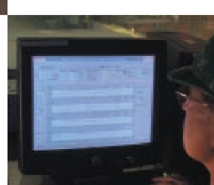
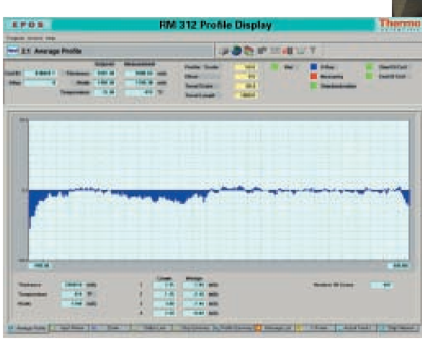
Product Specifications

The Thermo Scientfic RM 312 instantaneously and continuously measures centerline and transverse thickness, temperature, profile, width, edge drop and shape at the exit of a hot rolling mill. The wealth of process control and quality assurance data from these measurements helps mill operators improve operating practices, thereby improving mill throughput and yield.

Thermo Scientific RM 312

Multi-Function Gauge





Features

- Alloy compensation
- 5 mm cross profile resolution
- Fast center-line AGC channel
- Accurate width measurement
- Temperature profile data
- Length profile
- Strip position
- Optional strip flatness

The Thermo Scientific RM 312 demonstrates excellence in non-contact total strip measurement. While the RM 312 is aimed primarily at mills producing hot steel strip, it may also be used on non-ferrous applications.

Owing to the fast acquisition time of an accurate cross profile, the RM 312 is ideally suited to automatic profile, flatness control systems, mass flow computations and other control systems.

System Benefits

The ability to fully characterize width, center-line thickness, thickness profile, and temperature profile over 100% of the length of the product, as it exits the finishing mill, offers a wealth of process control and quality assurance data never previously available.

Immediate benefits in product quality will accrue from mill operators and quality inspectors developing and applying new insights into the hot rolling process. Analysis of data will lead to new and improved operating practices in several areas including roll grinding, roll changes, guide practices and roll scheduling.

These new practices will result in improvements in dimensional quality with a corresponding increase in mill throughput and yield.

Only the RM 312 provides the necessary measurement performance to enable online refinement of rolling process models, with virtually instantaneous feedback of the results of changes without disruption to the rolling program.

Compensation Features

To optimize the accuracy of the RM 312 system when measuring materials with different compositions of alloys, there is a range of alloy compensation functions available as standard.

Also, since strip edges are often significantly cooler than the center, it is necessary to utilize a scanning pyrometer, so that the correct temperature compensation may be applied to the measurement of each detector element.

Shortly after the hot material leaves the exit of the rolling mill, the vertical position and orientation of the strip is not sufficiently defined to allow consistent accurate profile measurement in the absence of strip position compensation.

The stereoscopic design of the RM 312 overcomes this obstacle. By providing two transversely-separated sources of radiation, and rapidly switching between them in antiphase, the single detector array receives two distinct images in quick succession of the strip edge transition, taken from different positions.

From the system geometry, the edge positions can then be calculated by suitable software, originally developed for computer tomography.

