HEXAGON
METROLOGY

Quindos – the Ultimate Software package for Gears, Gear Tools and other Special Applications

Quindos gear packages

Gearings

- Cylindrical Gear
- Unknown Gear
- Involute & Lead Master
- Straight Bevel Gear
- Spiral Bevel Gear
- Cylindrical Worm
- Worm Wheel
- Double Evelop. Worm
- Extruder Worm
- Sprocket
- Curvic Coupling

Gear Tools

- Hob Cutter
- Cutter with single cutting plates
- Broach Shells
- Shaver Cutter
- Shaper Cutter
- Form cutter

Special Geometries

- Step Gearings
- Screw Compressor
- Camshaft
- Impeller

Inspection of Cylindrical Gears:

Hexagon CMMs and QUINDOS don't need a Rotary Table!
– but can be used if preferred !

Other features:

Gear diameter:	2mm up to 3700mm
Module:	≥ 0.25
Max. Tooth height:	not limited
Max. Shaft length:	not limited
Max. Gear weight:	not limited

Gears mounted on pallets

- ➔ High accuracy
- ➔ High throughput
- ➔ automatic execution

Available Standards:

DIN 3962 + VDI
ISO 1328-1
AGMA 2000-8
AGMA 2015-1
JIS 1702
CNOMO-G
Customer spec.: Caterpillar, Daimler, Eurocopter…..

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Measurement of 6 spur gear segments as pallet

- Alignment in gearing itself according to customer advice

- Pitch & Runout
- Tooth thickness, etc.
- Profile & Helix
- Tip circle
- Root circle

- Form & Position of Bores
- All Contours
- Wall thickness
- etc.

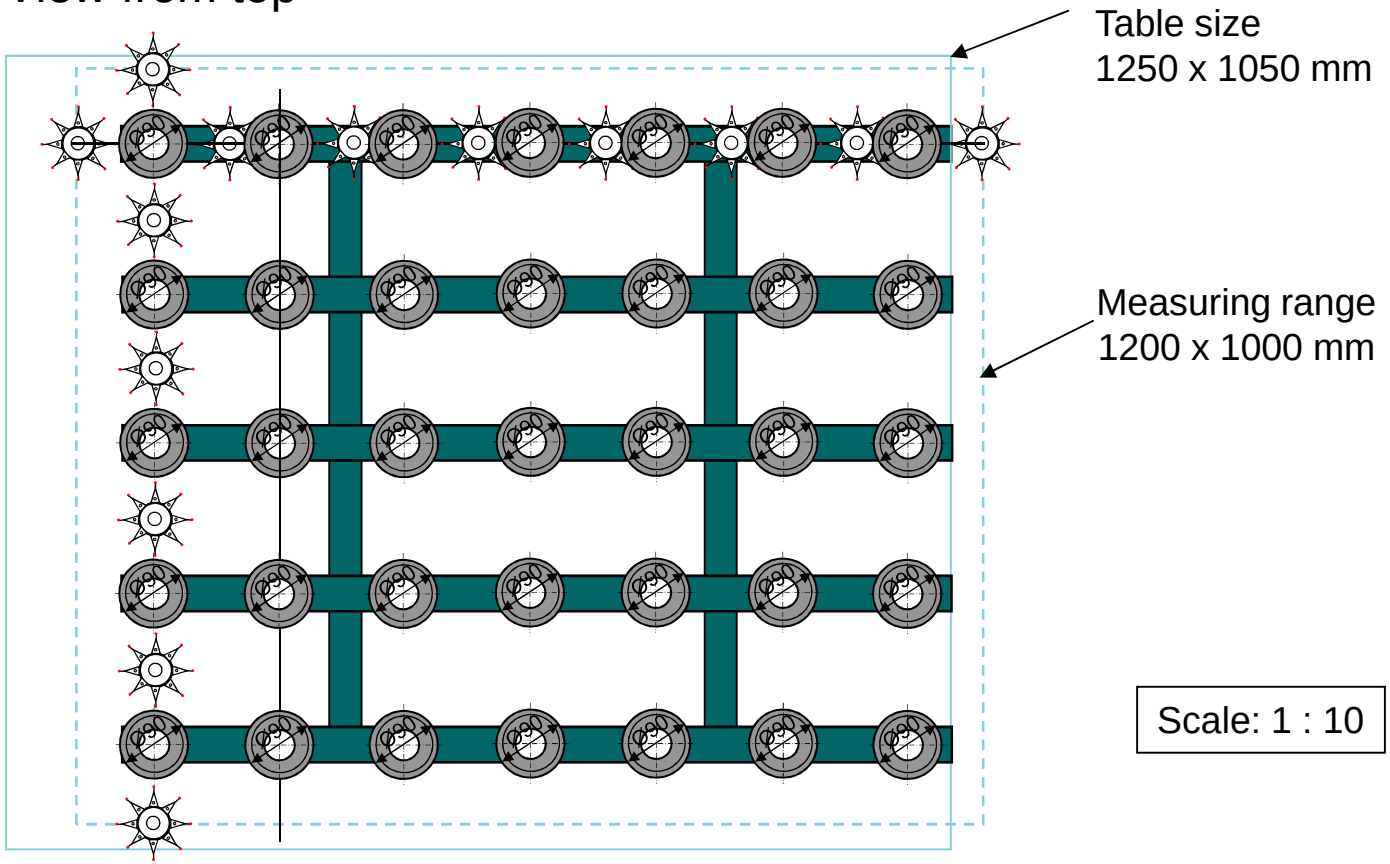
Automatic Gear Inspection on Pallets with PMM-C 700

Gear Tip Dia. 90mm:

35 helical gears

can be fixed and measured fully automatic in one set up on a Leitz PMM-C 700.

View from top



Measuring range required in Y (for gear dia. 90 mm, with 5mm clearance for moving):
50 + 5 + (5 x 90) + 4 x (5 + 100 + 5) + 50 + 7 = 1000 mm

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Measurement of Large Gears

(CMM + Gear Software = CMM + Gear Tester)

Gantry Type CMM for
Gear Diameter up to 3700 mm

Accuracy up to

E = 2.4 + L / 400 [µm]

P = 1.9 µm

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Measurement of small Gears

(CMM + Gear Software = CMM + Gear Tester)

CMM for Gear Diameter
down to 2mm

Accuracy up to

E = 0.8 + L / 350 [µm]

P = 0.8 µm

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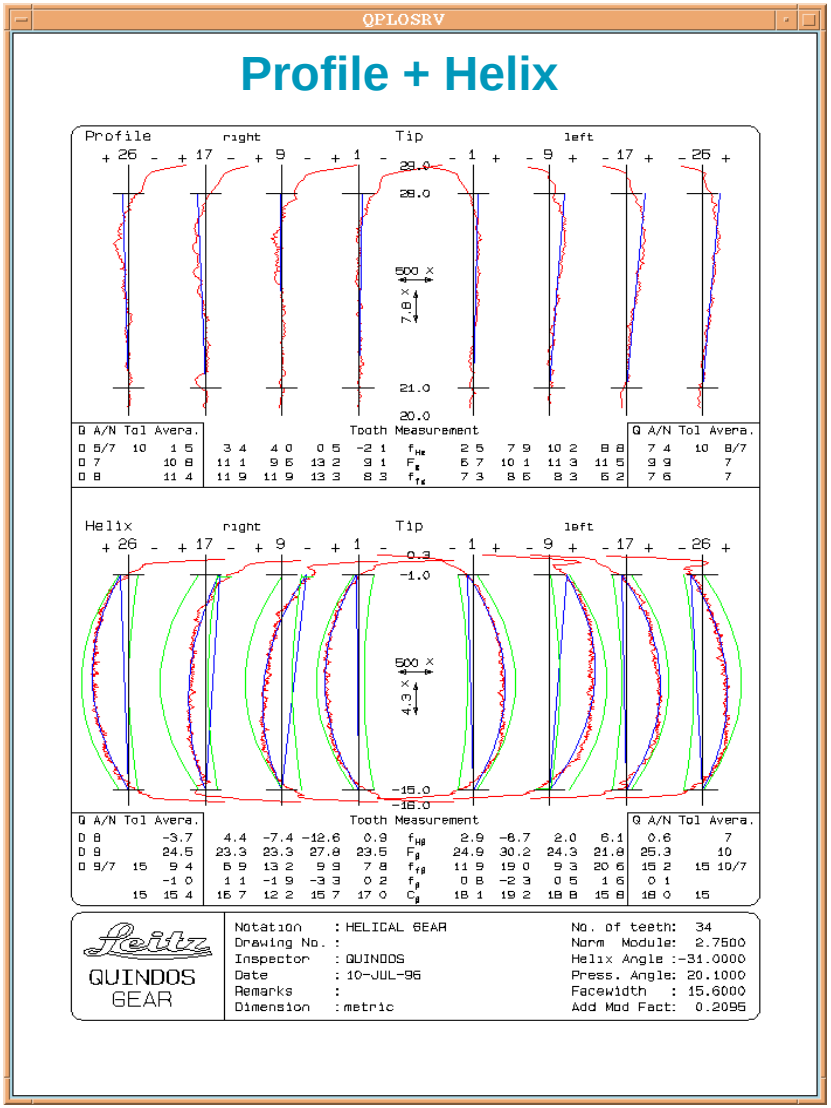
Quindos GEARHX - Evaluation



Profile (involute)

- Profile slope deviation $f_{H\alpha}$
- Total profile deviation F_{α}
- Profile form deviation $f_{f\alpha}$
- Profile crowning C_{α}
- Tip relief (VDI/VDE 2607)
- Root relief (VDI/VDE 2607)
- K-chart evaluation
- Pressure angle modification

Helix

- Helix slope evaluation $f_{H\beta}$
- Total helix deviation F_{β}
- Helix form deviation $f_{f\beta}$
- Helix crowning C_{β}
- End relief (VDI/VDE 2607)
- K-chart Evaluation
- Helix angle modification

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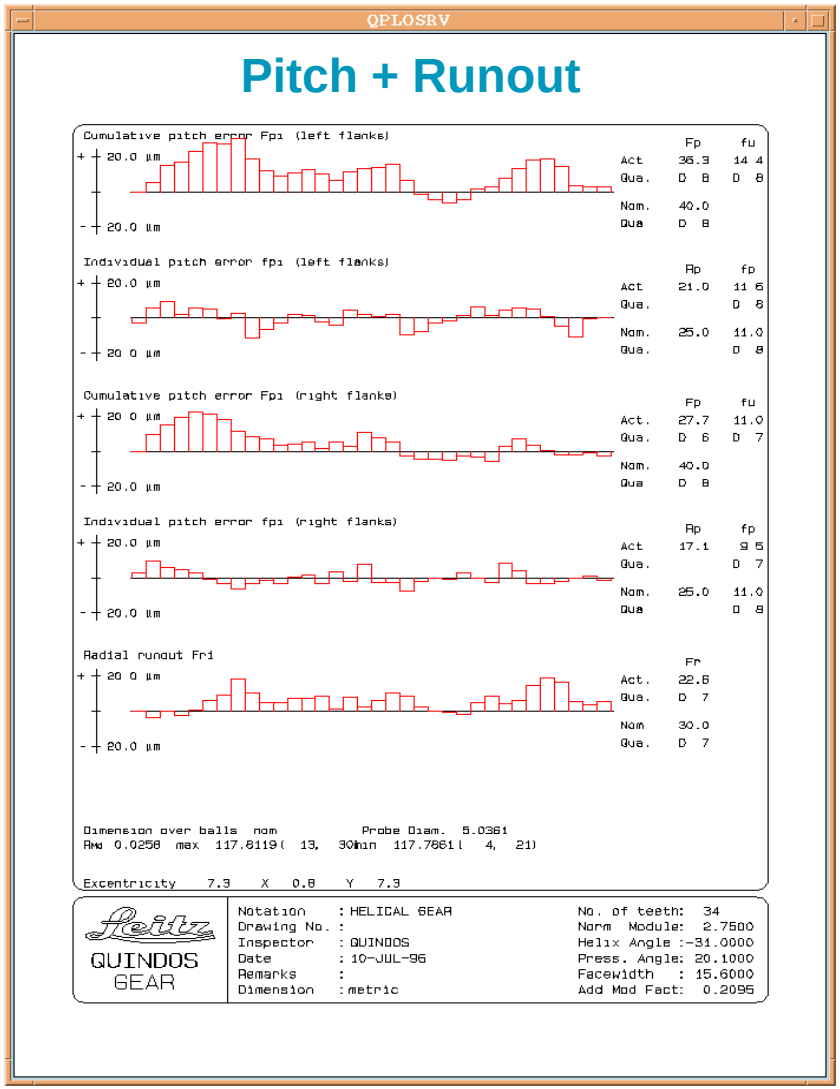
Quindos GEARHX - Evaluation



Pitch & Runout

- Cumulative pitch deviation Fp
- Individual pitch deviation fp
- Adjacent pitch deviation fu
- Variance of pitch deviation Rp
- Radial runout Fr
- Dimension over 2 balls
- Dimension over 1 ball
- Span over n teeth
- Tooth thickness
- Evaluation with and without eccentricity

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Quindos GEARHX – certified by PTB (German National Institute)

Physikalisch-Technische Bundesanstalt

Braunschweig und Berlin

PTB

Bericht
Report

Gegenstand: *Object*	Testdaten für evolventische Zylinderradauswertungen Testdata for cylindrical involute gear algorithms
Hersteller: *Manufacturer*	Leitz Messtechnik GmbH Siegmund-Hiepe-Str. 2-12 35578 Wetzlar
Typ: *Type*	QUINDOS 4304
Gerätenummer: *Serial number*	---
Antragsteller: *Applicant*	Leitz Messtechnik GmbH Siegmund-Hiepe-Str. 2-12 35578 Wetzlar

Anzahl der Seiten des Berichtes: 4
Number of pages of the report

Geschäftszeichen: *Reference No.*	PTB-5.33-04.046
Prüfzeichen: *Test mark*	---
Datum der Prüfung: *Date of test*	2004-09-02

Im Auftrag *By order* — Braunschweig, 2004-09-24 — Bearbeiter: *Examiner:*

Siegel *Seal*

Dr.-Ing. Franz Wäldele
Direktor und Professor

Dr.-Ing. Frank Härtig

Berichte ohne Unterschrift und ohne Siegel haben keine Gültigkeit. Dieser Bericht darf nur unverändert weiterverbreitet werden. Auszüge oder Änderungen bedürfen der Genehmigung der Physikalisch-Technischen Bundesanstalt.
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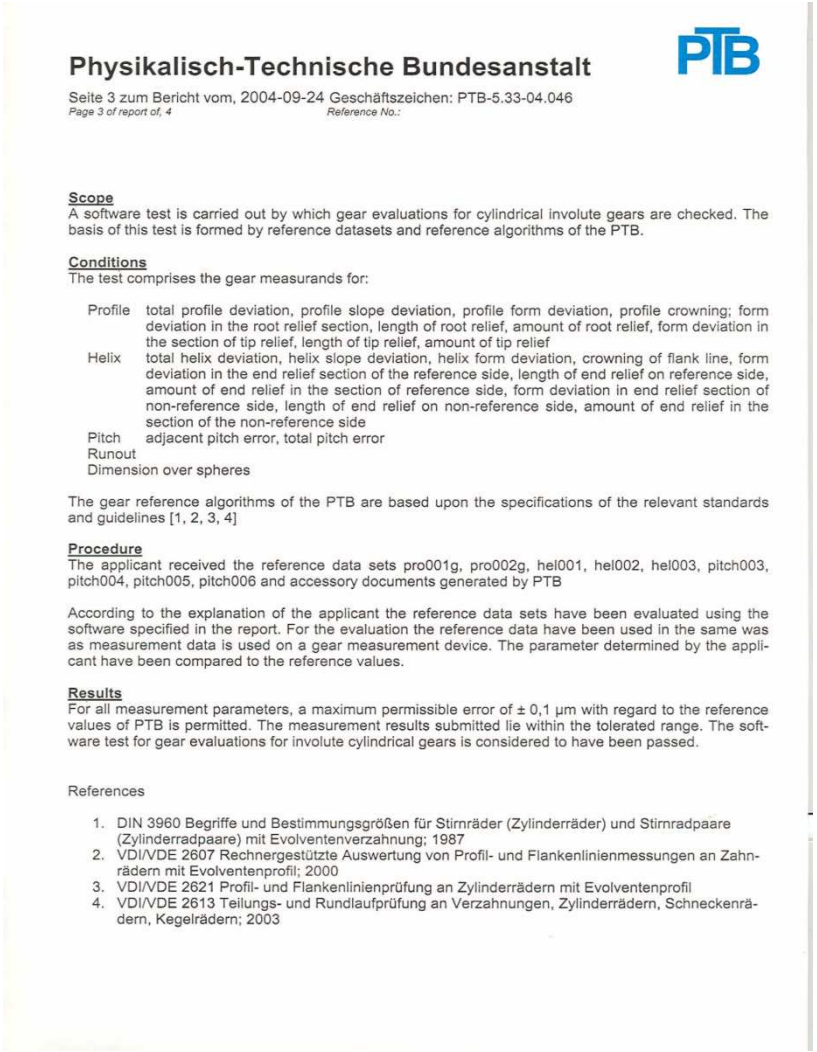

Physikalisch-Technische Bundesanstalt

PTB

Seite 3 zum Bericht vom, 2004-09-24 Geschäftszeichen: PTB-5.33-04.046
Page 3 of report of, 4 *Reference No.:*

Scope
A software test is carried out by which gear evaluations for cylindrical involute gears are checked. The basis of this test is formed by reference datasets and reference algorithms of the PTB.

