



3 D GRINDING TECHNOLOGY

Better runnability, better paper quality, better economy.





RollResearch 3D Grinding - Over 15 years Experience on Roll Grinding

In the mid of 90's, RollResearch International Ltd. developed the **3D Grinding™** technology in co-operation with Helsinki University of Technology and the Finnish paper mills. By 3D Grinding, a roll can be ground as round and straight, keeping in mind that the roll geometry should be optimal in production conditions.

We are very proud to be the first company in the world that provides true roundness measuring, **Hybrid 4-point measurement** to paper and steel industry customers. Understanding the geometry and rotational behavior of a roll is essential in achieving better rolls and better runnability.

The CNC device, **Hybrid GrindControl 3D™**, enables our customers to meet the quality demands of today and the future in roll grinding. 3D Grinding compensates the roundness error created, for example, by the roll's own bearings during the grinding process. The bed error is also neutralized. The **Hybrid GrindControl 3D™** can be installed on any roll grinding machine.

Our roll dynamics measuring device, **Hybrid DynaTest™**, has been developed in order to analyze roll's dynamic behavior at production speed. Measuring data from laser sensors are exported into 3D Grinding machine to produce optimized dynamic behavior at operating speed. The fact is that rounder rolls rotate better. Bending and deflection of the roll at the operating speed is compensated at the same time.

Various roll grinders have been retrofitted with **3D Grinding™** technology and the following improvements have been observed:

- Better runnability. Less barring vibration.
- Less dynamic runout at operational speed.
- Reduced coating variation for magazine papers.
- More accurate rolls.
- Reduced grinding time.
- Extended grinding intervals for roll covers.

Mill Experience

"We have selected RollResearch's 3D Grinding system in order to reduce grinding times and to get more accurate rolls. The new full automatic CNC makes the workshop people's life much easier as before. Grinding of papermachine rolls is a challenging precision job, and with the new

system it's possible to save time and money. We have been very satisfied with how RollResearch carried out the installation and commissioning of the devices." - Ove Jansson (see photo on previous side) , Roll Workshop Manager, Holmen Paper Braviken, Sweden.

Three Steps of Roll Geometry Error Compensation

The sophistication of grinding machine control systems can be categorized into three steps:

1. Compensation of roll's diameter profile error.

The grinding control systems, which are able to compensate the roll's caliper profile in an axial direction and eliminate the roll's CD (axial) profile errors, are many in the market. They are called as the first generation devices.

The first step is to compensate the errors coming from grinding machine. Things that have an effect on diameter profile are for example:

- grinding machine's bed error (slideway error)
- roll's deflection (sag)
- alignment
- wear of the grinding wheel.

2. CD and MD profile error compensation with 3D Grinding.

The second step is to compensate roundness error caused by roll's rotational errors (MD, Machine Direction).

The goal of 2nd step is a roll, which is precise in grinding shop. It fulfils the workshop tolerances. A roll can be ground as round and even in thickness.

Roll's roundness error is created when the systematic and roll-synchronized horizontal motion of the grinding wheel is copied on the workpiece. The systematic rotational error is caused by:

- roll's bending stiffness variation causes ovality (flexible paper machine rolls)
- bearings' inner rings (if axis is rigid then bearings' outer rings)
- bearing cones
- synchronous vibration regarding roll.

3. The Predictive 3D Grinding; Roll geometry's optimization for the production conditions.

The roll geometry is designed and ground so that the roll behavior is optimum in production. The roll can be ground as oval and curved in grinding machine, but it straightens in paper machine.

Predictive 3D Grinding - Optimizing Rolls for Production Conditions

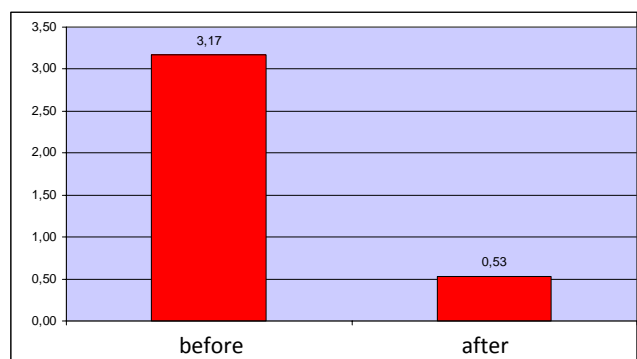
Roll maintenance based on process demands improves the runnability of the paper machine, decreases quality variations of a paper and extends lifetime of rolls.

