Geometric precision improves Equipment performances

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Entwicklung und Produktion von Mess- und Prüfsystemen zur Maschinenausrichtung, Maschinenüberwachung und Service in den Bereichen der industriellen Instandhaltung und Qualitätssicherung.

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Homepage: www.pruftechnik.com
Introduction

- Assets must run faster and faster, provide more volume and better quality.
- Which element of a system (product, process and machine life - MTBF), can we improve with precise geometric technology

Presentation of Geometric Technologies and Condition Monitoring Methods

- Self leveling rotating laser to measure straightness and flatness accurately and roll parallelism (better than 0.025 mrad) over long distance
- Inertial gyroscopes technology and self leveled rotating laser to measure the parallelism of rollers
- Fine roll and machines element (coupling, fans,..) balancing operation (without roller disassembly) and movement monitoring with vibrations technologies
- Laser optical shaft alignment of rigid, flexible and Cardan couplings with optimized target values
Product quality, process quality and continuous production through geometrical precision – Examples
• Flatness and straightness accurately measured over long distances using accurate self-leveled rotating Laser (up to 0.025 mrad),
• Determination of the reference center axe of rolls set for a straight running path of the production plant.
• Rolls parallelism ensure good process flow.
• Precise rolls parallelism using inertial ring laser gyroscope technology with a daily high measurement capacity of rolls.
• Roller and machines movement during production
• Laser optical coupling and cardan alignment to reduce the potential excitation to the rolls and the asset and to extend machine life

Conclusions
Introduction
Introduction

- **Assets muss run faster and faster, provide more volume and better quality.**

  - The production of steel plates has been growing and better quality is always required from customer. More sheet/plate metal are needed worldwide.
  - Carmaker and heavy vehicle,
  - Welded tube
  - Ship building (matrix panels, heavy plates, steel ring, hot rolled sheet, various coated flat products,..)
  - Building, pre painted steel plates
  - Special coating (zins, alu, magnesium,..) and special treatment like improved grain oriented (GO) for better electrical efficiency
  - Food and beverage industry (cans) need lower packaging costs,
Introduction

**Which element of a system (product, process and machine life - MTBF), can we improve with precise geometric technology**

- Product quality can be improved,
- Production capacity through higher feed speed can be improved. To response to the market demand and to win efficiency, producers try to increase the speed of their assets to increase the volume. This is only possible with good installed assets.
- Uninterrupted production process due to wrong band position on the production asset (Band run away) can be assure
- MTBF of driver and driven assets like motors, gearboxes, pumps, fans, cylinders direct or indirect coupled on the production band, can be improved. Cardans coupling MTBF also could be improve/optimized with correct alignment and lubrication conditions.
Presentation of Geometric Technologies and Condition Monitoring Methods
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- Self leveling rotating laser to measure straightness and flatness accurately (better than 0.025 mrad) over long distance
  - This type of device deliver a reference on site to measure flatness, straightness, right angle check and parallelism. This is like a “laser marble”.

- The rotating laser creates a 2D measurement plane in the space. The Flatness of this laser plane is better than 0,025 mm/m (All laser errors combined)

- An accurate receiver (better than 0,02 mm) precisely measures the position of the laser to the object/machine/surface.
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- Self leveling rotating laser to measure straightness and flatness accurately (better than 0.025 mrad) over long distance

- instead theodolite and targets
Presentation of Geometric Technologies and Condition Monitoring Methods

- Self leveling rotating laser and sensor to measure Roll angular position

10 m to the left sensor is at left on the floor

Sensor at right
Presentation of Geometric Technologies and Condition Monitoring Methods

- Inertial gyroscopes technology and self leveled rotating laser to measure the parallelism of rollers
  - A gyro always keeps its rotation axis because of mass inertia (Aerospace Technology)
  - 3 orthogonal gyros define a 3-D system in space
  - That enables the measurement of relative positions in space
Presentation of Geometric Technologies and Condition Monitoring Methods

