Double flank gear roll inspection machines

The simple functional inspection
The basic principle of the double flank gear roll inspection is that a master gear (nearly perfect gear) and a workpiece gear are meshing free from backlash. One axis of rotation is mounted firmly and the other is mounted in a floating manner. The variations in distance when rolling the two gears are detected and form the basis for the evaluation of the gear profile with respect to the existing composite error caused by production.

When used with modern evaluation solutions such as a PC, hardware and software, the double flank gear roll inspection proves to be an efficient means of controlling the quality in a quick and easy way.

Advantages of Frenco’s double flank gear roll inspection machines:

- Stable machines for the shop floor use.
- Customer-specific design: The machines are perfectly adjusted to the specimen to be measured and to the conditions of measurement.
- The measuring force is infinitely variable.
- Rapid lift-off of the measurement carriage.
- Using non-rotating tips and mounting mandrels, the runout deviation is kept low.
- Special master gear pair for calibration.
- With the evaluation software 'FGI pro' being in-house developed, quick support is available should any issues arise.
- The master gears are manufactured in-house at FRENCO in Altdorf, Germany.
- On request, we can upgrade older double flank gear roll inspection machines with FRENCO measurement electronics and the FGI evaluation software.
Measurement of Geometries

spur gears

helical gears

worms

pinion and gear

pinion and worm

oil pump gear
Product Overview

ZWP 06

ZWP 14/24

ZWP 18

ZWP 30
<table>
<thead>
<tr>
<th>Features</th>
<th>ZWP 06</th>
<th>ZWP 14/24*</th>
<th>ZWP 18</th>
<th>ZWP 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centre distance</td>
<td>12 – 85 mm</td>
<td>12 – 85 mm</td>
<td>45 – 170 mm</td>
<td>45 – 170 (280)* mm</td>
</tr>
<tr>
<td>Centre distance with adapter for small centre distances</td>
<td>1 mm</td>
<td>1 mm</td>
<td>15 mm</td>
<td>15 mm</td>
</tr>
<tr>
<td>Max. diameter of specimen with steady centre attachment 3</td>
<td>80 mm</td>
<td>80 mm</td>
<td>400 mm</td>
<td>160 mm</td>
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<tr>
<td>Max. diameter of specimen with extension adapter</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Centre height size 1</td>
<td>-</td>
<td>40–100</td>
<td>-</td>
<td>60 – 220</td>
</tr>
<tr>
<td>Centre height size 2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>220 - 360</td>
</tr>
<tr>
<td>Centre height size 3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0 - 420</td>
</tr>
<tr>
<td>Range for height adjustable single end mounting</td>
<td>possible within limits</td>
<td>-</td>
<td>on request</td>
<td>-</td>
</tr>
<tr>
<td>2. steady centre attachment</td>
<td>no</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Adjustment of measuring force</td>
<td>0 – 5 N</td>
<td>possible within limits</td>
<td>0 – 20 N</td>
<td>0 – 50 N</td>
</tr>
<tr>
<td>Optional glass scale</td>
<td>yes</td>
<td>-</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Optional sensor for corrections of deviations of master gears</td>
<td>on request</td>
<td>yes</td>
<td>on request</td>
<td>on request</td>
</tr>
<tr>
<td>Range of application</td>
<td>small workpieces and plastic gears</td>
<td>large workpieces; robust for shop floor use</td>
<td>medium-sized workpieces; suitable for inspection laboratories</td>
<td>large wheels, worms and shafts, designed for heavy weights</td>
</tr>
<tr>
<td>Motor drive</td>
<td>standard</td>
<td>optional</td>
<td>standard</td>
<td>optional</td>
</tr>
<tr>
<td>Manual operation</td>
<td>-</td>
<td>yes</td>
<td>-</td>
<td>yes</td>
</tr>
<tr>
<td>Motor drive with 2. steady centre attachment</td>
<td>-</td>
<td>-</td>
<td>yes</td>
<td>optional</td>
</tr>
<tr>
<td>Manual operation with 2. steady centre attachment</td>
<td>-</td>
<td>yes</td>
<td>-</td>
<td>optional</td>
</tr>
</tbody>
</table>

*Version ZWP 24 is identical to ZWP 14, but has a larger machine base.*
ZWP 06

The universal measuring machine for small yet highly precise gears

The double flank gear roll inspection machine is specially designed for small high-precision gears. It is also suitable for plastic gears. The measuring force can be lowered to 0 N.

