ZD Series Gear Measuring Center

I. Product Introduction

ZD series gear measuring center is a novel product series of Harbin Zeada approaching the advanced world level. It adopts 4-axis (X, Y, Z, C) measuring principle, a natural granite base, an integrated layout, a quasi-3D digital scanning probe, a stylus management system based on magnetic adapters, (all-axis) full closed-loop control technologies, hierarchical CNC control techniques, high precision optical encoders, DDR and servo motors, precision roller guides, ball screw transmissions, computerized data acquisition and processing technologies etc. The instrument can automatically and precisely measure profile deviations, helix deviations, pitch deviations, cumulative pitch deviations, runout and other items of involute cylindrical gears (gear clusters, internal gears etc.), gear cutters (hobs, shaping cutters, shaving cutters etc.), worms, worm wheels, spiral (straight) bevel gears etc. Furthermore, it supports extensions such as measuring camshafts, cylindrical workpiece's index and scan tooth contours. ZD series gear measuring center leads the development direction of gear measuring instruments.

1. Main Technical Parameters

Model	ZD20	ZD30	ZD40	ZD50	ZD60	ZD80	ZD100	ZD120	ZD150	ZD200	ZD250	ZD300
Module (mm)	0.2-10	0.2-10	0.5-15	0.5-15	0.5-20	1-20	1-20	1-20	1-32	1-32	1-32	1-32
Max. outer diameter (mm)	250	350	450	550	650	850	1050	1250	1550	2050	2550	3050
Max. vertical measuring distance (mm)	280	330	350	380	450	600	600	600	1000	1000	1000	1000
Max. rolling length (mm)	±70	±90	±120	±140	±180	±230	±280	±280	±300	±300	±300	±300
Distance between centers (mm)	10-500	10-650	10-1000	10-1000	10-1000	10-1200	10-1200	10-1200	10-2000	10-2000	10-2000	10-2000
Helix angle measuring range (°)	0-90											
Max. permissible workpiece weight (kg)	80	150	300	500	500	800	2000	5000	8000	10000	12000	15000
Supply voltage/frequency	220V/50Hz		380V/50Hz									
Supply power (KVA)	3.0					5.0						

2. Measuring Functions

1) Cylindrical gear

1.1 Measuring types

- Standard configuration: spur gear, helical gear, external gear
- Optional configuration: internal gear, involute spline, rectangle spline, triangle spline, circular spline

1.2 Measuring items

- Tooth profile (involute): F_α, ff_α, fH_α, C_α; Lead (helix): F_β, ff_β, fH_β, C_β;
- Pitch (circular pitch): F_p, F_{pk}, f_{pt}, f_u, R_p; Runout: F_r

1.3 Measuring functions

- Standard configuration

- ✧ Workpiece clamping error compensation
- ✧ Contour scanning of tooth root, all teeth measurement, torsion measurement, topography measurement, gear cluster measurement, comparison analysis for heat treatment distortion
- ✧ Segment measurement (block or missed teeth), crowning setting, tip and root reliefs (profile), top and bottom reliefs (helix), K-Chart design (linear, circle, parabola)
- ✧ Statistical analysis
- ✧ Base tangent length, distance over balls, tooth thickness variation

- Optional configuration
  - ✧ Broken tooth surface measuring
  - ✧ Tooth surface definition options
  - ✧ Sign of helix angle error fHβ option
  - ✧ Average curve of profile and lead

1.4 Evaluation standard

- Standard configuration
  - ✧ GB10095, ISO1328, DIN3962, AGMA2000, JISB1702, GB2363, B18-1155, AGMA2015-1-A01
  - ✧ User-defined tolerance
- Optional configuration
  - ✧ GB/T 3478.1, DIN5480, ANSI-B92.1, JIS-B1603

2) Hob

2.1 Measuring types

- Standard configuration: gear hob, worm wheel hob
- Optional configuration: diameter-increasing worm wheel hob, rack hob, worm milling cutter, hob blank

2.2 Measuring items

- Standard configuration
  - ✧ Helix, profile (over cutting edge, behind cutting edge), meshing line, axial pitch, hub face runout, side clearance angle, tooth thickness
  - ✧ Gash lead, gash pitch, form and position of cutting face, tip circle runout, hub radial runout
  - ✧ Tooth profile type: ZA, ZN, ZI
  - ✧ Hob with modification: the protuberance amount

2.3 Evaluation standards

- GB6084, DIN3968, GOST9324
- User-defined tolerance

3) Shaping cutter (standard configuration)

