kaloMAX II

Manual

Version 1.03

BAQ

Manufacturer's address and contact details

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Made in Germany

Table of contents

1 Safety instructions

- Read the manual's instructions carefully before commissioning kaloMAX II
- Keep the manual for future reference
- Follow all safety and warning instructions, displayed on kaloMAX II
- Always place kaloMAX II on a flat surface
- Operate kaloMAX II only in areas, which are not classified as electrical dangerous
- The power supply to the IEC input bushing must be connected to ground, using the supplied IEC power cable
- kaloMAX II has to be equipped with fuses according to the manual's specification and correspond to the supply voltage
- Any replacement power line must have a specification equivalent to the one supplied
- While operating kaloMAX II you should remove loose clothing or jewelry that may get caught. Beware of moving parts
- Avoid inhaling solvent vapors when cleaning or using kaloMAX II
- Do not attempt to lift kaloMAX II at its shaft
- kaloMAX II mustn't be used in hazardous areas

Disposal

kaloMAX II must not be disposed of with household, commercial or industrial waste. Please observe the local disposal methods or contact us regarding the proper disposal of electronic equipment.

2 Scope of delivery

Basic device kaloMAX II

Universal bench vice for samples

IEC-power cable

Manual

Options/Accessoires:

Detachable vice

Consumables

Balls with different diameters

Diamond suspensions

Dust cover

Evaluation software kaloSOFT

Microscopes

Please check the completeness of the delivery immediately after receipt of the goods.

3 Specifications

Power supply:	85 – 264 VAC, 47 – 63 Hz Fuses: 5 x 20, 2 A t/250 V
Sample clamping range:	Rectangular disc: 4 – 50 mm Round disc: 4 – 50 mm Shaft: Ø 3 – 20 mm (clamping profiles adjusted to the sample's geometry on request)
Positioning range cross table:	25 x 25 mm
Ball diameter:	15 – 40 mm
Inclination of the sample level:	60°
Rotation speed of the driving shaft:	100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200 1/min (further steps on request)
Running times:	5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 70, 80, 90, 100, 110, 120, 150, 180 s (further steps on request)
Dimensions:	300 / 295 / 235 mm (W /D / H)
Weight:	6.6 kg

4 Introduction

With the coating thickness measurement instruments of the kaloMAX family, the coating thickness is determined by using the calotte grinding method. A hardened steel ball with an exact defined diameter, which lies loose between the driving shaft and the sample, is set into rotation by a motor-driven shaft (cf. schematic diagram).

Figure 1: *Measuring principle of the calotte grinding method*

Therefore, the steel ball is used to carry an abrasive slurry, such as diamond suspension or diamond paste. Thereby a groove is ground into the sample – the so-called calotte. The grinding time varies depending on the coating type (its thickness and wear resistance) between a few seconds and several minutes. If the coating system of the clamped sample is ground right through (depth of grinding > coating thickness), every single layer can be seen under the microscope as a concentric ring or ellipse (cylindrical sample).

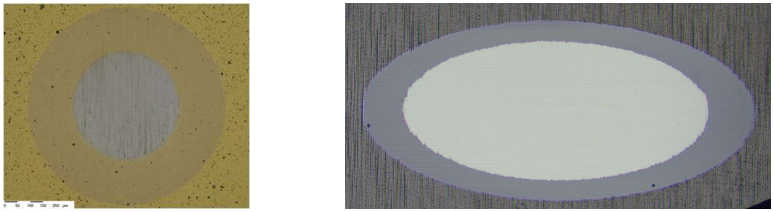


Figure 2: *Calottes on a flat (left) or cylindrical sample (right)*

Using the calotte grinding method, single layers and layer systems can be analyzed. Since, compared to the coating thicknesses, the diameter of the hardened steel ball is very large, the layer system is ground in a very flat angle, which in a way widens the coating (the diameter of the single ring is typically 200 times higher as the coating thickness).

As the to be measured layer thicknesses are in the µm range, the ground-in calottes are very small. In order to get recognizable boundaries, great importance was attached to the guidance of the ball on the driving shaft and on the bearing of the shaft, so that the ball cannot move vertically or horizontally during the grinding process.

Different combination of the rotation speed and the running time are saved under a program number and hereby allow quick and reproducible measurements on different layer types.

