OERLIKON

B 27 / BC 12 / CS 200

BEVEL GEAR TECHNOLOGY –
TOOL PREPARATION AND SETTING

KLINGELNBERG

Intelligent Solutions for Discerning Users

All around the world, manufacturers of gears and gear units ensure their leading edge in gear machining with innovative solution concepts from Klingelnberg.

The Oerlikon bevel gear technology division makes economical, high-precision production of bevel gears a reality for customers. All machines have been perfectly designed to work as a system family, enabling pre-machining and finishing of even the most complex gearings.

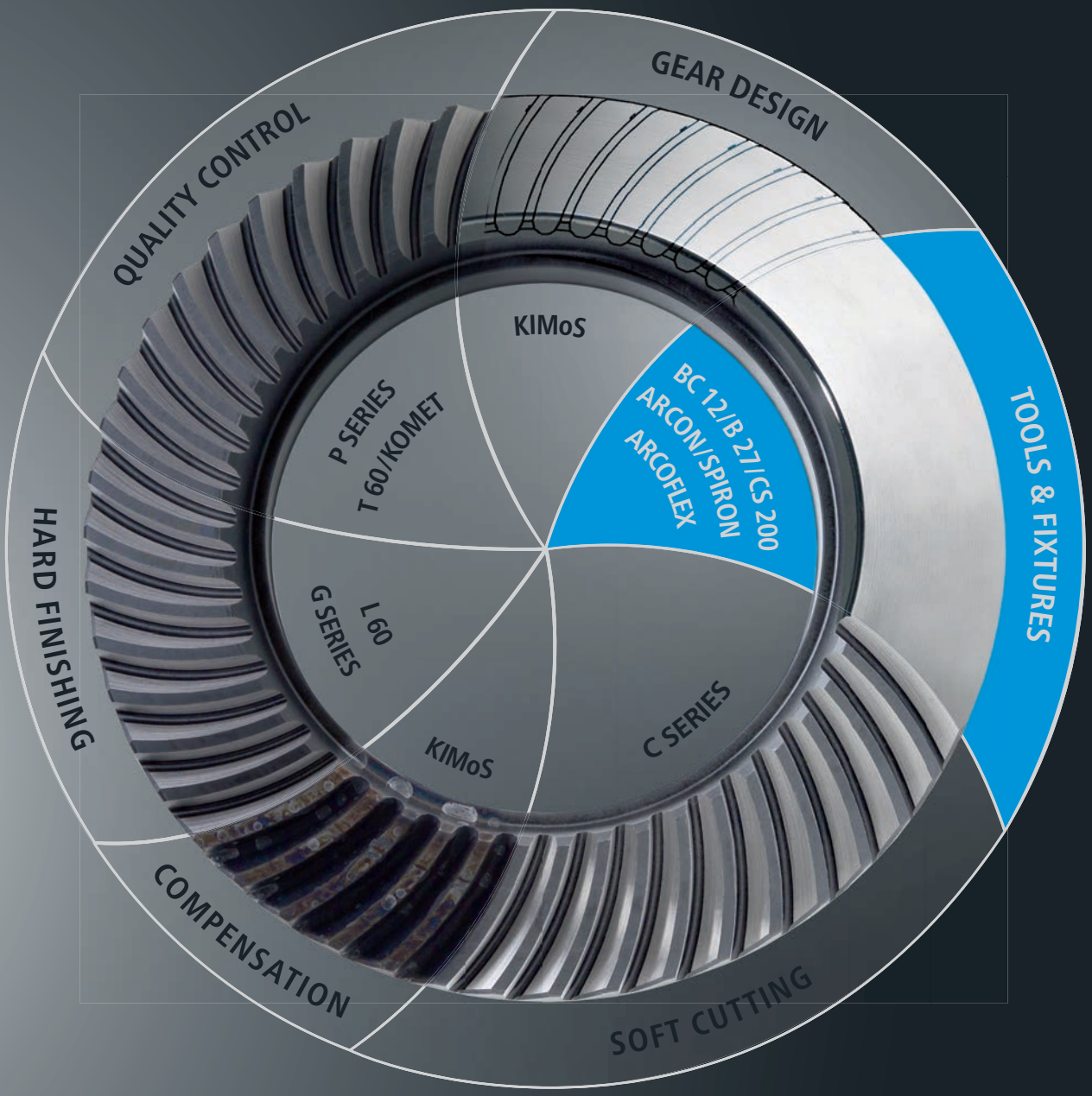
Klingelnberg offers the most advanced technology and the most efficient machines for each and every step in the process chain. The production process chain for bevel gears includes tool preparation, cutting, measuring, hardening, grinding or lapping and testing, among others. The powerful KIMoS (**K**lingelnberg **I**ntegrated **M**anufacturing **o**f **S**piral Bevel Gears) design software and the Closed Loop concept ensure transparency and documented quality throughout the entire process chain.

Oerlikon bevel gear machines were developed with real-world applications in mind and meet the varying demands of a whole range of application industries. The target markets include the automotive industry, the commercial vehicle industry, the agricultural industry, shipbuilding, and aviation, as well as industrial gear unit manufacturing and plant engineering.

As a leading system supplier and in combination with these high-performance tool systems, Klingelnberg meets every requirement for flexible, efficient production – for the smallest and the largest lot sizes.

