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INNOVATIVE MEASURING TECHNOLOGIES

INNOVATIVE MEASURING TECHNOLOGIES IN PROCESSING LINES FOR BASIC AND FUTURE PRODUCTS[1]

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Abstract

The essential pre-requisite for attaining the high quality of product required from high-speed continuous production processes is the use of new measurement and control technologies. High availability and reproducible measuring results ensure the high level of process stability necessary for fully continuous operation. The requirements for the optimisation of quality across the complete production process and for quality analysis systems will be discussed. This report will present examples of basic and new measurement technologies in Processing Lines. The following new developments will be discussed in detail:Coating weight gauging systems with x-rays for metallic coating; Coating weight gauging systems with ß-rays for paint coating; Coating weight gauging systems with visible ultra-violet light (UV-VIS) for thin paint and organic coatings; Coating weight gauging systems with infrared light (IR, NIR) for organic coatings; Coating weight gauging systems with laser (ellipsometry) for thin oil layer and organic coatings; Automatic coating control systems.The measuring and control systems in this presentation must be seen as high-tech solutions in the field of processing technology. The measuring methods and technologies described are, together with optimised process models and precision control loops and actuators, the main pre-requisites for achieving the quality of product required from high-speed continuous production processes. Interconnected quality management systems enable optimisation across the complete production process.

Key words: Coating measurement; Coating control.

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1 INTRODUCTION

IMS Messsysteme GmbH (IMS) was established in 1980. IMS is an international group of companies in the field of measuring technology for the steel and nonferrous metal industry. IMS develops and manufactures radiometric and optical measuring systems for flat and tubular products. IMS has two main divisions, the Hot Rolling Mill (HRM) division and the Cold Rolling Mill (CRM) division.
The essential pre-requisite for attaining the high quality of product required from high-speed continuous production processes is the use of new measurement and control technologies. High availability and reproducible measuring results ensure the high level of process stability necessary for fully continuous operation. The requirements for the optimisation of quality across the complete production process and for quality analysis systems will be discussed.
This report will present examples of basic and new measurement and control technologies in Processing Lines. The following new developments will be discussed in detail:

- Coating weight gauging systems with x-rays for metallic coating
- Coating weight gauging systems with ß-rays for paint coating
- Coating weight gauging systems with visible ultra-violet light (UV-VIS) for thin paint and organic coatings
- Coating weight gauging systems with infrared light (IR, NIR) for organic coatings
- Coating weight gauging systems with laser (ellipsometry) for thin oil layer and organic coatings
- Automatic coating control systems

This paper is (only) about coating measurement and control systems introduced or improved recently. Other long term established measurement systems aren't discussed here. IMS is the worldwide major supplier for HRM and CRM measurement systems. Simultaneous Multi Channel Thickness, Coating Weight- and Thickness Profile measurement systems for flat and tubular products, using x-ray, Isotope radiation or different optical methods, are state of the art and main products.

2 INNOVATIVE MEASURING TECHNOLOGY

2.1 General Mill Layout

On the shown mill layout, according the Figures 1 and 2 we concentrate only on the Coating Weight Gauges.

