Method for Configuring a Double- or Single-Sided Processing Machine, and Double- or Single-Sided Processing Machine

The invention relates to a method for configuring a double- or single-sided processing machine with a preferably annular first working disk and a preferably annular counterbearing element, wherein the first working disk and the counterbearing element can be driven rotationally relative to each other, and wherein a preferably annular working gap for double-sided or single-sided processing of flat workpieces, preferably wafers, is formed between the first working disk and the counterbearing element.

The invention also relates to a double- or single-sided processing machine with a preferably annular first working disk and a preferably annular counterbearing element, wherein the first working disk and the counterbearing element can be driven rotationally relative to each other, and wherein a preferably annular working gap for double-sided or single-sided processing of flat workpieces, preferably wafers, is formed between the first working disk and the counterbearing element.

For example, in double-sided polishing machines, flat workpieces, such as wafers, are polished between preferably annular working disks. A preferably annular working gap is arranged between the working disks, in which the flat workpieces, for example wafers, are held during processing. For this purpose, what are known as rotor disks are typically arranged in the working gap, with recesses in which the workpieces are mounted in a floating manner. For processing, the working disks are driven rotationally relative to each other by means of a rotary drive and the rotor disks are also rotated in the working gap by external teeth of the rotor disks, which engage with corresponding teeth of pin rings. As a result, the workpieces are conveyed through the working gap along cycloidal paths during processing. In addition, a polishing agent, known as a slurry, is introduced into the working gap during double-sided polishing

and ensures abrasive processing. In addition, in double-sided polishing machines, the working disks regularly have polishing cloths, known as polishing pads, on their surfaces delimiting the working gap.

The goal of the processing is a shape of the completely processed workpieces that is as plane-parallel as possible. The working gap geometry is of decisive importance for this. A double-sided processing machine with means for generating a global deformation of one of the working disks is known from DE 10 2006 037 490 B4. In particular, the upper working disk can be deformed between a globally concave and a globally convex shape. In the case of such a global deformation, the concave or convex shape of the working disk first results over the entire diameter of the working disk, viewed in the radial direction. The ring surface of the preferably annular working disk delimiting the working gap remains planar in itself; however, opposite ring portions of the ring surface are deformed in relation to each other so that overall a concave or convex shape results.

A double-sided processing machine with means for generating a local deformation of one of the working disks, in particular between a local convex and a local concave shape, is also known from DE 10 2016 102 223 A1. In the case of such a local deformation, the convex or, respectively, concave shape results, in the radial direction, between the inner and outer edge of the, for example annular, working disk. Unlike with a global deformation, in the case of a local deformation the ring portions are thus themselves deformed concavely or convexly.

The two aforementioned embodiments can be combined in a double-sided processing machine. In this way, a wide range of working gap geometries can be generated. Thus, a processing of the workpieces that is as plane-parallel as possible or, respectively, a setting of the working gap that is preferred for the workpiece quality, whether this is parallel or not, can be ensured at all times, for example, in the case of partial wear of

the polishing cloths or in the case of changing temperatures of the components defining the working gap.

The geometry of the working gap has a decisive influence on the shape and the evenness of the processed workpieces. An optimal processing result is only achieved within a narrow parameter window. Due to production tolerances and varying geometries of, for example, polishing cloths, but also in the case of modified materials of specific components of the double-sided processing machine, such as the polishing disks, or a change in the typically provided cooling circuit in the working disks for tempering during processing, the position of this parameter window is not inherent for a specific double-sided processing machine and, apart from this, changes even between different double-sided processing machines of the same type. The right processing parameters for an optimal working gap must be determined manually in a complex manner. Usual methods are iterative. This means that experimental processing is performed repeatedly, the processed workpieces are measured, and the parameters are adjusted until a suitable working gap geometry is present. Alternatives are statistical design of experiments (DoE) processes. Both procedures have in common that they require a considerable number of data points (experiments) in order to determine the desired working point sufficiently exactly with algebraic or statistical methods. In addition to the considerable time and material outlay of this procedure, many workpieces are produced with the processing experiments, which workpieces are outside of the specification and accordingly form rejects.

Starting from the explained prior art, the object of the invention is therefore to provide a method and a double- or single-sided processing machine of the initially mentioned type, with which configuring for the processing of the workpieces is possible with little time and material outlay.

The invention solves this object through independent claims 1 and 9. Advantageous embodiments can be found in the dependent claims, the description and the figures.

For a method of the initially mentioned type, the invention solves the object through the following steps:

a) a control apparatus actuates means for step-by-step or continuously deforming the first working disk between a concave shape and a convex shape,

b) during the step-by-step or continuous deformation of the first working disk, the working gap width at at least two radially spaced apart locations of the first working disk is measured step-by-step or continuously and the measurement values are given to the control apparatus,

c) the control apparatus determines a measurement value average in each case from the preferably weighted measurement values of the working gap width at the at least two radially spaced apart locations,

d) the control apparatus determines the minimum of the preferably weighted measurement value averages and, on the basis of the determined minimum, specifies a target value for the means for deforming the first working disk as a starting value for the processing of flat workpieces in the double- or single-sided processing machine.