Oerlikon stick blade grinding machine B 27, Oerlikon cutter head setting CS 200 and checking device, Oerlikon stick blade measuring device BC 12

Exceptional Concepts for Every Process Step in Gear Technology



Top-Notch Expertise in Design with Unique Closed Loop Method

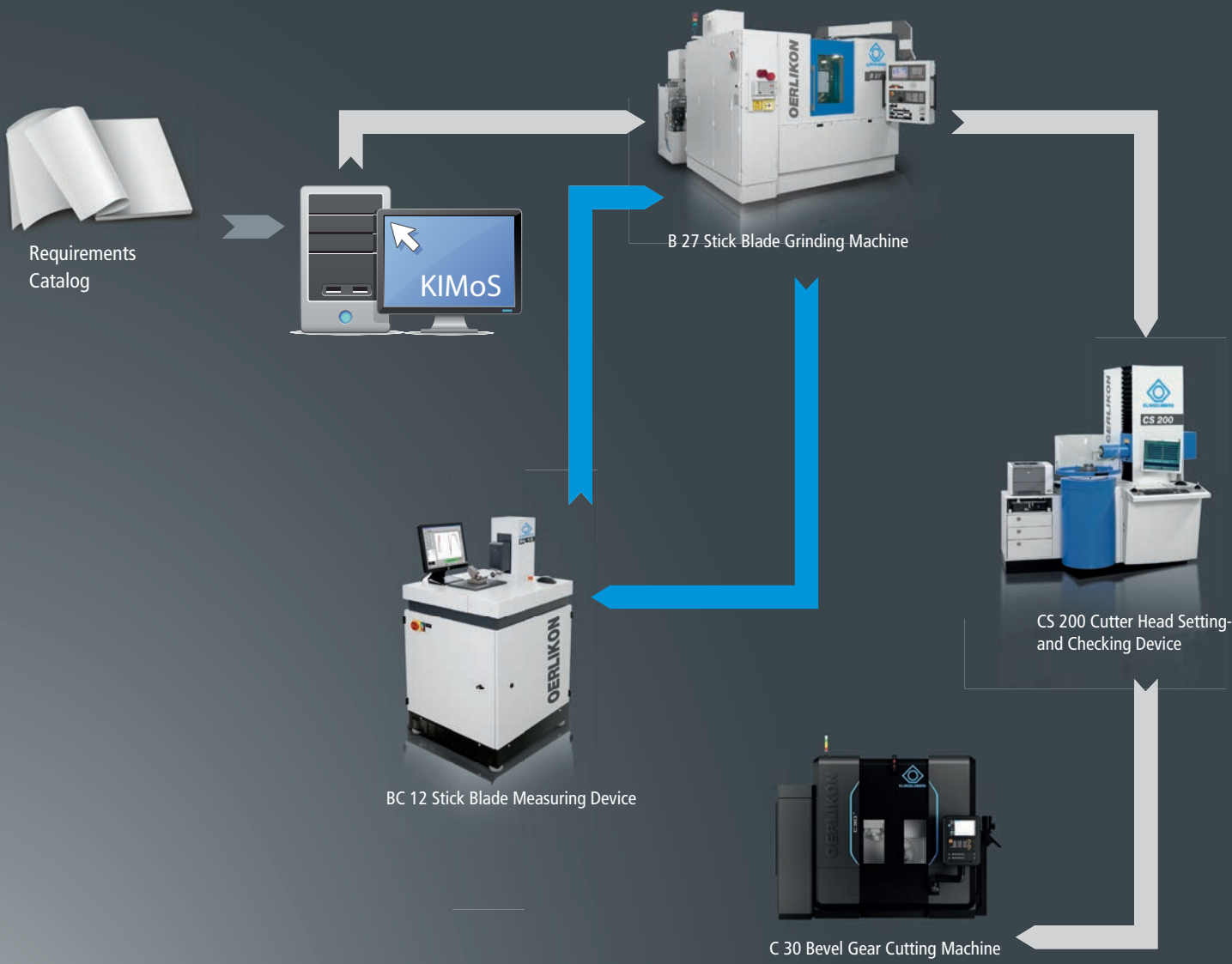
All bevel gears and hypoid gears are three-dimensional gearings. The complex tooth shape clearly shows that flexible design possibilities and the highest standards must be provided during both calculation and production.

The development of a bevel gear set begins with the design calculation: Within this process, the external dimensions of the gear set and the flank profile are designed such that the running behavior with and without load meets the desired requirements. The flank modifications are then determined by means of a rolling simulation of the tooth flanks and a downstream tooth contact analysis, and the desired running behavior and required load capacity are verified mathematically. The flank profile is defined by the specific tool shape and the machine movement. Moreover, with the neutral data format and the KIMoS software package, it is possible to measure, optimize and manufacture all commercially available gearings. Based on the neutral data, production on the machine tools takes place in Closed Loops. The tooth flank profile is specified by theoretical nominal data based on the calculation with KIMoS and can then be measured on a precision measuring center. The KOMET correction program measures any deviations and sends the corresponding corrections to the production machine in the network group.

Another Closed Loop for the tool system replaces the production of reference blades initially required in the past; the blade and cutter head geometry is already included in the neutral data. The comparison of the blades against the nominal data is performed by the BC 12 stick blade measuring device. Additionally, deviations can be compensated on the B-series stick blade grinding machines. In this way, a Closed Loop can be realized for the tool system. With the Oerlikon cutter head setting and checking device CS 200, the blades in the cutter head are adjusted accurately and quickly, inspected and documented in a semi-automatic process.

- With the neutral data format and the KIMoS software package, all commonly available gearings can be measured, optimized and manufactured
- Based on neutral data, production on the machine tools takes place in Closed Loops
- KOMET correction program for calculating deviations
- Direct production of stick blade contour according to nominal data (included in neutral data)

Closed Loop Method for Tool Systems



High-Precision Stick Blade Grinding Machine for Stick Blades of all Bevel Gearing Types

Maximum precision, economic production, multi-grinding methods, compact machine layout and automatic handling are the key features of the Oerlikon stick blade grinding machine B 27, which was designed to grind HSS and carbide blades for cutting spiral and hypoid gears of all systems. The intelligent machine concept designed for robustness ensures maximum profile and repetition accuracy while at the same time providing the shortest machining times.