3.1 Measuring types

- Spur shaping cutter, helical shaping cutter

3.2 Measuring items

- Tooth profile (involute): F_α, ff_α, fH_α, C_α; Lead (helix): F_β, ff_β, fH_β, C_β
- Pitch (circular pitch): F_p, F_{pk}, f_{pt}, f_u, R_p; Runout: F_r
- Rake angle at head, draft angle at head, lead of cutting face, runout of cutting face

3.3 Measuring functions

- Segment measurement (block or missed teeth)
- Crowning setting

3.4 Evaluation standards

- DIN1829, GOST10059-80, GB/T6082, JB/T 3095
- User-defined tolerance

4) Shaving cutter (standard configuration)

4.1 Grooving types

- Ring-shaped, spiral

4.2 Measuring items

- Tooth profile (involute): F_α, ff_α, fH_α, C_α; Lead (helix): F_β, ff_β, fH_β, C_β;
- Pitch (circular pitch): F_p, F_{pk}, f_{pt}, f_u, R_p; Runout: F_r
- Serration Measurement

4.3 Measuring functions

- Multi-section modification, Crowning setting

4.4 Evaluation standards

- GB/T 14333-93、GB/T 14333-2008、GB/T 21950-2008、DIN3962、ISO1328
- User-defined tolerance

5) Worm (optional configuration)

5.1 Measuring types

- Single lead worm, double lead worm

5.2 Measuring items

- Tooth profile: F_α, ff_α, fH_α, C_α; Lead (helix): F_β, ff_β, fH_β, C_β, f_{pz}
- Pitch: f_{px}, F_{px}
- hub radial runout, hub face runout: f_{rp}
- Tooth thickness variation R_s
- Tooth profile types: ZA, ZN1, ZN2, ZN3, ZI, ZK, ZC

5.3 Measuring functions

- Crowning setting, multi-start worm set

5.4 Evaluation standards

- DIN3974, AGMA2011, GB10089, GB10227
- User-defined tolerance

6) Worm wheel (optional configuration)

6.1 Measuring types

- Single module worm wheel, double module worm wheel

6.2 Measuring items

- Tooth profile: F_{α}, ff_{α}, fH_{α}, C_{α}
- Pitch (circular pitch): F_p, F_{pk}, f_{pt}, f_u, R_p; Runout: F_r
- Tooth thickness S_n
- Tooth profile types: ZA, ZN1, ZN2, ZN3, ZI, ZK

6.3 Measuring functions

- Segment measurement (block or missed teeth), crowning setting

6.4 Evaluation standards

- DIN3974, AGMA2011, GB10089
- User-defined tolerance

7) Bevel gear (optional configuration)

7.1 Measuring types

- Straight bevel gear, helical bevel gear
- Straight bevel gear mold
- Circular-arc bevel gear (face milling)
- Cycloid bevel gear (face hobbing)

7.2 Measuring items

- Tooth surface topology, pitch (circular pitch), runout F_r, tooth thickness

7.3 Measuring functions

- Calculate corrections for machine settings and/or tool data
- Manual pitch measurement, unknown bevel gear topography measurement etc.

8) Circular-arc **bevel gear milling cutter (optional configuration)**

- Measuring items (outer cutter, inner cutter): Point diameter, cutter space, profile form deviation, tooth profile angle, circular pitch, runout of side cutting edge, runout of top cutting edge, hub face runout

9) Cylindrical workpiece's index measuring software (optional configuration)

- Measuring items: Pitch (circular pitch) of elements distributed uniformly on a cylinder

10) Rack software (optional configuration)

- Measuring types: spur rack, helical rack
- Measuring items: tooth profile, tooth lead, pitch

11) Camshaft (optional configuration)

12) Contour scanning (optional configuration)

3. Main Precision Indices

No.	Item	Accuracy Requirement	Verification Tool
1	Circular runout of top center and bottom center	0.002 mm	a. 1 μm mikrokator b. Magnetic stand

2	Parallelism between probe and ligature of two centers	Front surface: 0.004 mm / 300 mm Side surface: 0.003mm / 300 mm	a. 1 μm mikrokator b. Magnetic stand c. Precision mandrel (300 mm)
3	Concentricity between two centers	0.002 mm / 50 mm 0.004 mm / 300 mm	a. 1 μm indicator b. Magnetic stand c. Precision mandrel d. (50mm, 300 mm)
4	Accuracy error of profile and helix deviations	Profile: 0.002 mm Helix: 0.002 mm	Master
5	Repeatability of profile and helix deviations	Profile: 0.001 mm Helix: 0.001 mm	Master
6	Repeatability of pitch deviation	Pitch: 0.002 mm	Standard gear