For a device of the initially mentioned type, the invention solves the object in that

- a control apparatus is provided, which is designed to actuate means for step-by-step or continuously deforming the first working disk between a concave shape and a convex shape,
- measuring apparatuses are provided, which are designed to measure the working gap width step-by-step or continuously at at least two radially spaced apart locations of the first working disk during the step-by-step or

continuous deformation of the first working disk and to give the measurement values to the control apparatus,

- the control apparatus is designed to determine a measurement value average in each case from the preferably weighted measurement values of the working gap width at the at least two radially spaced apart locations,
- the control apparatus is designed to determine the minimum of the preferably weighted measurement value averages and, on the basis of the determined minimum, specify a target value for the means for deforming the first working disk as a starting value for the processing of flat workpieces in the double- or single-sided processing machine.

The double- or single-sided processing machine according to the invention can be in particular a double- or single-sided polishing machine. However, the double- or single-sided processing machine can also be a double- or single-sided lapping machine or double- or single-sided grinding machine. The double- or single-sided processing machine has a preferably annular first working disk and a preferably annular counterbearing element. In a single-sided processing machine, the counterbearing element can be designed, for example, as a simple weight or pressure cylinder. The counterbearing element can preferably be a preferably annular second working disk. The first working disk and the counterbearing element can be driven rotationally relative to each other, and a preferably annular working gap for processing flat workpieces, such as wafers, is formed between the first working disk and the counterbearing element. In particular when it is a double- or single-sided polishing machine, at least the first working disk, preferably also the counterbearing element or, respectively, the second working disk, can have a polishing lining (polishing pad) on its surface(s) delimiting the working gap. In addition, during processing, a polishing agent, in particular a polishing liquid (slurry), can be introduced into the working gap in a manner known per se. The working disks can also be provided with tempering

channels, through which a tempering liquid, for example, cooling water, is conducted to temper the working disk(s) during operation.

The double- or single-sided processing machine serves in particular for plane-parallel processing of flat workpieces. For processing, the workpieces can be accommodated, in a manner known per se, in a swimming manner in recesses of rotor disks arranged in the working gap. The first working disk and the counterbearing element are driven rotationally relative to each other, for example, by a corresponding drive shaft and at least one drive motor, during operation. It is possible that only one of the first working disk and counterbearing element is driven rotationally. However, both the first working disk and the counterbearing element can also be driven rotationally, in this case typically in opposite directions. For example, in the case of a double-sided processing machine, the rotor disks can also be moved rotationally through the working gap by a suitable kinematic system in the course of the relative rotation between the first working disk and the counterbearing element, so that workpieces arranged in the recesses of the rotor disks describe cycloidal paths in the working gap. For example, the rotor disks can have teeth on their outer edges that engage with corresponding teeth of pin rings. Such machines form what is known as a planetary kinematic system.

The first working disk and/or the counterbearing element can each be held by a support disk. Like the first working disk and the counterbearing element, the support disks can also be annular or have at least annular support portions.

According to the invention, a control apparatus is provided, which actuates means for deforming the first working disk between a concave shape and a convex shape step-by-step or continuously to deform the first working disk between the concave shape and the convex shape. During the step-by-step or continuous deformation of the first working disk between the convex shape and the concave shape, the thickness or,

respectively, width of the working gap is measured accordingly step-by-step or continuously at at least two radially spaced apart locations by measuring apparatuses. For example, in the case of step-by-step deformation of the first working disk, the working gap width is measured at the at least two locations at each deformation step. The working gap width is defined by the distance between the surfaces of the first working disk and of the counterbearing element delimiting the working gap. If the first working disk or the counterbearing element have a working lining, such as a polishing cloth, the distance and thus the working gap width can be formed accordingly between the working linings. The working gap width can be measured by the measuring apparatuses, for example, by distance sensors. Optical measuring apparatuses or eddy current measuring apparatuses, for example, can be considered.

After the deformation of the first working disk between the concave shape and the convex shape is completed, there are thus at least two series of measurements for the working gap width, namely for the at least two radially spaced apart measurement locations. Of course, the working gap width could also be measured and evaluated according to the invention at more than two radially spaced apart measurement locations, for example, at three radially spaced apart measurement locations.

The control apparatus also determines an average in each case from the measurement values, recorded for the respective deformation of the first working disk, of the working gap width at the at least two radially spaced apart measurement locations. The averages are thus formed in each case for a specific degree of deformation of the first working disk from the measurement values at the at least two radially spaced apart locations of the first working disk. The average can be, for example, a weighted average, in which the measurement values at the at least two radially spaced apart locations are included with a weighting factor. Such a weighting can be desired, for example, in the case of radial measuring points arranged non-symmetrically in

relation to each other. There is thus a series of averages corresponding to the series of measurements for the working gap width.

The control apparatus now also determines the minimum of this series of averages. The series of measurements and the series of averages can be determined, for example, in the case of a step-by-step deformation of the first working disk by a curve fit along the individual measuring points. Accordingly, the series of averages can also be determined by a curve fit. On this basis, the control apparatus can establish the minimum of the series of averages mathematically in a simple manner.