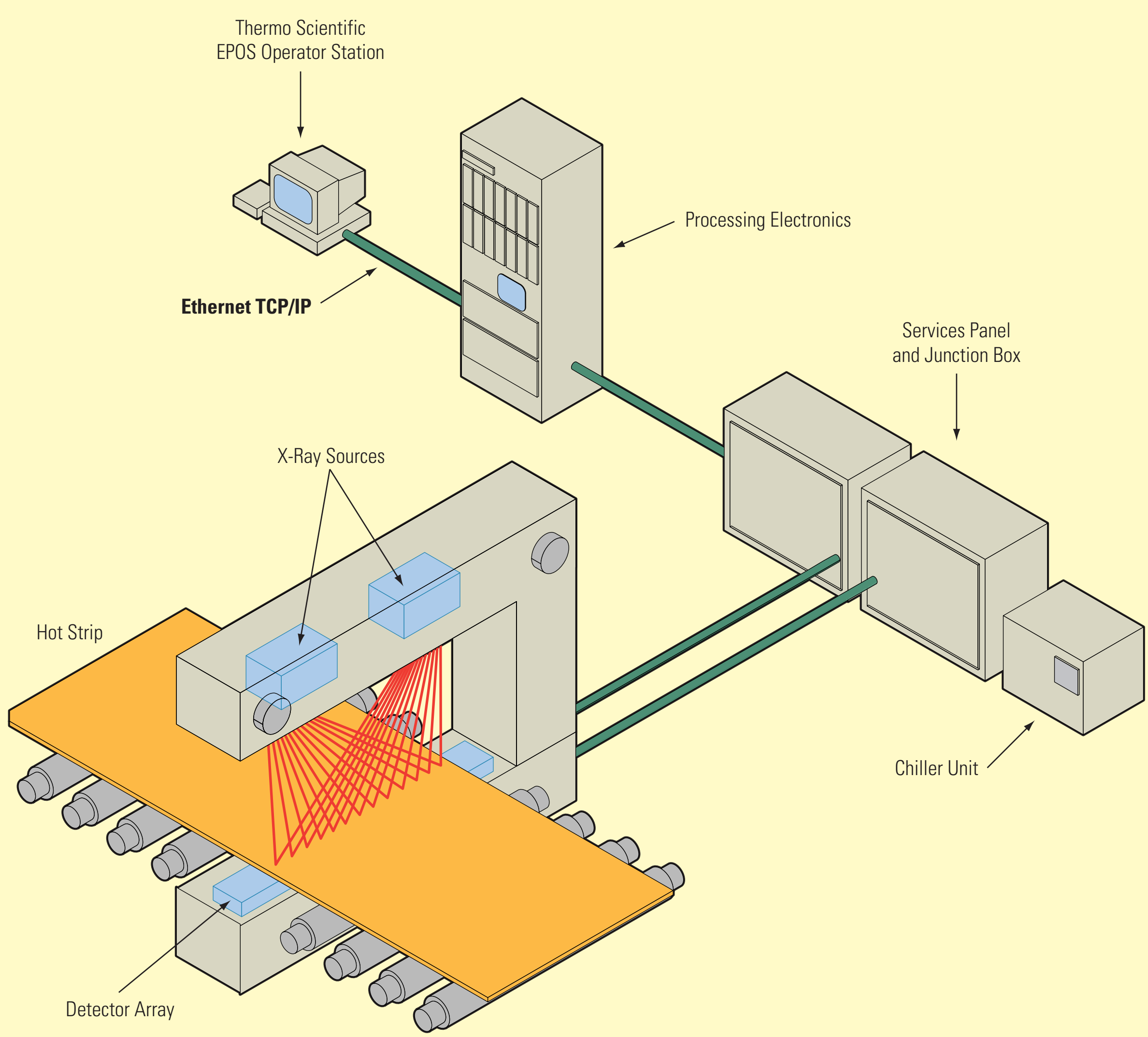
Having determined both the absolute position in space of each point across the strip, both scattering and angle-related errors can be automatically corrected—the first from calibration data and the second by computation from the strip angle.

System Displays

The RM 312 system provides a number of graphical display pages for the mill operator and/or quality control inspector.

Measurement data are processed in real time to produce the following displays:

- Graduated color maps of thickness and temperature *cross-strip* profiles.
- Graduated color maps of thickness and temperature *length* profiles.
- Graphical presentation of cross-strip thickness and temperature profiles.
- Point display of thickness, crown, wedge and edge drop.
- Graphical and numeric statistics on measured and calculated parameters.



In addition to the listed displays, the system also provides analog and digital signals for the mill control computer and for process analysis.

System Performance

The RM 312 system is designed to provide 100% characterization of the material edge position and transverse thickness and temperature profiles throughout the entire length of the product. Installation close to the last mill stand enables dynamic control of transverse thickness profile by means of roll shifting or bending.

Derivation of the AGC signal is made by calculating the position of the actual center of the material relative to the gauges, determining the thickness of this point, and deriving a signal proportional to the deviation from the target. A number of detector element signals, comparable to a discrete thickness gauge, are automatically combined to give a low noise, rapid response AGC output. Strip width measurements are taken at the same frequency as the thickness profile and, unlike other profile gauges, can be directly related to the thickness profile measurement, independent of the product tilt or lift. Transverse temperature profile measurements are taken 40 times per second with a typical measurement accuracy of ±5°C (±9°F).

Wedge, crown, edge drop and the strip position relative to the roller table are calculated and displayed every 100 ms. Outputs are available to alert the operator and mill computer to the presences of out-of-tolerance thickness, ridges, etc.

The RM 312 features built-in redundancy, both in X-ray generation and the detection systems. The gauge will operate with a single source functioning or defective detector element. In the event of a detector element being defective, it is automatically identified and eliminated from both profile and AGC outputs.

Measurement errors due to the build-up of dirt and drift effects are cancelled out by a standardization that is carried out automatically at the end of each coil.

RM 312 Flatness Features

The standard RM 312 gauges track strip edge position in space, both horizontally and vertically, to high accuracy. These data are measured across the strip, perpendicular to the process direction, and are updated every 5 ms. The standard gauge algorithm uses this information to produce a straight-line fit between the points at each update, then having calculated the slope of the straight line, a second algorithm compensates the measurements made from each radiation source against both the cosine and scattered radiation errors.

