Examples of Technology to Improve Quality beginning from Development to Production for Steel Strips

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- Quality aspects for development and production of steel grades from the view of controlling and monitoring the process:
  - Process Simulators for Steel Grade and Process Development
  - Measurement Systems for Quality Improvement
  - Condition Monitoring Systems for Preventive Maintenance
  - Laboratory tests for retained austenite
- Future prospects
Company

Turnover (Mio. €) 

Employees

Owners | Subsidiaries
---|---
voestalpine | breuckmann
SIEMENS | precison in 3D
VATRON | vatron gmbh

ACC M - Austrian Center of Competence in Mechatronics

vatron gmbh, along with the Linz Center of Mechatronics (LCM) and the Department of Mechatronics of the Johannes Kepler University, is an Austrian Center of Competence in Mechatronics (ACCM).

A renowned consortium consisting of well established companies and scientists recognized the world over for their expertise is working in an especially ambitious and high-level research program.

The research activities are focused on the following technical areas

- Computational and Experimental Process Modeling and Simulation
- Mechanics and Model Based Control
- Information and Control
- Mechatronic Design of Machines and Components
- Sensors and Signals
- Wireless Technologies
The vatron Quality Assistance Philosophy

1. Identify the important process steps
2. Separately simulate these steps
3. Monitor the production process with respect to the results
4. Monitor the production plant with respect to reliability and output

Vatron operates in the fields of:
- Steel Industry: Steelmaking, Casting, Rolling, Annealing, Galvanizing, Coating
- Steel treatment industry
- Non ferrous metals
- Mechanical engineering
- Chemical industry
- Plastics- & paper industry
- Environment & energy
- Cement / lime / gypsum

Steel Grade and Process Development

- Results must be transferable to the industrial situation. Verification of test results in line trials ensures the quality and effectiveness of product and process development.
- Specimen size must be sufficient to allow material characterization as well as determination of application properties.
- Systematic parameter variations must be possible in a very defined way with a high level of reproducibility.
- Testing of process parameters which are not realized on existing lines - giving the possibility of testing very exotic and innovative materials or process steps
- High productivity, which means test runs which are easy to handle for a single operator with high throughput at comparatively low costs.
- Generous installation of sensor equipment that is to some extent not even possible in the industrial line.
- For easy evaluation the measurement values must be stored in a central data base.
All simulators of vatron are PC-based, which gives a simple setting of the desired test parameters with an intuitive HMI without knowledge of programming languages.

Different test parameters (recipes) can be stored ready for use.

The PC-based solution also allows easy setup of a connection to the local network. The test data can be evaluated just after the test by researchers from different office workplaces. In the event that site service is required then support via remote control is available.

In order to strengthen the position there is a clear trend from premium steel producers to build technology centers as a core area for development, a research facility equipped to simulate the entire process chain, ranging from the manufacture to processing of steel on the lab scale.

Experimental simulation starts with an analysis concept derived from experience in the manufacture of this steel grade, standardized or customer requirements, as well as operational possibilities. A test cast is produced on a laboratory scale and then hot rolled and cold rolled. Thanks to investments in a technology center, with the simulator equipment for hot and cold rolling / skin passing, annealing and hot-dip coating, it is now possible to close the continuous process chain for steel manufacture in the laboratory.
Steel Grade and Process Development

galva.sim – Simulator for heat treatment and galvanizing process

- one example for our big range of simulators
- annealing - galvanizing

... a picture tells more than a thousand words ...

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Inspection of Edge Surface Quality

Influence edge quality

- Main parameters
  - Overlap U
  - Gap u
  - Pre-track x

- Condition of knife
  - Abrasion of knife
  - Defects like knife-breakouts

- Used materials, plant settings
  - Steel grade of knives
  - Steel grade of strip
  - Plant speed

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Moveable sensors - typical for finishing line applications

- Synchronization with knife circumference, Image quality independent of width, thickness, speed
- 100 % inspection of the strip
- Determination of the C/B ratio
- Detection of knife breakouts
- Detection of general bad edge quality
- Burr measurement with threshold warning optionally

Examples of edge defects detectable with edge.mon
(yellow = automatic edge quality warning, red = automatic knife breakout alarm)

Good

Gap too low

Breakout

Inhomogeneous (partial worn knife)

= one circumference of knife independent of strip speed
Inspection of Edge Surface Quality

Improvements by aspect of Quality optimization

- Avoid strip tears … in CRM by knife breakout detection
- Increase productivity … by simultaneous monitoring of the edges at drive side and operator side
- Reduce scrap … no downtimes necessary to control the trimmed edges
- Reduce scrap … by immediate recognition of defects
- Reduce maintenance costs … by avoiding defects on rollers as a result of knife defects
- Save setup time … by optimization of the knife settings and knife material
- Save tool costs … by life time optimization of the tools
- Reduce reclamation costs … by improvement of edge quality

Measurement of Mechanical Steel Strip Properties

testing of steel strip properties (tensile strength, yield strength)

- in-line measurement of yield strength and tensile strength
- non destructive, contact less
- immediate results
Measurement of Mechanical Steel Strip Properties

Material state
- alloy composition
- structure
- grain size, texture
- dislocation, chemical deposition

Mechanical characteristics
- strength
  - yield strength, tensile strength
- hardness
  - surface-, corehardness
  - hardness penetration depth
- ductility
  - strain hardening exp., anisotropism