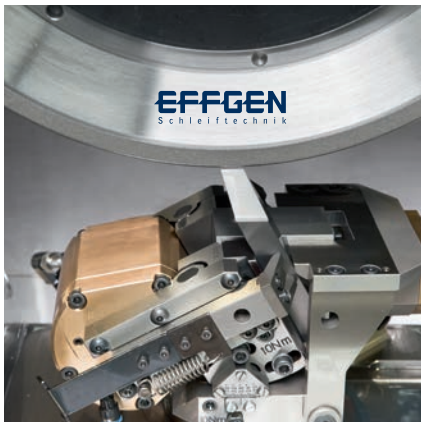
The machine operates using the profile grinding method with dressable corundum grinding wheels as well as in generating mode with dual grinding wheels made of CBN (for HSS) or diamond (for carbide). The dual grinding wheels used in the dual-action grinding technique combine roughing and finishing and provide maximum accuracy in the shortest machining time. In order to ensure accuracy, the grinding wheel dressing device (with driven diamond dressing roll) is located for the profile grinding method on the longitudinal table directly next to the stick blade to be ground. In the case of generating grinding, the position of the grinding wheel is monitored by a sensor, and any deviations are automatically compensated.

The B 27 is equipped with a workpiece handling device that can be loaded with up to 528 blades. Once saved, the geometry and technological data are retrieved automatically by the cassette encoding. This allows unmanned operation of up to three full shifts.

Oerlikon stick blade grinding machine B 27

Robust, Compact Machine Design

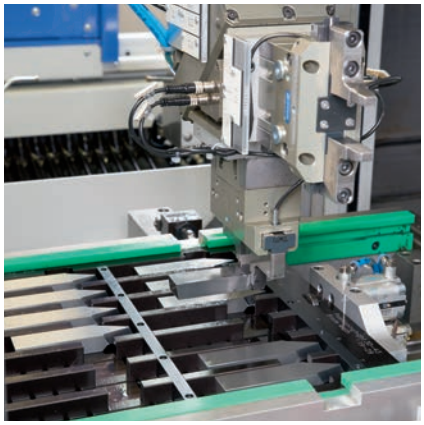
- Intelligent machine design ensures maximum profile and repetition accuracy while at the same time providing the shortest machining times
- Blades for bevel gear and power skiving cutter heads can be made with all standard blade cross sections from approx. 5 x 9 mm to 19.05 x 27.94 mm
- Maximum precision with maximum efficiency
- Process has been tested and approved around the world



Multi-Grinding Methods for an Economical Production Process

- Designed for grinding HSS and carbide blades (Oerlikon FS, FN, FSS, ARCON®, SPIRON®, RSR®, TRI-AC® and PENTAC®) for cutting spiral and hypoid gears of all systems
- The machine operates using the profile grinding method with dressable corundum grinding wheels as well as in generating mode with CBN or diamond dual grinding wheels
- Use of Effgen Dual grinding wheels ensures high repeatability when grinding stick blade profiles and low wear with maximum accuracy

ARCON® – registered for KLINGELNBERG GmbH, Hückeswagen (D)
SPIRON® – registered for KLINGELNBERG AG, Zurich (CH)
RSR®, PENTAC® and TRI-AC® – registered for The Gleason Works, Rochester/NY (USA)



Automatic Workpiece Handling

- Cost-effective production of tools thanks to internal automation
- Tool handling station can be loaded with up to 528 blades
- Once saved, the geometry and technological data are retrieved automatically by the cassette encoding
- Unmanned operation up to three shifts possible

Module for Manufacturing Bevel Gears Using the Closed Loop Method

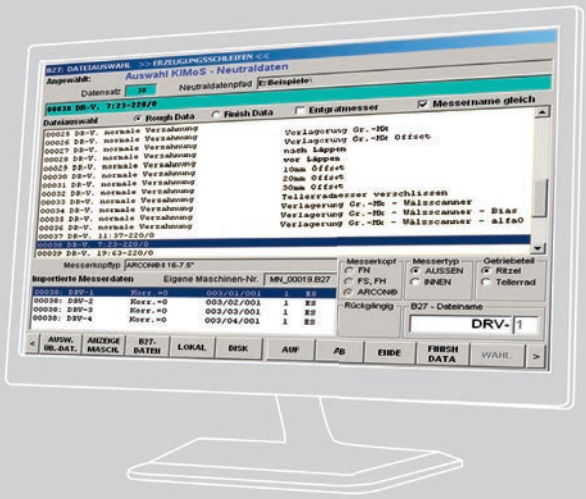
- Blade quality guaranteed and documented at the start of the production chain, even for new designs
- Grinding and measuring of blades directly according to KIMoS nominal data
- No manual input of blade geometry or correction data required
- Manual data input option for common third-party formats

