

The invention concerns a device for connecting two tool sections having a common axis, particularly an axis of rotation, with a fitting pin projecting axially from the first tool section, with an annular surface surrounding the fitting pin at its root, with a connecting sleeve projecting axially from the second tool section, having a mating bore for receiving the fitting pin and an annular end face which is pressable against the annular surface, with a one-part or multi-part tightening bolt movable in a cross bore of the fitting pin and, if necessary, arranged rotatably about its axis, having an internal or external cone at its ends, and with two retaining screws guided in diametrically opposed internal threads of the connecting sleeve, having an external or internal cone facing the inside of the sleeve and corresponding to the internal or external cone of the tightening bolt, which are lockable with the tightening bolt in a wedge-like manner during the tightening operation, the tightening bolt and the retaining screws having an axial offset causing, during the tightening operation, a pulling of the fitting pin into the mating bore and a mutual pressing together of the annular surface and the end face.

A device of this type is known (GB-A 2094191) in which the tightening bolt is designed as a one-piece connecting or self-aligning bolt, one end of which may be designed as an internal cone and the other end of which may be designed as an external cone. With this device, the tightening operation is started by screwing in the retaining screw (tightening screw) provided with the external cone. If contact occurs during the screwing in of the tightening screw, then the forces introduced via the screw first occur on the tightening screw side of the self-aligning bolt. At the same time, the self-aligning bolt is first pressed on the tightening screw side against the base of the cross bore facing the end of the fitting pin in such a manner that the fitting pin is drawn into the mating bore. This also occurs immediately thereafter when the external cone of the self-aligning bolt comes to stop on the internal cone of the opposed retaining screw. As soon as a specific tightening effect has

occurred, the radial forces are fully transformed into an axial component which presses together the annular surface of the fitting pin and the end face of the connecting sleeve. This type of bracing preferentially results in reinforcement of the connecting device in the direction of the self-aligning bolt. The torsional forces occurring during the machining operation cause the adjacent internal and external cones to stop against one another, which is made possible, in particular, in that the self-aligning bolt is able to rotate slightly about its own axis. Thus, the bracing between the annular surface and end surface is increased, thus also increasing the rigidity of the connection. Furthermore, the stopping effect causes a non-harmonic vibration response in the region of the connection with the result that the natural frequency of the system is shifted in relation to the torsional moment and any torsional vibration which might occur is therefore dampened.

Furthermore, in a device of the type cited at the start, it is known to design the tightening bolt in two parts and to initiate the tightening operation with a driving key (key drift) arranged between the two parts of the tightening bolt and axially operable via a drawing-in device arranged on the machine side. Here, as well, the tightening operation leads to bracing of the tightening bolts provided with an external cone and the retaining screws arranged in an internal thread of the connecting sleeve and provided with an internal cone. Here, as well, the connecting device is preferentially reinforced in the direction of the tightening bolts.

The invention is based on the aim of improving the connecting device of the type cited at the start so that the flexural strength transversely to the axis of the tightening bolt is increased and the changing precision and the damping behaviour are improved.

The combinations of features specified in claims 1 and 2 are recommended in order to fulfil this aim. Further advantageous

embodiments and developments of the invention are given in the dependent claims.

The invention starts from the idea that four-point contact between the fitting pin and mating bore in two directions which are perpendicular to one another guarantees precise centric alignment, taking account of the movability of the tightening bolt, and thus high changing precision. In addition, this also results in reinforcement of the connecting device in two bending directions which are perpendicular to one another.

In order to achieve this, it is recommended according to a first variant of the invention that the wall thickness and the material of the connecting sleeve, the clearance between the fitting pin and the mating bore, and the clamping force which is exerable in the sleeve material via the retaining screws be determined with respect to one another so that, in the tightened state, the connecting sleeve is also elastically widened in the axial direction of the tightening bolt and, transversely thereto, is pressed with the inner surface of the mating bore against the surface of the fitting pin, with elastic reduction in diameter in diametrically opposed regions. Appropriate selection of the wall thicknesses and of the external and internal tolerances of the fitting pin and the mating bore thus provides a four-point contact with the advantages described above of increased flexural rigidity transversely to the direction of the tightening bolt and improved self-centring and changing precision. The vibration response of the connection system in the event of flexural and torsional vibrations is also improved by this effect.