On the basis of the determined minimum, the control apparatus specifies a target value for the means for deforming the first working disk. This target value serves as a starting value for the processing of flat workpieces in the double- or single-sided processing machine. The target value or, respectively, the target values can be specified such that the target value or, respectively, the target values are displayed to an operating person on an operating interface so that the operating person can then actuate the means for deforming the first working disk according to the target value or, respectively, the target values. However, it is also possible for the control apparatus to actuate the means for deforming the first working disk automatically on the basis of the target value determined from the minimum of the measurement value averages. In this case, the double- or single-sided processing machine can be configured according to the invention fully automatically by the control apparatus. The control apparatus can also be a control and regulation apparatus.

In any case, the double- or single-sided processing machine is configured partially automatically by the control apparatus as a setup. The double- or single-sided processing machine can be configured accordingly without iterative processing of workpieces and subsequent measurement. The time outlay associated with the configuration is considerably shorter than in the prior art, in particular also shorter

than a single processing process required for an iterative determination of the configuration parameters. With an iterative determination, a plurality of processing processes must also be performed and evaluated. In the best case, according to the invention the production of reject workpieces can be completely avoided.

A pressure or, respectively, a force exerted by the means for deforming the first working disk, for example, can be considered as target values for the control values of the means for deforming the first working disk. The result of the configuration process according to the invention is a working gap geometry, in particular a working gap width and a global and/or local deformation of the first working disk and, if applicable, of the counterbearing element, with which a processing result that is satisfactory at the beginning of the process can be implemented. Of course, it may be possible to process the target value specified by the control apparatus still further, for example, to add it, for example, to a processing-specific or machine-specific offset value. By performing the configuration process according to the invention multiple times, the wear of components of the double- or single-sided processing machine, for example, of working linings such as polishing cloths, can also be monitored. Deterioration of the working linings thus leads to a change in the working gap width. Further wear or, respectively, a necessary replacement of the working linings can be inferred from corresponding monitoring.

According to one embodiment, it can be provided that the control apparatus identifies the measurement values of the working gap width, forming the minimum of the measurement value averages, at the at least two radially spaced apart locations, and that the control apparatus specifies the actuation values of the means for deforming the first working disk corresponding to the identified measurement values of the working gap width at the at least two radially spaced apart locations as the target value. In this embodiment, the control apparatus identifies the at least two measurement values at the at least two radially spaced apart locations, the average of which forms

the minimum of the measurement value averages, on the basis of the previously determined minimum of the measurement value averages. The values, corresponding to these identified measurement values of the working gap width, for actuating the means for deforming the first working disk are then specified by the control apparatus as the target value. In this way, the target value can be specified in a particularly simple manner.

The means for deforming the first working disk can generate a global deformation of the first working disk. Additionally or alternatively, it is possible that the means for deforming the first working disk generate a local deformation of the first working disk. It is also possible that means for globally and/or locally deforming the counterbearing element are also provided.

As explained previously, a local concave or convex deformation, as it is known, for example, from DE 10 2016 102 223 A1, must be differentiated from a global concave or convex deformation, as it is known, for example, from DE 10 2006 037 490 B4. In the case of a local deformation, the convex or, respectively, concave shape or, respectively, deformation is present in the radial direction between the inner and outer edge of the, for example annular, working disk or, respectively, the annular working surface of the working disk delimiting the working gap. If the first working disk is not annular, the convex or, respectively, concave deformation is present in the radial direction between the center and the outer edge of the working disk. In the case of a global deformation, the concave or convex shape results, as explained, over the entire diameter of the working disk viewed in the radial direction. However, in the case of an exclusively global deformation, the working surface is planar in each case in the radial direction between the inner and outer edge of an annular working disk or, respectively, between the center and the outer edge of a non-annular working disk.

According to the invention, the means for deforming the first working disk and/or the counterbearing element can be both means for generating a global deformation and means for generating a local deformation. In the case of a combination of both types of deformation, the working gap can be adjusted to the respective requirements in a particularly flexible and precise way.

According to another configuration, it can be provided that, in a first method step, the steps a) to d) are performed with means for generating a global deformation of the first working disk, and in a second, subsequent method step, the steps a) to d) are performed once again with means for generating a local deformation of the first working disk or of the counterbearing element, wherein during the second method step, the means for generating the global deformation are actuated with the target value specified after performing the first method step.

It can furthermore be provided that, in a first method step, the steps a) to d) are performed with means for generating a local deformation of the first working disk, and in a second, subsequent method step, the steps a) to d) are performed once again with means for generating a global deformation of the first working disk or of the counterbearing element, wherein during the second method step, the means for generating the local deformation are actuated with the target value specified after performing the first method step.

In these embodiments, the method according to the invention with the steps a) to d) is executed twice in a row, namely first with a global or local deformation of the first working disk between a concave shape and a convex shape and establishing a target for actuating the means for generating the global or local deformation. The means for generating the respective other of global or local deformation are held constant during this first portion of the method. During the second portion of the method, now with the other of global or local deformation of the first working disk, or preferably of the

counterbearing element in the form of a second working disk, between a concave shape and a convex shape, the means for generating the first of global or local deformation are held constant at the actuated target value established previously in the first portion of the method, and a target value is established and specified as an actuation value for the means for generating the respective other of global or local deformation.