Conditions
The test comprises the gear measurands for:

Profile	total profile deviation, profile slope deviation, profile form deviation, profile crowning; form deviation in the root relief section, length of root relief, amount of root relief, form deviation in the section of tip relief, length of tip relief, amount of tip relief
Helix	total helix deviation, helix slope deviation, helix form deviation, crowning of flank line, form deviation in the end relief section of the reference side, length of end relief on reference side, amount of end relief in the section of reference side, form deviation in end relief section of non-reference side, length of end relief on non-reference side, amount of end relief in the section of the non-reference side
Pitch	adjacent pitch error, total pitch error
Runout	
Dimension over spheres	

The gear reference algorithms of the PTB are based upon the specifications of the relevant standards and guidelines [1, 2, 3, 4]

Procedure
The applicant received the reference data sets pro001g, pro002g, hel001, hel002, hel003, pitch003, pitch004, pitch005, pitch006 and accessory documents generated by PTB

According to the explanation of the applicant the reference data sets have been evaluated using the software specified in the report. For the evaluation the reference data have been used in the same was as measurement data is used on a gear measurement device. The parameter determined by the applicant have been compared to the reference values.

Results
For all measurement parameters, a maximum permissible error of ± 0,1 µm with regard to the reference values of PTB is permitted. The measurement results submitted lie within the tolerated range. The software test for gear evaluations for involute cylindrical gears is considered to have been passed.

References

1. DIN 3960 Begriffe und Bestimmungsgrößen für Stirnräder (Zylinderräder) und Stirnradpaare (Zylinderradpaare) mit Evolventenverzahnung; 1987
2. VDI/VDE 2607 Rechnergestützte Auswertung von Profil- und Flankenlinienmessungen an Zahnrädern mit Evolventenprofil; 2000
3. VDI/VDE 2621 Profil- und Flankenlinienprüfung an Zylinderrädern mit Evolventenprofil
4. VDI/VDE 2613 Teilungs- und Rundlaufprüfung an Verzahnungen, Zylinderrädern, Schneckenrädern, Kegelrädern; 2003

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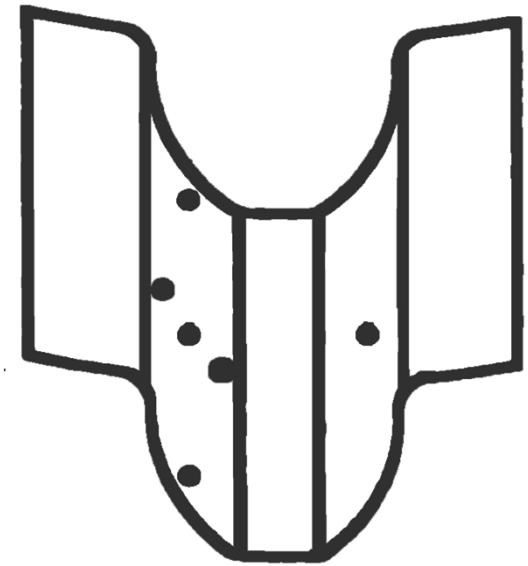
Quindos GearXY

Determination of unknown Gear



Strategy

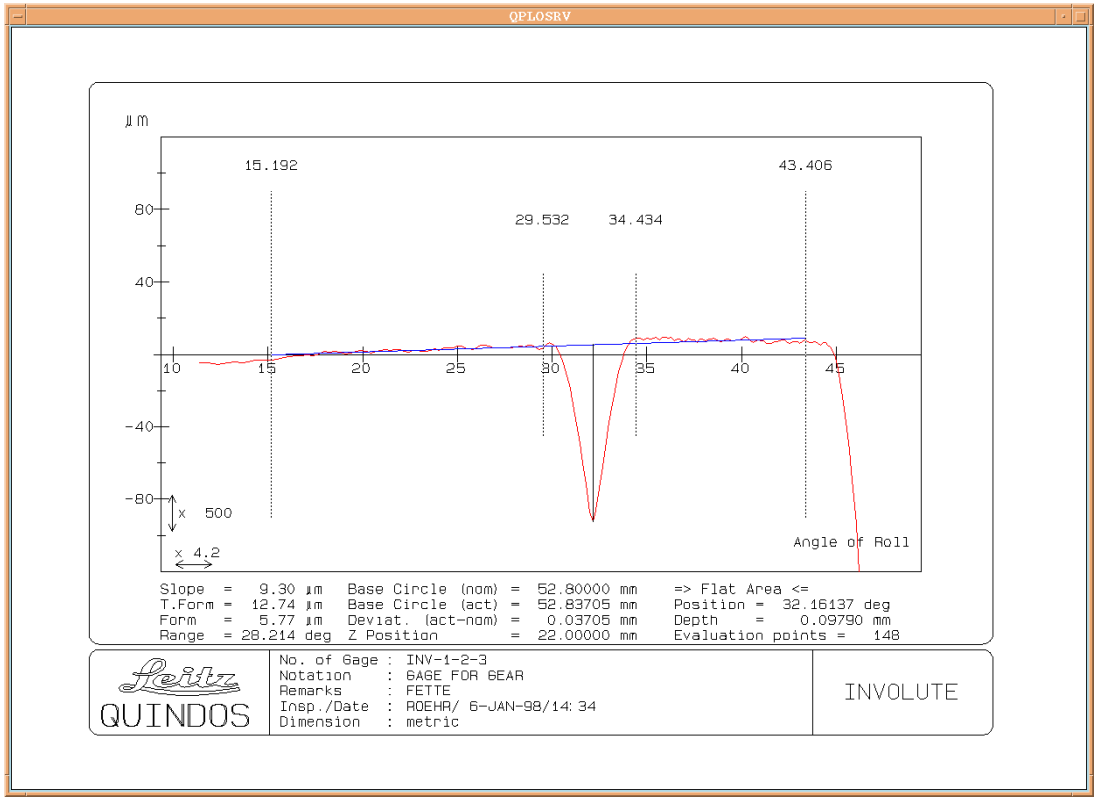
- Define gear axis
- 1x probing at tip circle
- 1x probing at root circle
- 1x probing at upper and lower face
- 6 points at gear flank
  - 5 at one flank
  - 1 point at opposite flank

Results

- Normal module
- Pressure angle
- Helix angle
- Addendum modification factor
- Crowning of profile and helix
- Tip circle diameter
- Root circle diameter
- Gear width

Quindos Gear Gauges

Inspection of Involute and Lead Masters



Involute Master

- Determination of fHα, Fα, ffα inside evaluation range
- Position and depth of flat areas (see plot)
- Determination of actual base circle diameter
- Evaluation with respect to actual or nominal base circle diameter
- Plot with respect to angle of roll or angle of roll

Lead Master

- analog

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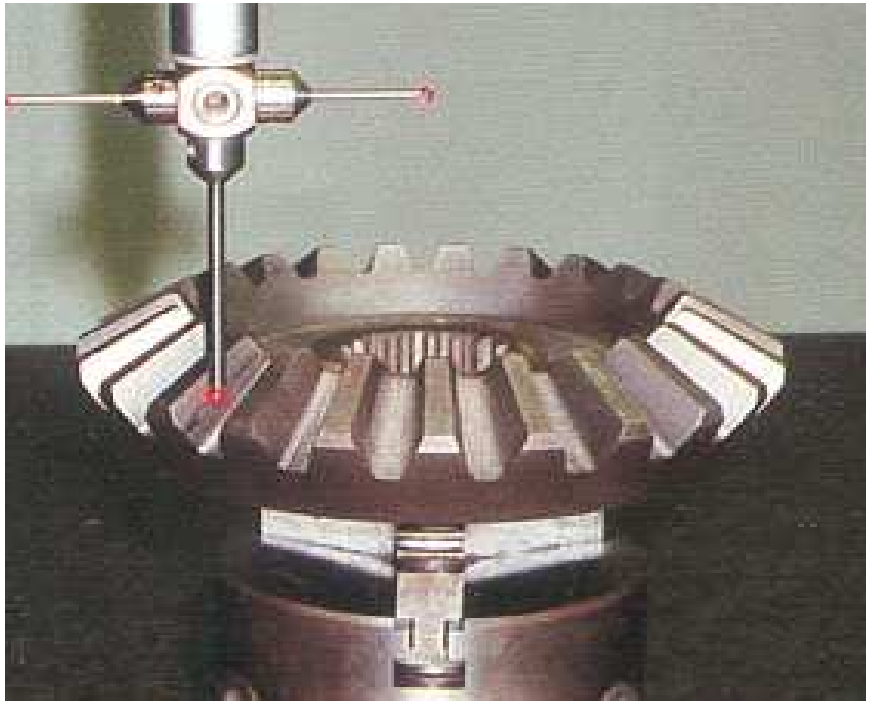
Quindos GEARSB

Measurement of Straight Bevel Gears according to DIN 3971

Measurement of external
& internal Gearings,
Dies and Electrodes



Topography Measurement

- with theoretical points (Octoid Gearing of the 1st kind)
- with Master Grid

Profile Measurement

- like cylindrical gear

Flank Trace Measurement

- like cylindrical gear

Pitch & Runout

Bestfit

- to improve alignment

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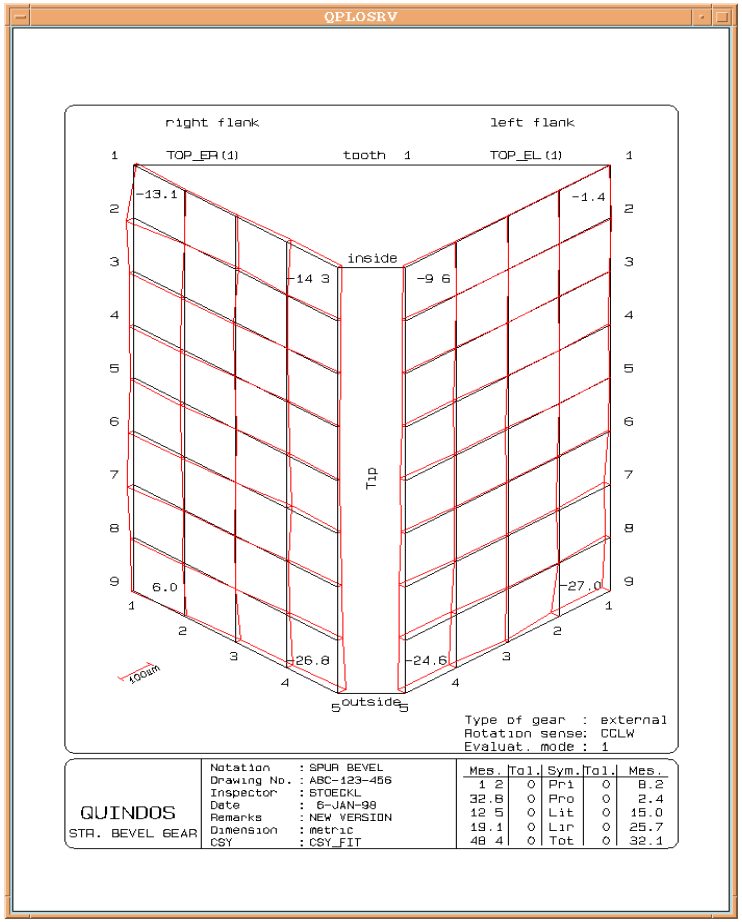
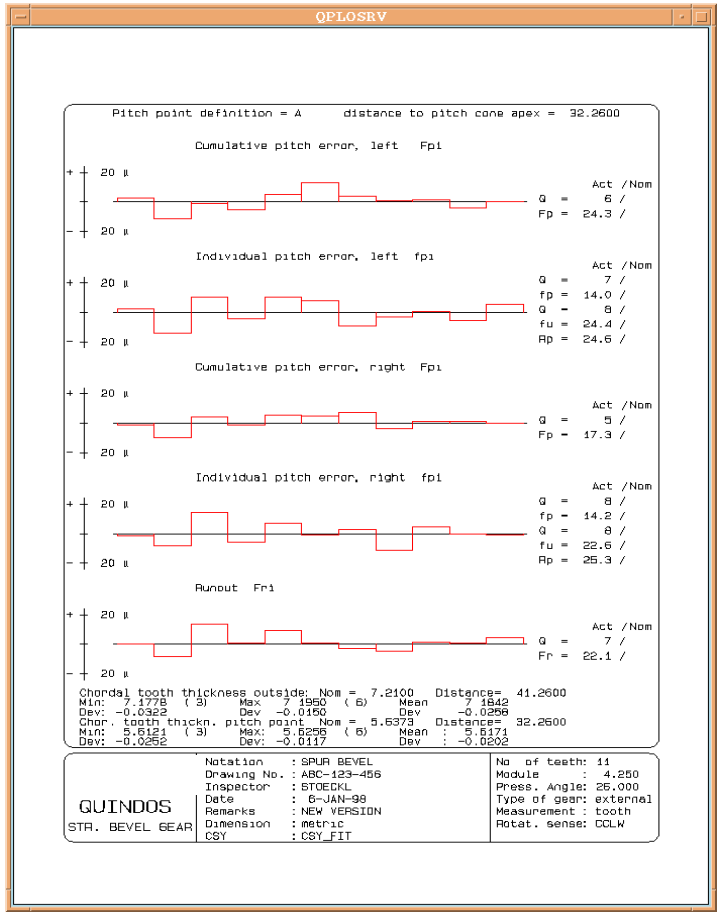
Quindos GEARSB - Evaluation of Straight Bevel Gear