- Inertial gyroscopes technology and self leveled rotating laser to measure the parallelism of rollers

- **Methode**
  - The gyroscopes are calibrated before every job with Earth rotation
  - Three orthogonally arranged laser gyroscopes take measurement values along the patented „Sweep“ mode.
  - According to these values the relative position in space of the roll can be calculated – similar to the navigation system of a space shuttle.
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- Fine roll and machines element (coupling, fans..) balancing operation (without roller disassembly) and movement monitoring with vibrations technologies
  - While vibration analysis does not always lead to immediate improvements, vibrations can be reduced significantly by balancing the machine under operation conditions. Field
  - Using a simple 2 channels FFT analyzer with balancing program, 2 Accelerometers and one trigger (RPM). Balancing can be perform on 1 or 2 plans depending of machines.
  - The vibrations coming from an unbalance are potential source of machines resonance excitation.

The device show directly the benefit of the balancing job:
- residual masse,
- norm balancing quality
- and vibration level

8.5 mm/s rms

0.75 mm/s rms
Presentation of Geometric Technologies and Condition Monitoring Methods

- Fine roll and machines element (coupling, fans,..) balancing operation (without roller disassembly) and movement monitoring with vibrations technologies

- Online mobile system
  - Integrated in Robust case, industrial-duty housing (IP 64)
  - Measuring devices with 20 continuous and synchronous measurement channels
  - Connections for sensors and communication (Ethernet, vibration and process parameters, wireless with mobile Card,..)
  - Configuration and analysis of measurement data
  - Industrial PC integrated for data storage in case of long-term use (Months)
Laser optical shaft alignment of rigid, flexible and Cardan couplings with optimized target values

- Laser shaft alignment device allow to measure, to quantify easily the quality of the machines alignment and to correct the misalignment.
- Misalignment at the coupling position between machines increase the risk of failure and reduce the MTBF of machines and bearing element.

The vibrations coming from misalignment are potential source of machines resonance excitation in radial and axial directions.
Presentation of Geometric Technologies and Condition Monitoring Methods

- Laser optical shaft alignment of rigid, flexible and Cardan couplings with optimized target values
  - Increased lifetime of seals
  - Increased lifetime of bearings by reduction of vibrations
  - Decreased maintenance necessity of aggregates
  - Decreased power consumption by well aligned aggregates

- The vibrations coming from misalignment are potential source of machines resonance excitation in radial and axial directions.
Presentation of Geometric Technologies and Condition Monitoring Methods

- Laser optical shaft alignment of rigid, flexible and Cardan couplings with optimized target values
  - Also on cardan shaft, using special bracket. The cardan need less angular misalignment to work properly (tolerance about 0,25 ° max, depending of the speed)

Without the spacer shaft

or with the spacer shaft mounted
Practical examples about experiences and developed techniques using the following technologies
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- Flatness and straightness accurately measured over long distances using accurate self-leveled rotating Laser (up to 0.025 mrad),

**Check and correct the flatness of a cooling band for automotive motor bloc.**

Requirement: 0.1 mm Flatness within 2 m and 0.4 mm over 26 m.

- This have to be check every year and corrected

- Before corrections

- After corrections
Practical examples about experiences and developed techniques using the following technologies

- Determination of the reference center axe of rolls set for a straight running path of the production plant.

Check and correction of the straightness of a reference line over 80 m and extension for the installation of a new module.
Practical examples about experiences and developed techniques using the following technologies

- Determination of the reference center axe of rolls set for a straight running path of the production plant.

**Alignment of a milling machine regarding the product flow**

- 2 Milling machines are working a metal slab. The 2 Machines are driven with a pulley transmission. The alignment of the milling machines and the slab flow direction are not optimized. Consequences are:
  - a very quick wear of the belt. (about 2 k€)
  - 8 hours are required to change the belt (production stop)
Practical examples about experiences and developed techniques using the following technologies

- Determination of the reference center axe of rolls set for a straight running path of the production plant.