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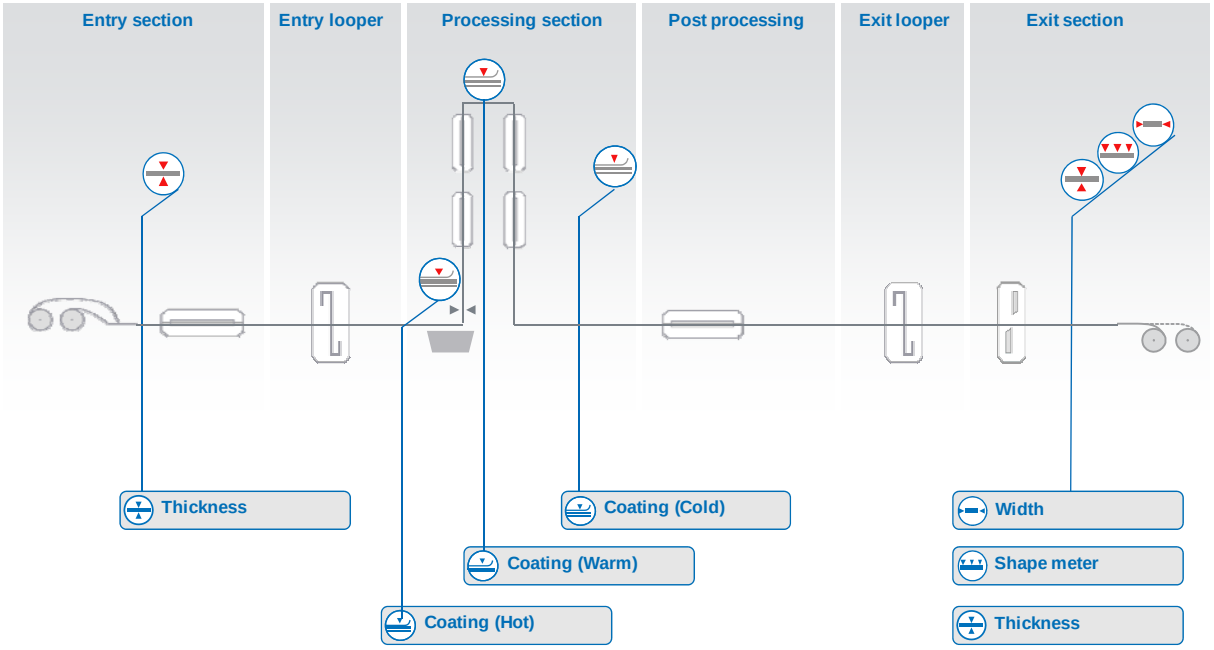

Figure 1. General mill layout of Hot Dip Galvanizing Line.

Type of Gauges in Hot Dip Galvanizing Lines	**Location**
Coating Weight Gauge (hot position)	After Zinc pot
Coating Weight Gauge (warm position)	Top of processing section
Coating Weight Gauge (cold position)	Exit of processing section

