MEASURING OF ROLLED STRIP PROFILE

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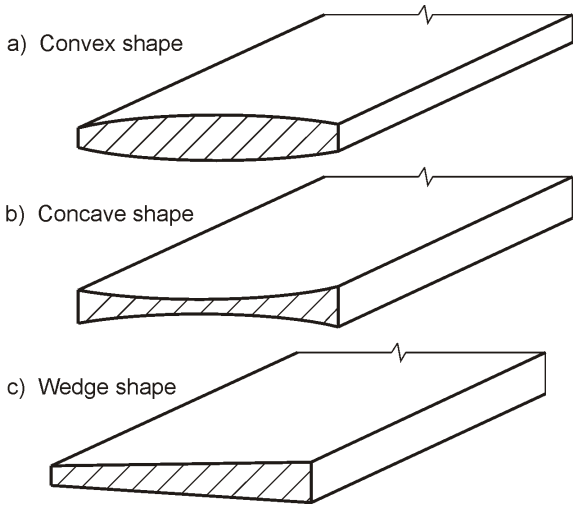
PREAMBLE

Not even the best-manufactured metal strip will achieve the perfect geometry, as far as perpendicular and longitudinal profiles, straightness, and surface flatness are concerned. The strip can come close to the ideal to varying degrees, and in some cases it can even be difficult to find any deviations. But to produce an 'ideal' strip is invariably uneconomical. For this reason, in practice, the strips are manufactured within specified

The basic imperfections of transverse strip profile are convex (1a) concave (1b) or wedge (1c) profile types.



Pic. 1 Basic types of imperfect strip profile.

The rolling process experiences many other profile problems caused for example by the work rolls wear off or damage and it is impertinent to follow up all possible causes changing the transverse strip profile shape continuously to ensure the optimal roll usage.

USED METHODS FOR MEASURING OF TRANSVERSE STRIP PROFILE

Presently, the profile shape is mainly measured on cut samples by hand micrometers in few predetermined spots and results are manually recorded into tables and graphs, statistically expressed for future comparisons. This method enables only very imperfect profile presentation influenced except other by slight changes of measuring procedures, changes in recording persons etc. Disadvantage is also the cumbersome and elaborate work used to collect and convey the measured results.

Using X-ray thickness scanner it is possible to provide only rough (orientation) measurement of strip profile – due to the strip movement the measurement is done not in the transverse direction but at a slant angle depending on the strip speed. Measurement is not done from the strip very edge not even when the strip is motionless furthermore is also not provided at singular points (spots) but x-raying a surface of several cm square.

On-line measurement using multi-points X-ray instruments having in the measuring head more detectors to check profile in limited number of spots and again provide only partial information about the strip profile.

On-line measuring instrument Shapemeter is placed directly at the rolling line and measures tension of single lines across strip lines usually not providing a direct readings and furthermore measures only few strip sections. It is very useful for transverse profile comparison but cannot evaluate changes of profile done by roll wear.

Next, very often used measuring method is an off-line measurement using tables with fastened trip sample onto it. Values evaluated by either moving measuring head or sample are transferred to graphical printer for further comparison and decision. Numeric evaluation, statistical calculation and data storage are usually not a part of this instrument. Measuring head is to be set manually against measured thickness and width of the sample.

STRIP PROFILE GAUGE MPP, FROM UVB TECHNIK S.R.O.

Strip profile gauge MPP is designated as a laboratory instrument for fully automatic strip thickness measuring of a cut sample. New, improved method enable fully automatic gauging of inserted and hold down sample measured by perpendicularly touch down sensing units. Measuring is fully automatic – at a pressing of start up button measuring head positions itself over the sample and the sensing unit gauges and evaluates thickness values across the width plotting the strip profile. It is not necessary to set up the instrument to the nominal measured thickness or strip width, as at the end of the unit journey it will automatically return to the original start up position. Measured information is automatically transferred to an evaluation unit of a personal computer and strip thickness profile is plotted with accuracy of 1 micrometer. Al input data are automatically evaluated by standard formulae for wedge ness and convex ness of strip profiles or by customers requirements and formulae. It is possible to print out data sheets in numerical or graphical forms and/ or transfer them to higher computer systems for archiving and later evaluations.