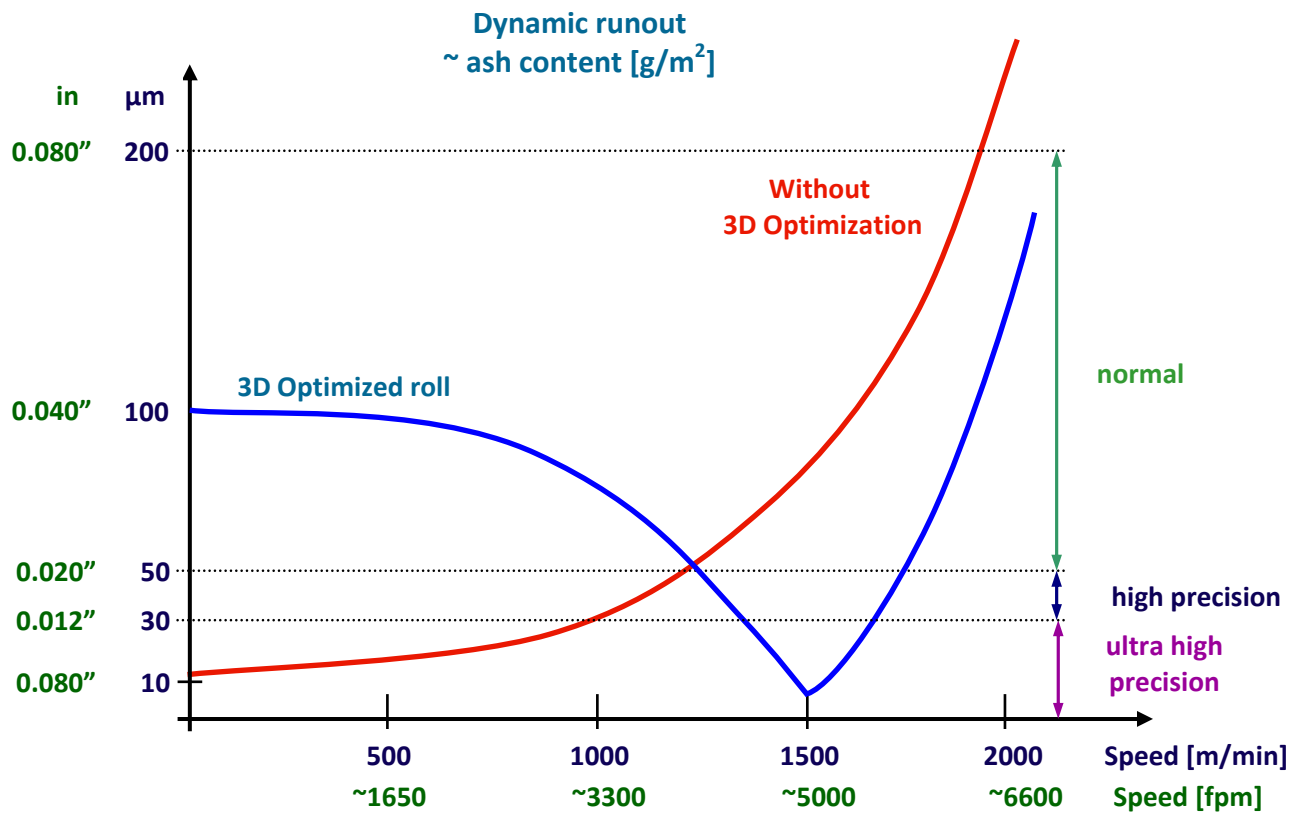
The aim of the traditional grinding process is to achieve good cylindricity and minimum runout at roll grinding shop.

Paper manufacturing process, however, requires good dynamic behavior at the operating speed.

