Universal Chuck for NC Turning in One-off Manufacturing and Flexible Manufacturing Systems

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The innovative lathe chuck satisfies the demands of flexible manufacturing: quick jaw changing, automatic jaw stepping, main spindle positioning, controlled main spindle moving, automatic adjusting for given diameter remote control. The functions of the chuck are controlled by the programming of slide motion beside the conventional mechanisms.

Keywords: chuck development, quick jaw change, flexible manufacturing

1. Introduction

In the previous development stages [1–4], it was still necessary to position the main spindle and to make it turn 9–10 degrees precisely. These functions are already available in the most recent versions of control logic. Additionally, there exist several NC control logic systems, which are not based on the positioning, and the 9–10 degree turn of the main spindle, thus they do not provide such functions at all or their performance does not meet the required levels of precision and reliability.

No NC chuck providing the above functions exists on the market and the simplicity of this novel design results from it needing no novel activating mechanisms, measurement or control system. It performs its functions by means of devices already provided in the machine. The application of the design is therefore very economical in one-off production. In flexible manufacturing systems, the costs are substantially lower when compared to the costs arising from the use of conventional NC chuck designs.

2. The structure of chuck

Figure 1 shows an axonometric view of the chuck structure. The inner jaws *4* are moved by the central draw head *2* through a wedge mechanism. The motion of the inner jaws is transferred to the base outer jaws *7* by a toothed coupler *5*.

In the disengaged state of the toothed coupler, the inner jaws can return to their initial position without carrying the jaws with them. The outer jaws are held in place by the brake heads. The cyclic operation results in the stepping of the outer jaws, thus changing the diameter range.

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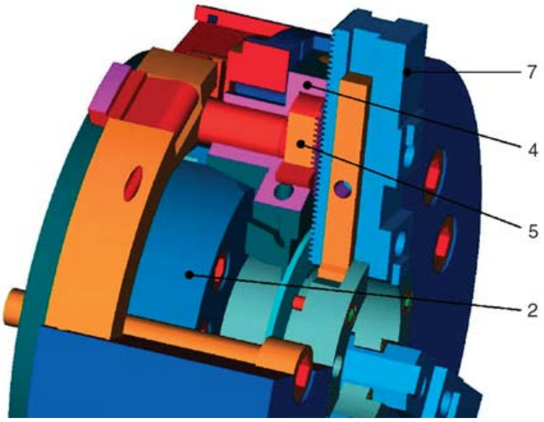

Fig. 1. Structure of developed chuck

One stroke of the central draw head *2* is defined by a two-pitch displacement of the toothed coupler. By using the rear position-sensory switch, the displacement of the central draw head may be halved to provide a one-pitch displacement. This results in sufficiently overlapping diameter ranges for the stepping.

The most important feature of these solutions is the extremely safe and automatic operation of the toothed coupler, which is provided by a dual mechanical locking system.

The elements of the primary locking mechanism are illustrated in *Figure 2*. The wedge-type control surfaces *8*

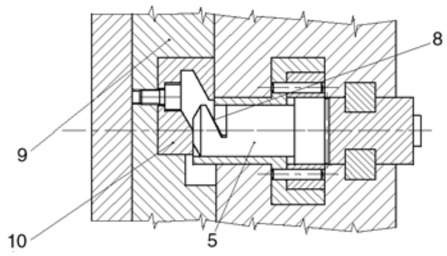

Fig. 2. Chuck primary locking mechanism

formed on the rear side of the toothed coupler are connected to the respective surface of the wedge-type control members *10* fixed to the control ring *9*. The wedge-type control surfaces are capable of drawing the toothed coupler *5* backwards, as well as pushing it ahead, whereas at the normal position of the control ring, areas of the wedge-type control surface, which are orthogonal to the axis of rotation, can support and securely lock the toothed coupler in its foremost state with engaged teeth. In order to maintain this state, the control ring is not allowed to slide off. This is achieved by a secondary locking mechanism.