PowerTrain Solutions

Topography



Pitch • Runout • Tooth Thickness



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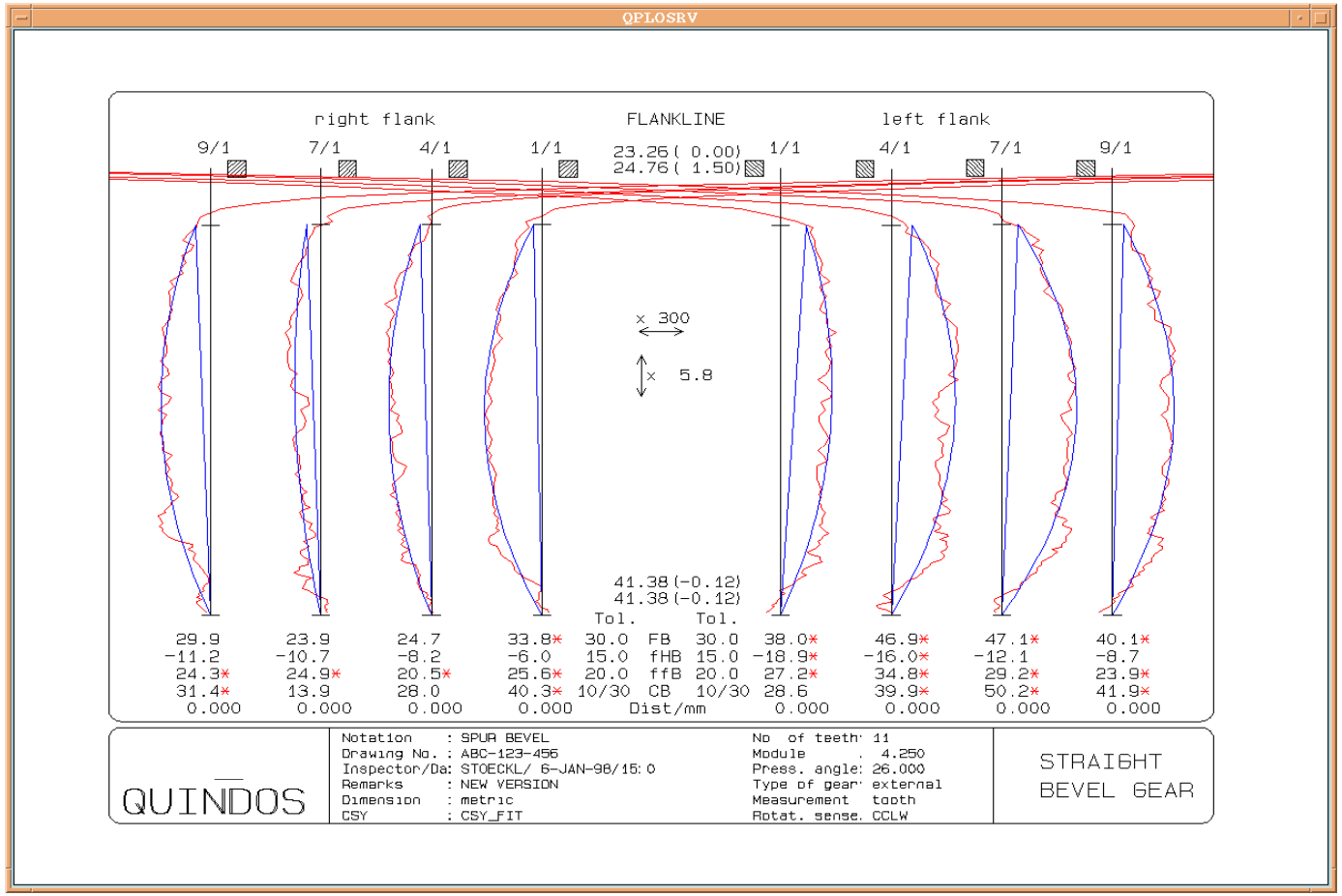
Quindos GEARHX - Evaluation of Profile (involute)

Flank trace evaluation according to Octoid geometry



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Quindos GEARBV – Spiral Bevel Gears and Crown Gears

Spiral Bevel Gear

Crown Gear

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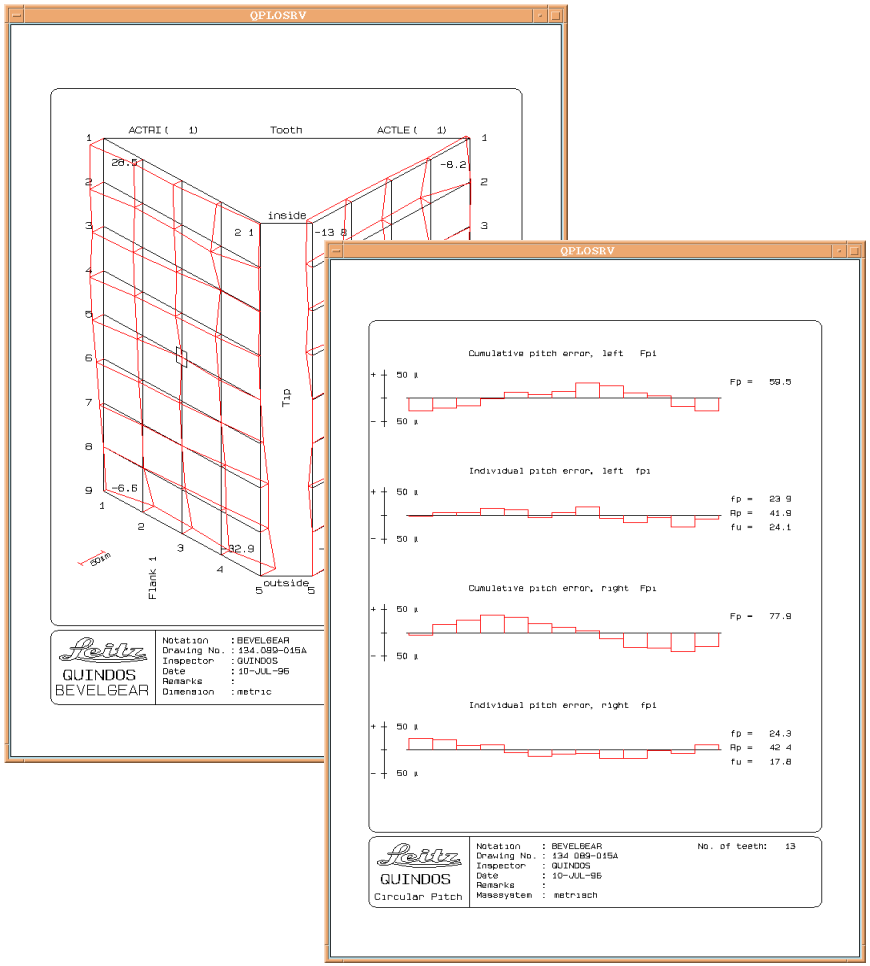
Quindos GEARBV – Spiral Bevel Gear

Quindos GEARBV - Evaluation



- Import of Master Files e.g. in Gleason, Klingelnberg (KEGMES), DMG Format
- Export of average result file e.g. in Gleason Format
- Measurement of a Master Gear
- Automatic generation of the moving path without rotary table
- Actual nominal comparison of topography with different fitting methods
- Evaluation of pitch, runout and tooth thickness
- Quality Grade according DIN or AGMA
- Large size Pinions measured with axis mounted horizontally

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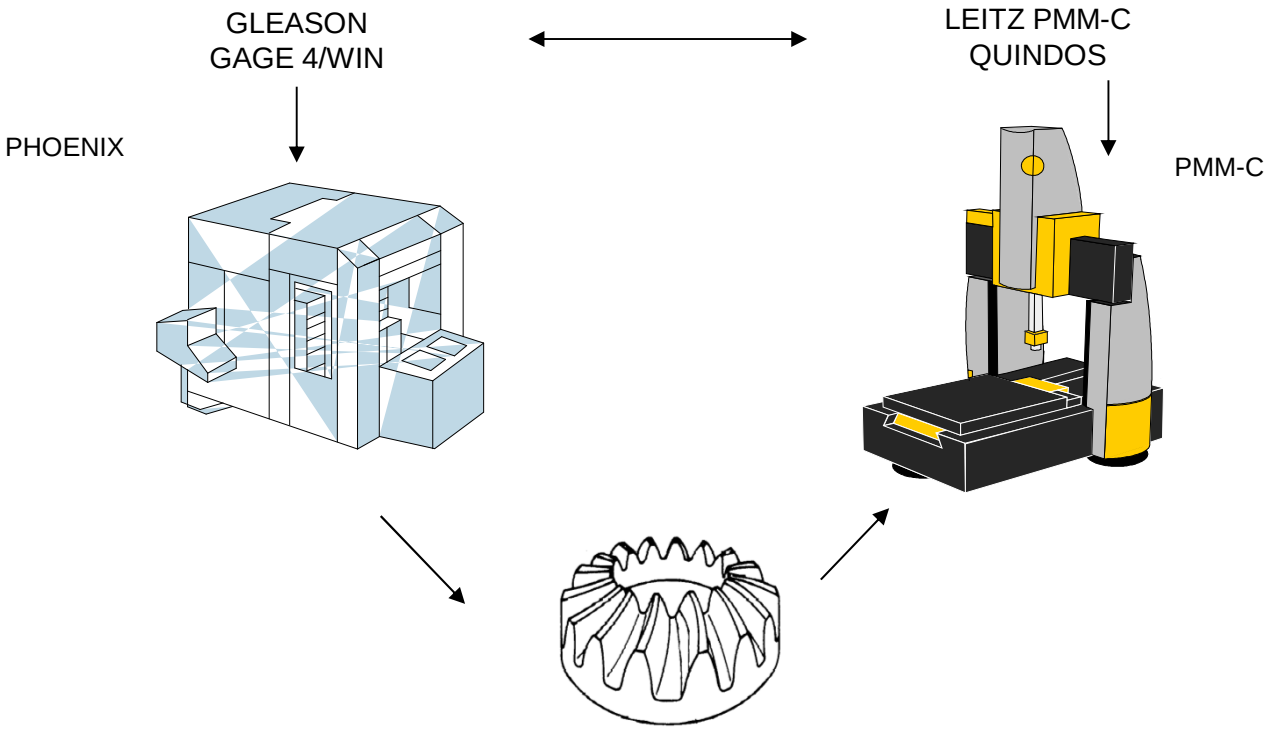
Quindos GEARBV – Interfaces to GLEASON, Klingelnberg, DMG

I.E. Correction of Machine Settings G-Age 4/WIN



Quindos WORMHX, WORMGL, WWHEEL

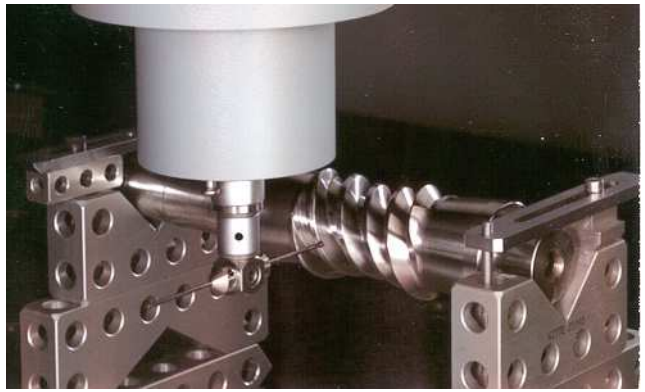
Cylindrical Worm, Double Env. Worm and Worm Wheel

Cylindrical Worm

Mounted horizontally

➔ Any length can be measured !

Double Enveloping Worm



Worm Wheel

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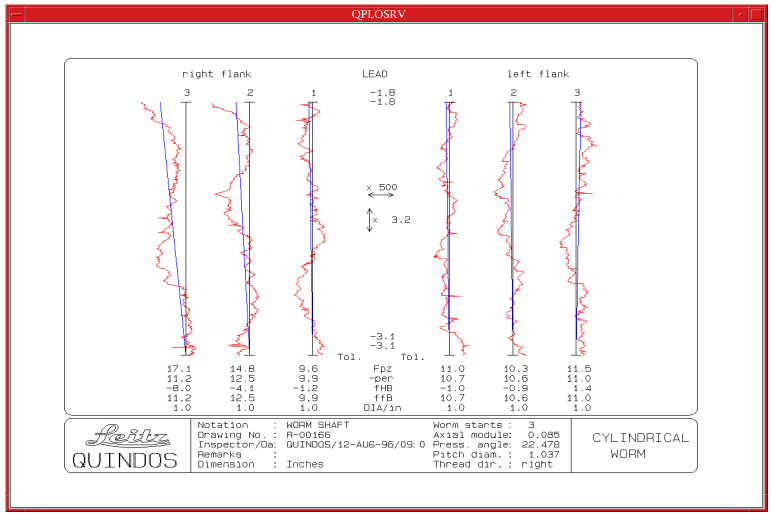
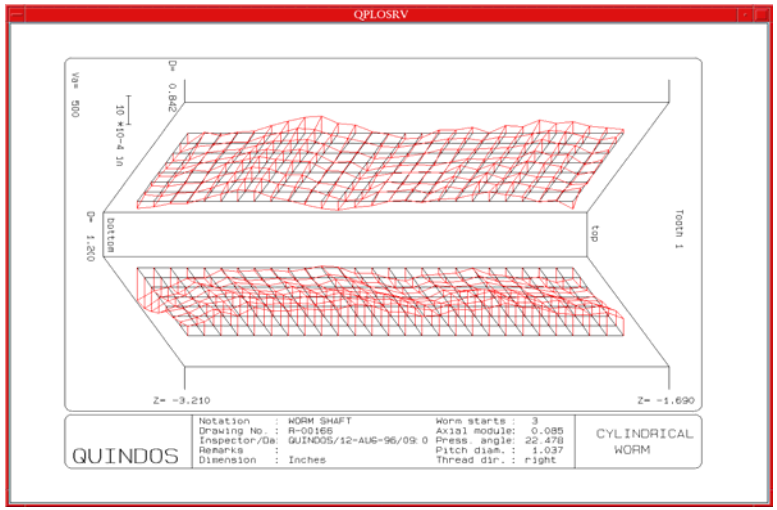
Quindos WORMHX - Cylindrical Worm

- Cylindrical Worms of type ZA, ZI, ZN, ZK and ZC (DIN 3965)
- Single or multi start worms
- LH or RH lead
- Duplex Worms
- Mounted in vertical or horizontal position

Quindos WORMHX - Cylindrical Worm evaluation





- Worm types ZA, ZI, ZN, ZK and ZC (DIN 3965)
- Lead at selectable diameter (Fpz, -per, fHß, ffß)
- Profile at selectable Z height (Fα, ffα, fHα, Cα)
- Axial pitch (Fp, fp, fu)
- Runout (given or calculated ball diameter)
- Normal tooth thickness
- Topography

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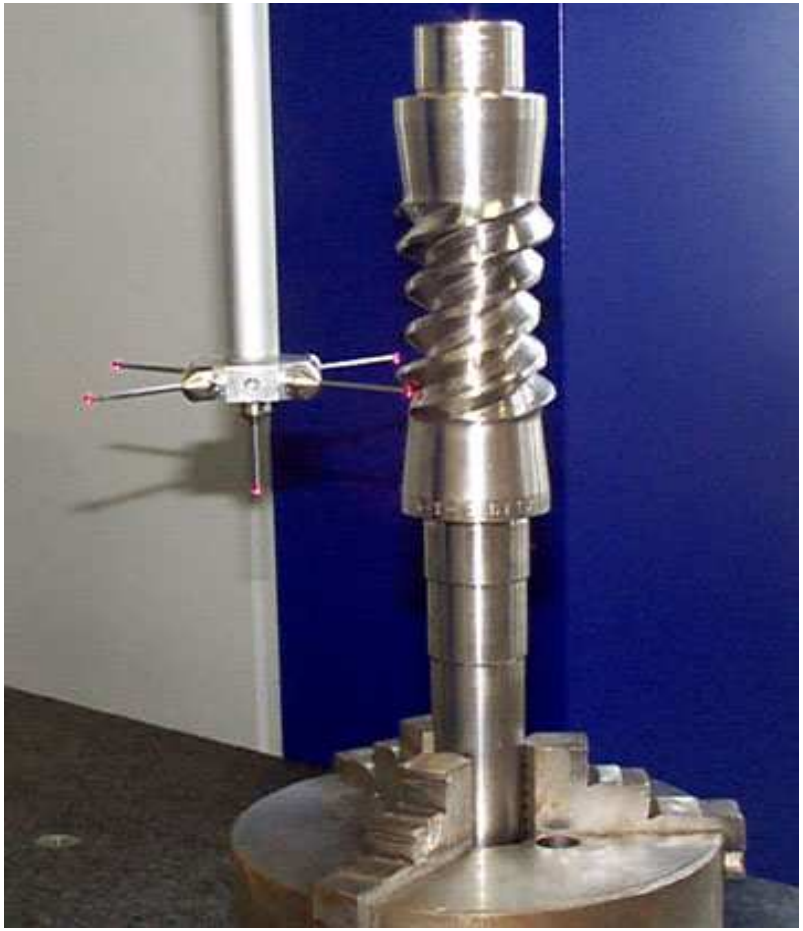
Quindos WORMGL – Double enveloping Worm (globoid)



Several types of generation (inclined grinding disk or straight sided skiving wheel)

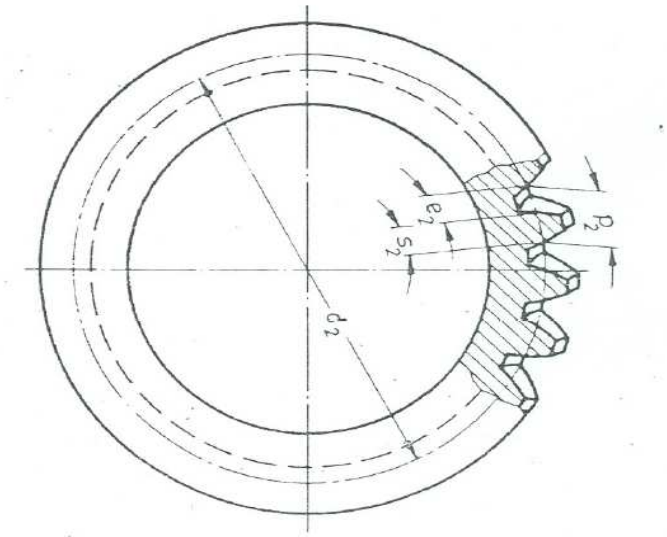
- 1 or multi-start worms
- LH or RH lead
- vertically or horizontally mounted
- Profile
- Lead
- Pitch
- Runout
- Axial bestfit independently for left and right flanks for improvement of machine setting

Quindos WWHEEL – Worm Wheel

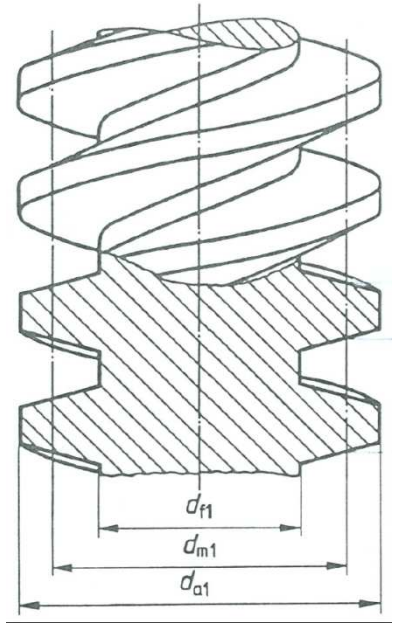
Worm Wheels for Cylindrical Worms of the types ZA, ZI, ZN, ZK and ZC (DIN 3965).