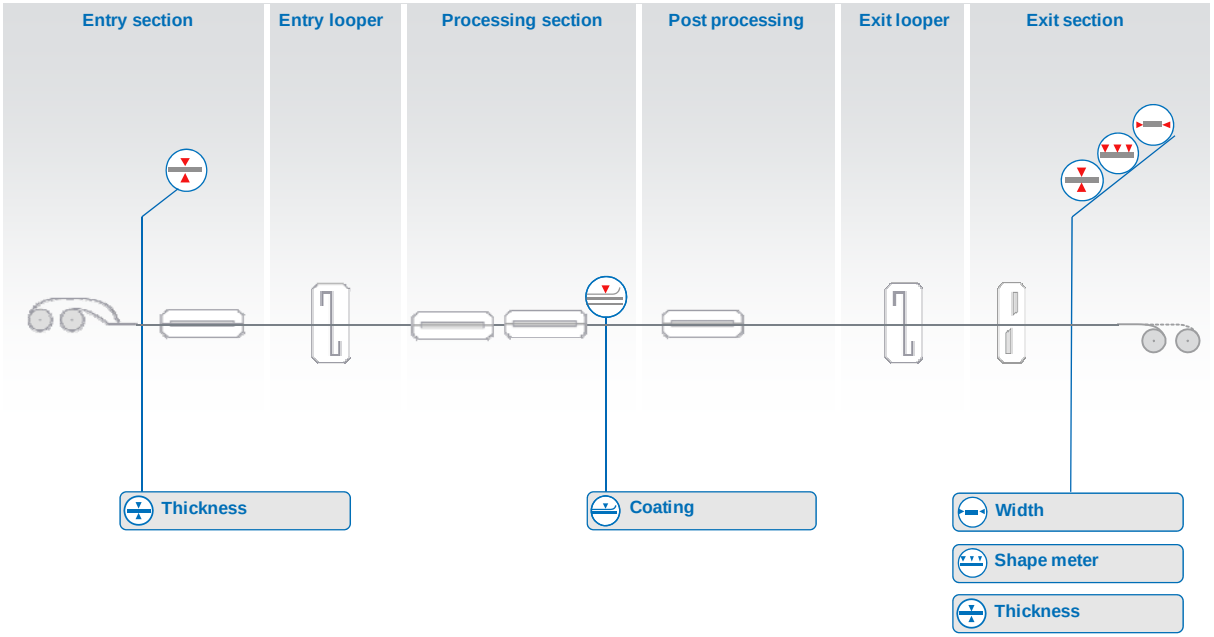

Figure 2. General mill layout of Electrolytic Tinning / Chromium / Galvanizing Lines.

Type of Gauges in Electrolytic Tinning / Chromium (TFSL) / Galvanizing Lines	**Location**
Coating Weight Gauge	Exit of processing section

The measured coating weight and coating cross profiles are forwarded to the coating control system. Advanced control systems, based on pre-setting, feed forward and

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feedback, guarantee the uniformity of the coating layer over the complete width and length of the strip.

2.1.1 Coating weight gauges with x-rays (x-ray fluorescence principle)

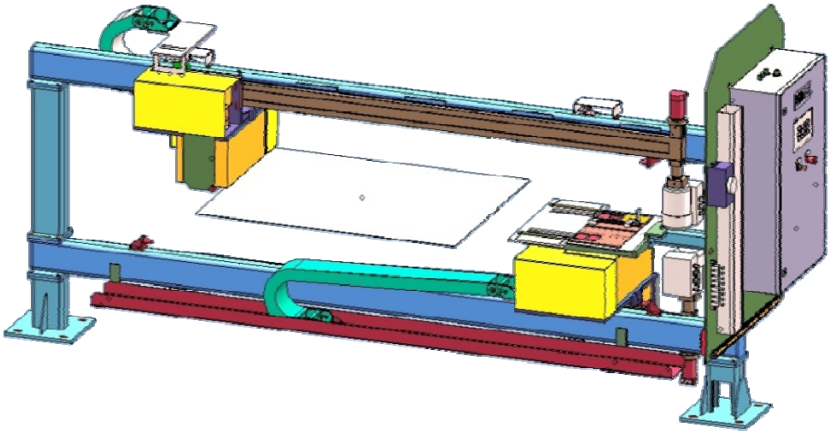

Figure 3. Coating weight gauges with x-rays.

Table 1. Material for Coating thickness measurement

Applicable for metal coatings, like	Remarks
• Tin	
• Chromium	
• Zinc	
• Zinc-Iron (Galvanneal)	Iron contents online measurable
• Zinc-Aluminium (Galfan, Galvalume)	Aluminium contents online measurable
• Aluminium	
On steel, aluminium and copper substrates	

During radiation of material with ionizing radiation, secondary radiation is scattered back in the direction of the radiation source. X-ray fluorescence radiation is used to record coating thickness with measurement techniques, according to Table 1.
One or more measuring heads, according the figure 3 are required for radiometric coating thickness measuring. Each “head” consists exactly of one source and, depending on the application of two to four detectors. Depending on the installation location, Coating Weight Gauges can be provided in various mechanical designs such as O-Frame, Traverses or C-frame.
The edge detection results from the measuring signal trend. All necessary calibrations are carried out automatically by the system in the park position.
For the online profile measurement are three main modes intended:

- Continues scan mode
- Dwelling mode (3 spots)
- Fixed mode

Various scan modes are available; they are selectable on a parameter screen of the system. The operators can set the head positions.
If required additional scan programs can be arranged during the engineering phase.