Crosswise Curvature

In this context, *curvature* is a measurement of how much a fit between transverse edge position measurements departs from a straight line.

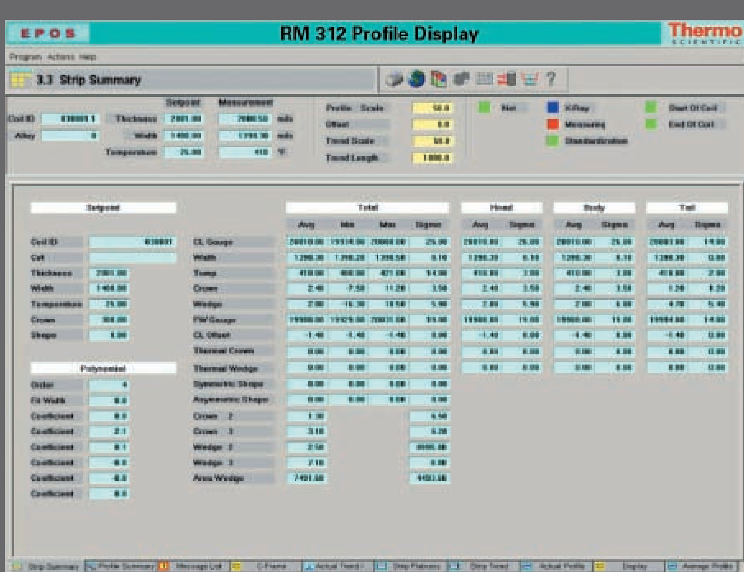
A development of the standard algorithm estimates the incremental change in angle of this line across the strip. This is done by taking simultaneous measurements using radiation originating from both radiation sources and analyzing how they differ across the strip—recalling that after a *straight line* angle compensation, either source would measure the same thickness.

With instantaneous edge position being known to high accuracy, software fits a best curve through the data points, yielding the curvature measurement. Successive measurements may be averaged over time.

Flatness

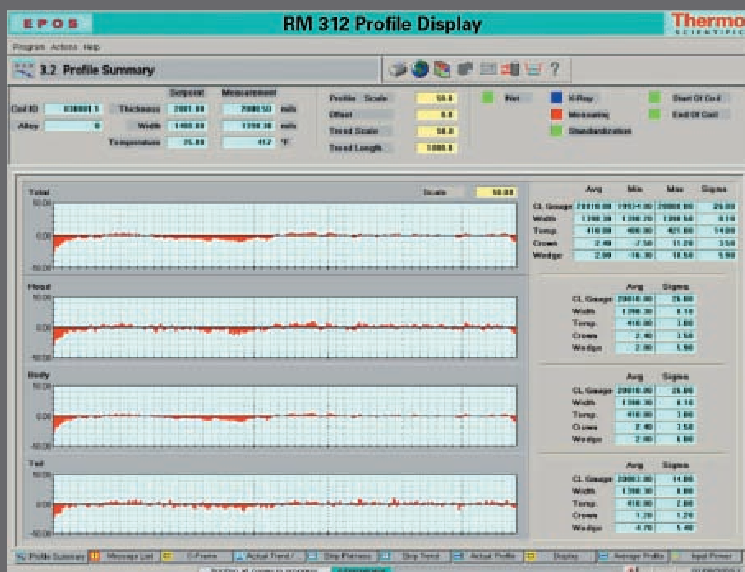
Flatness (shape) errors occur when the rate of extrusion of the strip from the roll bite is not constant across its width. This results in *edge waves*, *center buckle* and other similar defects that show up as vertical motion of the strip.

Flatness can be automatically inferred from the above curvature measurements once a *time* parameter is considered. To this end, the centerline strip speed is constantly measured to high accuracy by a built-in optical velocity meter. The profile gauge integrates the change in cross-sectional curvature against time to produce a surface variation. Flatness data will be provided in terms of vertical displacement at various points across the strip width or as the ratio between vertical displacement and wavelength (in I-units). Below about 100 I-units, the uncompensated effect of flatness on thickness and profile gauge measurements is small, and generally negligible. Above this value, there is a progressive deterioration in gauge thickness accuracy as the I-unit value increases. Hence, compensation is important. However, the effect upon center-referenced profile accuracy remains negligible (provided that the gauge measuring range is not exceeded) if the I-unit values measured at points across the width do not differ significantly—i.e., by >100 I-units.



System display of multiple variables

RM 312 — Multi-Function Gauge



EPOS display of profile dynamics

System display of flatness parameters

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