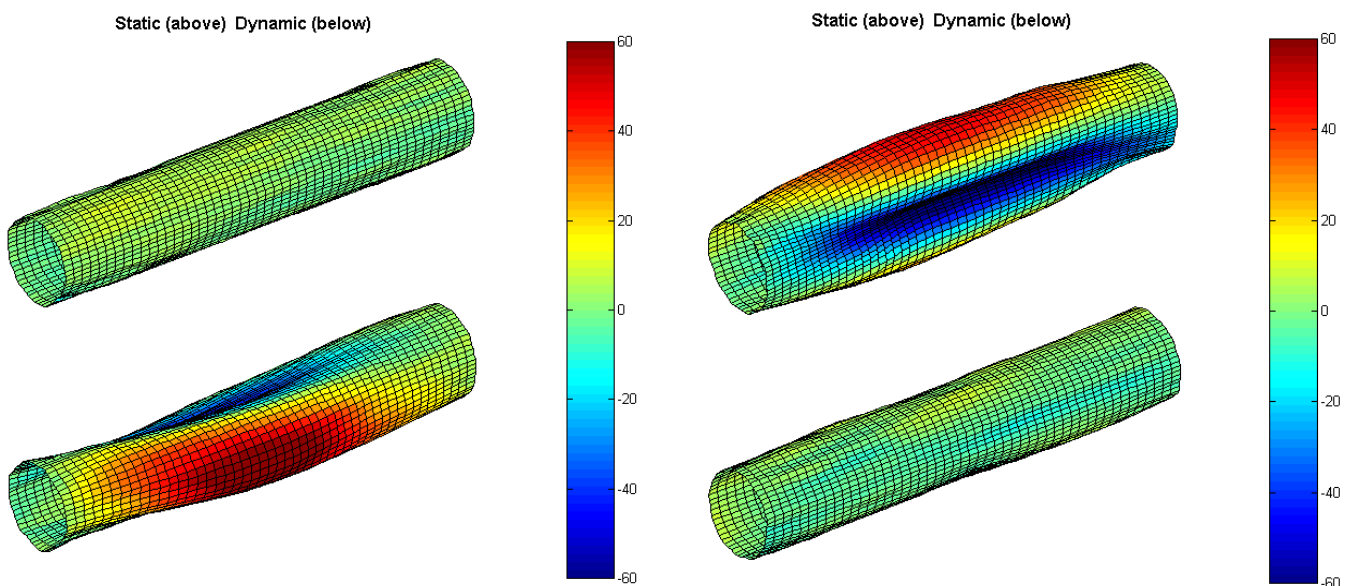
In **Hybrid 3D Grinding™** technology, changes in dynamic roundness and deflection of the roll due to increasing running speed are taken into account when the geometry is optimized for running speed of the paper machine.

Using **Hybrid DynaTest** and **Hybrid GrindControl 3D** devices together the runout of a backing roll of a coating station was decreased below 30 µm at the operating speed, in consequence of which the coating grammage variation (LWC paper) was decreased by 60%.





In the schematic figure above is shown how runout of a roll varies according to speed. The deflection of a backing roll is caused by centrifugal forces, therefore the red curve raises constantly as function of power of 2. After predictive 3D Grinding, the runout curve has its local minimum at 1500 m/min, which in this example is the running speed of coating machine.

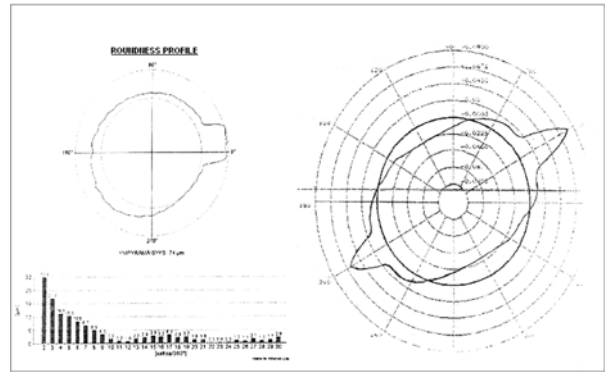


Geometry of a traditionally ground backing roll at grinding speed (above) and at operating speed. Runout of the roll 11 μm was measured at the grinding speed and up to 121 μm at the operating speed.

Geometry of a backing roll was optimized for operating speed by *Hybrid DynaTest* and *Hybrid GrindControl 3D* -systems. The runout of the roll at the grinding speed was 115 μm and as low as 26 μm at the operating speed.