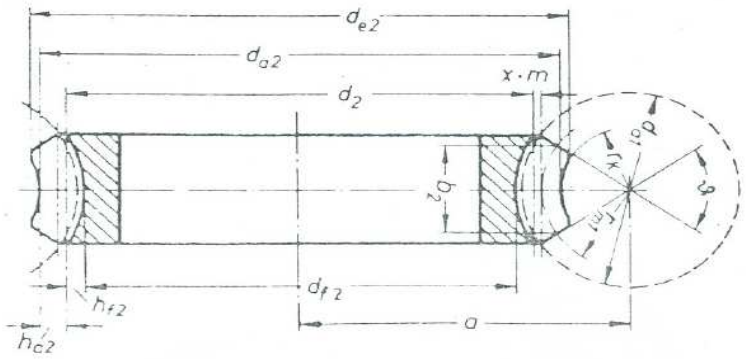
- Calculation as conjugate gearing to the mating worm
- No Master Grid necessary
- Pitch
- Runout
- Dimension over 2 Balls
- Profile
- Helix
- Topography
- Bestfit of axial Position
- Evaluation accord. to DIN, BSI and AGMA

Definition of Worm Wheel



No. of teeth
Tooth thickness





Type (ZA,ZI,ZN,ZK,ZC)
No. of starts
Hand of lead (LH, RH)

- pressure angle
- grinding disk parameter
- etc.

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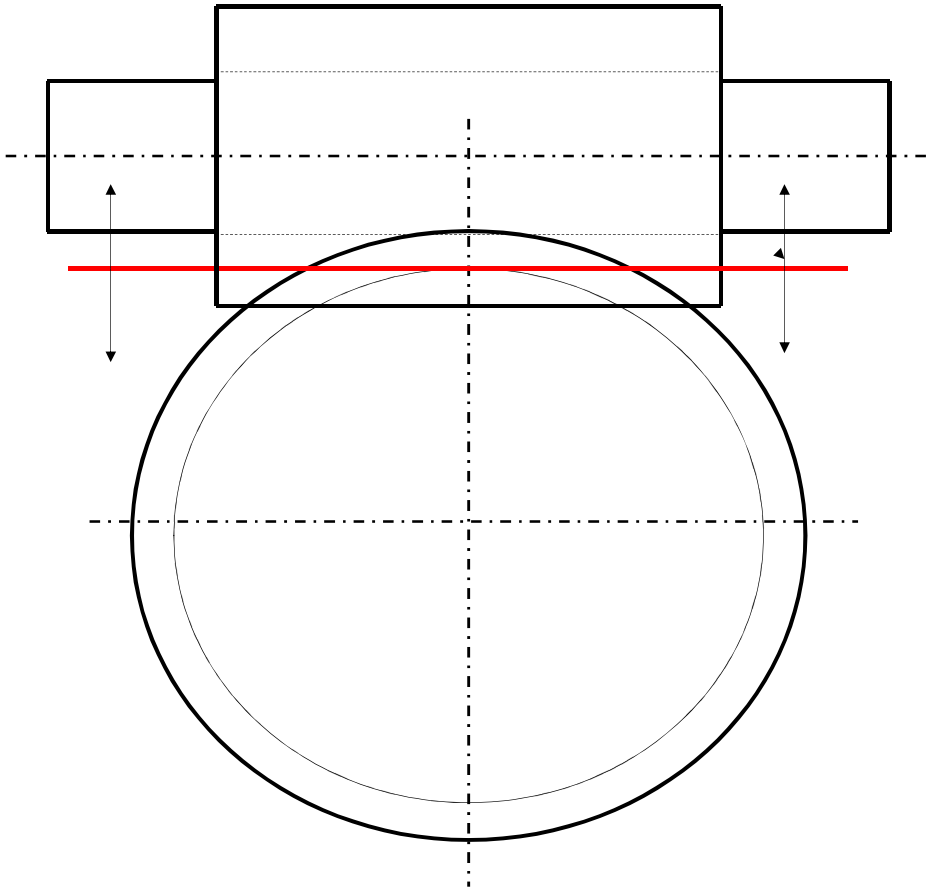
Generation of Worm Wheel Flanks



Worm point (x^1, y^1, z^1)
Normal direction (i^1, j^1, k^1)

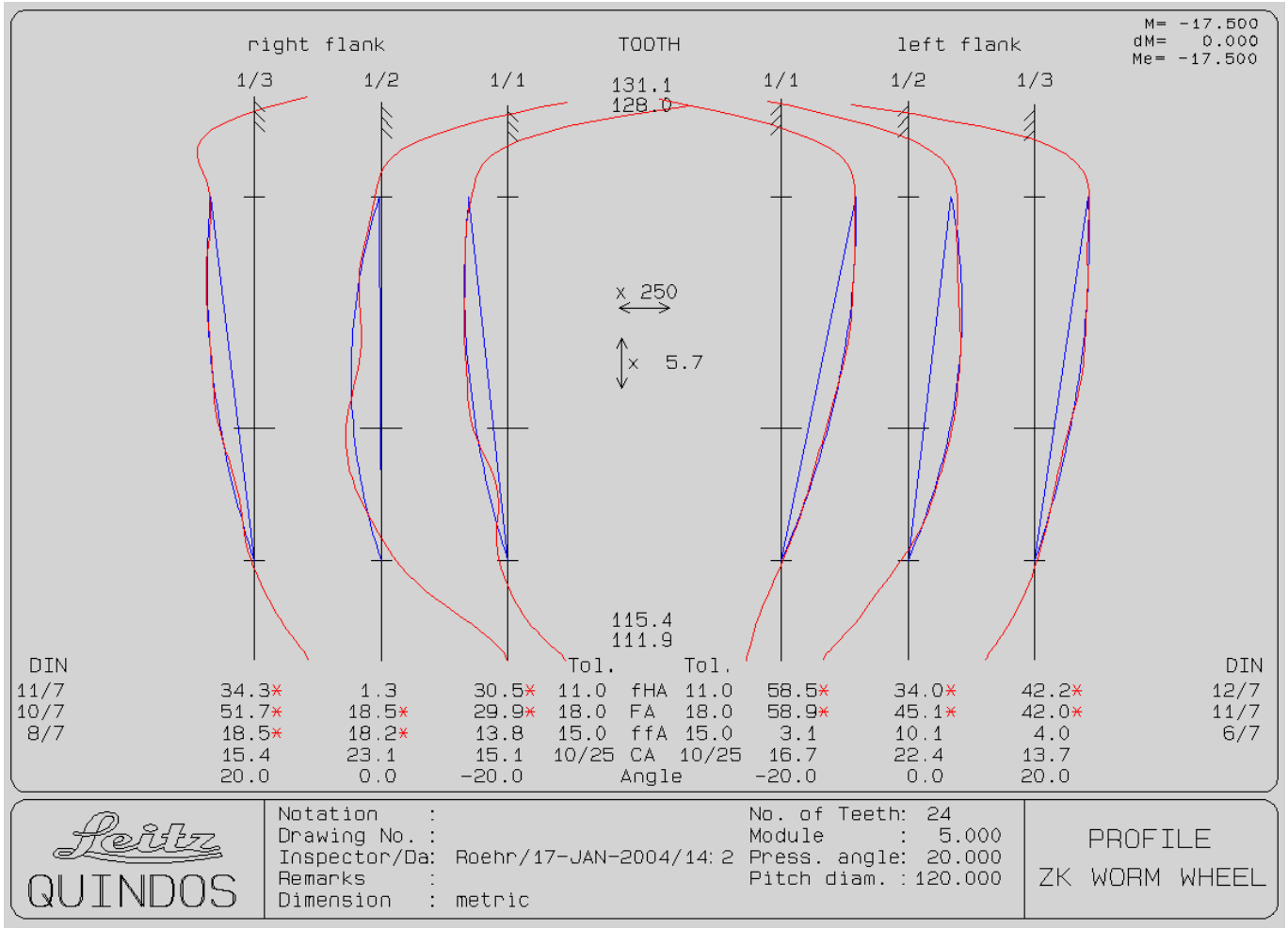
↓

Law of Gearing

↓

Worm Wheel point (x^2, y^2, z^2)
Normal direction (i^2, j^2, k^2)

Quindos WWHEEL – Profile Evaluation



fHα

Fα

ffα

Cα

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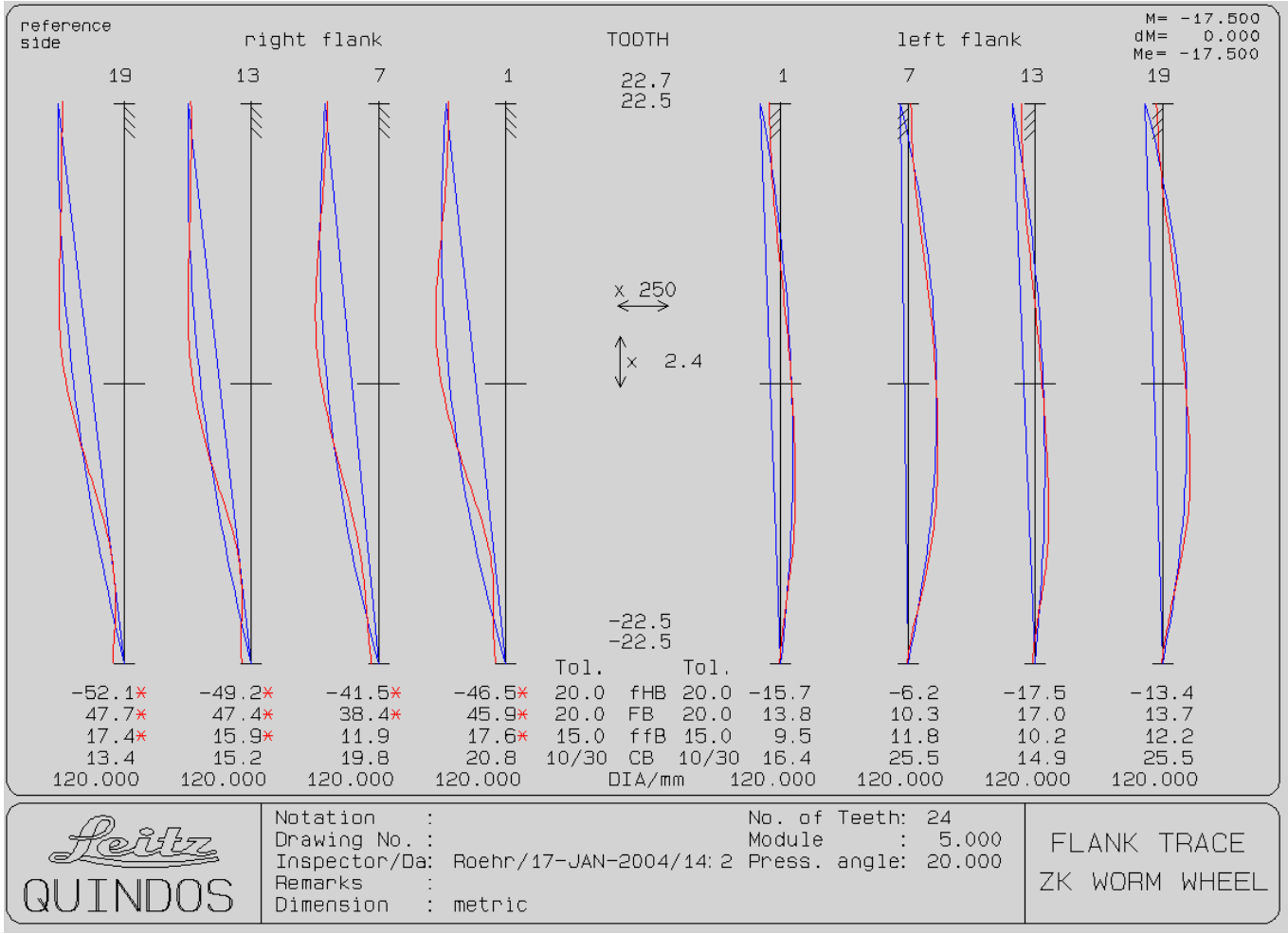
Quindos WWHEEL – Helix Evaluation



fHß

Fß

ffß

Cß

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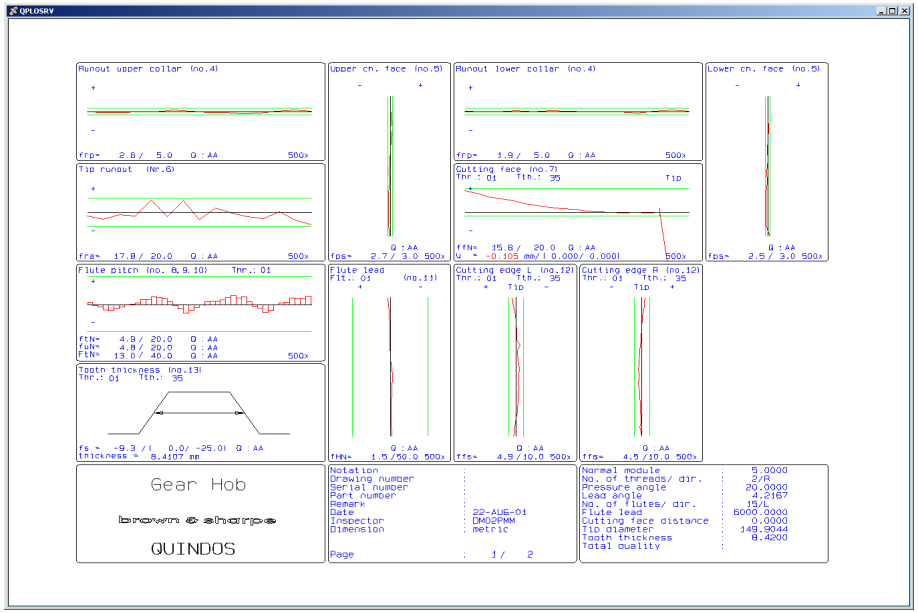
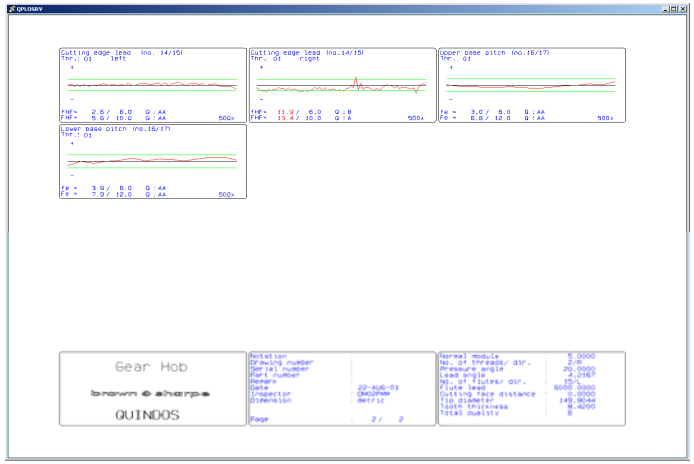
Quindos HOB – Hob cutter