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The measuring values for the „triple spot mode“ can be taken from the coating weight cross profiles in the „continuous cross profile mode“ and/or in „multiple dwelling mode“ (parameterized for 3 dwelling points).
In order to ensure the specified performance data, the strip needs to be controlled so the vertical pass line change does not exceed changes of more than ±2mm. Therefore we suggest (for solutions with an o-frame or c-frame) the installation of rolls before and behind the measuring point.
For coating weight cross profile measurement an edge disregarding zone can be parameterized for each strip edge separately from 0 - xmm. The preset value will be 20mm.

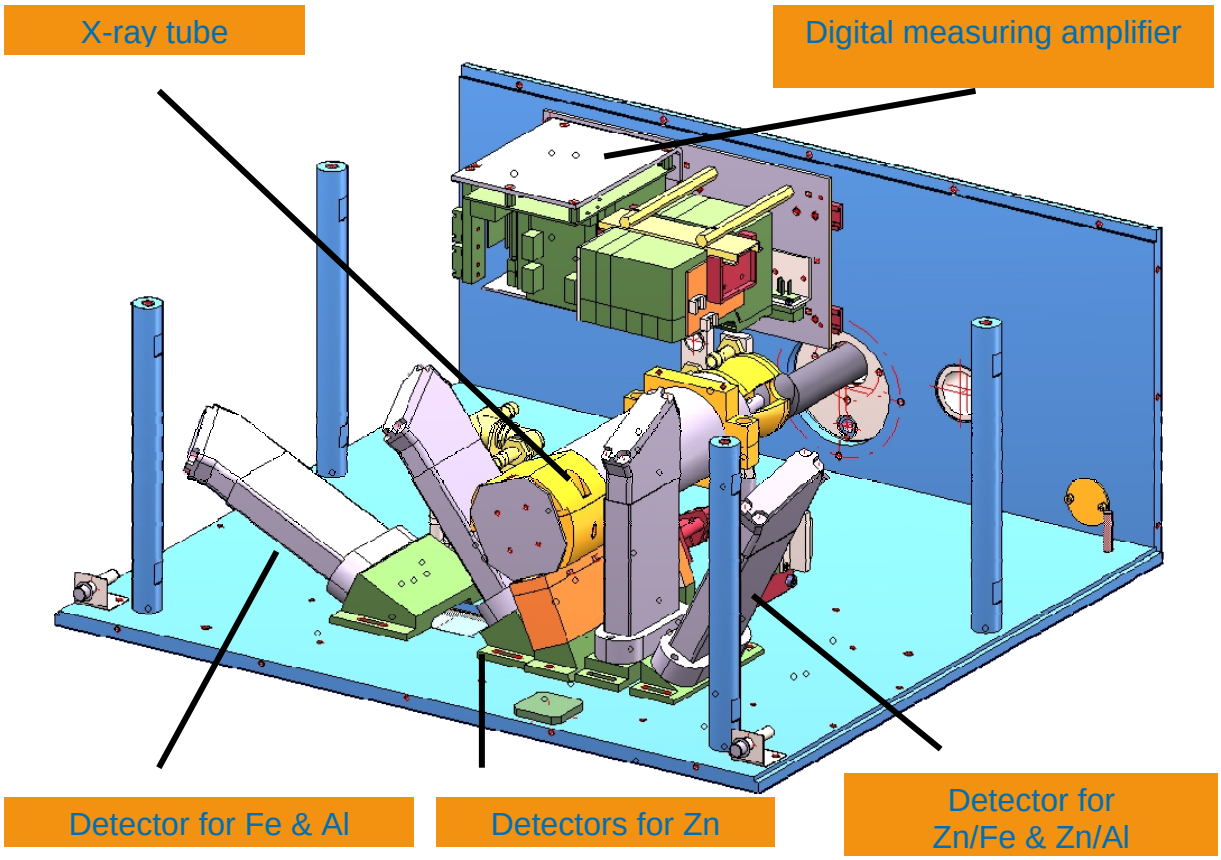

Figure 4. Detector head for radiometric coating weight measurement.