Alignment of a milling machine regarding the product flow

- To measure and correct the misalignment between the flow direction and the Milling machine rotation axes within 3 hours, we create a temporary reference line parallel to a worked slab and checked the machine axe 1 to the reference line, then the machine axe 2 to the machine axe 1.

Step 1:
- Rotating Laser and Pentaprisme (90° optical mirror) to create 2 marks on the floor.

Step 2:
- Rotating Laser to read 2 marks on the floor and create a laser line to measure the Axe 1.
Practical examples about experiences and developed techniques using the following technologies

- Rolls parallelism ensure good process flow.

**Generalities**

![Diagram showing Transversal force and Non symmetric web extension]
Practical examples about experiences and developed techniques using the following technologies

- Rolls parallelism ensure good process flow.

**Generalities**

- Increased product quality
- Evenly distributed forces on the production line
- Increased machine availability through:
  - Shorter measurement time (about 40 to 80 rolls within 8 Hours)
  - Decreasing web movement: sheet metals runs straight on rolls, without touching framework e.g.
Practical examples about experiences and developed techniques using the following technologies

- Rolls parallelism ensure good process flow.

**Tools used:**

- Inertial gyroscope devices PARALIGN, for:
  - quick measurement rate, about 40 to 80 Rolls per day (depend of the machine access) with report.
  - measure exclusively the parallelism of the roll,
  - no influence of the distance between rolls
  - no optical requirement

- Self leveled rotating laser
  - used to link the inertial measurement to the reference line / axe on the floor.
  - used to extend a reference line on the floor for additional module or production line modification
  - used to check the flatness of a roll set for laminated sheet.
  - used if the inertial technology is not possible (small machine)
Practical examples about experiences and developed techniques using the following technologies

- Precise rolls parallelism using inertial ring laser gyroscope technology with a daily high measurement capacity of rolls.

Applications

- Cold Rolling:
  - Pickling line
  - Tandem mill
  - Skin pass mill

- Hot-dip galvanizing line:
  - Annealing furnace
  - 4-high mill stand
  - Accumulator
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**Pickling line**

**Details of bath in pickling line**
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Tandem mill
Practical examples about experiences and developed techniques using the following technologies

- Precise rolls parallelism using inertial ring laser gyroscope technology with a daily high measurement capacity of rolls.

Skin pass mill
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- Precise rolls parallelism using inertial ring laser gyroscope technology with a daily high measurement capacity of rolls.

annealing furnace – as part of the hot dip galvanizing line
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**4-high mill stand – as part of the hot dip galvanizing line**

Especially the S-rolls are responsible for web driving and web tension. Their alignment is the most important issue in the galvanizing line.

As found

After corrections
Practical examples about experiences and developed techniques using the following technologies

- Precise rolls parallelism using inertial ring laser gyroscope technology with a daily high measurement capacity of rolls.

**Senzimir mill**

To measure the working roll position, a long measurement roll is mounted instead of the shorter working roll.

Afterwards the sendzimir is set under pressure.

The roll is measured outside the sendzimir.
Practical examples about experiences and developed techniques using the following technologies

- Precise rolls parallelism using inertial ring laser gyroscope technology with a daily high measurement capacity of rolls.

Accumulator – as part of the hot dip galvanizing line
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- Precise rolls parallelism using inertial ring laser gyroscope technology with a daily high measurement capacity of rolls.

**Accumulator**

The accumulator makes the continuous process possible. A good alignment of turn rolls is important, because of the high roll enlacement. Misaligned rolls cause web movement perpendicular to running direction. There are also accumulators with a row of supporting rollers without enlacement, this rollers should be measured also.
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- Precise rolls parallelism using inertial ring laser gyroscope technology with a daily high measurement capacity of rolls.