Maximum Flexibility and Accuracy With Shortest Machining Time

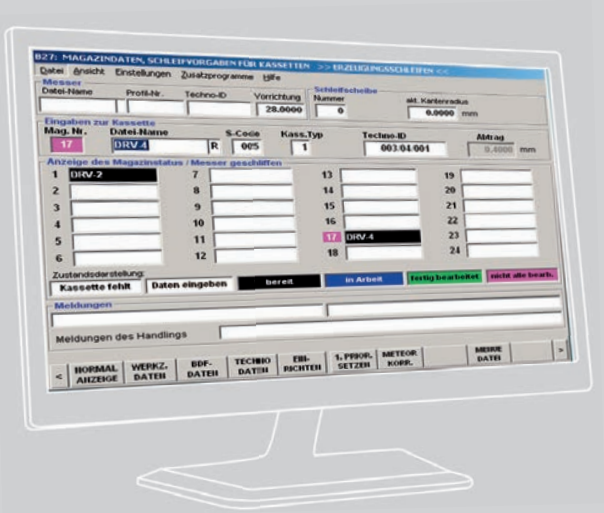
Based on the Closed Loop production process for stick blades, the B 27 operating concept systematically avoids potential sources of error such as manual entries by the machine operator. For each new design, the first step consists of loading the stick blade data from the neutral data record. To do so, the B 27 accesses the production database – the machine operator simply selects the data record and links it according to the blade type with a standard technology. The machine creates and then validates the grinding program. To start the grinding process the operator only has to specify the magazine position where the cassete has been entered and whether a pre-profiled or a new blade blank is be used for grinding. Of course, blade calculation and assignment of grinding orders to cassette positions can take place during the primary machining time.

The finished blade is then measured with the BC 12 or the P machine. Any necessary corrections are added to the production database, loaded automatically on the B 27 and taken into account for all subsequent stick blades.

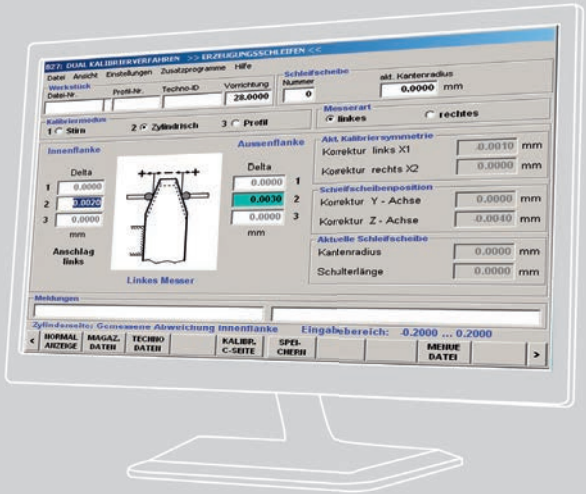
The calibration process on the B 27 is yet another highlight: Because the machine is calibrated at regular intervals following a grinding wheel change or change of tool clamping device, for example, reliable, outstanding input quality is assured for the Closed Loop.



Loading of stick blade data from a KIMoS database



Assignment of data records to cassette positions

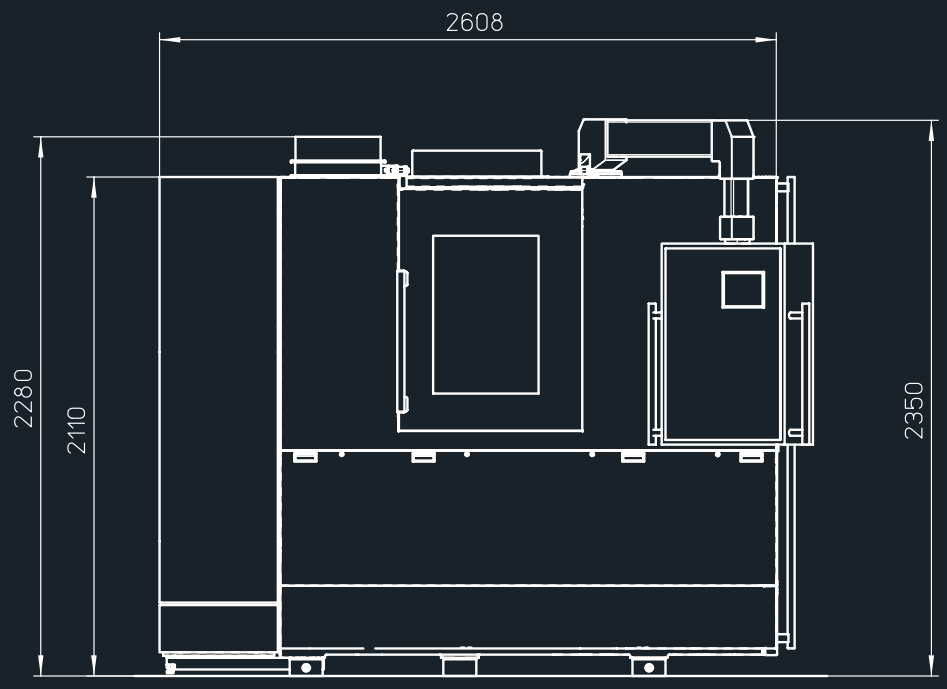


Calibrating the machine

Technical Data and Installation Dimensions

	B 27
Stick blade cross section (max.)	5 x 9 mm – 19.05 x 27.94 mm
Cutter head diameter (max.)	9“
Continuously adjustable grinding spindle peripheral speed	15 – 40 m/sec
Corundum grinding wheel dimensions (outside Ø x width x bore hole)	400 x 30 x 203.2 mm
	400 x 40 x 203.2 mm
	400 x 50 x 203.2 mm
CBN/Diamond dual wheel (outside Ø)	400 mm
Diamond dressing roll	150 mm
Total connected load	36 kVA
Machine dimensions, incl. cooling system approx. (L x W x H)	3,800 x 2,600 x 2,300 mm
Weight (incl. electrical system) approx.	7,700 kg

The above-mentioned maximum values were determined for industry-typical transmissions. Further testing may be required to determine whether maximum values can be combined.



Dimensions in mm

High-Precision Measurement of Stick Blades

Stick blade measurement closes the quality control loop between the stick blade grinding machine and the ground blade efficiently and simply. In the standard basic version of the BC 12 stick blade measuring device, both the position and the shape of the main and lateral cutting edges can be determined using a scanning procedure. The KIMoS calculation program provides the required contour data – thus eliminating the need for manual data input and reducing preparation times to a minimum. The correction for the stick blade grinding machine is calculated automatically and transferred to the stick blade grinding machine via the network. In this way, the quality of the ground surfaces is controlled, monitored, and documented.