The shown detector head, according Figure 4 allows measurements of Zinc, Galvanneal & Galvalume. All materials can be measured immediately without mechanical or electrical modifications. Only different calibration curves have to be loaded. Online measurements of Fe and Al contents are also possible.

2.1.2 Air knife control system

The presetting, according the figure 5 feed forward and feedback control strategy is based on the „Model Control System“ as developed by IMS Messsysteme GmbH and Nixie Oy for use in hot dip zinc coating lines.
The feedback control and model adaptation are utilizing only the coating profile information of traversing cold measuring heads. The edge areas of profiles can be parameterized away from the profile data to avoid the effects of non-ideal jet stripping

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process in the strip edges. The control system tolerates different dead lengths for top and bottom measuring heads.
The model contains the needed often strongly non linear relations of process parameters as:

- Coating layer
- Nozzle pressure
- Strip speed
- Air knife to strip distance
- Coating material
- Strip thickness
- Geometrical nozzle arrangement
- Strip alignment to the air knives based on cold measuring profiles

The model can also adapt the transition area from laminar to turbulent jet stream. Slow effects as geometrical and coating material influences are handled with automatic model data sets.
One of the model high lights is the very fast and flexible self adaptation to the ever changing process conditions.

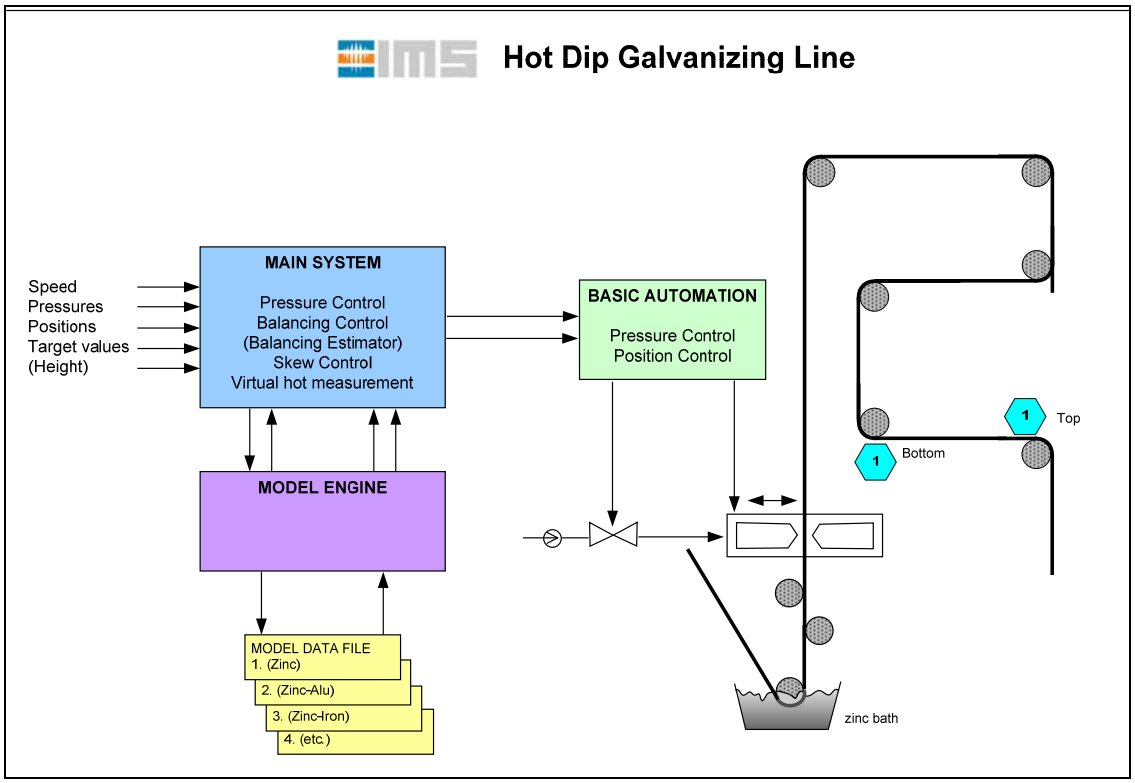

Figure 5. Air knife control system.