The sophisticated design is extraordinarily precise and sensitive. The measuring carriage is supported free from backlash on four leaf springs. This so-called parallelogram suspension is very sensitive and registers even the smallest change in centre distance.

The measurement process is motor driven by default. We recommend the FRENCO Software ‘FGI pro’ for the evaluation. This will enable you to control the quality of your workpieces easily, efficiently and reliably.

An extensive range of accessories meets all requirements.
Accessories

steady centre attachment

s = 40 - 100 mm
a = 40 mm

d = 0.6 - 8 mm

adapter for small centre distances

s = 15 - 50 mm
a = 20 mm

fixture for internal gears and splines

d = 8 mm
e = 60 mm

pivoting fixture

s = 15 - 50 mm
a = 16 mm
ZWP 14
Simple, robust, designed for shop-floor use

The ZWP 14 is the most robust double flank gear roll inspection machine of this product family and ideal for use on the shop-floor.

This machine can be driven manually or by motor. The centre distance can be adjusted manually via an adjustable adapter disc.

The measurement results are displayed on a dial indicator. An evaluation using our electronic measuring device MEG 32 is only possible if the machine is motorised.

The extensive range of accessories allows an individual customization to your requirements. Individual solutions for your measuring tasks are also possible.
Accessories

steady centre attachment small
\[ s_{\text{MAX}} = 370 \text{ mm} \]

steady centre attachment large
\[ s_{\text{MAX}} = 420 \text{ mm} \]

centre fixture to mount the workpiece only
\[ s_{\text{MAX}} = 140 \text{ mm} \]

Pivoting support for worms and worm gears
\[ s_{\text{MAX}} = 150 \text{ mm} \]
\[ w = \pm 45^\circ \]

Fixed support for worms and worm gears (symmetrical or asymmetrical)
\[ s_{\text{MAX}} = 250 \text{ mm} \]

Height adjustable adapter to measure worms
Stoke = 100 mm

Adjustable quill

Fine adjustment for accurate measuring force

Adapter for small centre distances
\[ d = 1-16 \text{ mm} \]
\[ d = 4-22 \text{ mm} \]
ZWP 18

Highest precision and comfortable handling

The high quality ZWP 18 (previous 898) features a sophisticated setup and allows high precision measurements.

The centre distance can be changed easily and quickly by adjusting the measuring carriage with a hand-wheel. The adjustable mandrels allow simple and convenient adjustment of the height of the gears to be inspected. Many accessory items can easily be attached to the instrument.

The drive motor is integrated in the device. To ensure highest precision, the measuring carriages are mounted on very smooth running guideways.
Accessories

steady centre attachment
\[ s_{\text{MAX}} = 370 \text{ mm} \]

Centre fixture
to mount the workpiece only
\[ s_{\text{MAX}} = 140 \text{ mm} \]

Pivoting support for
worms and worm gears
\[ s_{\text{MAX}} = 150 \text{ mm} \]
\[ w = \pm 45^\circ \]

Fixed support for
worms and worm gears
(symmetrical or asymmetrical)
\[ s_{\text{MAX}} = 250 \text{ mm} \]

Mounting for internal gear
and spline measurements

Adapter for small centre distances
\[ e_{\text{MIN}} = 16 \text{ mm} \]
\[ e_{\text{MIN}} = 22 \text{ mm} \]
ZWP 30

The specialist for large gear wheels, shafts and worms

With ZWP 30 it is possible to measure gears and splines with a pitch circle diameter of up to 550 mm and shafts with a length of up to 600 mm.