**Rolls before welder**

There are two payoff-reels in this electrolytic galvanizing line, the web is guided to a welder to make a continuous process possible. In this particular case the web coming from the second unwinder on the right side was guided to the welder with a horizontal misalignment due to web movement perpendicular to the running direction. Surely there is a centring station in front of the welder, but by centring the material a tension force is generated in the web, what influences the quality.
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**Rolls before welder**

A possible cause:

- the web coming from unwinder1 is tensed and moved due to misalignment of roll3 and roll17.
- the web is tensed by roll47 right after the welding unit.
Practical examples about experiences and developed techniques using the following technologies

- Precise rolls parallelism using inertial ring laser gyroscope technology with a daily high measurement capacity of rolls.

**Horizontal plating cells**

- Another problem on the same line:
- The distance between two horizontally positioned cells is 9mm, the web is guided in-between tensed by roll-pairs between the cells.

From time to time the web touched the cells producing a short circuit and destroying the cell.

Cost: Approx. 20,000€
Practical examples about experiences and developed techniques using the following technologies

- Precise rolls parallelism using inertial ring laser gyroscope technology with a daily high measurement capacity of rolls.

**Horizontal plating cells**

- A possible reason for this issue is probably a roll misalignment, leading to fluttering or bowing the web by horizontal misalignment. Unfortunately it wasn’t possible to measure the lower rolls, which also might have an influence on the web movement due to pressure between the lower and upper rollers.
Practical examples about experiences and developed techniques using the following technologies

- Roller and machines movements during production

Concrete Foundation monitoring during production

- Measurement of the movement of concrete pillar with laser and online system equipment.
Practical examples about experiences and developed techniques using the following technologies

- Roller and machines movements during production

Concrete Foundation monitoring during production
- Measurement of the movement of concrete pillar with laser and online system equipment.

![Graph showing movement of concrete pillar with laser and online system equipment.](image)
Practical examples about experiences and developed techniques using the following technologies

- Roller and machines movements during production

**Analysis with a mobile online system** (Vibrations, process parameters, ..)

- Measurement of the movement of uncoiler and pulling station with displacement sensors. For the analysis a mobile VIBGUARD online system was used. Signals from displacement sensors and triaxsensors were recorded synchronously and continuously. The results have been read and stored with VIBGUARD VIEWER software.
Practical examples about experiences and developed techniques using the following technologies

- **Roller and machines movements during production**

  **Analysis with a mobile online system** (Vibrations, process parameters, ..)

  - During every winding process the relocation of the reels have been detected in radial horizontal and vertical direction by the displacement sensors. In the report you can easily see the geometrical position changes depending on the pulling force.
Practical examples about experiences and developed techniques using the following technologies

- Laser optical coupling and cardan alignment to reduce the potential excitation to the rolls and the asset and to extend machine life

**Cardan alignment**
- Cardan shafts compensate parallel offset, the angular range must be reduced to a minimum
- Condition required for high lifetimes:
  - $\beta_1 - \beta_2 < 0.25^\circ$
Practical examples about experiences and developed techniques using the following technologies

- Laser optical coupling and cardan alignment to reduce the potential excitation to the rolls and the asset and to extend machine life

**Cardan alignment**

- With specially designed brackets and new measuring methods, we allow cardan shafts to be aligned without removing the shaft.
Practical examples about experiences and developed techniques using the following technologies

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**Coil support alignment**

- measurement and correction with standard unibeam laser shaft technique.
Conclusions
Conclusions

- Geometric precision improves equipment performances and the benefit can be seen directly in term of:
  - product quality,
  - process quality
  - machine availability and increase of the asset MTBF

- The advanced technologies used are not science fiction and are affordable via product investments and training or/and via high end services jobs:
  - inertial measurement of roll parallelism with PARALIGN® (unique device on the market with inertial measurement for Roll parallelism in use in the industry),
  - self leveled rotating laser with high accuracy,
  - unibeam laser-based alignment of coupling and cardan,
  - vibration measurement and online monitoring equipments,
Thank you