



### Noise-Testing

Both wheels mesh at high speed, approx. 200 min<sup>-1</sup>. The acceleration of the slide is measured using an acceleration sensor.

The value measured is not directly used for classification. The time signal is transformed via FFT and the root mean square of the frequency spectrum within certain bands is evaluated.

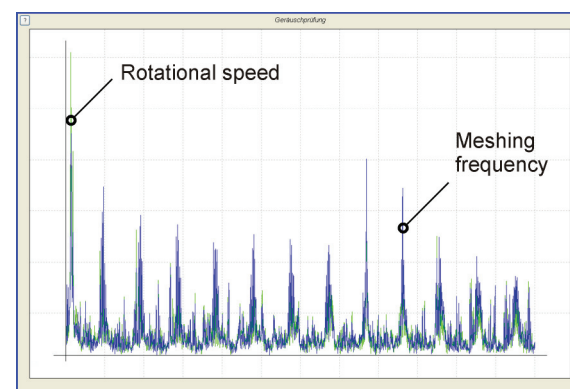
With **n** as rotational speed and **z** as number of teeth, characteristic bands may be located around:

- Rotational speed **n**
- Double of rotational speed **2n**
- Meshing frequency **zn**

The maximum amplitude may be used to detect knocks on the flanks e.g. as a smoothing criterion or for marking of conspicuous teeth.

This measurement method does not lead to results that are directly comparable between different testers. The limits for classification are usually acquired by **teach-in**.

During a short teach-in period, the system does not do the classification itself, but the user decides for the result. After that period, the system can classify by comparing the actual measuring data with the previously stored limits.



Numerous mathematical methods are used to identify significant criteria in time- as well as in frequency domain

### Advantages of Roller-Testers

- **Very fast:**  
Suitable for 100%-quality-inspection
- **Easy to implement:**  
No advanced knowledge or extensive training necessary for the user in production
- **Reliable and easy to maintain:**  
Mandrel and master gear have to be exchanged or reworked after 40.000 - 60.000 cycles

### Disadvantages of Roller-Testers

- All failures in master gear, mandrel, slide, bearings and UUT interfere the measuring results and subsequently depending actions.

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## Integrated Inspection Units for Quality Assurance in Production Lines

### Modularity

Our concept encapsulates the function from the form. The outline always follows the same geometrical design. The functionalities are implemented with sub-assemblies mounted on standardized flanges. Every single module occupies less than 1m<sup>2</sup>.

Even if you start with a manually loaded tester, you will not have to face restrictions in the future when expanding up to a fully integrated automated production line with robotic handling.

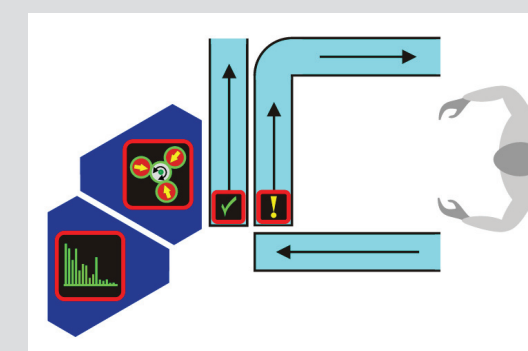
Unleash your imagination!

With our modules you can implement sophisticated quality assurance combined with flexible handling and conveying, all at a reasonable price. Our portfolio already includes:

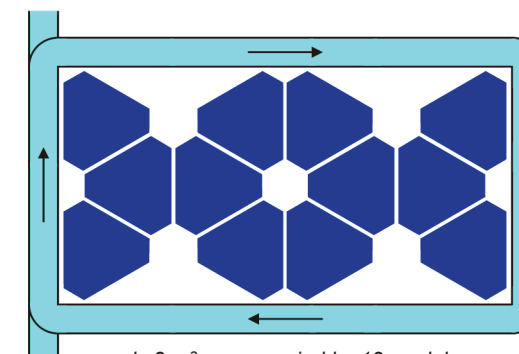
- Roller-Tester-Module
- Marking-Module
- Smoothing-Module



and will be extended continuously.