In this way, the means for generating the global deformation and the means for generating the local deformation can be set one after the other to a target value that is optimal for the processing result. Setting to the target values and holding during the respective portions of the method can in turn take place automatically by the control apparatus. Of course, the aforementioned two procedures can also be performed one after the other, if applicable also multiple times.

According to another embodiment, before method step a), the control apparatus can actuate means for generating an axial relative movement between the first working disk and the counterbearing element once or multiple times so that the first working disk and the counterbearing element are pressed against each other with their surfaces delimiting the working gap. The means for generating the axial relative movement can comprise in particular an axial drive of the first working disk and/or of the counterbearing element. By pressing together the first working disk and the counterbearing element with their surfaces delimiting the working gap, a working lining of the first working disk and/or of the counterbearing element can be compressed and any remaining liquid contained in it can be pressed out. As a result, identical starting conditions, including with regard to the working lining, for example, a polishing cloth, are ensured before the beginning of the configuring process according to the invention.

According to another embodiment, the means for deforming the first working disk can be designed to generate a global deformation of the first working disk. It can also be provided that the first working disk is fastened to a first support disk, and that a support ring is provided, on which the first support disk is suspended, wherein between the support ring and a ring portion of the first support disk lying radially outward from the support ring, means controllable by the control apparatus are arranged, by means of which a radial force can be applied to the first support disk over the circumference of the support ring with the aid of a force generator. Such an embodiment for generating a global deformation is known, for example, from DE 10 2006 037 490 B4. It can be used as described in this document in the present invention.

In principle, the means for generating a global deformation of the first working disk and/or a local deformation of the first working disk or of the counterbearing element can be hydraulic means and/or pneumatic means and/or mechanical means. Suitable actuators for manipulating the geometry of the first working disk and/or of the counterbearing element are provided in each case. The first working disk can be, for example, an upper working disk and the counterbearing element can be a lower counterbearing element, for example, a lower working disk.

As already explained, the means for deforming the first working disk can be designed to generate a local deformation of the first working disk. Means for deforming the counterbearing element can also be provided, which are designed to generate a local deformation of the counterbearing element.

It can then furthermore be provided that the first working disk is fastened to a first support disk and/or that the counterbearing element is fastened to a second support disk, wherein the means for generating the local deformation of the first working disk and/or of the counterbearing element comprise an annular pressure volume designed

between the first support disk and the first working disk and/or between the second support disk and the counterbearing element, which pressure volume is connected to a fluid supply that can be actuated by the control apparatus such that a pressure is built up in the pressure volume and generates a specified local deformation of the first working disk and/or of the counterbearing element. Furthermore, it can be provided that the first working disk is fastened to the first support disk only in the region of its outer edge and in the region of the its inner edge and/or that the counterbearing element is fastened to the second support disk only in the region of its outer edge and in the region of its inner edge. These embodiments for generating the local deformation are known, for example, from DE 10 2016 102 223 A1. They can be used as described there in the present invention.

As already explained, it can be provided that the counterbearing element is formed by a preferably annular second working disk, wherein the first and second working disks are arranged coaxially to each other and can be driven rotationally relative to each other, wherein the working gap for double-sided or single-sided processing of flat workpieces is formed between the working disks.

The method according to the invention can be performed with the double- or single-sided processing machine according to the invention. Accordingly, the double- or single-sided processing machine according to the invention, in particular its control apparatus and its measuring apparatuses, can be designed to perform the method according to the invention.

Exemplary embodiments of the invention are explained below in greater detail using figures. They show schematically:

Figure 1 a double-sided processing machine according to the invention in a partial depiction according to a first exemplary embodiment,

Figure 2 two operating states of the double-sided processing machine shown in Figure 1,

Figure 3 a double-sided processing machine according to the invention in a partial depiction in a sectional view according to another exemplary embodiment,

Figure 4 the double-sided processing machine from Figure 3 in another operating state,

Figure 5 the double-sided processing machine from Figure 3 in another operating state,

Figure 6 a diagram for illustrating the configuring process of the double-sided processing machine shown in Figure 1,

Figure 7 a diagram for illustrating the configuring process of the double-sided processing machine shown in Figure 3.

The double-sided processing machine shown in Figure 1, which can be, for example, a double-sided polishing machine, has an upper support disk 10 and a lower support disk 12, which are each connected to a shaft of a rotary drive, which is not shown. A first working disk 14 is connected to the upper support disk 10, and a second working disk 16 is connected to the lower support disk 12. The working disks 14, 16 are each designed annularly like the support disks 10, 12 and form between them a working gap s. The working disks 14, 16 can each have, for example, a working lining, for example a polishing cloth, on their surfaces delimiting the working gap s. The support disks 10, 12 can also be provided with a suitable tempering channel system in order

to effect a tempering, for example, cooling, during operation by passing a tempering liquid, for example cooling water, through it.