- Measurement of all features as defined in DIN 3968.
- Additionally to DIN the Axial Pitch and the Tooth Height for topping hobs
- All measurement also for multi start hobs
- The flutes can be straight or helical

Quindos HOB – Hob Cutter Evaluation





- Radial and axial runout of test collars
- Radial runout of tooth tip
- Shape and position of cutting face
- Pitch of the flutes
- Deviation of flute lead over 100 mm
- Form deviation of cutting edge
- Tooth thickness
- Hob lead over cutting edge
- Base pitch deviations
- Axial pitch
- Tooth height

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Hob Cutter for large gears (setup with cutting plates)

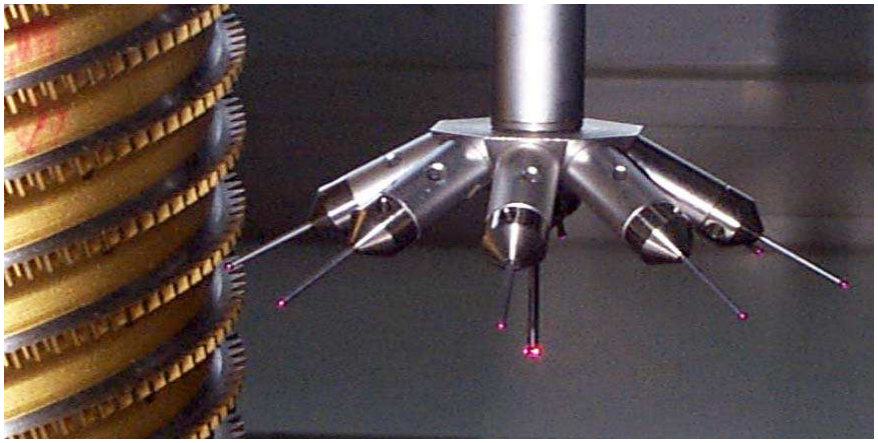
Determination of typical deviation parameters of the Hob with a special Quindos program

Quindos BROACH Shell

Broach shells with ring type spaces as well as helical chip spaces can be inspected.

The gearing may be straight or helical with left hand or right hand lead.

Tools for hard broaching with negative face angles can also be inspected



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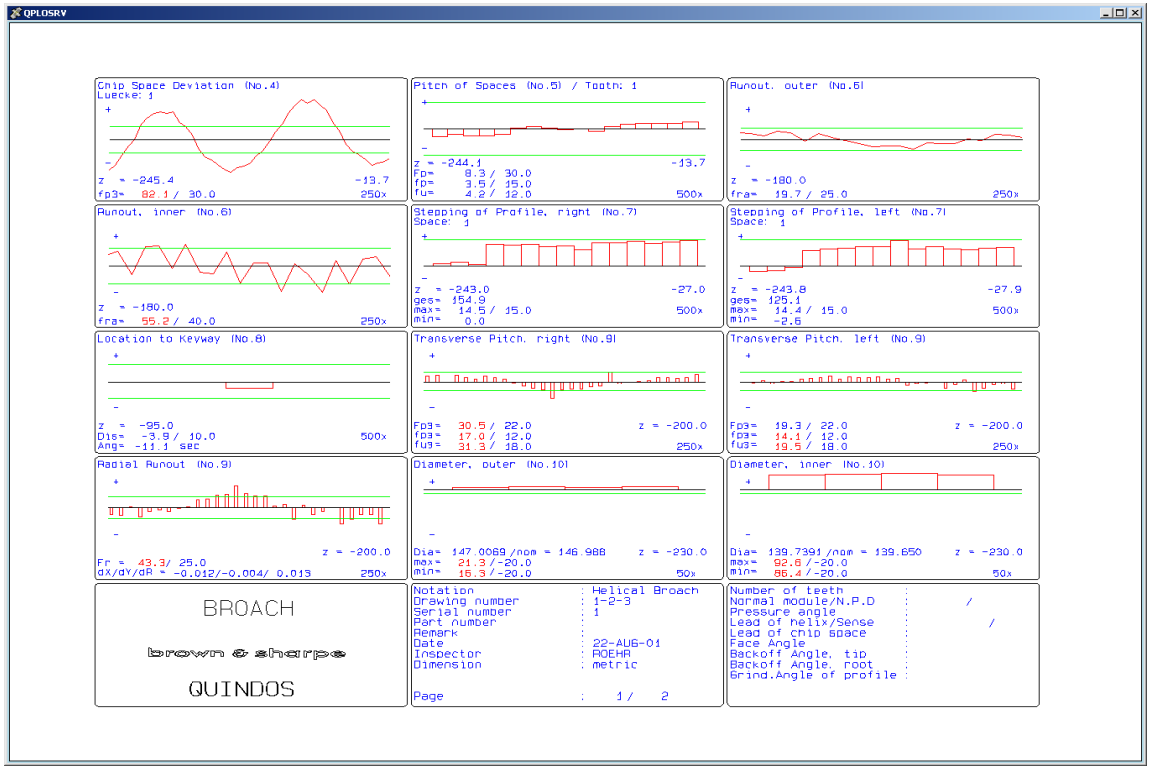
Quindos BROACH – Evaluation



- lead deviation / axial runout of chip space
- pitch of chip space
- radial runout outer / inner
- stepping of profile
- location to keyway
- transverse pitch in finishing area
- diameter inner / outer (single positions)
- dimension over 2 balls

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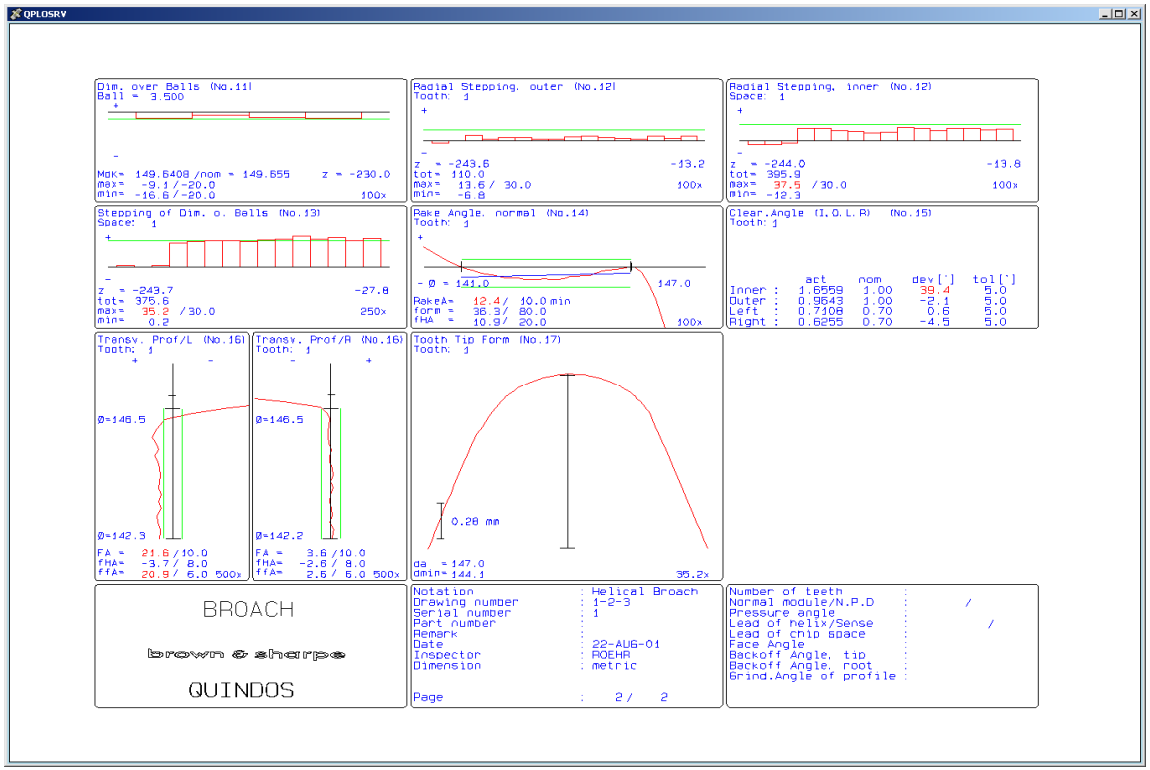
Quindos BROACH – Evaluation



- radial stepping of inner / outer radius
- radial stepping of dimension over 1 ball
- face angle in normal plane
- back off angle (inner, outer, profile)
- transverse tooth profile
- form of tooth tip

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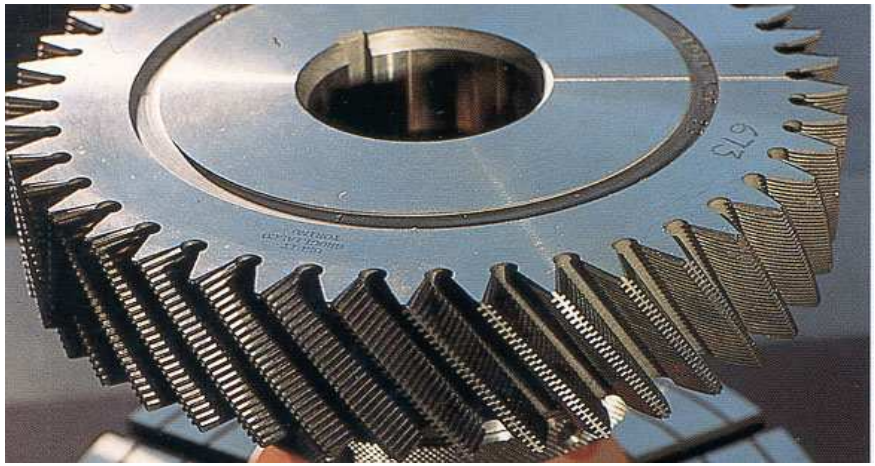
Quindos SHAVER - Shaving Gear

The option Shaving Gear provides the tools for the complete inspection of shaving cutters.

The travel path of the CMM as well as all probing and scan lines required for the inspection are generated automatically.



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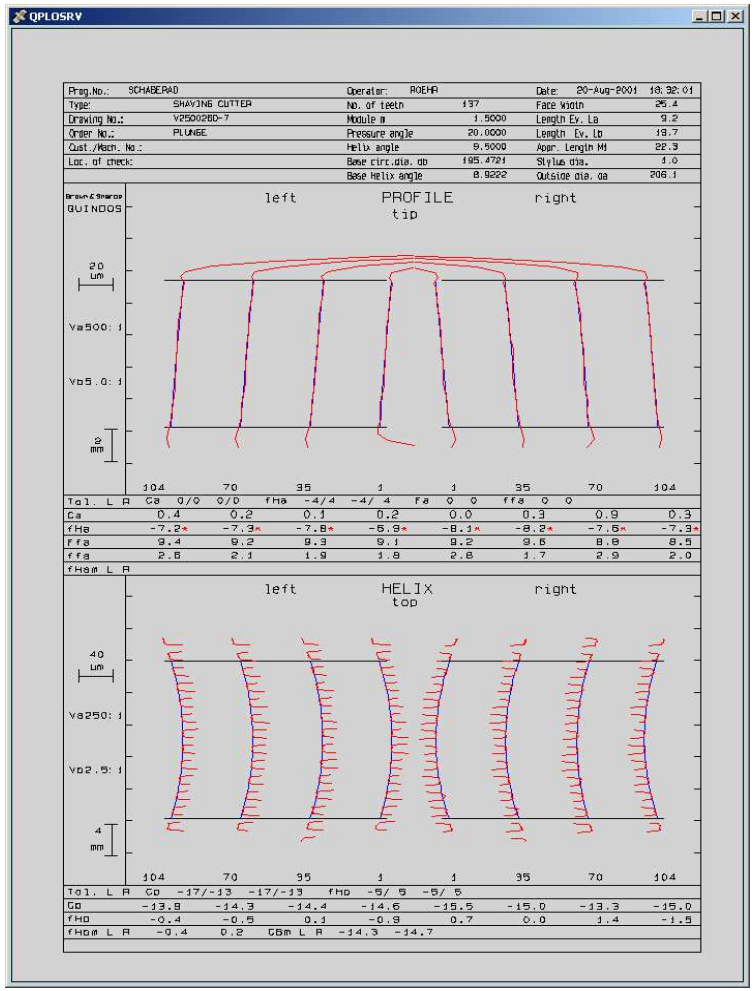
Quindos SHAVER - Shaving Gears Evaluation



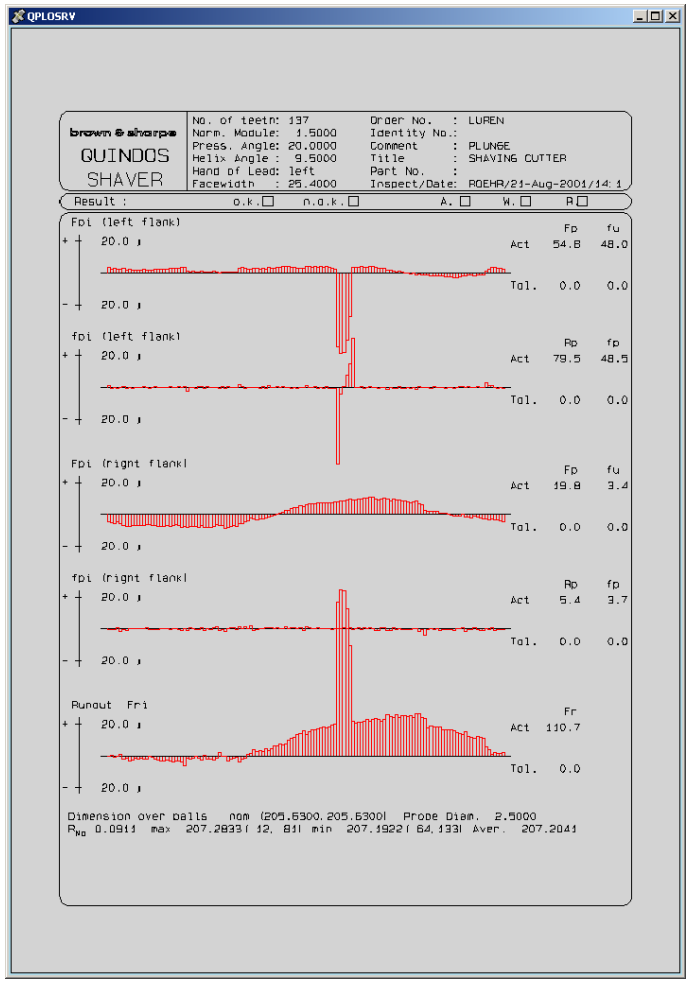
Evaluation of Profile (involute)

- Profile slope deviation $f_{H\alpha}$
- Total profile deviation F_{α}
- Profile form deviation $f_{f\alpha}$
- Profile crowning C_{α}
- Mean profile slope deviation $f_{H\alpha}$

Evaluation of Helix

- Helix slope deviation $f_{H\beta}$
- Tooth crowning C_{β}
- Mean helix slope deviation $f_{H\beta m}$
- Mean tooth crowning C_{β}

Quindos SHAVER - Shaving Gears Evaluation



Evaluation of Runout and Pitch

- cumulative pitch deviation Fp
- individual pitch deviation fp
- adjacent pitch deviation fu
- variance of pitch deviation Rp
- radial runout Fr
- Dimension over balls
- Span over n teeth
- Tooth thickness
- Elimination of eccentricity

HEXAGON METROLOGY

Quindos SHAPER - Shaper Cutter

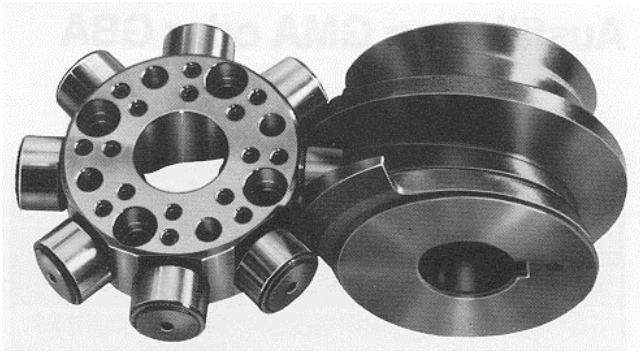
Inspection of spur and helical shaper cutters according to DIN 1829.