The BC 12 was designed as a standing workstation. The workshop-friendly design consists of the fully encapsulated measuring device with measuring 3D tracer head, an integrated CNC control, a built-in PC with Microsoft® Windows® 7 operating system and a network connection. A laser printer with accessory container is optionally available.

The measuring device is operated with the PC mouse using the graphical user interface of the Meteorit software. The ergonomic workstation features large work surfaces and a drawer for storing the keyboard and accessories.

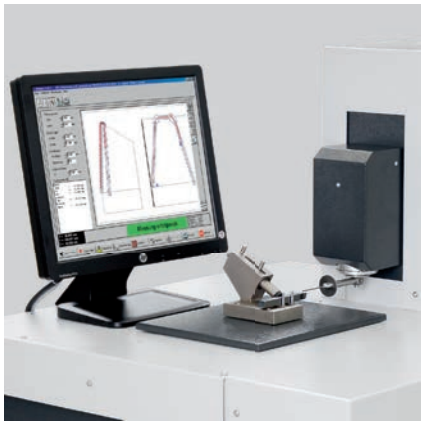
Oerlikon stick blade measuring device BC 12

Compact Machine Design

- Ergonomic standing workstation with large work surfaces and a drawer for storing keyboard and accessories
- Measuring device suitable for shop-floor operation next to the stick blade grinding machine
- Laster printer with accessories container (optional)
- Wear-free, maintenance-free drives

High Measurement Accuracy

- Highly precise, reliable measuring results through the use of P machine technology for the design, 3D tracer head and CNC control (the relevant P machine technology is used)
- Rapid measurement of complete stick blade geometry (position, shape and angular deviations of the main and auxiliary cutting edge as well as the rake face)
- Consistent use of blade shaft as reference for production, measurement, and mounting of stick blades
- Universal quick clamping device for all blade cross sections from approx. 5 x 9 mm to 19.05 x 27.94 mm
- A wealth of information in the shortest measuring times



Easy Operation

- Operation takes place with the PC mouse using the graphical user interface of the Meteorit software
- Required contour data provided via the KIMoS calculation program via networks
- Short setup times
- Automatic correction calculation for the stick blade grinding machine

Module for Manufacturing Bevel Gears Using the Closed Loop Method

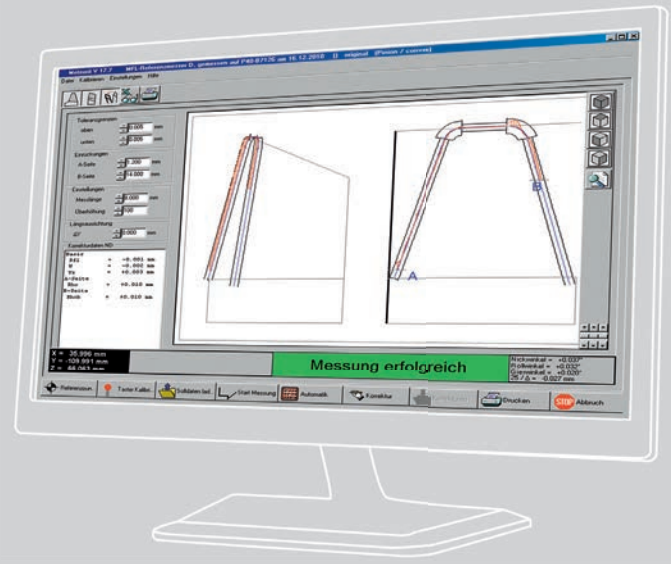
- The quality control loop between the stick blade grinding machine and the ground blade is closed efficiently and simply by measuring the stick blades
- Data required for the measurement are provided by the KIMoS program with the "Stick blade calculation" option

High-Precision Measurement of Stick Blades with Meteorit Software

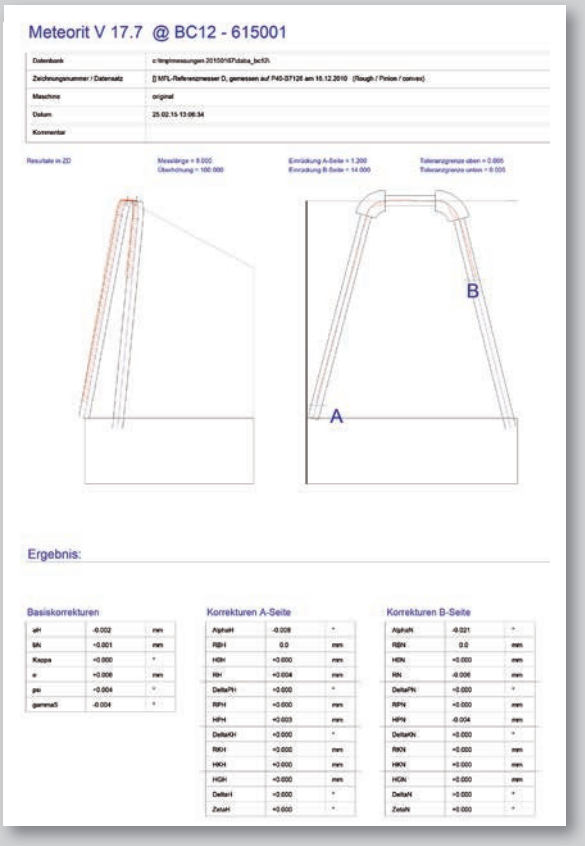
For a quality-relevant evaluation of a stick blade, a number of elements are important: The main cutting edge of the stick blade must meet the most stringent requirements, since these define the accuracy of the flank profile. Moreover the position of the rake face – particularly in continuous processes – is also key for the flank profile. The tip and tip radius of the stick blade must also meet strict precision requirements, as these generate the tooth root geometry. For all elements, not only are the position and angular conformity of critical importance; so too is their shape. An additional difficulty in the measurement task is that the cutting edges of a ground carbide blade are extremely sharp but sensitive at the same time. This makes measurement a challenge.