The upper support disk 10 has a ring portion 18 extending upwards approximately in the middle of the radial extension of its working surface. A support ring 20, which is connected to the upper shaft 24 of the rotary drive via arms 22 arranged in a star shape, is located inside the ring portion 18. Through means not shown in Figure 1, the support disk 10 is suspended on the support ring so that a rotation of the shaft 24 also causes a rotation of the working disk 14 in this way.

A ring slot 26 is formed between the support ring 20 and the ring portion 18. The ring slot is sealed and connected to the channel 28. The channel is in connection with a pressure intensifier 30, which is supplied with variable pressure by a proportional valve 32. The depiction is only schematic. It is intended to indicate that it is possible with the aid of the pressure intensifier 30 and the proportional valve 32 to generate and maintain a specified pressure in the ring slot 26. The proportional valve 32 is actuated by a control apparatus 34, which receives measurement values of the working gap width of the working gap s, measured with the aid of two sensors 42 or, respectively, 44 embedded in the first working disk 14, at two radially spaced apart measurement locations.

The left depiction in Figure 2 shows how the upper working disk 14 takes on a convex shape by generating a suitable pressure in the ring slow. It is understood that the depiction is highly exaggerated. The convexity is in gap width differences in the µ-range in relation to the lower working disk 16. The right depiction in Figure 2 shows how, due to the described deformation of the upper support disk 10 and thus of the upper working disk 14, it now takes on a concave shape.

To configure the double-sided processing machine, the control apparatus 34 controls the proportional valve 32 as part of the means for generating a global deformation of the first working disk 14 for step-by-step or continuously deforming the first working disk 14 between a global convex shape as shown in the left depiction in Figure 2 and a global concave shape as shown in the right depiction in Figure 2. During the step-by-step or continuous deformation of the first working disk 14, the width of the working gap s or, respectively, the distance between the surfaces of the working disks 14, 16 delimiting the working gap is measured at the two radially spaced apart locations of the first working disk 14 by the sensors 42 and 44 as measuring apparatuses 42, 44 and the measurement values are given to the control apparatus 34. From the measurement values of the working gap width at the at least two radially spaced apart locations, the control apparatus 34 determines a measurement value average in each case. The control apparatus also determines the minimum of the measurement value averages and, on the basis of the determined minimum, specifies a target value for the means for deforming the first working disk 14 as a starting value for the processing of flat workpieces in the double-sided processing machine, in the present case in particular a first target value for the proportional valve 32.

In Figures 3 to 5, a double-sided processing machine according to another exemplary embodiment is shown. In the exemplary embodiment according to Figures 3 to 5, means for generating a local deformation of the lower, second working disk 16 are provided. This exemplary embodiment can be combined with the exemplary embodiment according to Figures 1 to 2 such that the double-sided processing machine has both the means for generating a global deformation of the first working disk 14 shown in Figures 1 and 2 and the means for generating a local deformation of the second working disk 16 shown in Figures 3 to 5. The configuring process explained in the following for the double-sided processing machine according to Figures 3 to 5 can be performed accordingly independently of the configuring process explained above in reference to Figures 1 and 2 or in a second portion of the method

after the configuring process explained above in reference to Figures 1 and 2 is completed as part of a first portion of the method. In the latter case, the control apparatus 34 actuates the means for generating the global deformation according to Figures 1 and 2 to the target value determined as explained above and keeps it constant during the configuring process in relation to Figures 3 to 5, as described below.

In Figures 3 to 5, some of the same reference signs are used as in Figures 1 and 2. In this respect, they are in principle functionally identical components, which can be combined as explained with the exemplary embodiment according to Figures 1 and 2.

As explained in relation to the exemplary embodiment according to Figures 1 and 2, the double-sided processing machine according to the invention shown in Figures 3 and 5 also has an annular upper support disk 10 and a likewise annular lower support disk 12. A first annular upper working disk 14 is in turn fastened to the upper support disk 10 and a second, likewise annular lower working disk 16 is fastened to the lower support disk 12. Between the annular working disks 14, 16, a likewise annular working gap s is in turn formed, in which flat workpieces, for example, wafers, are processed on both sides during operation. The double-sided processing machine can be, for example, a polishing machine, a lapping machine, or a grinding machine, as in Figures 1 and 2.

The upper support disk 10 and with it the upper working disk 14 and/or the lower support disk 12 and with it the lower working disk 16 can be driven rotationally relative to each other by a suitable drive apparatus, comprising, for example, an upper drive shaft and/or a lower drive shaft and at least one drive motor. Such a drive apparatus is known per se and is not shown in more detail for clarity reasons. In a manner that is also known per se, the workpieces to be processed can be held in the working gap s in a swimming manner in rotor disks. With a suitable kinematic system, for example a planetary kinematic system, it can be ensured that the rotor disks also

rotate through the working gap s in the course of the relative rotation of the support disks 10, 12 or, respectively, working disks 14, 16. In the upper working disk 14 or the upper support disk 10 and possibly also the lower working disk 16 or the lower support disk 12, tempering channels can be designed, through which a tempering fluid, for example, a tempering liquid such as cooling water, can be conducted during operation. This is also known per se and is not shown in more detail.