5 Commissoning

kaloMAX II must be placed that no shocks or vibrations occur during the grinding process. Power is supplied via a wide-range power supply unit with an input voltage range of 85 - 264 V and a frequency of 47 - 63 Hz.

Due to CE regulations, the nameplate only indicates ranges that are restricted by 10 % each at the top and bottom.

Balls (usually made of hardened steel) with a suitable diameter and an abrasive slurry (e.g. diamond slurry) are required for operation.

With bigger steel balls is the ground-in calotte flatter, which means that the diameter measured under the microscope differs more. This leads to a higher measuring accuracy. On the other hand, for the same depth, the ground-in volume is larger. The grinding time is because of that a bit higher, as the contact pressure by unit area decreases with increasing grinding depth. A good compromise is mostly a ball diameter of 30 mm.

The grit size of the used diamond suspension must be suitable for the layer thickness and type. A rougher grit size leads to a shorter grinding time due to the higher abrasiveness. As a result, the grinding marks become less clear. Generally, diamond suspensions with a grit size between 0.5 µm and 3 µm work well.

6 General operation instructions

6.1 Operating elements

Power switch/ fuses: The power switch and the fuses (5x20, 2 A t/250 V) are located at the back side of the unit between power connector and power switch.

Sample holder: The samples to be tested are clamped in a vice. The clamping profiles mounted on the jaws of the vice can be rotated by 180° for better clamping of cylindrical samples. In case of damage, they can be easily replaced.

Cross table: The vice is mounted on a cross table, which allows positioning of the specimens to be tested in the range of 25 x 25 mm.

Movable stand: The adjustment to different ball diameters or sample thicknesses is done by moving the entire unit of sample holder and cross table. To move the unit, the fixing screw at the back side has to be loosened.

LED readouts: The LED readouts show the actual values for the speed (rpm), the grinding time (s) and the selected program. After power up, the last parameters are active. When the motor is started, the remaining grinding time will be displayed

continually.

6.2 Key functions

The 'START'-key starts the grinding process using the active parameter for speed and grinding time.

The 'STOP'-key stops the grinding. The motor stops immediately.

The 'ENTER'-key is used to set up a new program.

Cursor keys

The ↑↓ keys next to the displays for speed and grinding time can be used to change the corresponding values stepwise. If a parameter is changed, the program number is set to '-'. The grinding process with this new combination can be started with the 'START' key.

6.3 Option detachable vice

The vice incl. the clamped sample can be removed from the cross table. It can then be determined under a microscope whether the coating has already been ground through. If further grinding is required, the vice can be replaced on the kaloMAX II. The high-precision dowel pins ensure that the grinding continues at exactly the same point. When removing and reinserting the vice, make sure that it is not tilted and that there are no particles on the back of the vice. To remove the vice, it should be grasped on the outside, at the level of the two dowel pins (see figure below).

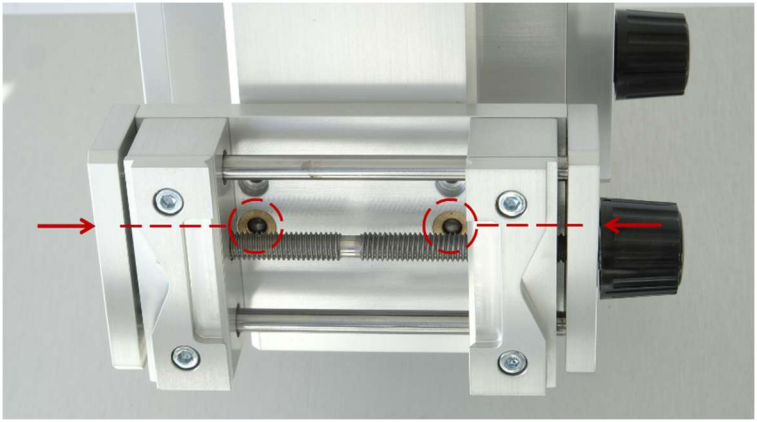


Figure 3: *detachable vice*

7 Programming

The kaloMAX II provides the possibility to save frequently used combinations of the parameters speed and grinding time under a program number, so that they can be accessed quickly when required. After switching on the kaloMAX II, the last program used is always active. The ↑↓ keys next to the readout are used to change the program. The corresponding values for speed and grinding time are displayed immediately.