4. Hardware Introduction (hardware configuration see attached Table 1)

1) **Stable host system:** The instrument consists of a natural granite (or precise cast iron) base; a CNC rotary axis (C) with a DDR motor, precision ball bearing and high-resolution optical encoders; three linear axes (X, Y, Z) with AC servo drive units, ball screw transmissions, THK and linear roller guides and precision linear optical encoders; a workpiece guide with a precision linear guide. The tail stock (G axis) utilizes ball screw transmission and is driven by an AC servo motor. It automatically stops when reaching the measuring position.
2) **Advanced quasi-3D digital probe system:** Zeada has patented technology for the (quasi-)3D digital probe system. The probe system supports measurements simultaneously using any two measuring directions (XY, XZ, YZ). Measurements simultaneously using all three measuring directions (XYZ) are not supported. The probe system uses precision optical encoders (RENISHAW) in measuring directions, offering stable signals against interference. The stylus has a 3-point magnetic adapter for fixation, enabling easy stylus replacements and offering high positioning repeatability. There are electronic limits and mechanical out-of-limit protections in X/Y/Z-directions. Additionally, the probe can be locked separately or combined in X/Y/Z-directions. The probe system satisfies various requirements in gear and gear cutter measuring.
3) **International stylus management system:** The instrument adopts a stylus management system used worldwide on high-end gear measuring centers. Every stylus and measuring rod are pre-calibrated for distortion corrections. The tangential, vertical and radial calibration data

are automatically saved, avoiding needs for frequent re-calibrations. Styli can be replaced through their 3-point magnetic adapters. The stylus management system is integrated and offers precautionary information.

4) **Reliable encoders as positioning references:** HEIDENHAIN (Germany) and RENISHAW (UK) encoders with high accuracy and stability are adopted as positioning references, offering high measuring precision, stability and reliability.
5) **Precise control and data acquisition system:** With IMAC-LX (Delta Tau, USA) controllers, the control system is (all-axis) full closed-loop. All linear axes utilize AC servo motors. The rotary axis utilizes a direct drive rotary (DDR) motor. The coordination of IMAC-LX controllers and DDL, AC servo motors enables (all-axis) full closed-loop control and complete data acquisition on measuring positions. All measuring actions are completed automatically.
6) **Unique hierarchical control techniques:** The instrument adopts hierarchical control techniques. All movements with high real-time requirements are accomplished in the lower control layer, while data acquisition, calculation, processing, display and printing are accomplished with a computer in the upper control layer. Such work division enhances the reliability, efficiency and measuring speed of the instrument, offering possibilities for any measuring process.

5. Software Introduction

Zeada gear measuring software has the following features:

1) **Full-automatic measurement:** After parameter input, all measurements, data acquisition, error compensation (compensation of loading and guide errors), data evaluation and result output are completed automatically.
2) **High-density uniform sampling:** All measurements of ZD series have a uniform sampling interval of 0.02 mm. Data processing, display and printing are all based on this sampling technique, enabling the inspection of real tooth surface conditions.
3) **User-friendly interfaces:** Zeada software completes many operations through functional buttons, such as parameter input, measuring mode setting, error evaluation selection, parameter saving and loading, measuring result display etc. The clearly annotated functional keys on the keyboard simplifies measuring operations even more.
4) **Automatic calculation:** The software automatically calculates measuring and evaluation lengths according to basic gear parameters (number of teeth, module, pressure angle, helix angle, modification coefficient etc.). Length scale and error scale can be set automatically and manually. The computer automatically and accurately computes measuring and evaluation positions. The evaluation position of tooth profile can be computed with three methods: tip and root circle, matching gear and standard rack. The evaluation ranges can also be manually adjusted according to drawings or measuring requirements.
5) **Compensation of eccentricity error in clamping:** When clamping a workpiece, the datum

axis of the workpiece sometimes does not coincide with the rotation axis of the instrument. Zeada software can detect the eccentricity and deflection error in clamping and add compensations accordingly in measuring motions and measuring result evaluations. This technology is especially important for the measuring of internal gears and other workpieces without center holes for fixation. Zeada is the first company in China mastering this technology, greatly improved the measuring accuracy and efficiency of Zeada's gear measuring centers.