Magnetic characteristics
- electrical conductivity
- magnetic properties
  - hysteresis loop, permeability
  - coercive field strength, remanence
  - directional dependency of harmonic eddy current signals

Start of constriction

Fracture

Hysteresis
Newest and most advanced in-line measurement system for mechanical properties on market
- Precise measurement of tensile strength and yield strength
- No plant parameters required for inline measurement of mechanical properties
- Measurement occurs through the complete steel strip thickness
- Measurement allows to traverse the entire width of the steel strip
- Close-to-edge measurement
- Self check of system condition (sensor status, measurement chain, data acquisition)
- Reduction of customer claims
- Reduction in number of destructive tensile tests
- Increased quality resulting from advanced process control
- Process optimization with respect to plant parameter settings, energy, output
Early Fault Detection in Drive Trains

Functionality

- periodic vibration measurement
- automatic fault level calculation
- fully configurable auto analysis
- automatic alarming via e-mail or SMS
- database assisted long term trending
- easy access via webbrowser
- easy to use for both experts and beginners
- integrated expert signal analysis tools

Benefits of early fault detection

- saving repair costs
- optimizing yield performance
- effective repair work
- saving logistics costs

System layout

[Diagram showing server connected to vibration signals via optical fibre and signals via profibus, with 10V or 20mA signals and temperature and other signals.]
Early Fault Detection in Drive Trains

Measurement and analysis

- Data acquisition
  - Parameters
  - Plausibility checks
  - Raw data storage

- Analysis server
  - Plausibility checks
  - Automatic fault analysis
  - Alarming

- Web interface
  - Configuration
  - Trending
  - Manual analysis

Fault example

- First automatic alarm
- Trend of bearing level
- Repair at planned stop, approx. 6 months after first alarm
Early Fault Detection in Drive Trains

Fault example

without online CMS
- severe consecutive damage
- probable total loss of gearbox
- massive production loss

with drive.mon
- repair costs saving 75%
- repair work scheduled in regular production stop

visual inspection confirms drive.mon alarm

Measurement of Retained Austenite

The amount of austenite is a very important parameter for high quality steels. E.g. the tensile strength of TRIP-steel (TRIP = Transformation-Induced Plasticity) depends on the amount of retained austenite in it.

Various methods have been used to determine the amount of retained austenite (e.g. Schäffler diagram, x-ray-diffractometry). But all these methods have a low reproducibility or are not easy to handle.

The application of the magnetic yoke of vatron is based on the fact, that ferrite and austenite differ completely in their magnetic behaviour. Ferrite with its bcc structure is a magnetic material whereas austenite with its fcc-structured atomic lattice is non-magnetic.
When a ferritic specimen is brought into a magnetic field it is magnetized. If this magnetized specimen pushed through a measurement coil a voltage pulse is induced in the coil. The magnetization is proportional to the integral of the voltage pulse.

\[ J_m \propto \int U_{ind} \, dt \]

Intrinsic induction of the specimen
Induced voltage in the measuring coil

Austenitic material does not show this behaviour. This means the higher the amount of austenite in a sample is the lower is \( J_m \).

So, in the case of magnetic saturation \( J_m \) can be used to calculate the amount of retained austenite in the measured samples. For this theoretical intrinsic induction the austenite-free material of the same chemical composition is needed. This can be calculated as follows.

\[ J_m^{fe} - \sum_n a_n A_n \]

Intrinsic induction of pure iron in the state of saturation
Amount of the element \( n \) in the specimen

The intrinsic induction of pure iron in the state of saturation and the decreasing factors are known from literature. The amount of retained austenite now can finally calculated to:

\[ A_{aust}\% = \frac{J_m^{fe} - \sum_n a_n A_n - J_m^{irr}}{J_m^{fe} - \sum_n a_n A_n} \times 100\% \]

\( A_{aust} \): Amount of austenite in the specimen
\( J_m^{fe} \): Intrinsic induction of pure iron in the state of saturation
\( J_m^{irr} \): Intrinsic induction of the specimen
\( a_n \): Decreasing factor of element \( n \)
\( A_n \): Amount of the element \( n \) in the specimen

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**Measurement of Retained Austenite**

- Easy to use PC-program
- Any shape of the specimen possible
- Measuring range for austenite in ferritic steel: 1% - 30%
- Measuring range for ferrite in austenitic steel: 1% - 30%
- Reproducibility: ± 0.5%

- Weight: 500 kg
- Magnetic field strength: 20 000 A/cm
- Power supply: Three-phase current: 380 V-480 V 7kVA (for the yoke) 110 V-220 V (for the PC)
- Cooling water: 4 l/min / min. 3.5 bar
- Water connection: 6 mm \( \bigcirc \)
- PC: Pentium III or higher, 128 MB RAM or more
- Operating system: Windows 2000 or Windows XP
- Dimensions of the specimen: length: \( \leq 15 \) mm
Summary and Outlook

- Introduction vatron

- Quality aspects for development and production of steel grades from the view of controlling and monitoring the process:
  - Process Simulators for Steel Grade and Process Development
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  - Condition Monitoring Systems for Preventive Maintenance
  - Laboratory tests

- Future prospects
  - Processes in steel are defined and automated on a high level
  - High stability in respect to process parameters
  - Research focus: inline characterization of product parameters
  - Research focus: relationship between product and process parameters
We focus on achieving the most successful production line for our customers

Take a further step towards future, contact us!

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