Create a new program:

- Set the desired values for speed and grinding time
- Press the ´ENTER´ key
- Select the desired program number. The decimal point behind the number shows, that the programming is not yet completed. All keys except the 'ENTER' key are disabled.
- Press ´ENTER´ to complete the programming. The decimal point behind the program number disappears.

8 Performing a measurement

In order to determine the coating thickness with the highest possible accuracy, an accurate micrograph of the calotte is required. This depends on the following factors:

- Abrasive (e.g. diamond suspension)
- Speed
- Grinding time
- Ball diameter
- Normal force

The kaloMAX II is started with the power switch on the back of the device. The measurements can then be started directly.

Step 1: Sample clamping and positioning

First, the sample is cleaned if necessary and then clamped in the vice of the kaloMAX II. The normal force is then set by adjusting the distance between the sample and the driving shaft. As shown in the schematic diagram (Figure 1), the weight of the ball will be taken up by both the driving shaft and the sample. The greater the distance between sample and driving shaft, the greater the normal force on the sample. Afterwards, the sample can be positioned with the cross table so that the calotte is ground at the desired position.

Step 2: Choosing the grinding parameters

The grinding parameters speed and grinding time are set. It is possible to set these individually with the corresponding ↑↓ keys as well as to use a saved program (see Section 7).

Step 3: Laying the ball on the driving shaft

The ball is cleaned and can then be placed between the sample and the traction rings of the kaloMAX II.

Step 4: Applying the abrasive

A small amount of the abrasive (usually diamond suspension) is applied to the ball. A pipette or glass rod, for example, can be used for this purpose.

In some cases, it may be advantageous to apply several drops of the diamond suspension around the circumference of the ball. For this purpose, the shaft of the kaloMAX II can be rotated manually.

Step 5: Grinding process

The grinding process is started with the START key. The remaining time in the display runs backwards to zero. Afterwards, the sample can be placed under the microscope to determine the coating thickness (see Section 9).

Neither the ball nor the driving shaft may be touched during the grinding process.

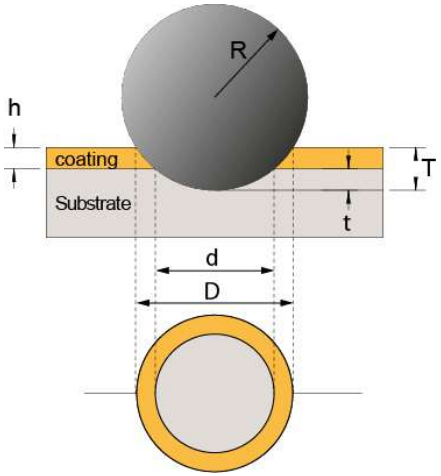
9 Evaluation of the calottes

Using the calotte grinding method, single layers and layer systems can be analyzed. Since, compared to the coating thicknesses, the diameter of the hardened steel ball is very large, the layer system is ground in a very flat angle, which in a way widens the coating. For this reason, the evaluation can be performed with a normal reflected light microscope (e.g. GSX-500).

For more information about GSX-500 and kaloSOFT, visit www.baq.de

9.1 Coating thickness measurement on flat samples

In order to be able to measure the thickness of a coating, the grinding depth must be greater than the coating thickness. If this is the case, each individual layer is visible under the microscope as a ring whose diameters can be measured.



Designations

h: coating thickness

R: radius of the ball

T: total depth of penetration

t: depth of penetration into the substrate

D: outer diameter of the calotte

d: inner diameter of the calotte

Figure 4: *Coating thickness measurement on flat samples*

The total penetration depth of the ball is:

$$T = R - \sqrt{R^2 - D^2/4} \quad (1)$$

The depth of penetration into the substrate is:

$$t = R - \sqrt{R^2 - D^2/4} \quad (2)$$

The thickness of the layer results from the difference:

$$h = T - t \quad (3)$$

$$h = \sqrt{R^2 - d^2/4} - \sqrt{R^2 - D^2/4} \quad (4)$$

If the coating is very thin and the calotte is only slightly ground into the substrate, the diameters D and d are very small compared to the radius of the sphere. In this case, the equation can be simplified to:

$$h = \frac{D^2 - d^2}{8 \cdot R} \quad (5)$$

It can be seen from equation 5 that the accuracy of the coating thickness measurement with the calotte grinding method depends on the accuracy with which the diameters D and d can be determined, since the error of R is less than 1‰. Meticulous measurement of the two diameters is also important because the two values are squared in the coating thickness calculation. To obtain a high accuracy, it is recommended to choose the depth of grind such that D ≈ 2 · d.