The double-sided processing machine shown in Figures 3 to 5 has in turn measuring apparatuses that measure the width of the working gap s at multiple, in the present case three, radially spaced apart locations, as shown in Figure 3 with the reference signs 46, 48, 50. Like the measuring apparatuses 42, 44 in the exemplary embodiment according to Figures 1 and 2, the measuring apparatuses according to the exemplary embodiment of Figures 3 to 5 also measure in particular the distance between the surfaces of the working disks 14, 16 delimiting the working gap s. As can be seen, the distance measuring apparatus illustrated with the reference sign 46 measures the distance between the upper working disk 14 and the lower working disk 16 in the region of the radially outer edge of the working gap s. The distance measuring apparatus illustrated with the reference sign 50 measures the distance between the upper working disk 14 and the lower working disk 16 in the region of the radially inner edge of the working gap s. The distance measuring apparatus illustrated with the reference sign 48 measures the distance between the upper working disk 14 and the lower working disk 16 in the middle of the working gap s. The measurement values of the working gap width obtained by the measuring apparatuses are in turn transmitted to the control apparatus 34.

In the present case, the lower working disk 16 is fastened to the lower support disk 12 only in the region of its outer edge and in the region of its inner edge, for example, screwed along a partial circle in each case, as illustrated in Figure 1 with the reference signs 52 and 54. In contrast, the lower working disk 16 is not fastened to the lower

support disk 12 between these fastening locations 52 and 54. Instead, between these fastening locations 52, 54, an annular pressure volume 56 is located between the lower support disk 12 and the lower working disk 16. The pressure volume 56 is connected to a pressure fluid reservoir not shown in greater detail in the figures, for example a liquid reservoir, in particular a water reservoir, via a dynamic pressure line 58. In the dynamic pressure line 58, a pump and a control valve can be arranged, which can be actuated by the control apparatus 34 as the means for generating a local deformation of the lower working disk 16. In this way, a desired pressure, which acts on the lower working disk 16, can be built up in the pressure volume 56 by fluid introduced into the pressure volume 56. The pressure prevailing in the pressure volume 56 can be measured by a pressure measuring apparatus not shown in greater detail. The measurement data of the pressure measuring apparatus can also be applied to the control apparatus 34 so that the control apparatus 34 can set a specified pressure in the pressure volume 56.

Due to its freedom of movement between the fastening locations 52, 54, the lower working disk 16 can be brought into a convex shape locally, as indicated in Figure 4 by a dotted line at the reference sign 60, by setting a sufficiently high pressure in the pressure volume 56. If one assumes a pressure p_0 in the pressure volume 56 in the operating state of Figure 3, in which the lower working disk 16 has a planar shape, the convex deformation of the lower working disk 16 shown in Figure 4 with 60 can be achieved by setting a pressure $p_1 > p_0$. On the other hand, a local concave deformation of the lower working disk 16 can be achieved by setting a pressure $p_2 < p_0$ in the pressure volume 56, as illustrated in Figure 5 by a dotted line with the reference sign 62.

In this case, it can be seen that the lower working disk 16 can take on a locally convex shape (Figure 4) or, respectively, a locally concave shape (Figure 5), viewed in the

radial direction, between its inner edge, in the region of the fastening location 52, and its outer edge, in the region of the fastening location 54.

As explained above in relation to Figures 1 and 2, an automatic configuring process is also performed by the control apparatus 34 in the exemplary embodiment according to Figures 3 to 5. For this purpose, the control apparatus 34 first actuates the means for step-by-step or continuously deforming the first working disk between a locally concave shape and a locally convex shape, as shown in Figures 4 and 5 with the reference signs 60 and 62. During the step-by-step or continuous deformation of the first working disk 14, the working gap width at, in the present case, three radially spaced apart locations of the first working disk 14 is measured step-by-step or continuously and the measurement values are given to the control apparatus 34. On this basis, the control apparatus 34 determines a measurement value average at each of the, in the present case, three radially spaced apart locations. For example, the measurement values at the three different radial locations can be weighted in that the measurement values are included in the average determination with corresponding weighting factors. The control apparatus 34 furthermore determines the minimum of the measurement value averages and, on the basis of the determined minimum, specifies a target value for the means for deforming the second working disk 16 as a starting value for the processing of flat workpieces in the double-sided processing machine. In particular, the control apparatus 34 controls the pressure in the pressure volume 56 for this purpose via the dynamic pressure line 58 according to the determined target value.

As explained, the method described for Figures 3 to 5 can be performed in particular in a second portion of the method after the first portion of the method described for Figures 1 and 2. In this way, a complete automatic configuration of the double-sided processing machine including the global and local working gap geometry that is optimal in each case for the processing can be specified and set by the control

apparatus 34. However, it is also conceivable for the method explained for Figures 3 to 5 to be performed without the method explained for Figures 1 and 2, wherein, in this case, the lower working disk 16 in Figures 3 to 5 can be the first working disk 16.