The design is stable and optimized for the shop-floor use. The workpieces’ large dimensions and heavy weight require special components to be installed.

A granite machine bed forms the base of the ZWP 30 onto which the measurement carriage and mounting attachments for the workpiece and master gear are installed. Despite heavy weight loads, it is important for the measurement carriage to move smoothly, precisely and free from backlash, which is ensured by the cross roller guides.

The changeover for the inspection of other specimens is easily and quickly to handle. Depending on the customer’s requirement, the measurements are carried out manually or automatically. The evaluation is carried out via a dial indicator or FRENCO’s FGI pro software.
Software

The software FGI pro includes both, the control of the drive and the evaluation of data. The software is in-house developed and programmed by our specialists for applications software. With the actual values being marked in colour, the specimen can quickly be evaluated as ‘Pass’ (green) or ‘Fail’ (red).

The software determines the following values:
- total radial composite deviation \( F_i'' \)
- tooth-to-tooth radial composite deviation \( f_i'' \)
- runout deviation by composite test \( F_r'' \)
- short-wave component \( f_k'' \)

Additionally, when machine has been calibrated:
- centre distance \( A_a'' \)
- dimension over balls \( M_dK \)
- tooth thickness \( S_n \)
- span size \( W_k \)

Further software properties:

- Easy input and amending of inspection options
- After the inspection, the workpiece will be turned to the position of maximum deviation (values are selectable)
- Language features:
  - German, English, Spanish, French, Portuguese, Polish, Hungarian and Chinese are available
  - Language of the program and output language can be selected freely (Unicode support)
  - Easy data exchange when corporate languages are different
- Archiving function: every single measurement data is saved
- Central, statistical analysis due to interfaces (qs-STAT®, CASQ-it 9000 and internal Ethernet-systems)
Retrofit

FRENCO retrofits earlier double flank gear roll inspection testers with the powerful measuring electronics MEG32 and the evaluation software FGI. The upgrade is ideal for devices with manual evaluation, pen recorder or earlier electronics.

For retrofitting, please send the machine to FRENCO GmbH. The device will be dismantled, cleaned and smaller repairs will be carried out. Furthermore, probe and motor will be replaced and an emergency-stop button will be installed (unless one is already installed).

The double flank gear roll tester will be completely refurbished!

The following devices can be retrofitted:
- Mahr 894B, 896B, 898B, 898C
- Hommel ZWG8305, ZWG8315
- Höfler ZW300
- other types on request
Calibration

If the actual centre distance is to be measured, it is necessary to calibrate the machine with known centre distances. The easiest way to do that is by using shafts, discs and gauge blocks.

It is also possible to use 2 master gears.
Traceability

The Physikalisch-Technische Bundesanstalt (PTB, the national metrology institute in Germany) does not offer traceability for double flank gear rolling inspection parameters. This means that the PTB does not calibrate $F_i''$, $f_i''$, $F_r''$ or $f_k''$.

FRENCO is probably the only company worldwide that is able to calibrate the gear and double flank gear rolling tester parameters $F_i''$, $f_i''$, $F_r''$ and $f_k''$.

To this end, a highly precise limit calibration set MPE, consisting of 5 master gears, was measured under calibration conditions approximately 2,000 times on 75 different double flank gear rolling testers from around the world.

All measurement results were analysed using statistical methods, rogue results eliminated and arithmetic mean values and intervention limits calculated.

Finally, the calibration values $F_i''$, $f_i''$, $F_r''$, $f_k''$ and the measurement uncertainties $U_F''$, $U_f''$, $U_F r''$ and $U_f k''$ can now be calculated using these values.

There are 12 such limit calibration sets MPE worldwide, five of which, with various geometries, are held by FRENCO.

The principle for determining the calibration values and measurement uncertainties

**What is it used for?**

- Calibration of Double Flank Gear Rolling Testers (ZWP)
- Evaluation of ZWP
- Determination of measurement uncertainty of ZWP
- Conformity assessment (Fail/Pass)
Calibration set MPE

A complete calibration of double flank gear roll inspection machines is **only possible with a limit calibration set MPE**. Such a set consists of 5 master gears.