2.2 Coating Weight Gauges with ß-rays (ß-ray Fluorescence Principle)

Applicable for coatings, like:

- Paint
- Plastic
- Organic coatings
- Magnesium-oxide

A coating weight gauging system, according the figure 6 measures the individual coating layers. For this, it is necessary to measure the infinite thickness values of the

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base material and the coating material. Each individual measurement needs the data from the previous measurement and the infinite thickness value of the coating material in order to determine the coating weight. The infinite thickness value of the coating material is determined by measurement in a test gauge (laboratory gauge) directly before application in the coating line. It is measured in a wet state (wet index) and dry state (dry index). It is also possible to calculate the dry index from the wet index.
The coating weight can be determined on the top and bottom sides of the strip, in a wet or dry condition. The wet measuring points are situated directly at the coater and transmit measured values for fast-acting coating weight control. Dry measuring points are located after each drying oven. Due to the small distance (air gap) between the coated strip and the measuring head, the weld-seam position must be known (customer signals).
Roll coater control systems are also available.

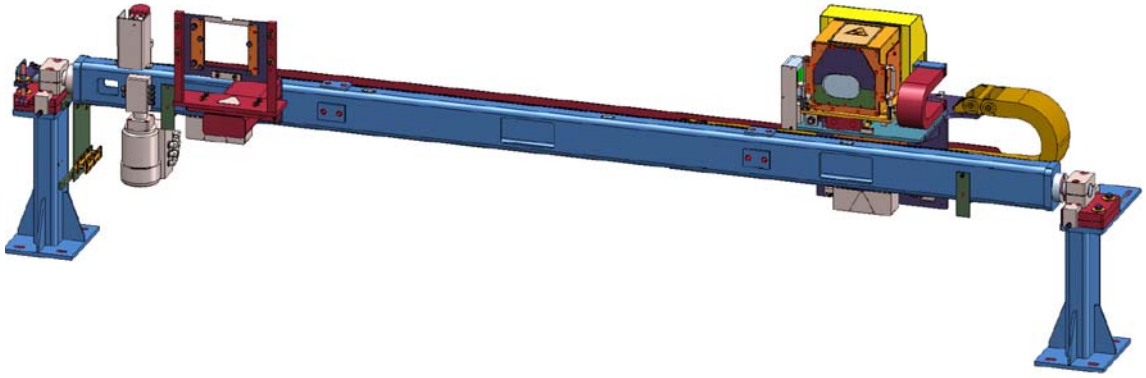

Figure 6. Coating weight gauges with ß-rays.

2.3 Coating Weight Gauging Systems with Visible Ultra-Violet Light (UV-VIS)

Applicable for coatings, like:

- Pre-treatment
- Primer coating
- Colour measurement and evaluation

UV-spectroscopy, according the figure 7 is used to provide an optical measurement of coating weight. Spectra in the range of 270–730nm are detected by a frequency of 100Hz. As a detector is used a measuring head which measuring distance is approximately 50mm.
The primary measuring data is transferred to a spectrometer unit via fiber optical cable. This data is processed mathematically in an in-built processing unit to provide a quantitative value of the coating weight. By a process of internal averaging (multiple spectra producing a single measured value) a typical measuring frequency of one measurement/second is achieved. Long-term measurement stability is assured by the regular measurement of reference standard plates.
After the installation the customer is able to calibrate the system with new materials by himself.
Because the measuring system uses optical measuring technology, dark paints (near black) cannot be measured. Optical measurement is especially suitable for thin coatings and pre-treatment coatings, e.g. Primer coatings. The range of strip temperatures and the strip roughness must be known to take into consideration for the calibration.