For this extensive measurement task, a scanning measurement method has been developed that enables a comprehensive ascertainment of the geometry of the cutting edges, the tip radius, the tip and the rake face. This continuously scanning kinematics is not only extremely fast – it is also gentle on the tool and probe during the measurement.

The Meteorit software was developed specifically for the measurement of stick blades and is also used on the BC 12. The software provides all procedures required to measure a blade on an intuitive interface. This includes loading of neutral data from the database, configuring and carrying out the measurement task, calculating and saving the corrections and documenting the measuring results. Individual tolerances can be specified for the different areas of the stick blade. As the measuring result, the actual geometry is clearly displayed as a deviation from the nominal geometry of the stick blade. If necessary this can be documented on a compact measuring sheet together with the deviations. The automatically calculated correction values are transferred directly to the grinding machine.



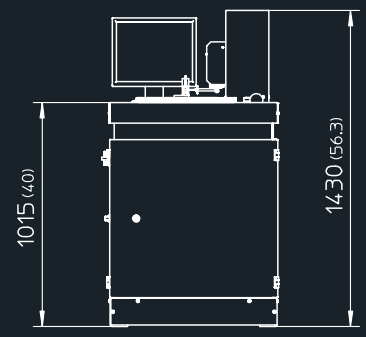
Meteorit software for all measuring runs with intuitive user interface

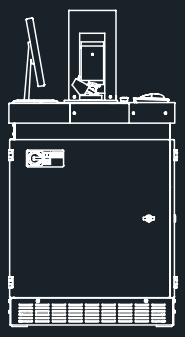


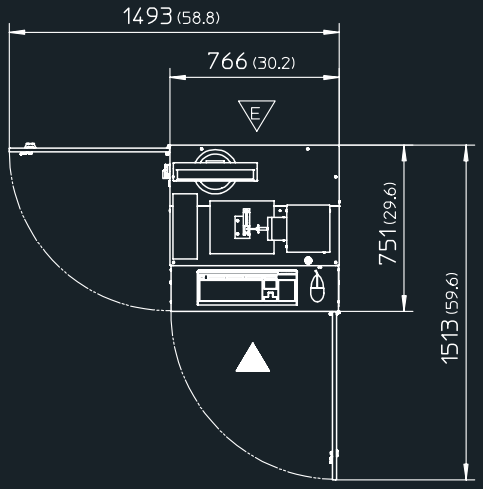
Measurement report of stick blade measurement

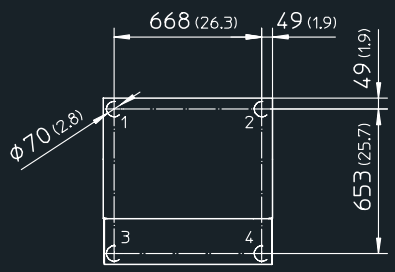
Technical Data and Installation Dimensions

	BC 12
Stick blade cross section (max.)	5 x 9 – 19.05 x 27.94 mm
Measuring length (probe-dependent, max.)	75 mm
Probing system	Measuring 3D tracer head, resolution < 0.05 µm
Total connected load	0.5 kVA
Machine dimensions (L x W x H) approx.	750 x 800 x 1,450 mm (without printer)
Total weight approx.	500 kg









Dimensions in mm and inches

High Gear Cutting Quality Thanks to Optimally Set Cutter Heads with a Long Service Life

In the production process for spiral-cut bevel gears, the quality of the gear cutting tools used plays a key role. Particularly in the case of dry cutting, high gear cutting quality and a long service life can only be achieved with accurately set cutter heads.

The Oerlikon cutter head setting and checking device CS 200 enables quick and easy setting of the individual blades, checks their position and documents the measuring results. The measuring run on the CNC-controlled checking device is semi-automated: On the screen, the individual actions for performing the procedure are displayed via the operator guidance. The positioning of the individual blades in the cutter head and the height of the blade tips is largely automated via a specific procedure and is simultaneously documented via an axial runout diagram. A subsequent measuring run checks the radial position of the internal and external cutting edges of all blades in the cutter head. If individual inspection parameters for the blades do not comply with the tolerance specifications, these can be repositioned individually.

Through the combination of a semi-automated setting procedure, operator-guided setup actions and an automatic measuring run, cutter heads can be set easily, quickly and with great accuracy.

Oerlikon cutter head setting and checking device CS 200

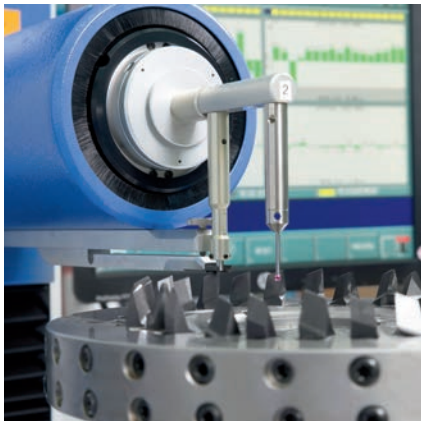
Compact Checking Device for Use on the Shop Floor

- Basic unit with cutter head clamping table, setting and measuring axes (Y/Z), 3D tracer head and operating unit and monitor
- Control system comprising CNC control, PC system and direct drives on all axes
- Measurement and positioning axes equipped with high-precision length and angle measuring systems as the basis for accurate setting and measuring results
- Receiving cone on cutter head clamping table with tolerance compensation