The cutting face can be conical or stepped.

Following evaluations are considered

- axial runout of cutting face
- radial runout at OD
- tooth thickness
- rake angle, clearance angle
- helix angle
- pitch and runout (fp, Fp, fu, Rp, Fr)
- dimension over balls
- profile ($f_{H\alpha}$, F_{α}, $f_{f\alpha}$)
- helix ($f_{H\beta}$, F_{β}, $f_{f\beta}$)

Quindos STEPGR – Step Gears

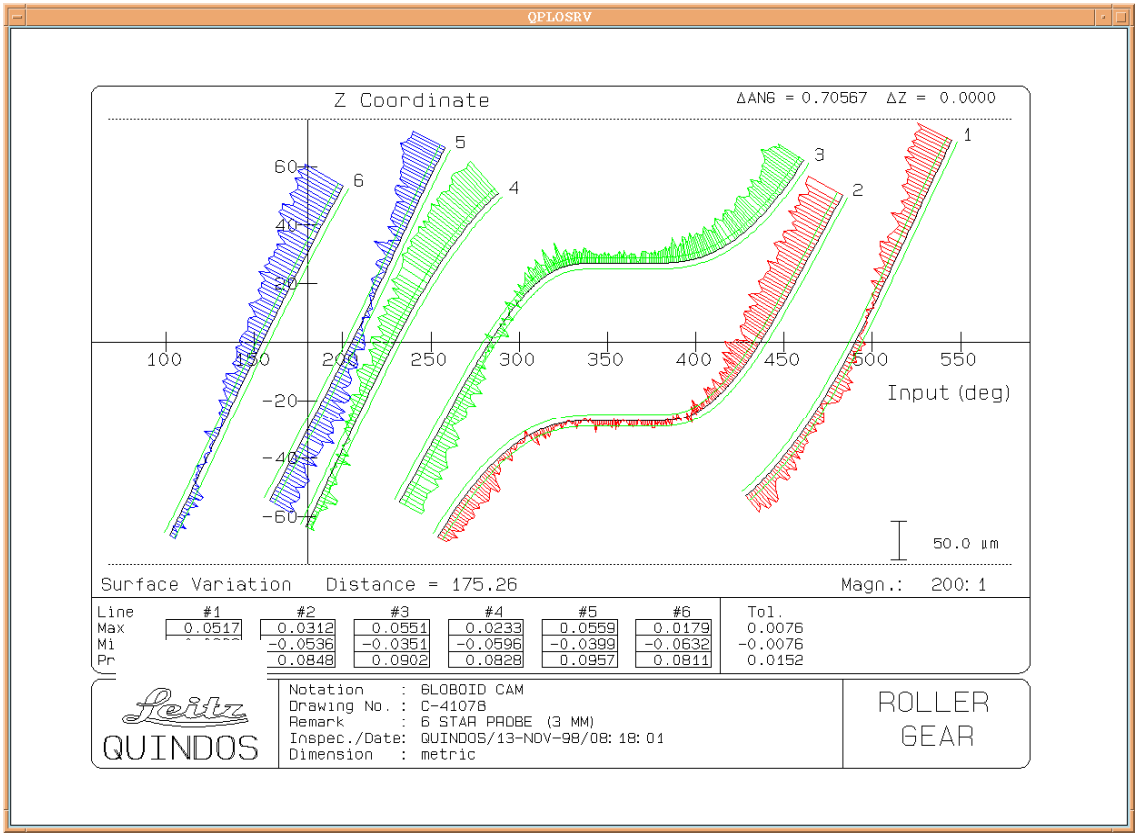


Cam Bodies of any size and shape

Input: Transmission Law and a few basic parameters

Quindos STEPGR – Step Gear Evaluation

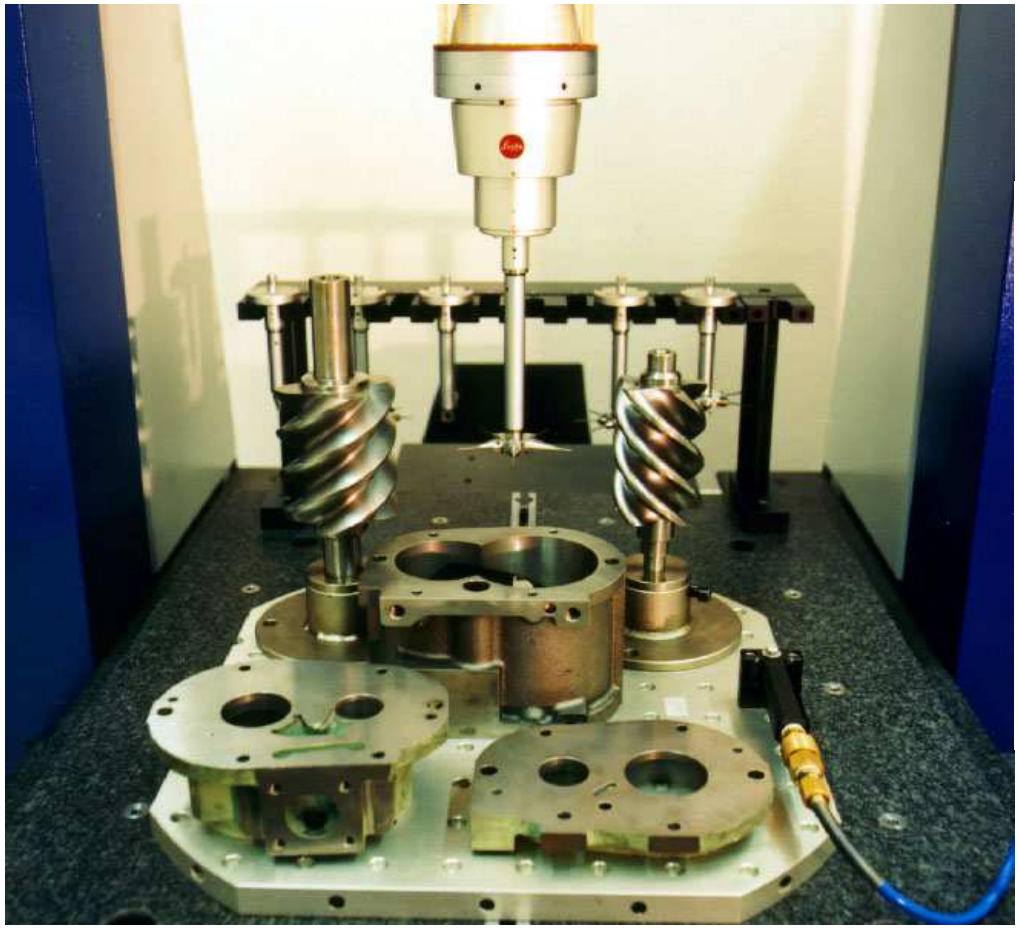
Surface Form Evaluation



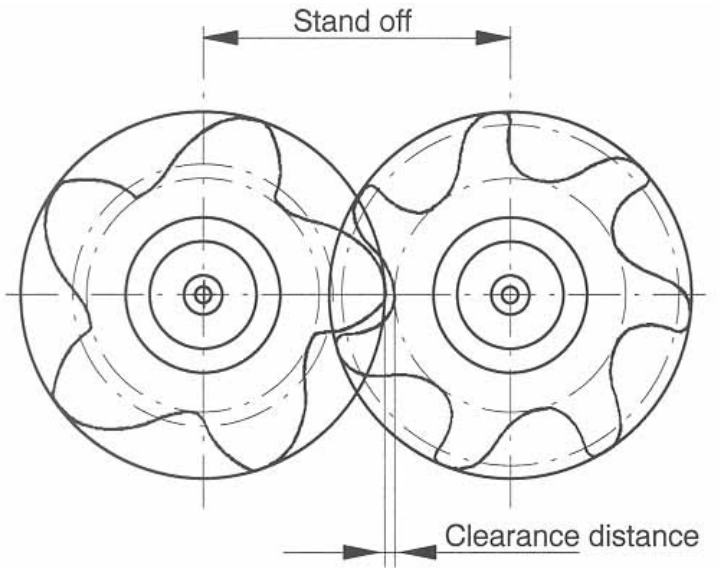
HEXAGON METROLOGY

Quindos SCRCMP- Screw Compressor

Complete measurement on a pallet

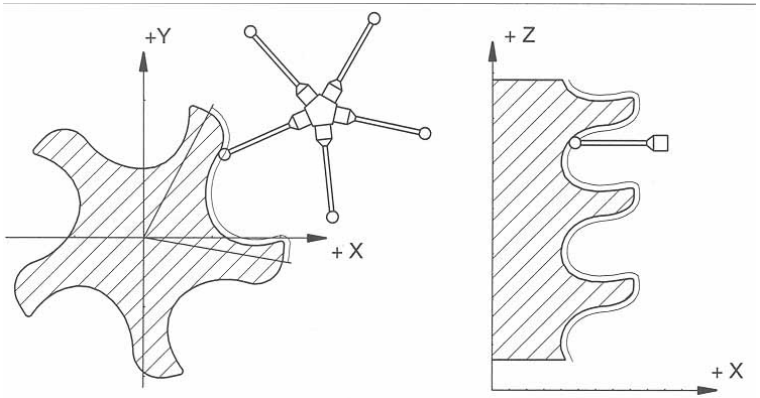


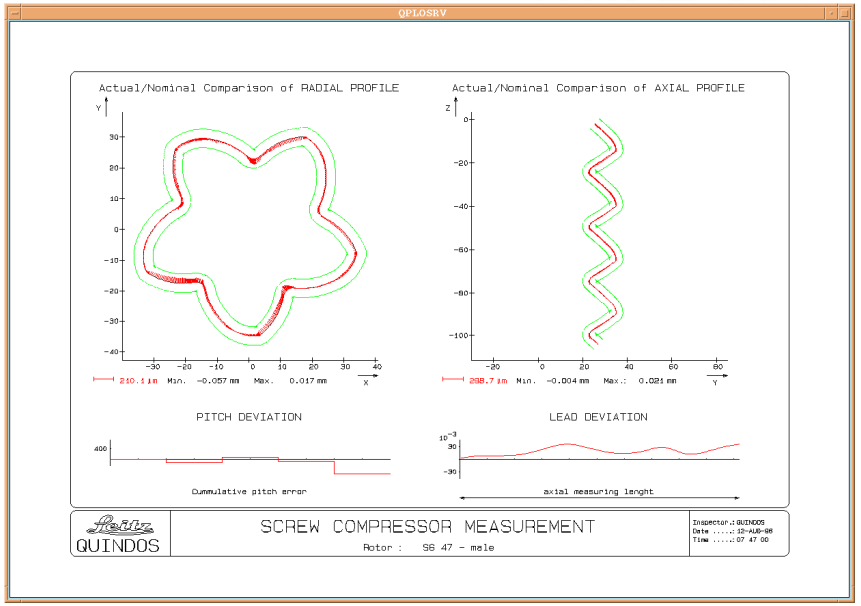
QUINDOS: Pairing of Rotors



HEXAGON METROLOGY

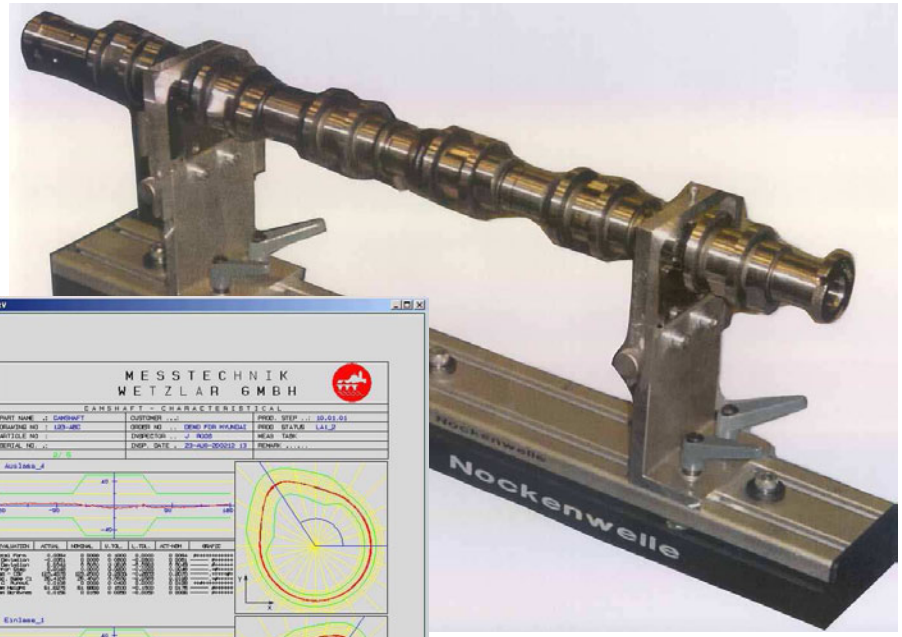
Quindos SCRCMP - Screw Compressor

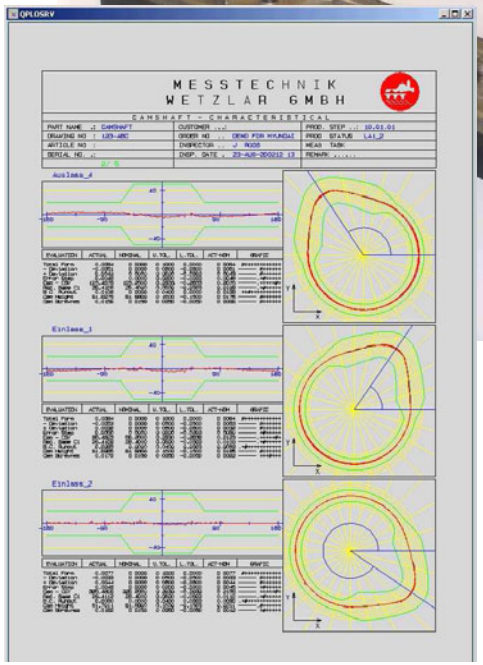




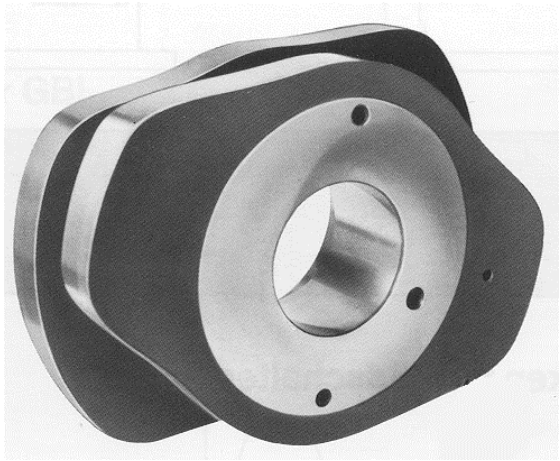
HEXAGON METROLOGY

Quindos Camshaft- Camshafts & Complementary CAMS

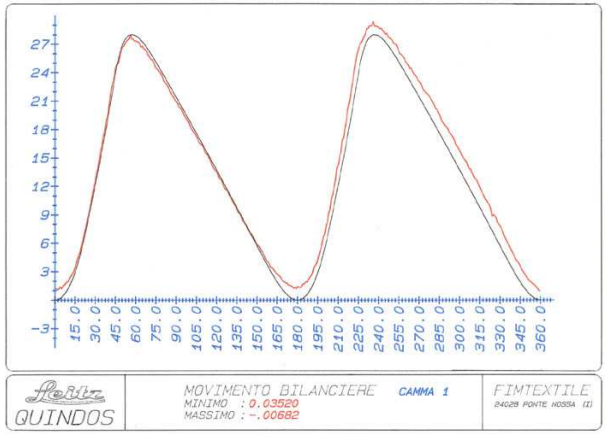




Fully automatic inspection
Of up to 24 Camshafts
On 1 fixture !