As an alternative to this and according to a second variant of the invention it is recommended that the cross bore located in the fitting pin have, in the region of its base facing the end of the pin, a recess extending over the length of the cross bore and forming at its longitudinal edges a contact surface for the clamped tightening bolt and that the fitting pin have at least one open notch above the cross bore.

The result of this measure is that, during the tightening operation, the fitting pin does not lie against the base of the bore facing the end of the pin, but rather lies against two contact lines on the cross bore, said contact lines on the cross bore being laterally offset with respect to the base of the bore. In this manner, in addition to the force component acting in the axial direction of the fitting pin, a radial force component is applied to the fitting pin during the tightening operation, said radial force component causing the fitting pin to bulge radially and elastically by the order of several microns (μ). This bulging bridges the clearance transversely to the direction of the tightening bolt and thus also leads to a self-centring four-point contact with the aforementioned advantages. In addition, this causes the elastic deformation of the connecting sleeve to be at least partially reversed or rendered superfluous.

According to an advantageous embodiment of the invention, the recess is formed by a bore which is eccentric with respect to the cross bore in the direction of the end of the pin, the diameter of said bore being smaller than the diameter of the cross bore. In principle, it is also possible to form the recess by an oval deformation of the cross bore, said oval deformation being elongated towards the end of the pin.

It has proven to be particularly advantageous if the edges of the recess define an angle of $\pm 40^\circ$ to $\pm 50^\circ$ about the cross bore axis with respect to the base of the bore on the end side.

A further advantage of this measure is that the tightening bolt is subject to additional clamping and reinforcement inside the cross bore, so that improved torque transfer is guaranteed during the machining operation.

The notch according to the invention may be arranged in the region of the base of the cross bore facing the free end of the pin and/or the root of the pin. During the tightening operation, this notch causes the cross bore to widen and thus causes

(increased) bulging of the fitting pin and the desired self-centring four-point contact. The depth of the notch should be a multiple of the wall thickness between the base of the notch and the end of the pin. If necessary, the notch may also be designed as a slot extending as far as the end of the pin. The width of the notch should be as small as possible. In order to prevent accumulations of dirt in the region of the notch, the notch may be filled with an elastomeric material.

The invention is explained in greater detail below with reference to the embodiments represented in a diagrammatic manner in the drawing; in which

Figure 1 is a longitudinal section through a connecting device with a one-piece tightening bolt in the tightened state;

Figure 2 is a cross-section through the connecting device according to figure 1;

Figure 3 is a longitudinal section through a connecting device with a two-part tightening bolt in the tightened state;

Figure 4 is a side view of a tool section with a cross bore in the fitting pin, said cross bore being modified according to the invention;

Figure 5 is a side view corresponding to figure 4 of a modified embodiment.

The connecting device represented in the drawing is used both for detachably coupling tools to a machine spindle and for connecting tool sections to one another. The term "tool sections" used above and below should be taken to mean those components which either contain a fitting pin or a connecting sleeve with a mating bore, thus in particular tool heads, tool shanks, extending and

reducing parts, adjusting heads, spindle attachment flanges and, where applicable, the actual machine spindle.

The connecting device shown in figures 1 and 2 substantially consists of a fitting pin 12 projecting axially from a first tool section 10, a receiving sleeve 16 projecting axially from a second tool section 14 and a tightening mechanism 18 for drawing the fitting pin 12 into the mating bore 20 of the receiving sleeve 16 and for generating plane surface to plane surface bracing between the annular surface 22 of the first tool section 10 surrounding the fitting pin and the annular end face 24 of the second tool section 14. The tightening mechanism 18 contains a tightening bolt 28, which is movably arranged in a cross bore 26 of the fitting pin 12, and two retaining screws 32', 32", which are guided in internal threads 30', 30" of the receiving sleeve 16 and are diametrically opposed to one another. The external cone 34 of the tightening bolt 28 engages in an internal cone 36 of the adjacent retaining screw 32' and, at its end opposite the external cone 34, has an internal cone 38 for receiving an external cone 40 formed on the retaining screw 32".