The **reference master gear** is the reference gear. It has got no modifications. Tooth No. 1 is marked. The four other master gears are rolled, measured and logged against tooth 1.

The **Fr - master** has got a radial run-out which presents itself as a long-wave sinusoidal Fr’’ deviation.

The **fi' - master** has got variations in tooth thickness, which cause a short-wave Fi’’ deviation.

The centre distance is calibrated with the **setting master centre distance**.

The **check master** has got a differing tooth thickness from that of the setting master centre distance. The deviation of the centre distance thereby caused has got a nominal size, which should present itself as the actual size during calibration. Deviations in the scale and linearity can thus be detected.

After every final inspection, maintenance and service a calibration certificate is issued containing all deviations. This certificate can be used as the basis for wear inspections, audits and certifications.
The **measurement uncertainty** of a double flank gear rolling tester can be determined using the calibrated **limit calibration set MPE**. The standardised method $U_{MS}$ in accordance to VDA-5 is applied.

Parameters and tolerances that are used as the basis will be agreed with the customer.

The following parameters:
- diametral dimension over/between balls
- tooth thickness
- centre distance

are directly traced, and the determined measurement uncertainties are directly based on the dimension of the Physikalisch-Technische Bundesanstalt (the national metrology institute).

The following parameters:
- radial composite error $F_r''$
- tooth-to-tooth composite deviation $f_{ii}''$
- composite runout deviation $F_{r''}$

are indirectly traced. The determined measurement uncertainties are based on stable mean values of large volume sample inspections.

By knowing the **measurement uncertainty**, the inspection planner knows if the inspection equipment is **suitable** for the measurement task or not. This is the reason why quality management systems require the determination of the measurement uncertainty, which has to be proved during quality audits.
Correction of deviations of master gears

Master gears are manufactured with the same precision as gauges, they are high-precision items. However small form variations cannot be avoided. Especially the runout deviation causes a deviation in the double flank gear roll inspection which cannot be disregarded. The actual runout deviation of the master gear is considered in the measuring uncertainty with twice its value, because the deviations of the master gear and the workpiece superimpose each other positively or negatively depending on the angular position.

If the runout deviation of the master gear is 0.006 mm, the measuring uncertainty increases by 0.012 mm.

This influence can be minimized by an increased accuracy of the master gear (e.g. using quality A according to the DIN 3970 (FRENCO QF)). By applying the correction of deviations of master gears this influence can be nearly completely avoided.

**Correction of deviations of master gears:**

The master gear or the driver has got a marking for the angular position which is read by a sensor. With a check master fitting to the master gear (number of teeth of the check master and number of teeth of the specimen must not have a common divisor) a correction run with multiple rotations is carried out. During this process the correction values are calculated and saved in the measuring electronic. With these calculated values the following measuring results are fully automatically corrected.
Frenco Product Range

High Precision Gears and Splines
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Gear and Spline Gauges
Master gears, Master wheels
Artefacts, Masters
Punches, Dies & Electrodes
Profiled Clamping Systems
Gear and spline manufacture

Instruments for Size Inspection Series V
----------------------------------------
VRK  Measuring Pins and Balls
VA  Gauges, Rocking Type
VP  Gauges with Face Stop
VM  Gauges, Gear & Spline Profiles
VD  Circumferential Backlash Measuring Instrument
VS  Customised solutions

Rotation Measuring Systems URM
-----------------------------------------
URM - K  with Balls and Pins
URM - R  with Master Wheels
EWP  Single flank gear roll inspection
ZWP  Double flank gear roll inspection
WS  Gear roll scan

Gear & Spline Inspection
-----------------------------------------------
DAkkS - Calibration
Monitoring of Inspection Equipment
Workpiece Inspections
Analysis of Deviations

Know-how Transfer
-----------------------------------------------
Software
Training, Seminars, Workshops
Consulting and Calculations
Literature and Documentations
National and International Standards

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