Loading Parts and unloading Scrap manually



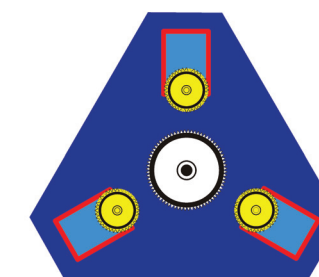
only 8 m<sup>2</sup> are occupied by 12 modules

Using a Scara-Robot opens up a wide variety of loading / unloading scenarios:

- via accumulating conveyors with arbitrary directions
- grouping modules in one satellite with parts circulating around on a conveyor
- integration into plant-wide tracking system with intelligent palettes

Even the modules themselves may be configured in different combinations. Fully utilising the three possible positions for the measurement units on one testing module you can inspect:

- three different gears on one component
- three different gears with similar bore diameter
- one gear with three different measuring methods (e.g. double-flank rolling, single-flank rolling, pitch)



UUT in the Center, 3 different Masters (yellow) on Slides

## Methods of Testing



### Basic Measuring Setup

Two different methods of testing can be realized with one setup:

- double-flank rolling inspection and
- noise testing

Both integrated methods are performed using *double-flank contact* without torque load:

The wheel to be tested (UUT) is clamped on a fixed axis, the master gear on a slide. The master gear is pressed against the UUT with a force of about 20N.

When rolling, both gears are in a *close mesh condition*, i.e. always both flanks of one tooth are in contact with the corresponding two tooth gap flanks of the counter gear.

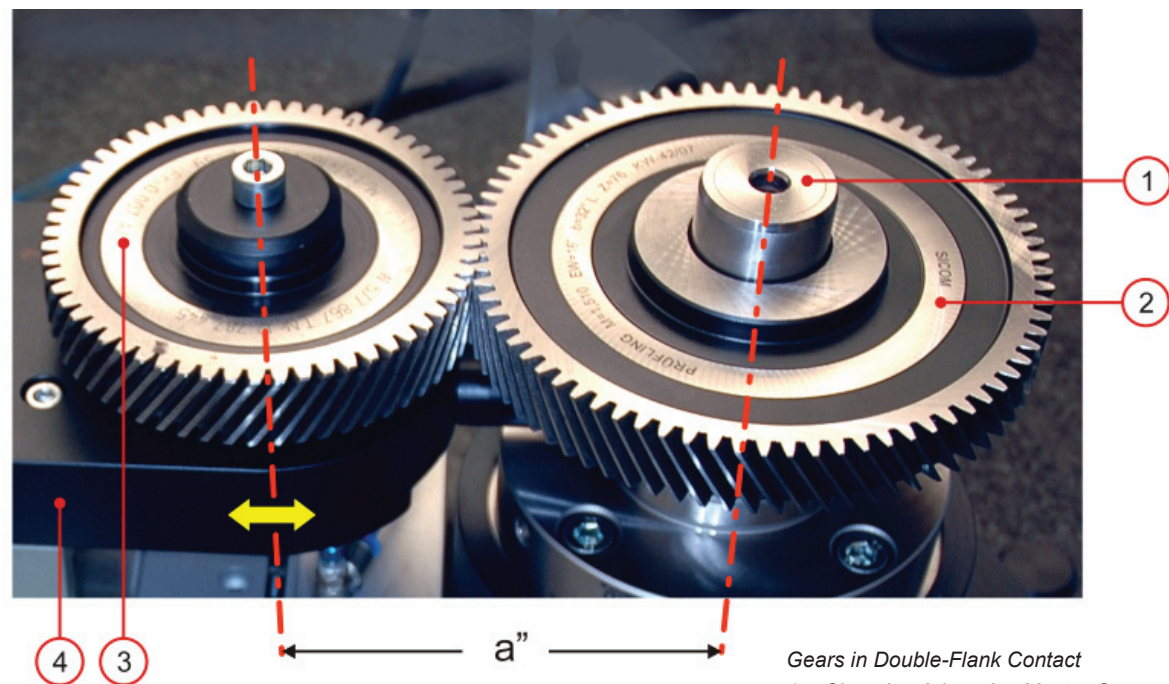
As this is not the rolling condition the gears are designed for, every single tooth mesh will lead to a deviation in center distance  $a''$ .