Further information on the consideration of measurement accuracy in the calotte grinding method at www.baq.de

9.2 Coating thickness measurement on cylindrical samples

If the calotte is ground into a cylindrical sample, ellipses result instead of rings. The coating thickness is calculated using the same formula as for flat samples. D and d must be determined on the longitudinal axis of the ellipse. The following figure illustrates the principle on the basis of a two-layer system:

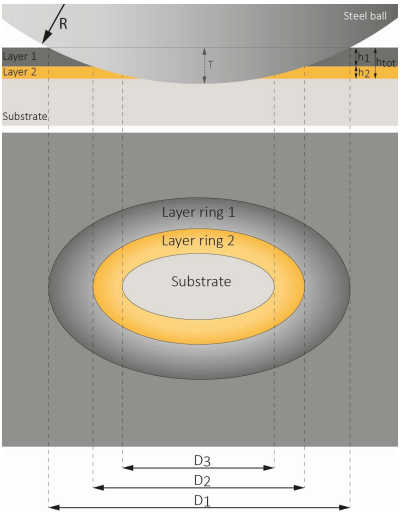
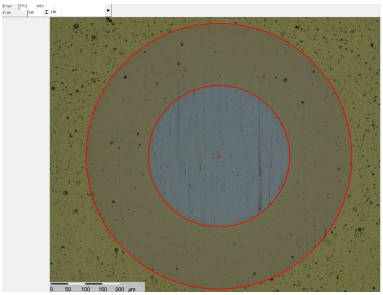
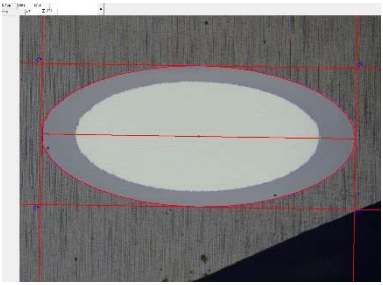


Figure 5: *Coating thickness measurement on cylindrical samples*

10 Example measurements

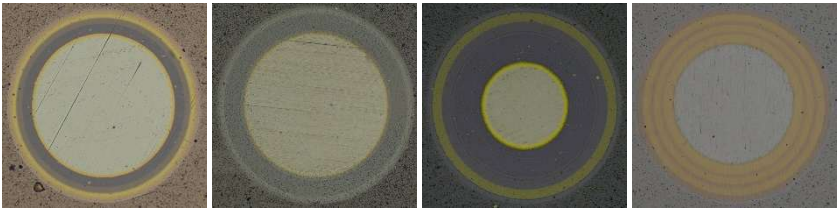


Coating:	**TiN**
Abrasive:	0.5 µm diamond suspension
Speed:	300 rpm
Time:	120 s
Ball-Ø:	30 mm
D = 777.3 µm	d = 415.1 µm
Coating thickness:	**3.60 µm**



Coating:	**AlTiN**
Abrasive:	0.5 µm diamond suspension
Speed:	100 rpm
Time:	180 s
Ball-Ø:	30 mm
D = 839.6 µm	d = 651.6 µm
Coating thickness:	**2.34 µm**

More calottes:



11 Maintenance of the unit

11.1 Cleaning

When cleaning the device, make sure that no liquids can get inside the kaloMAX II. The upper side is not completely sealed.

11.2 Fuses

Two 1 A delay-action fuses are placed in the power supply unit (double pole fuse protection).

11.3 Replacement of the driving shaft

If the traction rings on the driving shaft are damaged, it is easiest to replace the complete shaft unit, as the traction rings are ground for exact concentricity. This can only be done on the removed shaft. To remove the shaft, unscrew the cover on the left side. Then, after loosening the fixing screws on both sides of the shaft, the complete unit including the bearings can be pulled out to the left.

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