In order to produce the connection between the two tool sections 10, 14, the fitting pin 12, with the retaining screw 32" unscrewed, is first loosely introduced into the mating bore 20 of the receiving sleeve 16 until the plane surfaces 22, 24 come into contact. During the subsequent screwing of the retaining screw 32" into the internal thread 30", there is then contact between the retaining screw 32" and the tightening bolt 28 in the region of the cone surfaces 38, 40 which face one another. As the tightening operation continues, the tightening bolt 28 with its external cone 34 is pushed into the internal cone 36 until it comes into contact with the retaining screw 32'. In this state, the actual tightening operation starts, during which the clamping forces 42", 42' introduced by the retaining screws 32", 32' are converted into an axial force 44 via the conical contact surfaces on account of the axial offset a, said axial force 44 drawing the fitting pin 12 into the mating bore 20. The axial force 44 causes

a plane surface to plane surface bracing, indicated by the arrow 46, between the annular surface 22 of the first tool section and the end face 24 of the second tool section 14. At the same time, the axial clamping force 44 is transferred, via the tightening bolt 28 in the region of the base 50 of the cross bore 26 facing the end 48 of the pin, onto the fitting pin 12 and thus onto the first tool section 10. On the other hand, in the region of the retaining screws, the clamping forces must be absorbed and dissipated, via each associated internal thread 30', 30", inside the wall of the receiving sleeve 16. By selecting the wall thickness of the sleeve, the sleeve material and the clamping force introduced via the screws 32' and 32" with respect to one another, the restoring forces may be utilized for a specific elastic deformation of the connecting sleeve 16, which leads to an elongation of the mating bore 20 in the direction of the tightening bolt and to a corresponding reduction in cross-section transversely thereto (figure 2). The elastic deformations of the order of several microns (μ) which occur are represented in an exaggerated manner for illustrative purposes in figures 1 and 2. The reduction in diameter transversely to the tightening bolt 28 presses the inner surface of the mating bore against the surface of the fitting pin, whilst bridging the clearance, which is generally of the order of several microns (μ), on diametrically opposed sides. At the same time, the fitting pin is clamped from two sides in the direction of the forces represented by the arrows 52. Since, on the other hand, the tightening bolt 28 is freely movable in the cross bore 26 of the fitting pin 12 and is clamped between the retaining screws 32', 32" arranged rigidly in the connecting sleeve 16, a self-centring four-point contact is obtained in the region of the fitting pin 12 and the mating bore 20.

The embodiment shown in figure 3, which is designed as a spindle connection, differs from the embodiment shown in figures 1 and 2 in that the tightening bolt 28 is sub-divided into two diametrically opposed portions 28', 28" in the cross bore 26 and that the tightening operation may be initiated via a driving key

52 which acts against inner tapered surfaces of the tightening bolts 28', 28" and is axially movable via a tie rod 50. Here, the retaining screws 32 having an internal cone 36 are screwed from the inside of the mating bore 20 into the internal thread 30 of the receiving sleeve 16 and form a receiving means for the external cones 34 of the tightening bolts 28', 28". The tightening operation leads to a transmission of forces corresponding to figures 1 and 2 onto the tool sections 10, 14 to be connected together, so that reference may be made to the above explanations in this respect.

In the embodiments of a tool section 10 shown in figures 4 and 5, additional precautions have been taken in the fitting pin 12, which, independently of the measures described above or in conjunction with said measures, also lead to a self-centring four-point contact between the fitting pin 12 and the mating bore 20. The cross bore 26 for receiving the tightening bolt 28 has, for this purpose, a recess 60 at its base facing the end 48 of the pin, said recess 60 causing the fitting pin 28, which is not represented in figures 4 and 5, to be pressed, under the action of the drawing-in force 44, not at the lowest point against the base 50 of the bore on the end side, but rather against the edges 62 of the recess 60, said edges 62 being displaced laterally outwards. In this way, the force 44 in the region of the two edge lines 62 is broken down into an axial force component and a radial force component, the radial force component leading to radial and elastic bulging of the fitting pin 12, said bulging being directed transversely to the tightening bolt 28. In the embodiment shown, the recess 60 is formed by a bore, said bore being eccentrically offset towards the end 48 of the pin with respect to the cross bore 26 by the dimension e and being of smaller diameter d than the cross bore 26. However, the recess 60 must not be round and can consequently be produced in another manner. It is only important that there be a clear space in the region of the base 50 of the bore on the end side, said clear space being bridged, without contact, by the tightening bolt 28.

The bulging of the fitting pin 12 may be increased by a notch 64, 64' extending from the base of the bore to the end 48 of the pin and/or to the root 68 of the pin. In this case, the notch 64 may either be designed as a groove (figure 4) or as a through slot. In order to avoid accumulations of dirt, the notches 64, 64' may be filled with an elastomeric material.