Recorded over one revolution this will lead to a periodical short wave portion of the chart and shows a *constant* frequency and amplitude when a perfect gear is running with a perfect master gear.

But in reality you will find deviations from a perfect gear geometry, such as

- nicks and burrs on the active part of a flank, generally: damage
- occasional tooth thickness deviations
- radial run-out
- face wobble
- etc.

and all of them cause characteristic center distance deviations that can be evaluated with the two different methods possible with this setup.



Gears in Double-Flank Contact  
 1 = Clamping Arbor 3 = Master Gear  
 2 = UUT 4 = Measuring Slide

## Methods of Testing

### Double-Flank Rolling

The measuring system is to be calibrated first. At measurement both wheels mesh at slow speed, approx. 20 min<sup>-1</sup>. The displacement of the master gear slide is measured using a high resolution length encoder.

The value measured is the distance between master gear and the UUT axes related to the theoretical nominal double-flank rolling center distance (theor.  $a''$ ), which is set during calibration.

The evaluation of the measuring results is according to DIN 3960 and leads to the following characteristics:



Sketch of a Double-Flank Rolling Chart  $Fi''$

#### $Fi''$ Radial composite error

The radial composite error  $Fi''$ , is the variation in the double-flank center distance  $a''$ , i.e. it is the difference between the largest and the smallest double-flank center distance during one UUT revolution.

#### $fi''$ Radial tooth-to-tooth composite error

The radial tooth-to-tooth composite error is the largest difference in the double-flank rolling center distance  $a''$  which occurs within a rotating angle corresponding to the duration of one tooth engagement.

#### $Fr''$ Composite run-out error

The composite run-out error  $Fr''$  is the long wave portion in the radial composite error test diagram and therefore the distance between the highest and lowest point of the „average continuous line“.

#### $Aa''$ Deviation of rolling center distance

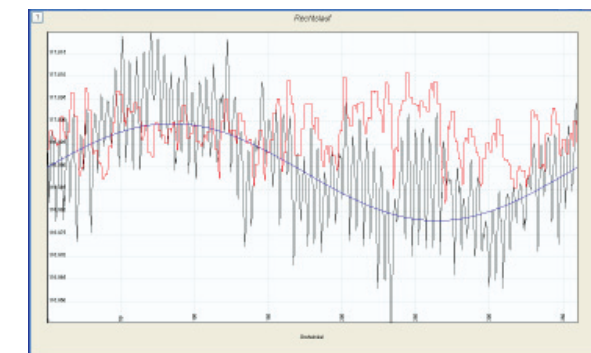
The deviation of the double-flank rolling center distance is the difference between the theoretical nominal value of the double-flank rolling center distance (theor.  $a''$ ) and the actual deviation (calculated from the position of  $Fr''/2$ ).

#### B Nick amplitude

Is the admissible deviation of double-flank rolling distance  $a''$  within a percentual share (to be defined) of one tooth engagement.

This value is used for determination of tooth flank damage during computerized chart evaluation. This type of freak value might be smaller than a typical  $fi''$  deflection but has to be larger than the effects of typical surface roughness in the corresponding manufacturing stage. It is to be defined together with the „Share“, a value of maximum 90 percent of the duration of one tooth engagement (=100 %).

The results acquired on different double-flank rolling testers are directly comparable. Classification can easily be done with reference to DIN 3960/61 or by building customized classes (definition of upper and lower limits) for the individual deviation parameters.



A real Double-Flank Rolling Chart gained on the measuring module described before. The red chart represents the  $fi''$  value separated from the  $Fr''$  long wave portion (blue). In the sketch  $fi''$  and  $Fr''$  are superimposed to each other like on the old fashion red-liners in the past of gear manufacturing.