Operator-Guided Setting and Checking Procedure

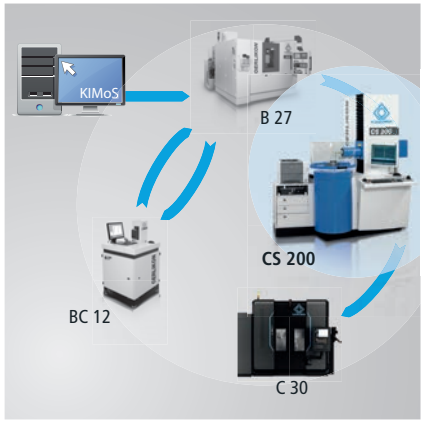
- Graphic representation of cutter head design and measuring results with tolerance test
- Instructions for the operator in plain text (no encrypted information)
- Easy assignment of measuring results to blades
- Documentation of setting and measuring results via printer
- Setting and checking procedure suitable for stick blade heads of type ARCON®, RSR, Spirapid, SPIRON®, TRI-AC®
- Neutral data interface

ARCON – registered for KLINGELNBERG GmbH, Hückeswagen (D)
SPIRON – registered for KLINGELNBERG AG, Zurich (CH)
TRI-AC – registered for The Gleason Works, Rochester/NY (USA)



Semi-Automated Setting Procedure

- Combined measuring device and slider for positioning blades and checking position (patented)
- Simultaneous measurement of blade tip height and output of axial runout diagram during setup process
- Short ground-to-ground setup times for a cutter head



Module for Manufacturing Bevel Gears Using the Closed Loop Method

- Target/actual comparison of blade contour on the BC 12 blade profile checking device
- Data feedback to the blade grinding device model B 27 and performance of a correction grind
- Positioning and setting of blades in the cutter head base body via the CS 200 setting device
- Use of the set-up cutter head on a bevel gear cutting machine

Carrying Out a Setting and Measurement Procedure on a CS 200

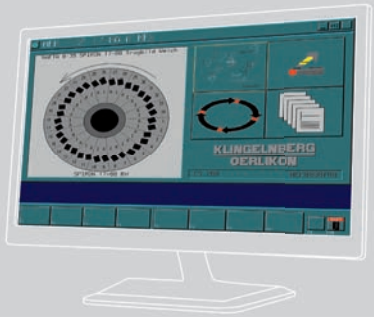
The cutter head to be checked is first placed on the rotary table of the checking device. The individual stick blades are inserted into the receiving pockets of the base body and are held in place initially via spring force in connection with special clamping screws in the base body. Because the cutter heads to be set are part of the manufacturing process for bevel gears, all relevant data have been calculated in advance via the KIMoS program system, such that the neutral data are also available for the CS checking device.

The data saved in a catalog can be called up via the operator guidance. A characteristic graphic of the cutter head with an identification of all set blades is displayed on the screen. As soon as the preparatory measures are complete and the procedure has been started accordingly, the operator receives the instruction to place the measuring device and slider in a starting position. The pre-positioned stick blades are then shifted to the target height via the device, such that the axial runout of the blade tips is displayed on the screen.

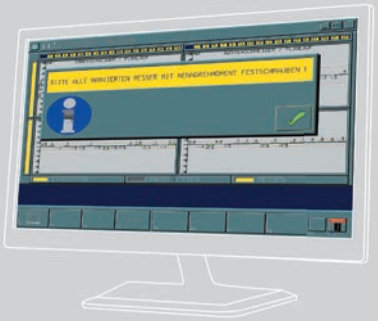
Finally, the operator receives the instruction to tighten the individual stick blades to the specified torque using the clamping screws. The concentricity of the blade edges (inner/outer blade) is then checked and also displayed on the screen. A color-coded mark (green/red) on the measuring beam indicates whether the respective measured value is in or out of tolerance. Because the position of the stick blades typically does not correspond to the specified tolerance after the first cycle, an additional cycle usually follows.

When all stick blades meet the tolerance specification, the concentricity of the blade edges (inside/outside) is checked and documented. Because the axial runout of the individual blades plays a subordinate role, relatively large deviations are permitted here.

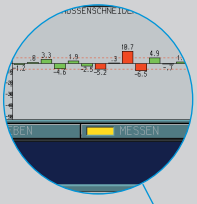
Cutter head seat



Cutter head graphic incl. identification of all blades used



Prompt to tighten clamping screws to specified torque

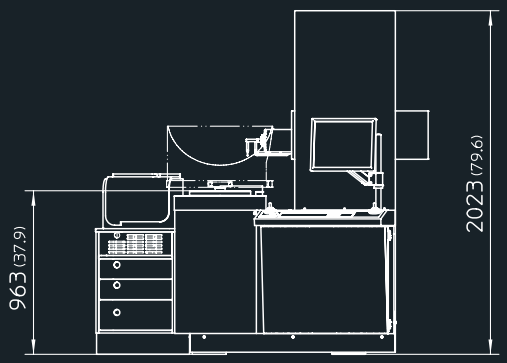


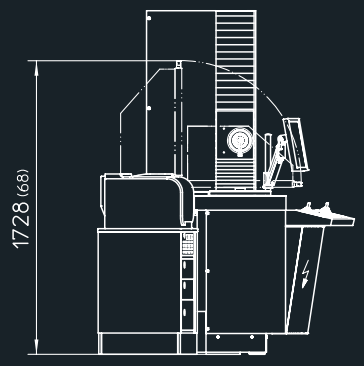
Color-coded mark of measuring beams indicate the tolerance status