The Hybrid Four-point Method – True Roundness Measuring

The **Hybrid** four-point method measures the true roundness profile. Traditional measuring devices on roll grinders contain only a two-point measuring. The two-point method cannot distinguish the roll's rotation center of the roll's roundness profile. A simple test of attaching a piece of tape on the surface of the roll is easy to be carried out. Tape is seen as two when using a two-point system (see figure right).



The Most Advanced Roll Measuring Devices from RollResearch

Full automatic Roll Measuring Device HYBRID WRMD4-3D-CP "M2009"

Measuring device:

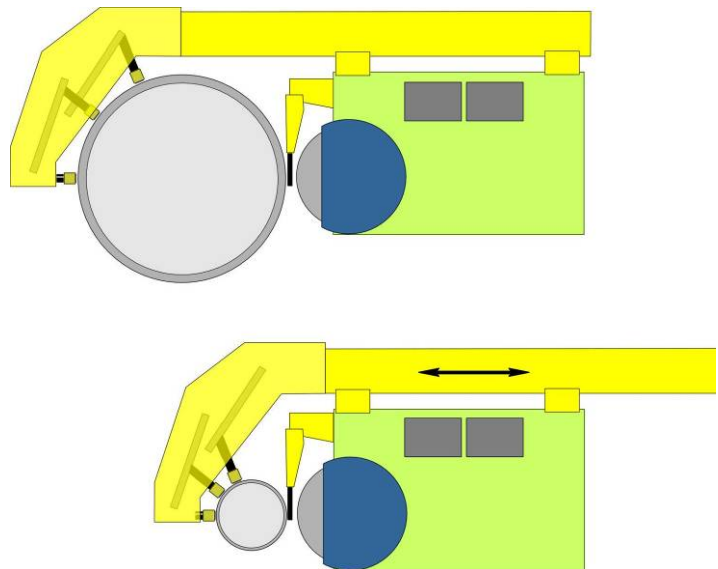
- Full automatic, motorized movements
- Carbon fiber C-frame is installed to horizontally moving X1 measuring beam.
- 3 measuring sensors on C-frame
- 1 measuring arm of lever type on wheel side.

Applicable for grinders:

- Waldrich Siegen CP type measuring device: 4-point upgrade using the existing X1-beam.
- Old grinders when new high precision measuring device is needed: new X1 beam is installed on top of X-carriage.

Benefits:

Compact and stiff design. Measurement on grinding wheel line: no waste of grinding length. In-process measurement.



Roll Grinder Modernizations - Hybrid GrindControl 3D

In a roll grinder modernization the carriage is lifted up, and the bed is scraped and aligned. The grinding spindle is overhauled or changed. All the worn parts like bearings and V-belts are replaced. Lubrication systems are modernized. Steady rests are motorized if automatic alignment is needed.

Roll grinder's control and electrical system is replaced based on **Siemens** components. No more "black box" controls with the high prices that goes with them.

Roll measuring device is updated to meet today's requirements. In most cases, an old measuring device on a carriage can be updated to a four-point measuring device. The measuring device is

always calibrated to fulfil the demands of ISO 9000 standard.

RollResearch provides all necessary attachments, as belt grinding unit, Venta-Nip grooving unit, superfinishing device, S-drive for gearbox rolls, dressing station, coolant unit, and dust exhausting unit. We can also relocate the grinder and provide foundation design and spring elements.

Finally, a comprehensive commissioning and start-up tests are carried out. Training is provided as well. Class training is given in advance and practical training is given during the start-up. An extensive documentation and teleservice is included in the delivery.

Roll Grinder Modernization References 1999 - 2010

<i>Client</i>	<i>Brand/ Type / Manufactured</i>	<i>Modernized</i>	<i>Picture</i>
 MYLLYKOSKI Myllykoski Paper, Myllykoski, Finland	Waldrich Siegen WST 2000/50 x 9000 1964	1999	
 sappi Sappi Fine Paper, Kirkniemi Mill, Finland	Waldrich Siegen WST 2000/50 x 9000 1965	2000	
 MYLLYKOSKI Myllykoski Paper, Myllykoski, Finland	Waldrich Siegen WST IIb 60 x 10000 1978	2001	
 RUUKKI Rautaruukki Steel, Hot Strip Mill, Finland	Herkules WS 1100 x 8000 1976	2001	
 IGGESUND PAPERBOARD Iggesund Paperboard, Sweden	Waldrich Siegen WS III 95/25 x7.500 1963	2001	
 metso paper Metso Paper, SYM-Roll Factory, Rautpohja, Finland	Herkules WS 450/850 1988	2002	