6) **Multiple evaluation systems:** Profile, helix and pitch can be evaluated according to GB, ISO, DIN, AGMA, JIS and GOST standards.
7) **Special functions:** All teeth measurement, segment measurement (block or missed teeth), comparison analysis for heat treatment distortion, torsion measurement, topography measurement, automatic unknown gear measurement etc.
8) **Customization possible:** We can offer customized software and report formats according to requirements.

II. Standard Configuration

The standard configuration includes the following parts. The actual configuration might differ from the standard configuration due to custom requirements. The actual configuration is specified in the technical agreement.

1. Measuring machine ---------- 1 set
2. Computer ---------- 1 set
3. Laser printer ---------- 1 piece
4. Printing paper ---------- 1 package
5. Operation manuals ---------- 1 set
6. Standard accessories
   - 6.1 Drive device ---------- 1 set
   - 6.2 Standard mandrel ---------- 1 piece
   - 6.3 Mikrokator ---------- 1 piece
   - 6.4 Allen wrench ---------- 1 piece
   - 6.5 Packing list ---------- 1 piece
   - 6.6 Accessory case ---------- 1 piece
7. Digital probe components
   - 7.1 Replaceable probe Φ0.5 ---------- 2 pieces
   - 7.2 Φ1 ---------- 2 piece
   - 7.3 Φ1.5 ---------- 2 pieces
   - 7.4 Φ2 ---------- 2 pieces
   - 7.5 Φ3 ---------- 2 pieces
   - 7.6 Magnetic adapter plate ---------- 3 sets
   - 7.7 Extension rods and linking parts ---------- 1 set

7.8 Probe component box ---------- 1 piece

8. Measuring software

8.1 Cylindrical gear measuring software ---------- 1 set

8.2 Shaping cutter measuring software ---------- 1 set

8.3 Shaving cutter measuring software ---------- 1 set

8.4 Hob measuring software ---------- 1 set

III. Optional Hardware and Software

1. Master
2. Three jaw chuck with connection plate
3. Internal gear measuring software
4. Non-involute spline measuring software
5. Worm measuring software
6. Worm wheel measuring software
7. Straight bevel gear measuring software
8. Straight bevel gear mold measuring software
9. Circular-arc bevel gear measuring software
10. Worm milling cutter measuring software
11. Rack hob (ring) measuring software
12. Circular-arc bevel gear milling cutter measuring software
13. Cylindrical workpiece's index measuring software
14. Rack measuring software
15. Special workpiece measuring software

IV. Requirements on Machine Installation and Environment

1. The installation foundation should be firm, flat and away from vibration source;
2. The instrument uses a two-phase AC 220V/50Hz (±5%) (or three-phase AC 380V/50Hz (±5%)) power supply. The user should equip the instrument with a two-phase (or three-phase) 3KW (or 5KW) stabilized voltage supply;
3. The environment should be free from electromagnetic interference. The instrument must be grounded;
4. The instrument should be used in metrology rooms. The environment should be kept at a constant temperature of 22±0.5℃; The environment humidity should be kept between 35%-65%.

V. Installation, Acceptance

1. Instrument packing box can only be opened under the supervision and approval of the technical personnel of the manufacturer;
2. After the completion of the instrument installation and adjustment, both parties should be jointly responsible for the on-site acceptance according to the main precision indices specified

in section I. 3. A Final Acceptance Report should be signed by both parties upon completion of the acceptance;

VI. Quality Assurance

The warranty period of the instrument is one year.

Table 1: Hardware configuration of ZD series gear measuring center

No.	Item	Model	Manufacturer/Area	Remarks
1	Guide	Zeada-made SSR series	Zeada/China THK/Japan	
2	Servo motor for linear axis	MINAS A6	Panasonic/Japan	
3	Drive for linear axis	MINAS A6	Panasonic/Japan	
4	Direct drive motor for rotary axis	KBM series	Kollmorgen/USA	
5	Drive for rotary axis	CDHD	SERVOTRONIX/Israel	
6	Servo motor for G axis (tailstock)	MINAS A6	Panasonic/Japan	
7	Servo drive for G axis (tailstock)	MINAS A6	Panasonic/Japan	
8	Rotary encoder	RON series	HEIDENHAIN/Germany	
9	Linear encoder	RGH series	RENISHAW/UK	
10	Numerical control system	IMAC-LX	Delta Tau/USA	
11	Gathering system	IMAC-LX	Delta Tau/USA	
12	Limit switch	E2E series	OMRON/Japan	
13	Encoders in the probe system	RGH series	RENISHAW/UK	The probe system is Zeada-patented
14	Computer		DELL	
15	Printer	HP CANON	HP/USA CANON/Japan	