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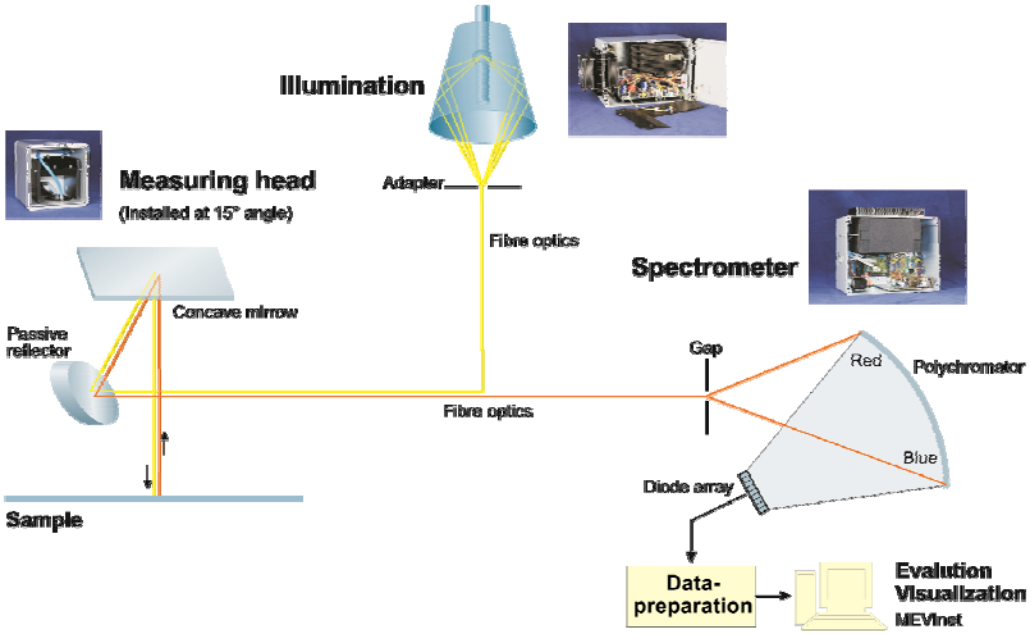

Figure 7. Coating weight gauging systems with visible ultra-violet light.

2.4 Coating Weight Gauges with Infrared Light (M-IR)

Applicable for:

- Oil layer
- Organic layer

The physical measuring principle of the oil layer thickness measurement is a non-contact, non-destructive measurement method, according the Figure 8. It is based on the spectral evaluation of absorption spectra. The oil layer thickness is irradiated by a measuring head with infrared-light source (IR). The light penetrates the transparent oil layer, is reflected by the substrate and penetrates the oil layer again. Due to the irradiation, the molecules are initiated to oscillate and absorb a part of the light energy. How much energy the molecules absorb and in which wavelength range is depending on the oil composition and the thickness of the oil layer. The reflected light passes back into the sensor head and is separated with a Michelson interferometer into its spectral components.

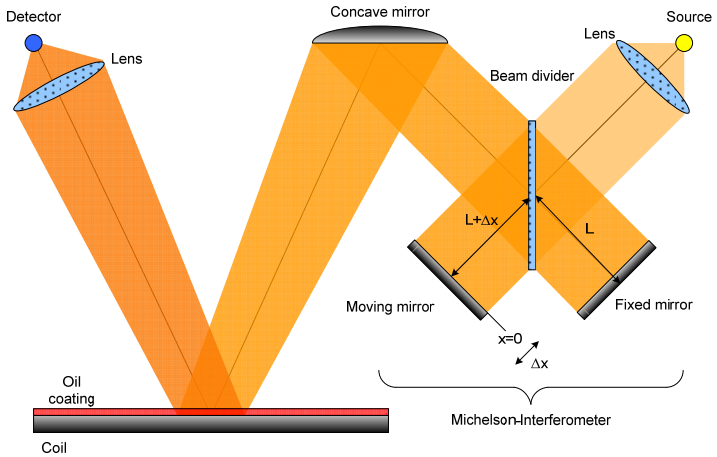

Figure 8. Coating weight gauges with infrared light.