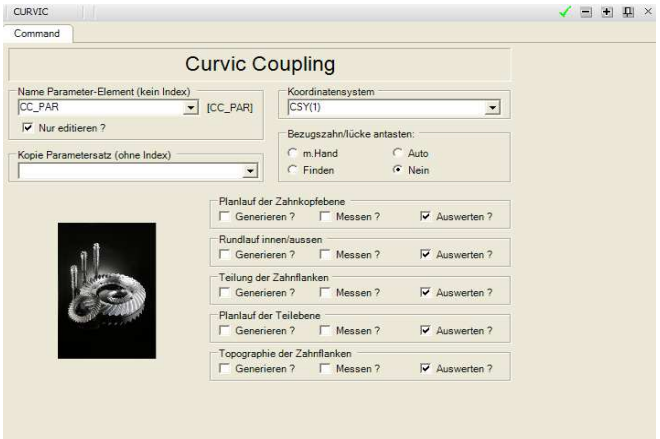
Complementary Cams



HEXAGON METROLOGY

Quindos Curvic Coupling

Toothed gears used for accurate mating & centering of rotating parts. Application: Turbine rotors, Crankshafts



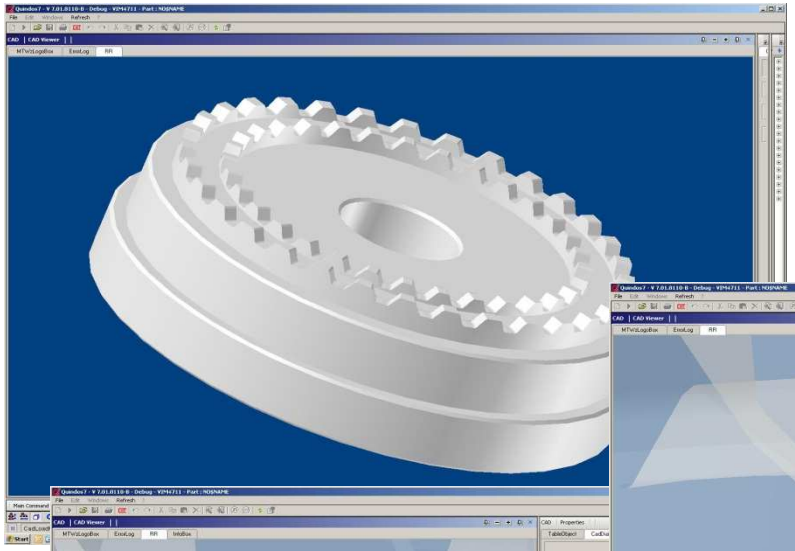
The Quindos Curvic Coupling option can be used to calibrate Curvic Coupling gauges used to check Curvic Coupling parts. The actual geometry is compared to the theoretical geometry in order to determine the pairing characteristics of the Curvic Coupling.

Features:

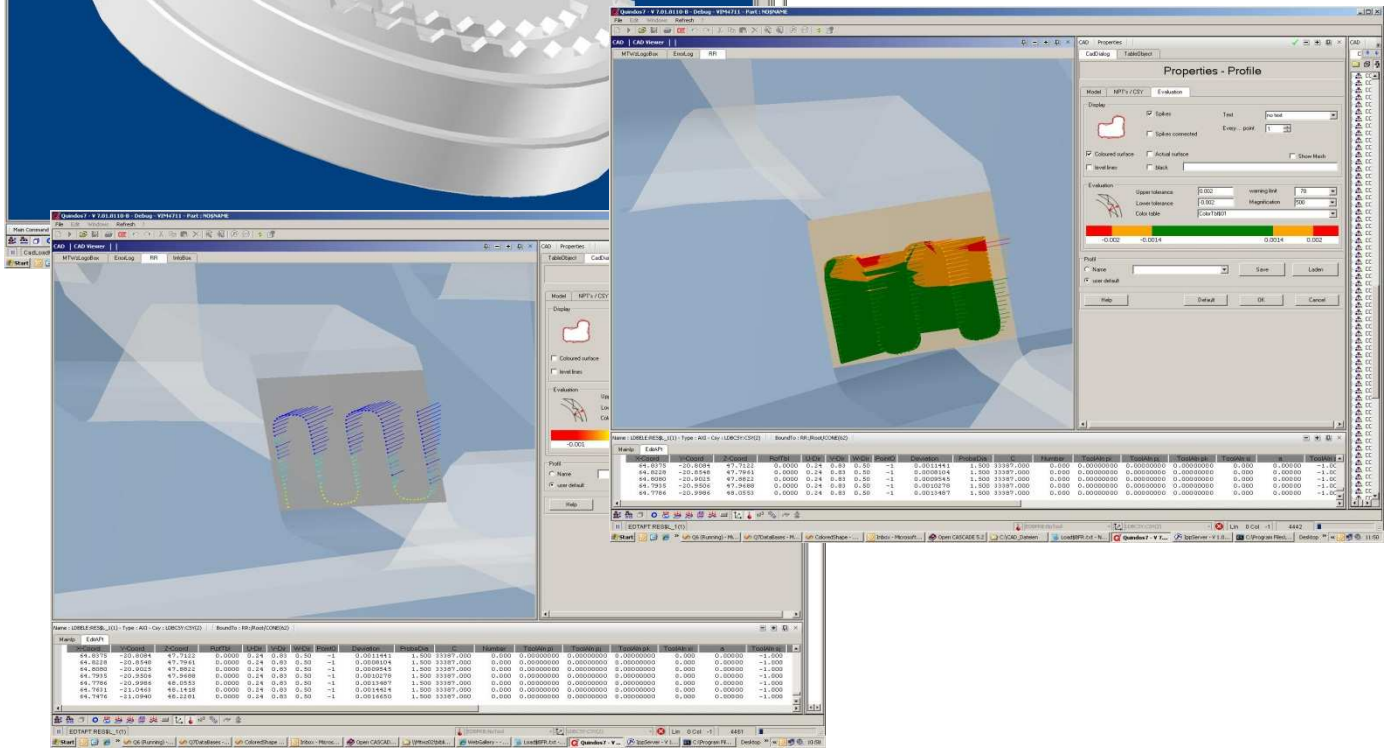
- Axial runout of the tooth face
- Runout of the outside surface of the coupling.
- Pitch of the tooth flanks
- Topography of the tooth flanks
- Simulated pairing with a Curvic coupling master part
- Contact pattern measurement of paring Simulation with CC-Master

HEXAGON METROLOGY

Quindos Curvic Coupling – Evaluation



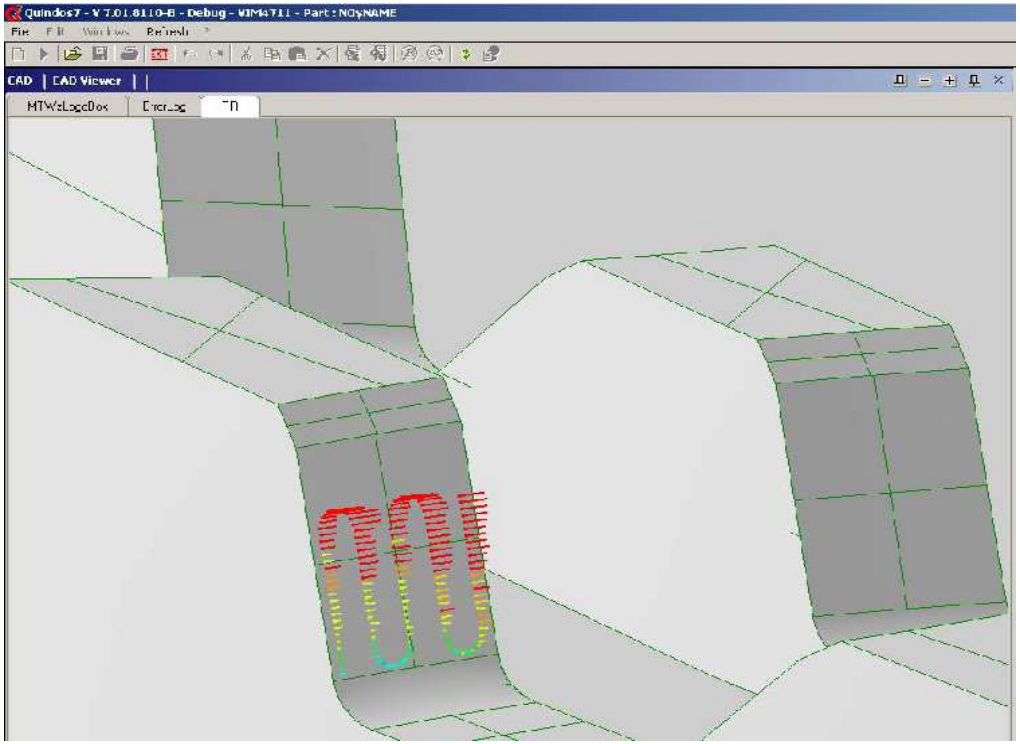
Curvic coupling master model generated in QUINDOS using the curvic coupling data and Quindos CAD



Topography measurement & results representation on the CAD model.

HEXAGON METROLOGY

Quindos Curvic Coupling - Evaluation



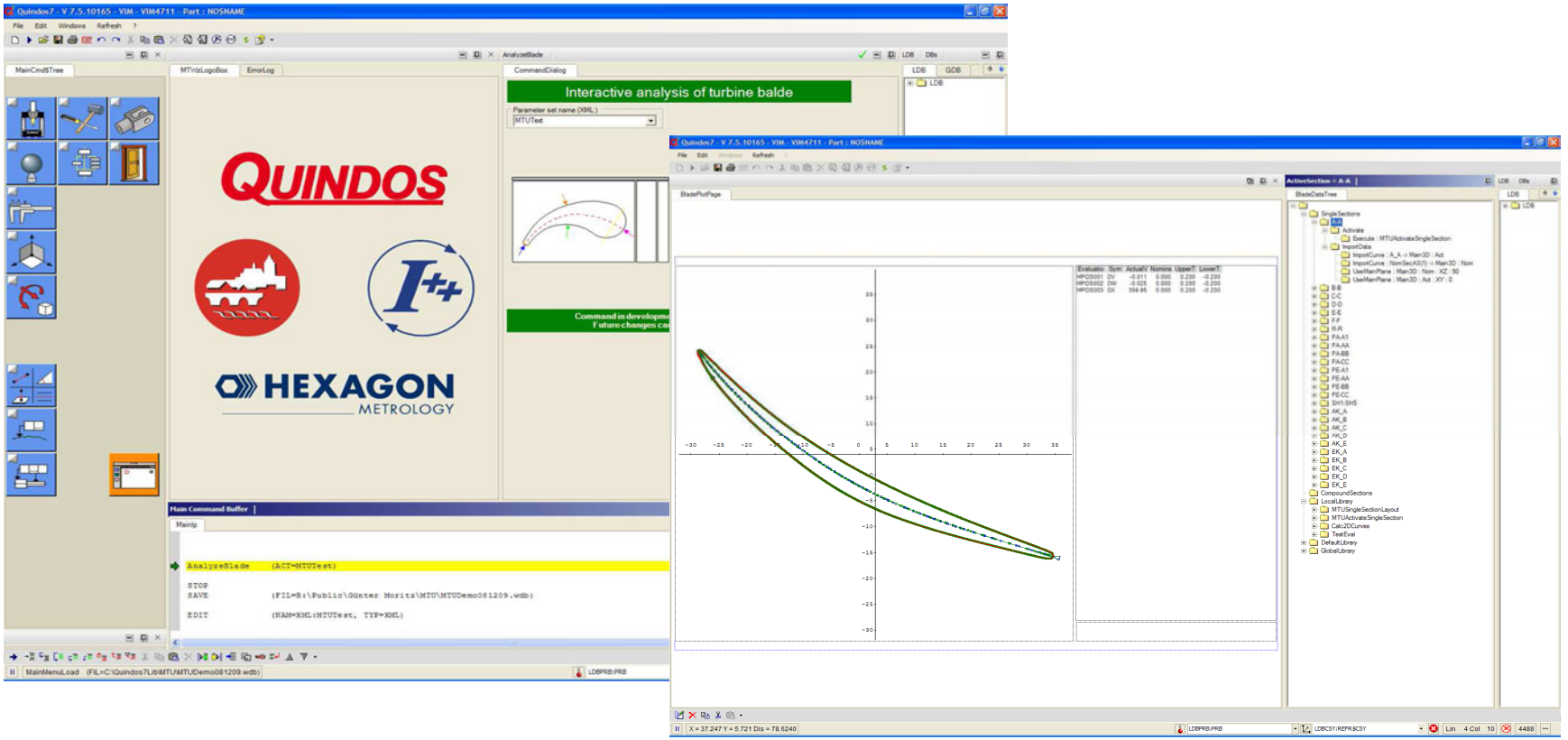
Topography measurement & contact representation

Sweep scanning of the topography is used to determine the contact pattern of the CC to be checked.

All of the flanks are measured in order to determine a true representation of the pairing quality of the curvic coupling with a master coupling. The result of the pairing is the eccentricity, axial runout & radial runout & pairing quality.

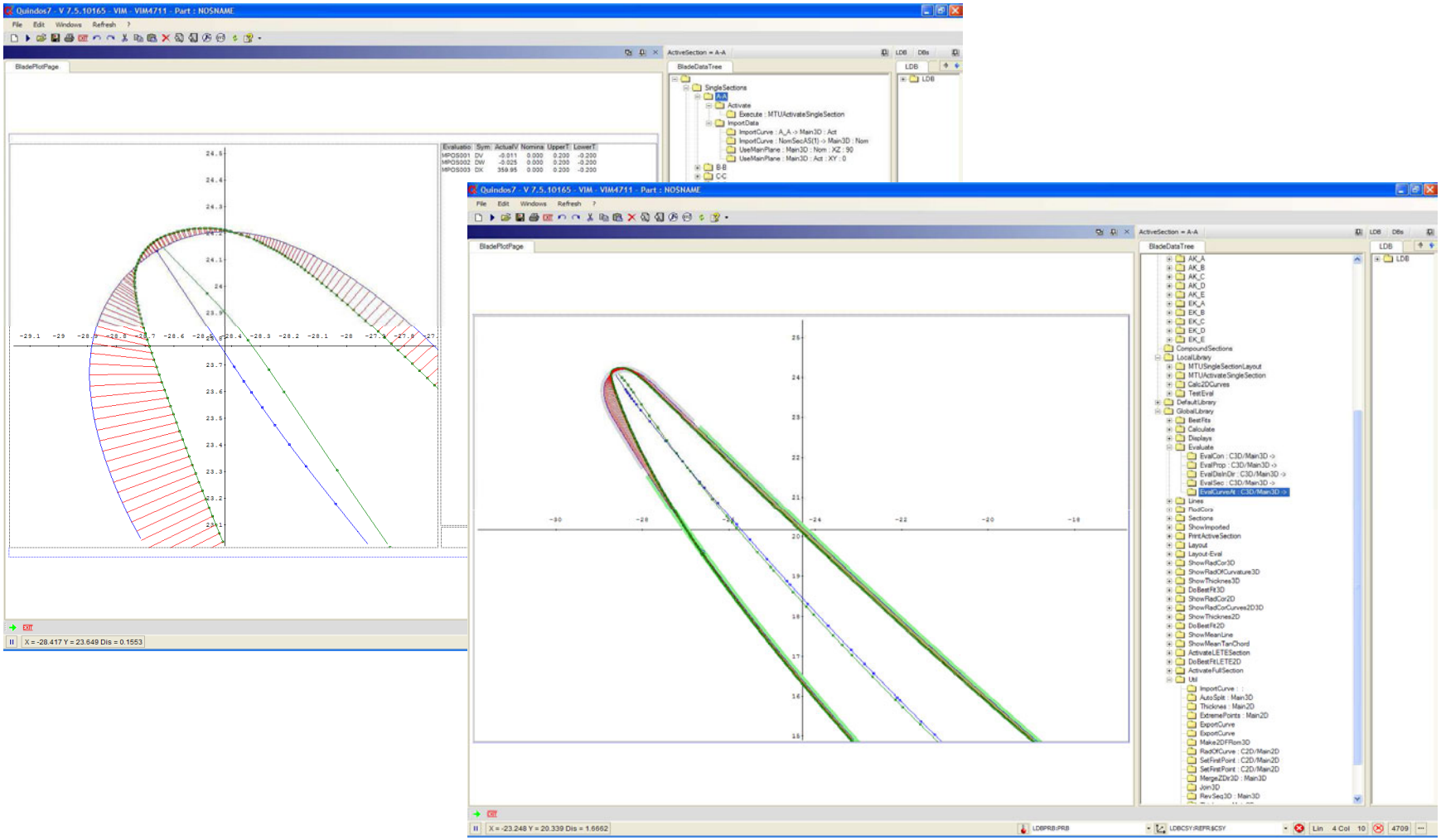
Ultimate Blade

- 2D Visualization and interactive evaluation tool for turbine profiles;
- Parameters can be defined interactive and saved for the CNC mode