Client

Brand/ Type / Manufactured

Modernized

Picture



Stora Enso
Fine Paper,
Oulu,
Finland

Waldrich Siegen
WS III CPT 85.200 x 14000
1997

2003



sappi

Sappi Fine Paper,
Kirkniemi Mill,
Finland

Herkules
WSB 450 x 14000
1996

2004



Metso Service Point
Borlänge,
Sweden

Waldrich Siegen
WS III T 50 x 12000
1966

2005



Metso Service Point
Borlänge,
Sweden

Waldrich Siegen
WST 60 x 12000
1968

2006



Norske Skog
Saugbrugs, Halden,
Norway

Waldrich Siegen
WS III CPT 75 x 14000
1991

2005



RUUKKI

Rautaruukki Steel,
Hot Strip Mill,
Finland

INNSE
RCH 36" x 5500
1991

2006



Client	Brand/ Type / Manufactured	Modernized	Picture
 UPM Stracel Paper Mill, Strasbourg, France	Voith WP7 1989	2006	
 Sahaviriya Steel Ind., Hot Strip Mill, Bangsaphan, Thailand	INNSE RCH 60" x 5500 1990	2007	
 Albany International, United Kingdom	New grinding machine	2008	
 Malaysian Newsprint Industries, Mentakab, Malaysia	Voith WP7/10 1998	2008	
 Metso Paper, Roll Factory, Järvenpää, Finland	Waldrich Siegen Waldrich WST 2000/25 1961	2008	
 Holmen Paper Braviken Sweden	Waldrich Siegen Waldrich WSTIII 50x13500 1975	2009	
 Norske Skog Saugbrugs, Halden, Norway	Waldrich Siegen WS III CPT 80.300 x 14000 1992	Autumn 2010	

Hybrid GrindControl 3D – Features

Fully flexible grinding programs:

Alignment:

- Automatic
- Manual

Dressing

- straight wheel
- crowned wheel
- conical wheel

Wheel diameter measurement

Absolute diameter measurement

Automatic wheel approach

Online & offline measurement

Handwheel overdrive in auto mode

Wheel width compensation

Roughing without measuring:

- an old basic curve may be used (bed error compensation)
- grinding without control
- constant current grinding

Roughing with 3D-compensation:

- current or position grinding

Finishing:

- current or position grinding
- compensation curves

Chamfering

- direct & round chamfers
- table chamfers

Superfinishing & belt grinding

- automatic change of Z-offset and grinding length

Ventanip milling

- constant pitch [mm/r]
- spiral or straight grooves

CD curves

- Alignment compensation (taper)
- Compensation of bed error
- Addition of residual error on the base curve
- Crowning: single, double, free shape
- Extra curve: stretching with a mouse, table import, and import from Dynatest device.

MD curves

- Compensation of roundness error generated without control
- Compensation of residual roundness error
- Sag compensation: on-line eccentricity compensation.

3D compensation curve

The program calculates a 3D tool path automatically from the MD and CD profiles. A servo controlled precision machining unit (U-axis) controls the machining depth as a function of C-axis (roll rotation) and Z-axis (carriage).

Reports

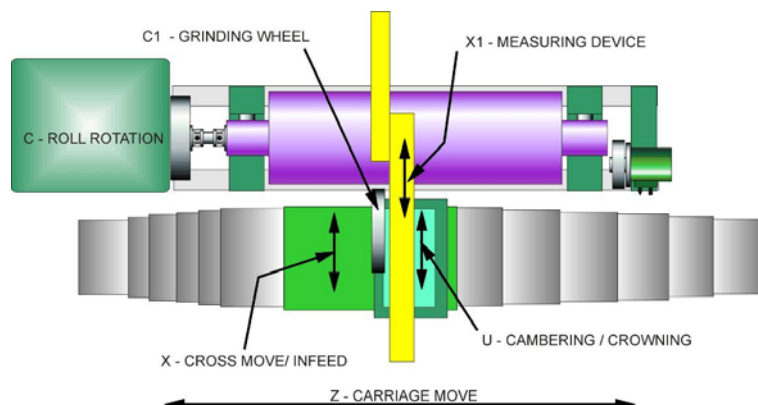
- Graphical scanning and deleting of old measurements
- Report printing in different languages
- Measuring and roll data in a database
- Ethernet interface