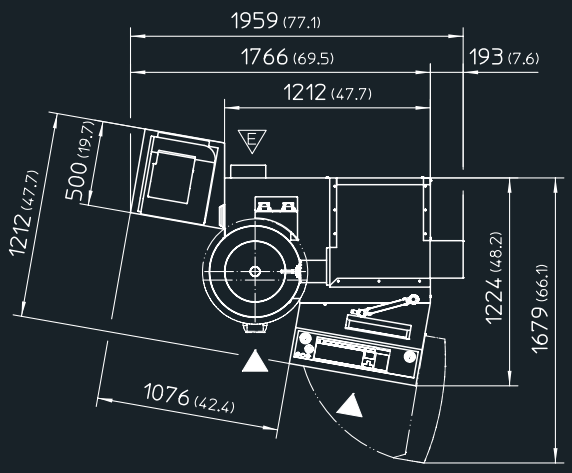
Checking and documentation of blade edges (inside/outside)

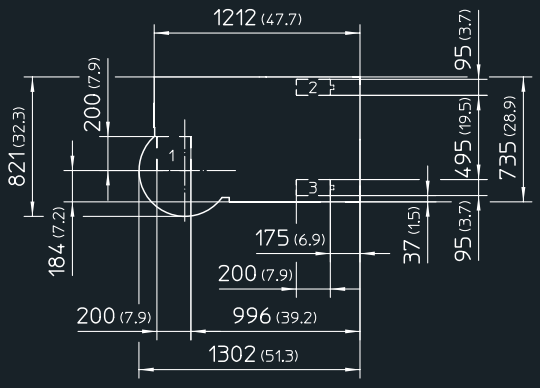
Technical Data and Installation Dimensions

	CS 200
Clampable cutter head type (max.)	460 mm (18")
Cutter head weight (max.)	150 kg
Cutter head mounting plate diameter	Ø 360 mm
Cutter head receiving cone, nominal diameter	Ø 58.227 mm
Z axis traversing range	200 mm
Chart recording magnification, continuous in area	±10 µm – ±500 µm
Total connected load	0.9 kVA
Machine dimensions (L x W x H) approx.	1,500 x 1,250 x 2,030 mm
Machine dimensions, incl. printer unit approx. (L x W x H)	2,000 x 1,500 x 2,030 mm
Net weight, incl. standard equipment approx.	2,300 kg









Dimensions in mm and inches

Drive Components with Guaranteed Quality Provide Optimal Performance

In countless industries, Klingelnberg solutions have become a fixture in the international market. To meet market requirements for high productivity in mass production and flexibility in small-batch production, Klingelnberg offers a range of solution concepts for just about any requirement.

Used throughout the world, the Simplified with Passion system plays an important part in ensuring that machine tasks are made simple. Moreover, the Klingelnberg system contributes to standardization and quality assurance on a global scale.

Automotive

In cars, spiral bevel gears are used in all-wheel-drive systems and rear-wheel-drive systems to transmit torque from the transmission "to the road". Due to increasing performance requirements, these drives must transmit outputs of over 300 kW in some cases. The bevel gears they use must be efficient, smooth-running, and low-maintenance. Reproducible quality in series production with the fastest possible production times are key requirements in this industry.

Commercial Vehicles

Commercial vehicles are always rear-wheel-driven. The bevel gear sets they use must transmit power in the range of 550 kW – with extremely high torque. This places high demands on durability and strength. The bevel gears must be efficient, rugged, and low-maintenance. Use of the integrated Klingelnberg system makes it possible to mass-produce bevel gears with the quality required.

Industrial Gear Units

The industrial gear unit sector comprises many different applications, all of which place great demands on the reliability of the drive components. The bevel gears for these sectors are often produced by companies specializing in small lot sizes and a variety of products. A stiff machine design and flexible, cost-effective tool systems are the keys to success for ranking among the market leaders in these sectors.

Aviation

Bevel gears used in the aviation industry must embody the highest quality in terms of pitch and concentricity (DIN 1–3) and must also execute rotational movements with absolute reliability. Just as important are other geometrical features such as surface finish, tooth root geometry, rotational error, high strength, and low weight. Frequently used in this industry are specialty materials, which place extreme demands on tools and processes.

Maritime Propulsion Technology

The bevel gears used in shipbuilding must demonstrate great reliability and durability even under the most extreme external conditions. The wide range of component diameters (up to 2 m) requires extensive bevel gear know-how to master the production process. Klingelnberg's many years of experience and its certification by all major classification societies are the customer's guarantee of the utmost product quality.

Agriculture

In agricultural applications such as tractors, spiral bevel gears are built into the rear axles. Harvesters and hay machines use straight bevel gears to enable the corresponding functions. Whereas the bevel gear set in a tractor rear axle drive must transmit up to
400 kW, the loads on straight bevel gears are comparably low. The most important market requirement for straight bevel gears is a modern production solution that is cost-efficient.

KLINGELNBERG Service

The KLINGELNBERG Group is a world leader in the development and manufacture of machines for bevel gear and cylindrical gear production, and precision measuring centers for gearing and axially symmetrical components, as well as the production of customized high-precision drive components. In addition to the headquarters in Zurich, Switzerland, further development and production facilities are located in Hückeswagen and Ettlingen, Germany.

The company also maintains a presence with Sales and Service offices and numerous marketing agents. On this basis, Klingelnberg offers users a comprehensive range of services for all aspects of toothed gear design, manufacturing, and quality inspection. The spectrum includes technical consulting, on-site machine acceptance, operator and software training as well as maintenance contracts.

KLINGELNBERG Solutions

Klingelnberg solutions are used in the automotive, commercial vehicle, and aviation industries, as well as in shipbuilding, the wind power industry, and the general transmission manufacturing industry. With numerous R&D engineers around the globe and over 200 registered patents, the company consistently demonstrates its capacity for innovation.

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