savings can be substantial.

One reason for the ability to achieve benefits such as those above is because of the ease of use that is designed into the system. It can be used by almost any worker, which allows for data collection during all shifts. Of course, engineers and supervisors can study and review the data at any time convenient for them.

Please refer to accompanying Figure 3 which compares time required to measure and record one roll's temperatures. Note within this illustration that single point methods are shown to acquire only 8 points whereas the TPD system will measure 40 points. In reality, consistently measuring and recording eight data points at repeatable locations on each roll is not probable using handheld single point techniques.

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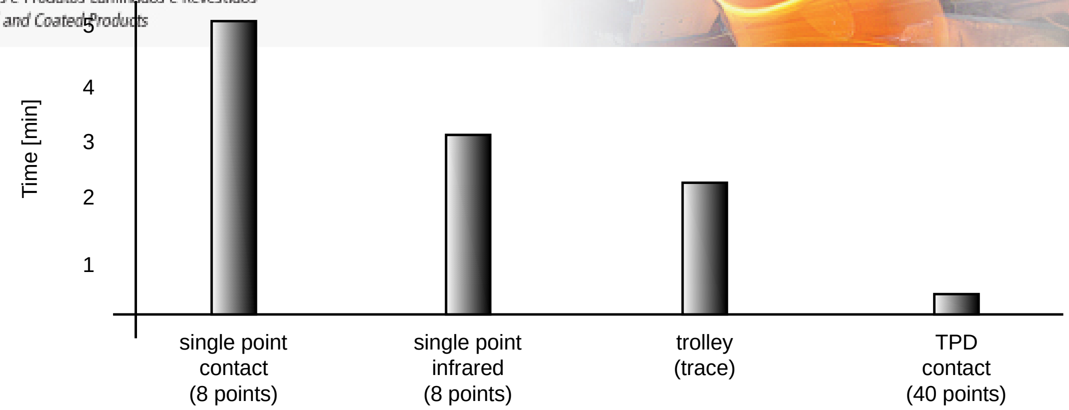

Figure 3: Comparison of actual temperature measurement and recording time. Data represents one roll with 2000 mm face.

5 SUMMARY

This paper has reviewed some common temperature measurement techniques, including the Spraying Systems Co. TPD. Major comparable features involve ease of use, speed of data collection, and resulting consistency of data. By using the TPD System, mills have experienced substantial benefits that directly affect product quality and reduced mill down time.