Diagnostics and safety

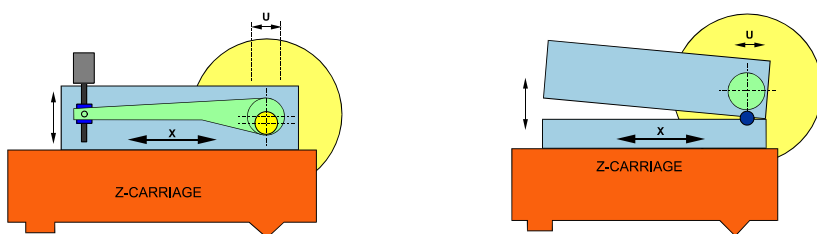
- Automatic toolout in error situations
- Blackout toolout
- Log files and warnings
- Teleservice.

Basics of 3D Grinding™

Hybrid GrindControl 3D system, including a four-point measuring device, has been developed to compensate for systematic roll geometry errors, and in addition to make desired target geometry.



In the figure above is shown the movement axes of a typical roll grinder. The accurate movement needed for 3D grinding is carried out usually by U-axis. Also X-axis is used sometimes if U-axis doesn't exist. The servo axis selected for 3D Grinding needs to be of very accurate and backlash-free design.

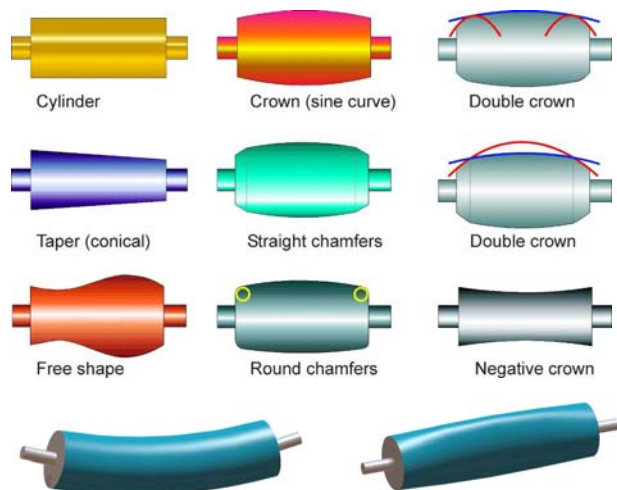


U-axis types: An eccentric spindle axis (left). A tilting mechanics (right).

The correction profile for the 3D Grinding™ is created from measurements gained after conventional grinding. For the correction profile a diameter variation measurement (CD-profile) and three roundness measurements (MD-profiles) are needed. These three roundness profiles are measured from both ends of the roll and one in the middle.

The correction profile is sent to the CNC-unit and used as a path for the tool axis for the second machining. After 3D Grinding the roll is measured again.

If the machine tool is stable as a function of time, the compensation curve can be applied directly to the final machining of a new roll (base curve). If many passes are needed like in grinding, an intermediate measurement can be carried out and the residual error can be taken into account in the compensation curve. This method reduces the machining time and the amount of material removed.



Hybrid DynaTest – Features



Runout in any direction

- Harmonics of runout (runout spectrum)
- Runout tolerances
- Detection of quality variation of paper resulting from rolls
- Resonance vibrations at sub-critical speeds
- Detection of runnability problems

Dynamic deflection

- deflection compensation by **3D Grinding**
- 3-plane balancing with counterweights
- displacement of center axis of mass

Dynamic roundness profile

- geometry compensation by **3D Grinding**: interface to **Hybrid GrindControl 3D**
- dynamic deformation of roundness profile

Rotational Error Motion of Bearing

- Bearing excitations and geometric errors of roll path and shaft error motion

Four laser sensors

Roll diameter range 200 - 2000 mm

Speed range 0 - 2500 m/min

Hybrid DynaBalance – Features



Balancing

- Balancing on own bearings or on conventional roller steadies
- Same balancing machine modules for roll weight 0,5 -80 tons
- Rotational speed range: 1 -40 Hz (60 – 2400 r/min)

Balancing Methods

- Calibration Factors
- Variable Factors
- Conventional Test Mass
- Center Mass Balancing (option)
- Prediction of dynamic deflection (option)

Hybrid DynaTest - Roll Dynamics Measuring Device



Improvement of runnability and reduction of the quality variation of a paper requires control of rolls' dynamic behavior at the operating speed.