HEXAGON METROLOGY

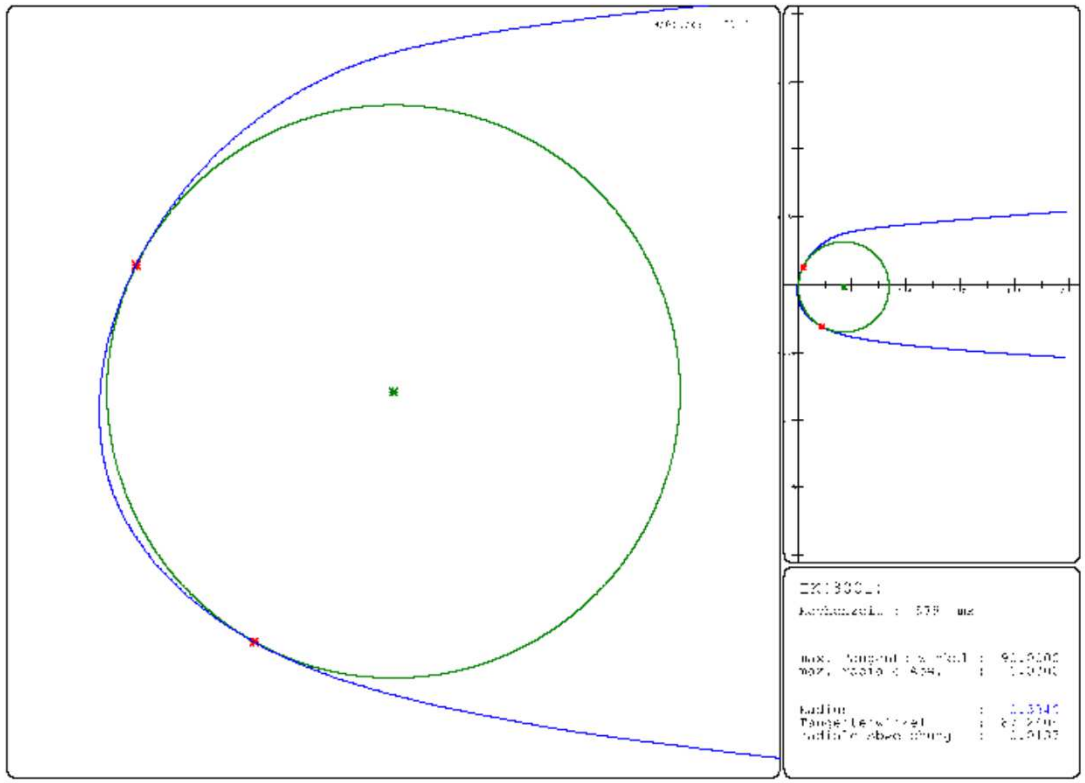
Ultimate Blade



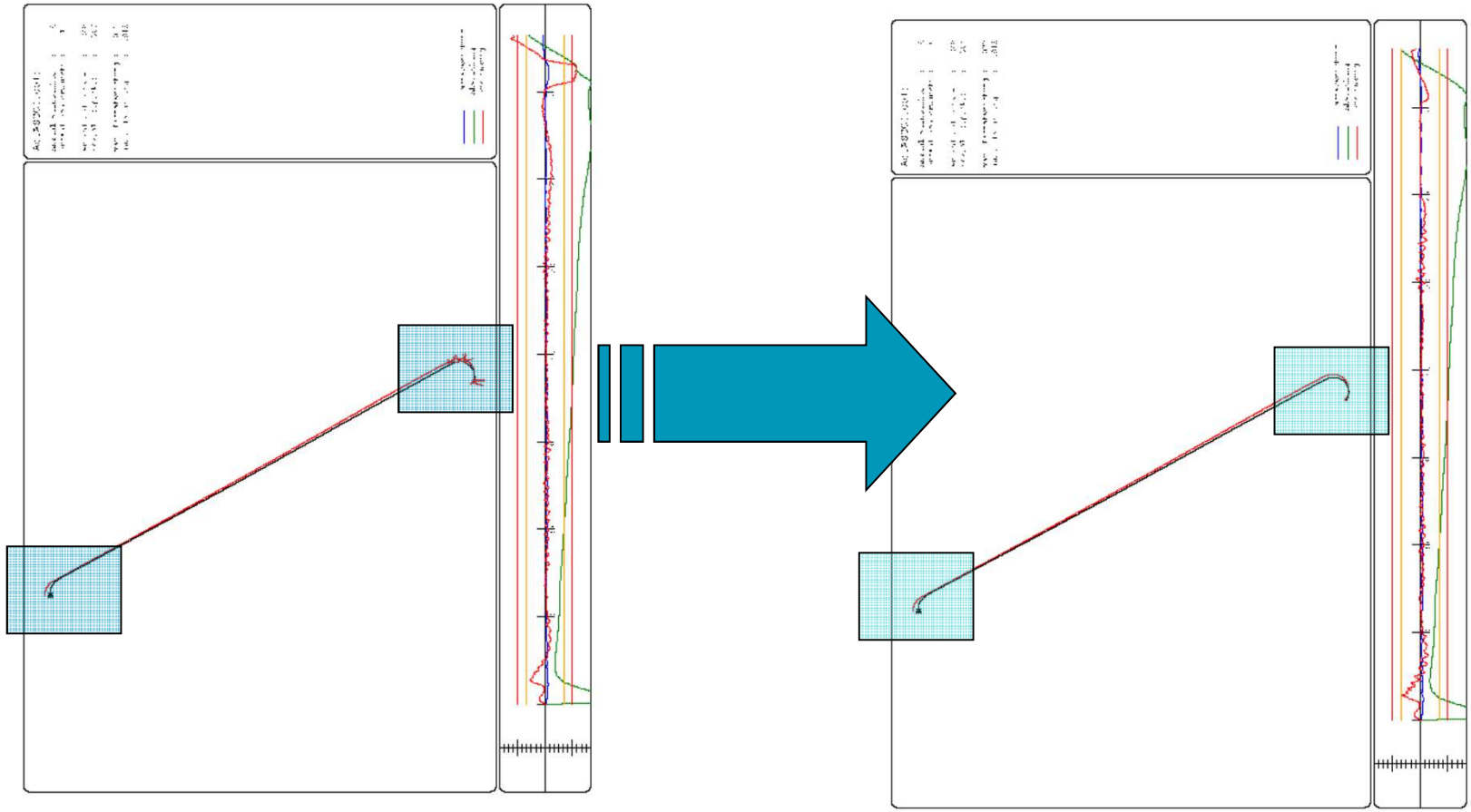
HEXAGON METROLOGY

Ultimate Blade

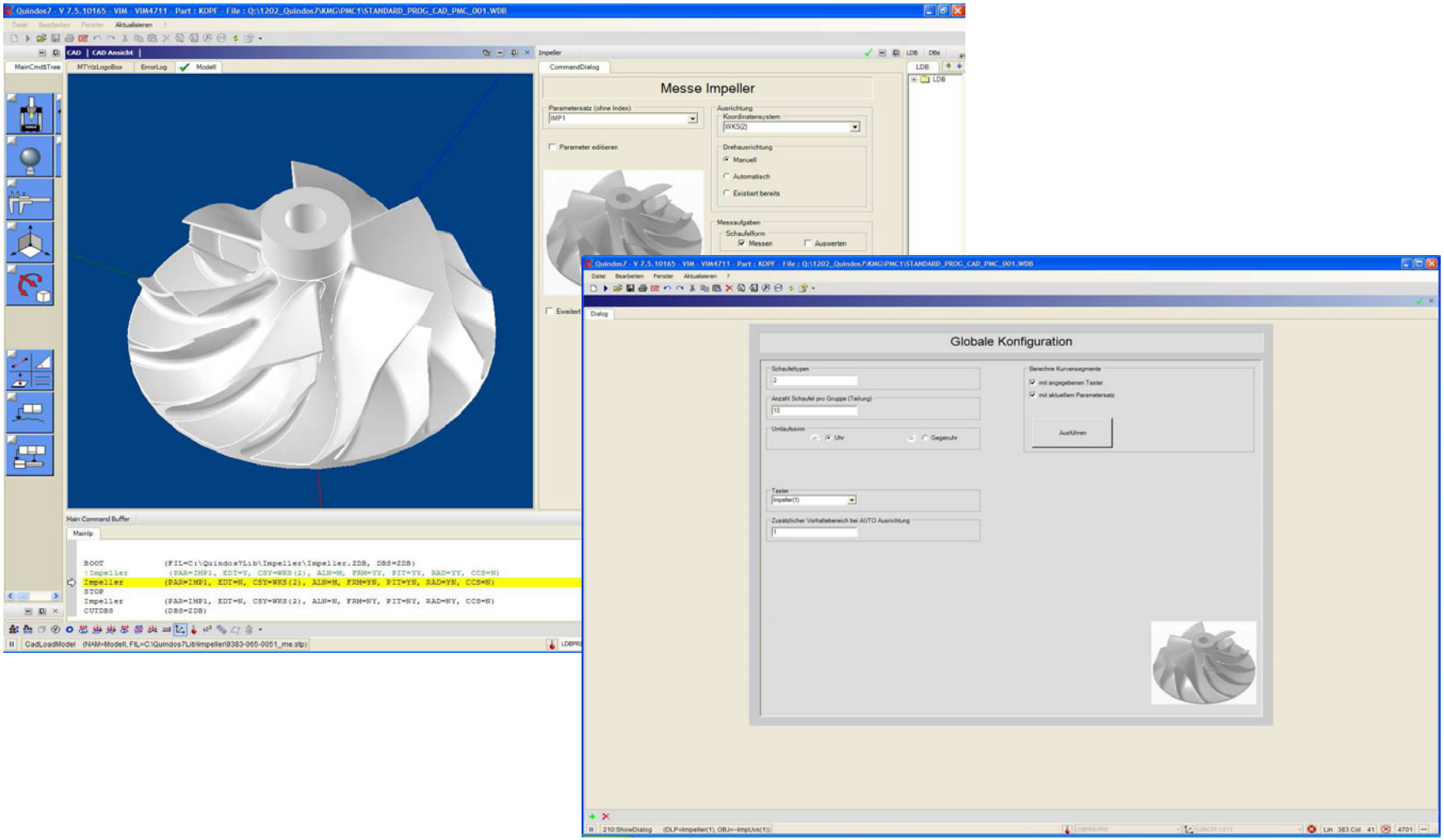
Automatic edge radius recognition.



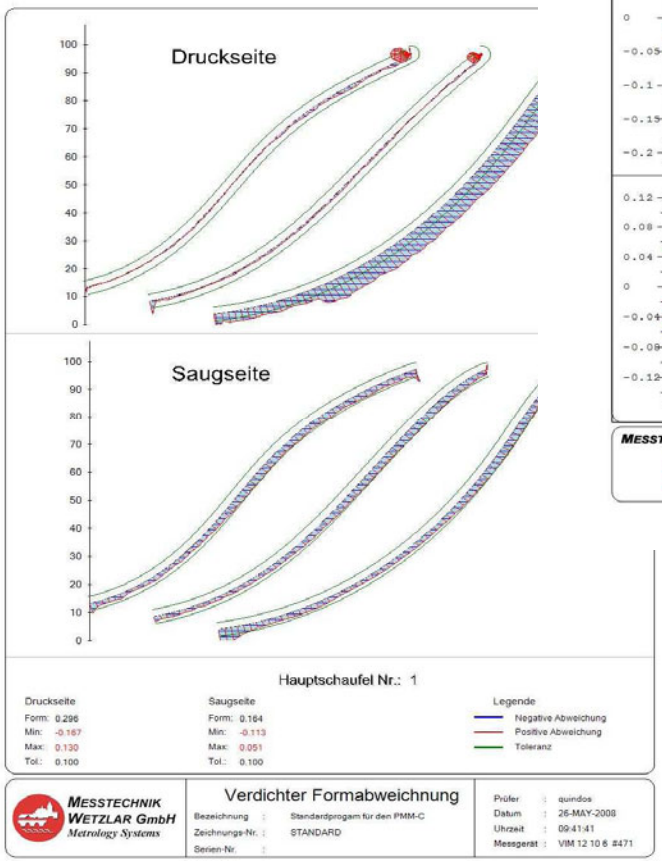
Ultimate Blade– Automatic path correction

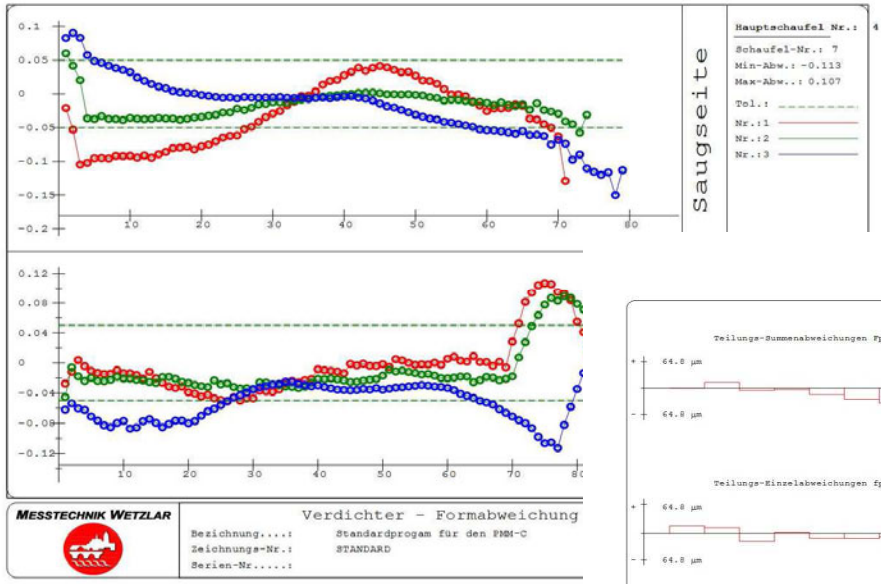


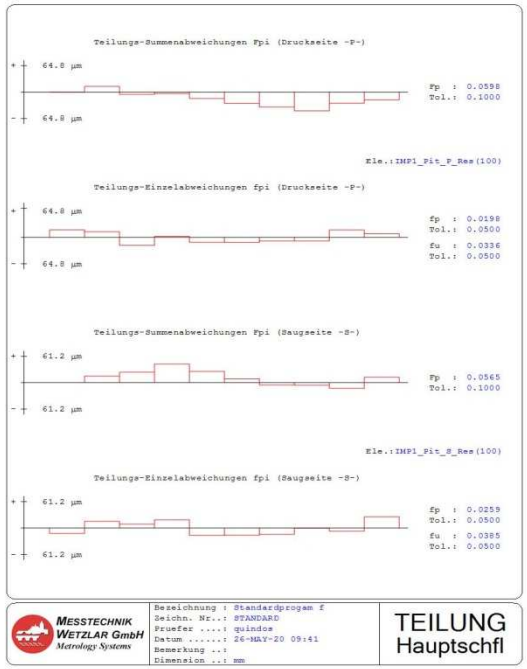
Impeller



Impeller







HEXAGON METROLOGY