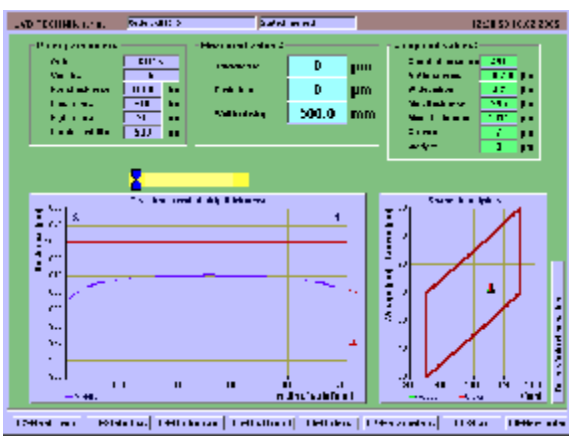
Pic.2 MPP Overall view

Pic.3 MPP Holders for sample placement

EVALUATING UNIT ENABLES

- Assign evaluation values of measured material (coil no; strip no; etc),
- Assign nominal (required) thickness and allowable tolerance,

- Digital presentation of measured thickness (as a single entry or continuously),
- Graphical display of measured deviation from nominal thickness (strip profile graph, distance from the edge / thickness deviation),
- Display of strip surface tolerance – to be explained later,
- Arithmetical calculation of profile parameters („crown“; „wedge“; „feather edge“; „thickness differences“); on request - other mathematical formulae could be discussed,
- Print out in tabular and graphical modes,
- Archiving of all measured parameters on HDD and company’s network,
- Evaluation of all archived data’s in tabular or graphical form.



Pic.4 Program display

BASIC TECHNICAL PARAMETERS

Sample strip thickness: max. 10 mm
Resolution: 0,001 mm
Max. deviation of measured thickness: ± 1 µm
Sample period: 1 mm
Max. width (length) of sample standard types: 1 500 and/or 2 000 mm
Working temperature: 0 °C to 45 °C

STRIP SURFACE FLATNESS – TOLERANCE DIAGRAM

The final outcome of graphical display on computer screen is a summary presentation of **“**Crown C” magnitude (Crown 40) and wedge shape of rolled strip W (Wedge 40) in the “tolerance diagram”. The “tolerance zone” is limited by band of borderline thicknesses Tmin & Tmax, and also by limiting band of **“**crowns**”** (Cmax).

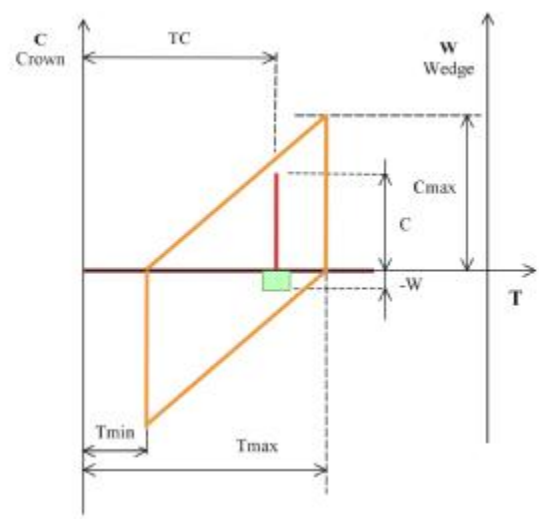
The resulting shape of “tolerance diagram” (in coordinates C – T) is a rhombus (see picture) with allowable values of “crown bands C moving in range:

$$T - Tmax < C < T - Tmin$$

hence

$$Tmax \geq T \geq Tmin$$

$$Cmax = Tmax - Tmin$$



Pic.5 Tolerance diagram of rolled strip flatness

BASIC EQUATIONS USED FOR PROFILE CALCULATION

Crown:

Magnitude of crown is given by the difference of thickness in the middle of rolled strip and average values of measured thicknesses 40 mm from the strip edge:

$$Crown40 = TC - \frac{TN40 + TS40}{2}$$

Wedge shape:

Magnitude of wedge shape is given by the difference of thicknesses 40 mm from strip edge:
Wedge40 = TN40 – TS40

Feather edge:

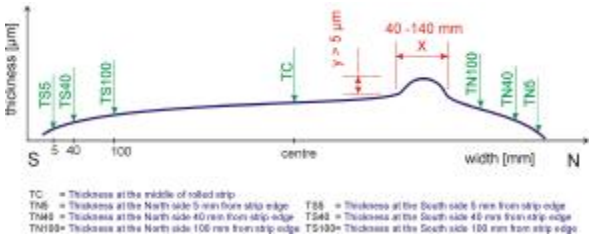
Its magnitude is given by percentage difference of thickness between points measured 5 mm and 100 mm from the strip edge:

$$FeatheredgeN = \frac{TN100 - TN5}{TN100} * 100\%$$

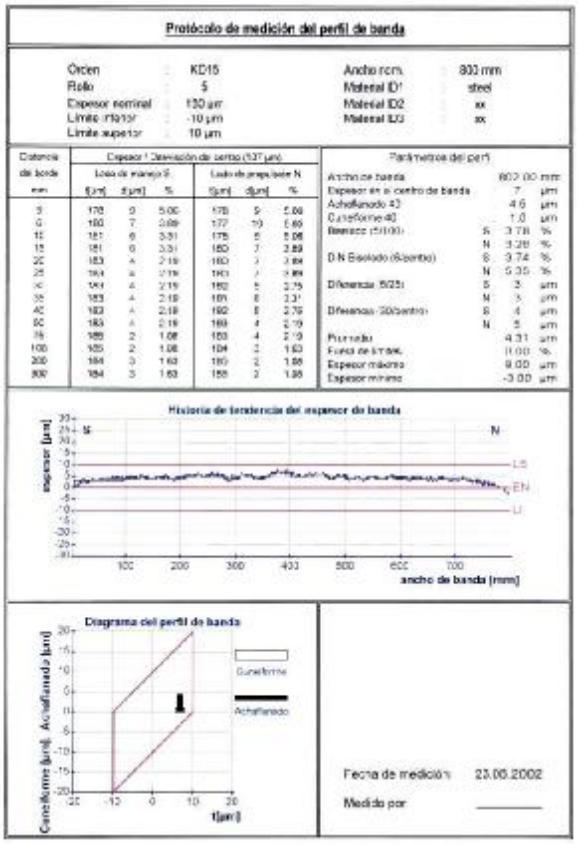
$$FeatheredgeS = \frac{TS100 - TS5}{TS100} * 100\%$$

High spot:

It is the highest point of imaginative theoretical curvature of rolled strip and its magnitude represents the wear of work rolls profile. Installed application will calculate measured dates and create a model of ideal quadratic curve depicting possible position of "High Spot" in supplied measured profile's values. Placing of the HIGH SPOT is given by the following conditions: (see picture 6) – width 40-140 mm, min.height 5 µm



Pic. 6 Graph of strip profile



Pic.7 MPP Print Out

USER EXPERIENCE

Quality department of Spanish company ARCELOR have been using two profile measuring instruments MPP and answered our questions investigating practicality of using these machines. It is necessary to point out that both applications had been bought for special applications at the rolling mill producing wide steel strip using one profile meter MPP in Quality Section at the tandem line and pickling line and the second in section of thin rolled strip – being in this case a follow up process. For this reason it is not possible to generalize obtained information and use results on all types of material and production processes.

1. Why the instrument had been bought / how it is used:

The necessity to use a laboratory type of profile-meter had been determined by production of new types of rolled materials where it have been important to follow, record and adjust strip thickness differences between mid and edges of the rolled strip. For example material DWI (high impurity free steel, maximum homogenise, with low anisotropy used for deep drawing) these types of steel are usually the initial material for cans production (Coca cola, Beer etc) where would the higher thickness differences between middle and edges of the strip influence the cans acceptance and quality – different height of the final products.

2. Results evaluation methods:

Directly at the rolling mill strip thickness is continuously check by X-ray gauging instrument by "scanning method" (strip in motion, gauge head moves transversely to the rolling direction) and measured results are compared to the results produced before-hand by the laboratory profile meter. The most follow up readings are CROWN and HIGH SPOT. CROWN indicates quality of rolled material, where is mostly important to achieve the minimum value, which theoretically should converge to 100% surface flatness but practically carries excessive risk of creating HIGH SPOT, signalling high "Wear Off" of Works Rolls in the rolling mill. WEDGE for example is a value followed up at the section of "thin rolled materials" only for information and is transferred to the hot strip mill for further processing.

CONCLUSION

None of presently operating mills works without an evaluation of rolled strip parameters and subsequent adjustment of its operating instructions. Methods used widely differ from a simple manual thickness measuring at predetermined point across the strip to partly or fully automatic measuring instruments. Measured values are statistically evaluated and stored for further reporting, quality analyses and rolling mills adjustments. Strip profile measuring instrument MPP is a complex equipment eliminating elaborate and time-consuming manual measurement with its inherited inacuracies and possible mistakes. Even in comparison to some of presently operating laboratory units it has few improvements worth of mentioning.

Instrument's head after sample positioning and fastening onto the measuring table starts reading in one mm intervals across the whole strip width. Complete printed tabulated and graphical report is immediately available to all "appointed" users on company's computer network. Professionals, without doubt will value the number of details making their work with the instrument and installed programs much easier as for example marking of diagrams in accordance to strip against the rolling mill position (Drive and Crew respectively North / South of mill), possibility of coil definition and its measurement program, immediate inspection / perusal of archives, selection in accordance with given criteria (i.e. Date; Thickness of material; Customer name etc.) respectively, the complete comparison of measured values of each graph by the help of two moving cursors and simultaneous projection of strip edge position and deviation from the nominal value. The measuring head itself, despite of modest laboratory working conditions is safeguarded by optical device scanning the sample position and auto diagnostic system continuously evaluating the working regime of the measuring instrument. Meticulous design of every detail resulted in an instrument of original features, economically very viable, inviting attention of more and more manufacturers of rolled strips.