Conventional balancing machines can not provide adequate information of rolls' dynamic behavior, because the measurement system determines only the state of imbalance.

The **Hybrid DynaTest** device detects phenomena resulting from the structural inaccuracies, an error motion of a bearing assembly and properties of the support structures.

Software consists of the routines for the measurement, analysis and numerical calculations together with an interface to provide machining information for **Hybrid GrindControl 3D** grinding machine.

Hybrid DynaBalance – One-Size Balancing Machine for All Paper Machine Rolls



The **Hybrid DynaBalance** balancing machine is designed specially for papermachine rolls: one machine for all size of rolls. Rotation with or without own bearings.

Teleservice & Diagnostics

The Hybrid GrindControl system is equipped with remote diagnostics. RollResearch teleservice engineer can see on-line the screens of client's machine at the office in Finland. Over 99% of troubles can be solved remotely, without expensive and time-consuming travelling to site.

- Focused and quick troubleshooting and help for machining process optimization
- Reduced operator training time
- Transfer of optimized machining programs



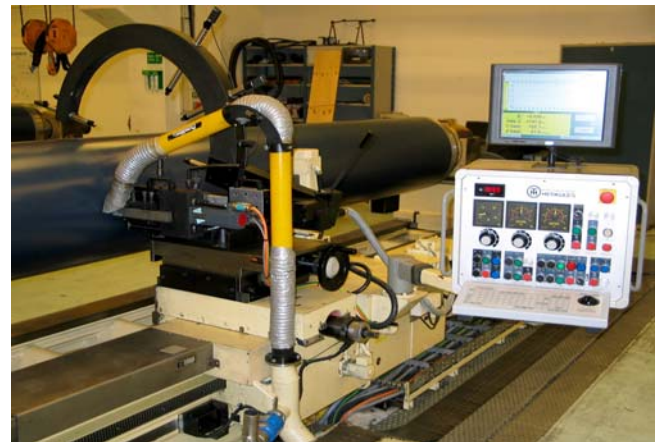
Training & Customer Care

Extensive training is given during startup. Training program will be designed to meet customer's needs.



Hybrid TurnControl 3D

Hybrid TurnControl 3D is a high speed 3D-machining attachment for turning of supercalender rolls. It compensates lathe's bed error as well as bearing errors of supercalender roll.

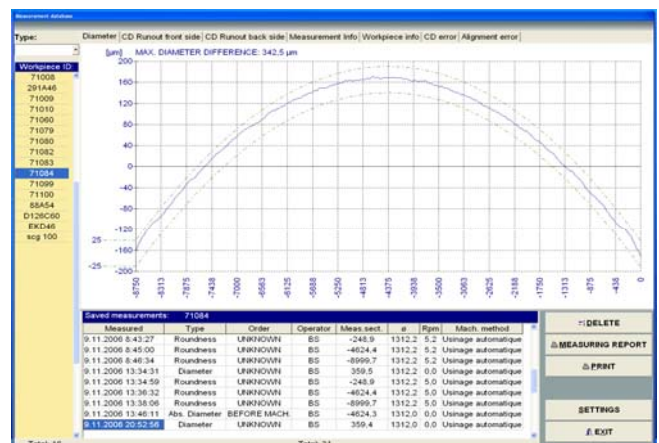


Roll Data Management

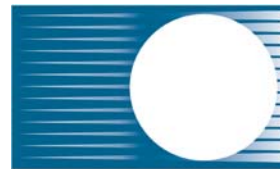
Local database. The basic version of Roll Data Management system consists of local SQL database and software installed in grinding machine's measuring computer.

The Hybrid GrindControl software in the measuring computer includes the following databases:

- Roll measurements
- Rolls, incl. grinding programs
- Roll types (templates for new rolls)
- Grinding wheels and wheel types
- Operators.



Roll Data Administrator (RDA). The RDA is an optional Internet browser based software with a database server. It is specially designed for roll workshops having several grinding machines.



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