In the diagram shown in Figure 6, the configuring process according to Figures 1 and 2 is explained in more detail. In particular, the working gap width (distance) is shown there over time (time) during a deformation of the first working disk 14 between a global concave shape and a global convex shape. The curve $d_{outside}$ shows the corresponding measurement values of the measuring apparatus 44 measuring the working gap width at the radially outer location and the curve d_{inside} shows the corresponding measurement values of the measuring apparatus 42 measuring at the radially inner location. The curve $d_{evaluated}$ is the associated series of averages, as determined by the control apparatus 34. The minimum of this series of averages $d_{evaluated}$ can now be taken as the ideal value. In the example shown, it corresponds largely to the crossover point between the groups d_{inside} and $d_{outside}$. The minimum can also be outside of the crossover point, depending on various parameters, such as the dressing formula or, respectively, wear of the polishing linings.

Figure 7 shows a corresponding diagram for the configuring process according to Figures 3 to 5. In this case, the curve $d_{outside}$ shows the series of measurements during the local deformation of the second working disk 16 between a locally concave shape and a locally convex shape at the measurement location 46 in Figure 3, meaning at the radially outer measurement location. The curve d_{inside} shows the series of measurements at the radially inner measurement location 50. The curve d_{middle} shows the measurement values in the middle region 48 in Figure 3. The curve $d_{evaluated}$ in turn shows a series of averages for the series of measurements. The minimum can in turn be seen as an optimal value for the start of the processing process.

List of Reference Signs

s	Working gap
d_{inside}	Curve
$d_{outside}$	Curve
d_{middle}	Curve
$d_{evaluated}$	Curve
10	Upper support disk
12	Lower support disk
14	First working disk
16	Second working disk
18	Ring portion
20	Support ring
22	Arms
24	Upper shaft
26	Ring slot
28	Channel
30	Pressure intensifier
32	Proportional valve
34	Control apparatus
42	Sensor
44	Sensor
46	Distance measurement
48	Distance measurement
50	Distance measurement
52	Fastening location
54	Fastening location
56	Pressure volume
58	Dynamic pressure line
60	Convex deformation
62	Concave deformation

Claims

1. A method for configuring a double- or single-sided processing machine with a preferably annular first working disk (14) and a preferably annular counterbearing element (16), wherein the first working disk (14) and the counterbearing element (16) can be driven rotationally relative to each other, and wherein a preferably annular working gap (s) for double-sided or single-sided processing of flat workpieces, preferably wafers, is formed between the first working disk (14) and the counterbearing element (16), characterized by the following steps:
   a) a control apparatus (34) actuates means for step-by-step or continuously deforming the first working disk (14) between a concave shape and a convex shape,
   b) during the step-by-step or continuous deformation of the first working disk (14), the working gap width at at least two radially spaced apart locations of the first working disk (14) is measured step-by-step or continuously and the measurement values are given to the control apparatus (34),
   c) the control apparatus (34) determines a measurement value average in each case from the measurement values of the working gap width at the at least two radially spaced apart locations,
   d) the control apparatus (34) determines the minimum of the measurement value averages and, on the basis of the determined minimum, specifies a target value for the means for deforming the first working disk (14) as a starting value for the processing of flat workpieces in the double- or single-sided processing machine.

2. The method according to claim 1, characterized that the control apparatus (34) identifies the measurement values of the working gap width forming the

minimum of the measurement value averages at the at least two radially spaced apart locations, and that the control apparatus (34) specifies the actuation values of the means for deforming the first working disk (14) corresponding to the identified measurement values of the working gap width at the at least two radially spaced apart locations.

3. The method according to one of the preceding claims, characterized in that the means for deforming the first working disk (14) generate a global deformation and/or a local deformation of the first working disk (14).

4. The method according to one of the preceding claims, characterized in that means for globally and/or locally deforming the counterbearing element (16) are furthermore provided.

5. The method according to one of claims 3 or 4, characterized in that, in a first portion of the method, the steps a) to d) are performed with means for generating a global deformation of the first working disk (14), and in a second, subsequent portion of the method, the steps a) to d) are performed once again with means for generating a local deformation of the first working disk (14) or of the counterbearing element (16), wherein during the second portion of the method, the means for generating the global deformation are actuated with the target value specified after performing the first portion of the method.

6. The method according to one of claims 3 to 5, characterized in that, in a first portion of the method, the steps a) to d) are performed with means for generating a local deformation of the first working disk (14), and in a second, subsequent portion of the method, the steps a) to d) are performed once again with means for generating a global deformation of the first working disk (14) or of the counterbearing element (16), wherein during the second portion of the method,

the means for generating the local deformation are actuated with the target value specified after performing the first portion of the method.

7. The machine according to one of the preceding claims, characterized in that, before method step a), the control apparatus (34) actuates means for generating an axial relative movement between the first working disk (14) and the counterbearing element (16) once or multiple times so that the first working disk (14) and the counterbearing element (16) are pressed against each other with their surfaces delimiting the working gap (s).

8. The method according to one of the preceding claims, characterized in that it is performed with a double- or single-sided processing machine according to one of the following claims.