Claims

1. Device for connecting two tool sections (10, 14) having a common axis, particularly an axis of rotation, with a fitting pin (12) projecting axially from the first tool section (10), with an annular surface (22) surrounding the fitting pin (12) at its root, with a connecting sleeve (16) projecting axially from the second tool section (14), having a mating bore (20) for receiving the fitting pin (12) and an annular end face (24) which is pressable against the annular surface (22), with a one-part or multi-part tightening bolt (28; 28'; 28'') movable in a cross bore (26) of the fitting pin (12) and, if necessary, arranged rotatably about its axis, having an internal or external cone (38, 34) at its ends, and with two retaining screws (32', 32'') (32', 32'') guided in diametrically opposed internal threads (30', 30'') of the connecting sleeve (16), having an external or internal cone (40, 36) facing the inside of the sleeve and corresponding to the internal or external cone (38, 34) of the tightening bolt (28), which are braceable in a wedge-like manner with the tightening bolt (28) during the tightening operation, the tightening bolt (28) and the retaining screws (32', 32'') having an axial offset causing, during the tightening operation, a drawing of the fitting pin (12) into the mating bore (20) and a mutual pressing together of the annular surface (22) and the end face (24), characterised in that the wall thickness and the material of the connecting sleeve (16), the clearance between the fitting pin (12) and mating bore (20) and the clamping force which is introducible in the sleeve material via the retaining screws (32', 32'') are determined with respect to each other so that the connecting sleeve in the clamped state is elastically widened in the axial direction of the tightening bolt (28) and, transversely thereto, is pressed, with elastic reduction in diameter in diametrically opposed regions



(52), with the inner surface of the mating bore (20), against the surface of fitting pin (12).

2. Device for connecting two tool sections (10, 14) having a common axis, particularly an axis of rotation, with a fitting pin (12) projecting axially from the first tool section (10), with an annular surface (22) surrounding the fitting pin (12) at its root, with a connecting sleeve (16) projecting axially from the second tool section, having a mating bore (20) for receiving the fitting pin (12) and an annular end face (24) which is pressable against the annular surface (22), with a one-part or multi-part tightening bolt (28; 28'; 28'') movable in a cross bore (26) of the fitting pin (12) and, if necessary, arranged rotatably about its axis, having an internal or external cone (38, 34) or a key taper at its ends, and with two retaining screws (32', 32'') guided in diametrically opposed internal threads (30, 30') of the connecting sleeve (16), having an external or internal cone (40, 36) or a key taper facing the inside of the sleeve and corresponding to the internal or external cone (38, 34) or the key taper of the tightening bolt (28), which are braceable in a wedge-like manner with the tightening bolt (28) during the tightening operation, the tightening bolt (28) and the retaining screws (32', 32'') having an axial offset (a) causing, during the tightening operation, a drawing of the fitting pin (12) into the mating bore (20) and a mutual pressing together of the annular surface (22) and the end face (24), **characterised in that** the cross bore (26) in the fitting pin (12) has, in the region of its base facing the end of the pin, a recess (60) extending over the length of the cross bore and forming, at its longitudinal edges (62), a contact surface for the clamped tightening bolt (28) and that the fitting pin (12) has at least one notch (64, 64') extending over the length of the cross bore and open to the inside of the cross bore (26).



3. Device according to claim 2, characterised in that the recess (60) is formed by a bore which is eccentrically offset with respect to the cross bore (26) in the direction of the end (48) of the pin, said bore being of smaller diameter than the cross bore (26).
4. Device according to claim 2, characterised in that the recess is formed by an oval deformation of the cross bore, said oval deformation being elongated towards the end (48) of the pin.
5. Device according to one of claims 2 to 4, characterised in that the longitudinal edges (62) of the recess (60) define an angle of $\pm 40^\circ$ to $\pm 50^\circ$ about the cross bore axis with respect to the base on the end side of the bore.
6. Device according to one of claims 2 to 5, characterised in that the notch (64) is arranged in the region of the base (50) of the cross bore (26) which faces the free end (48) of the pin.
7. Device according to one of claims 2 to 6, characterised in that the notch (64') is arranged in the region of the base of the cross bore (26) which faces the root (68) of the pin.
8. Device according to claim 6, characterised in that the depth of the notch (64) is a multiple of the wall thickness between the base of the notch and the end (48) of the pin.
9. Device according to claim 6, characterised in that the notch (64) is designed as a slot extending as far as the end (48) of the pin.
10. Device according to one of claims 2 to 9, characterised in that the notch (64, 64') is filled with an elastomeric material.