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By dividing and superimposing, the emitted and received light is brought into interference and imaged on a point-detector. The inclusion of a continuous spectrum is done by movement of the movable mirror, the scanning. The changes in intensity of the light are detected by the scanning detector, converted in electrical signals and forwarded as Interferogram to a computer unit. Through Fourier-Transformation (FT) the Interferogram is converted to absorption spectra.
The thickness of the oil layer is determined by the absorption spectra with help of the factor analysis.

2.5 Thickness Measurements of thin Oil Layer & other Organic Coatings

Applicable for:

- Thin oil & dirt layer
- Thin organic layer

Ellipsometry is a highly sensitive optical measuring method which uses reflection-induced changes in the polarization state of light, according the figure 9. In the application described here, the method provides layer thickness measurements in the nanometre range that means film weight measurements in the milligram range (1 - 100 mg/m²) on steel strip, running at speeds of up to 2000 m/min.

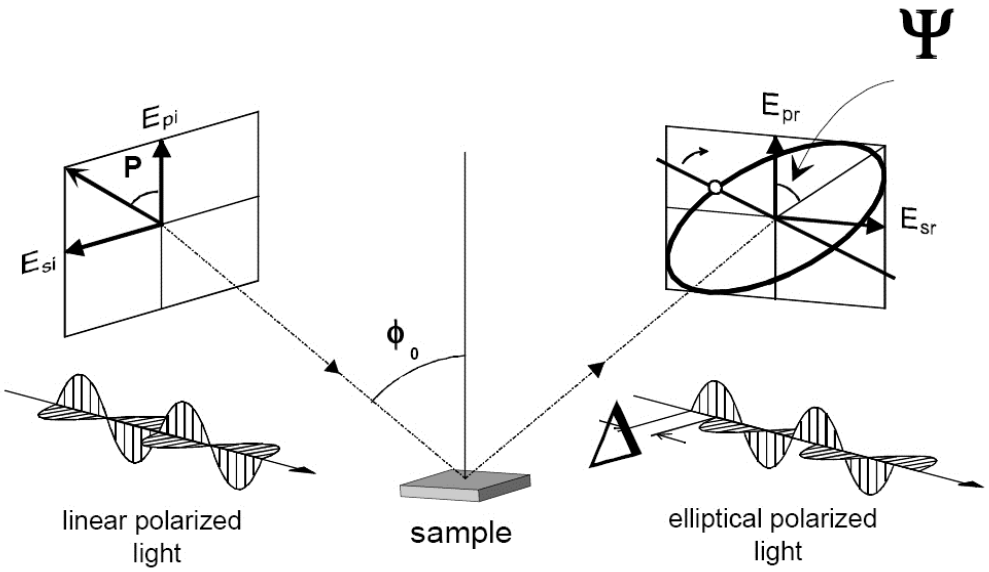

Figure 9. Thickness Measurements oft hin Oil Layer & other organic coatings.

3 SUMMARY

The measuring systems in this presentation must be seen as high-tech solutions in the field of processing line and rolling mill technology. The measuring methods and technologies described are, together with optimised process models and precision control loops and actuators, the main pre-requisites for achieving the quality of product required from high-speed continuous production processes. Interconnected quality management systems enable optimisation across the complete production process.
IMS Messsysteme GmbH supplies the necessary measurement systems and technology and above those systems the required data acquisition and evaluating system (MEVInet-Q) to allow correlation between process parameters and product quality from slab to final cold rolled sheet. The main target is to identify defects in the

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material being processed in the production chain. And further on to avoid any defects with bad effect on final product quality in connection with process automation systems.
Outlook: Future development projects for IMS will be e.g. grain structure analysis and chemical analysis based on x-ray technology to measure and to verify product properties on-line.

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