9. A double- or single-sided processing machine with a preferably annular first working disk (14) and a preferably annular counterbearing element (16), wherein the first working disk (14) and the counterbearing element (16) can be driven rotationally relative to each other, and wherein a preferably annular working gap (s) for double-sided or single-sided processing of flat workpieces, preferably wafers, is formed between the first working disk (14) and the counterbearing element (16), characterized in that
   - a control apparatus (34) is provided, which is designed to actuate means for step-by-step or continuously deforming the first working disk (14) between a concave shape and a convex shape,
   - measuring apparatuses (42, 44, 46, 48, 50) are provided, which are designed to measure the working gap width step-by-step or continuously at at least two radially spaced apart locations of the first working disk (14) during the step-by-step or continuous deformation of the first working disk (14) and to give the measurement values to the control apparatus (34),

- the control apparatus (34) is designed to determine a measurement value average in each case from the measurement values of the working gap width at the at least two radially spaced apart locations,
- the control apparatus (34) is designed to determine the minimum of the measurement value averages and, on the basis of the determined minimum, specify a target value for the means for deforming the first working disk (14) as a starting value for the processing of flat workpieces in the double- or single-sided processing machine.

10. The double- or single-sided processing machine according to claim 9, characterized that the control apparatus (34) is designed to determine the measurement values of the working gap width forming the minimum of the measurement value averages at the at least two radially spaced apart locations, and that the control apparatus (34) is designed to specify the actuation values of the means for deforming the first working disk (14) corresponding to the identified measurement values of the working gap width at least two radially spaced apart locations as the target value.

11. The double- or single-sided processing machine according to one of claims 9 or 10, characterized in that the means for deforming the first working disk (14) are designed to generate a global deformation and/or a local deformation of the first working disk (14).

12. The double- or single-sided processing machine according to claim 11, characterized in that the first working disk (14) is fastened to a first support disk (10), and that a support ring (20) is provided on which the first support disk (10) is suspended, wherein between the support ring (20) and a ring portion (18) of the first support disk (10) lying radially outward from the support ring (20), means controllable by the control apparatus (34) are arranged,

by means of which a radial force can be applied to the first support disk (10) over the circumference of the support ring (20) with the aid of a force generator.

13. The double- or single-sided processing machine according to one of claims 9 to 12, characterized in that means for globally and/or locally deforming the counterbearing element (16) are also provided.

14. The double- or single-sided processing machine according to one of claims 11 to 13, characterized in that the means for generating a global and/or local deformation of the first working disk (14) and/or the means for generating a global and/or local deformation of the counterbearing element (16) are hydraulic means and/or pneumatic means and/or mechanical means.

15. The double- or single-sided processing machine according to one of claims 11 to 14, characterized in that the first working disk (14) is fastened to a first support disk (10) and/or that the counterbearing element (16) is fastened to a second support disk (12), wherein the means for generating the local deformation of the first working disk (14) and/or of the counterbearing element (16) comprise an annular pressure volume (56) designed between the first support disk (10) and the first working disk (14) and/or between the second support disk (12) and the counterbearing element (16), which pressure volume is connected to a fluid supply that can be actuated by the control apparatus (34) such that a pressure is built up in the pressure volume (56) and generates a specified local deformation of the first working disk (14) and/or of the counterbearing element (16).

16. The double- or single-sided processing machine according to one of claims 11 to 15, characterized in that the first working disk (14) is fastened to the first support disk (10) only in the region of its outer edge and in the region of the its inner edge and/or that the counterbearing element (16) is fastened to the second

support disk (12) only in the region of its outer edge and in the region of its inner edge.

17. The double- or single-sided processing machine according to one of claims 9 to 16, characterized in that the counterbearing element (16) is formed by a preferably annular second working disk (16), wherein the first and second working disks (14, 16) are arranged coaxially to each other and can be driven rotationally relative to each other, wherein the working gap (s) for double-sided or single-sided processing of flat workpieces is formed between the working disks (14, 16).

18. The double- or single-sided processing machine according to one of claims 9 to 17, characterized in that it is designed to perform the method according to one of claims 1 to 8.

19. The double- or single-sided processing machine according to claim 18, characterized in that the control apparatus (34) is designed, in a first portion of the method, to perform the method steps a) to d) with means for generating a global deformation of the first working disk (14), and in a second, subsequent portion of the method, to once again perform the method steps a) to d) with means for generating a local deformation of the first working disk (14) or of the counterbearing element (16), and during the second portion of the method, to actuate the means for generating the global deformation with the target value specified after performing the first portion of the method.

20. The double- or single-sided processing machine according to one of claims 18 or 19, characterized in that the control apparatus (34) is designed, in a first portion of the method, to perform the method steps a) to d) with means for generating a local deformation of the first working disk (14), and in a second, subsequent portion of the method, to once again perform the method steps a) to

d) with means for generating a global deformation of the first working disk (14) or of the counterbearing element (16), and during the second portion of the method, to actuate the means for generating the local deformation with the target value specified after performing the first portion of the method.

21. The double- or single-sided processing machine according to one of claims 18 to 20, characterized in that the control apparatus (34) is designed, before method step a), to actuate means for generating an axial relative movement between the first working disk (14) and the counterbearing element (16) once or multiple times so that the first working disk (14) and the counterbearing element (16) are pressed against each other with their surfaces delimiting the working gap (s).