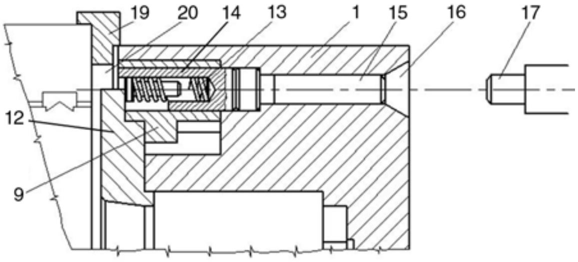

Fig. 3. Chuck secondary locking mechanism

Elements of the secondary locking mechanism are shown in *Figure 3*. The lock *14* is guided in an axial hole in the control ring *9*, wherein the lock *14* is pushed towards the front surface of the chuck by a spring *13* leaning against a centring disc *12*. In this way, the spring pushes the front end of the lock *14* into a locking hole *20* formed in the chuck body *1*. Thus the control ring *9* is prevented from rotating around relative to the chuck body. The front surface of the front part of the lock *14* is engaged with the push rod *15* which is arranged in an extension of the locking hole of the chuck body, this extension also extends through the chuck body.

This hole extending through the chuck body has an end part in the form of a cone *16*. In its initial state, the end part of the push rod *15* is at the smaller, inner diameter of the cone. From this position, the push rod can be pushed into the locking hole *20* of the stationary ring *19* mounted on to the machine body by a coupling mechanism *17* fixed to the cross slide of the machine carrying chuck.

3. The operation of coupling mechanism

Figure 4 is a schematic of the coupling mechanism. The chock *22* is fixed to the cross slide *21*. The stud *23* fixed in the chock is located in a hole in the tilting plate *24*, which can be rotated around the stud. The angle of tilt of the tilting plate is limited by a stop *25* that presses against the upper plane surface of the cross slide *21* and is fixed to the back side of the tilting plate *24* and can be adjusted. The housing *26* is screwed onto the tilting plate. The sleeve *27* guided in the housing is pushed into its front

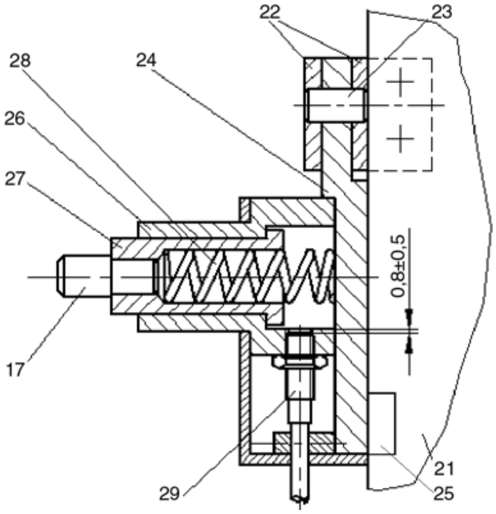

Fig. 4. Schematic of the coupling mechanism

position by the spring *28*. The axial displacement of the sleeve is indicated by the position switch *29*. The coupling stud *17* is fixed in the sleeve.

4. Positioning of main spindle, precise rotation and quick jaw replacement by movement of the slide

Figure 5 shows the operation of the coupling mechanism and the chuck. These elements are arranged in three main parts of the chuck:

– the chuck body *1*,
– the control ring *9*, and
– the stationary ring *19* fixed to the machine.

4.1. Positioning of main spindle (*Figure 5 I., II.*)

In the initial position (*I*), the main spindle is not able to get into the positioning state *X* as shown in *Figure 5*. The coupling mechanism *K* is pushed ahead by the base slide motion Z_1, then the coupling stud *17* butts to on the front surface of the chuck and is pushed against the spring *28* arranged in the coupling mechanism. This is also indicated by the position switch *29*. The extent of the intrusion is equal to the depth of the cone *16*.

Seeking motion: by the motion X_2–X_1 of the cross slide, the coupling mechanism should be moved up to its error state X_2, where the coupling stud springs into the cone. Subsequently, through the motion X_1–X_2, the coupling stud should transfer the chuck into the orientating state, where the lock *11* faces to the locking hole *20* of the stationary ring *19*. In this way, the *positioning of the main spindle is* (*II*). The seeking motions X_2–X_1 and X_1–X_2 are not necessary if the main spindle is stationary or is rotating slowly. Under these conditions, the coupling stud can spring into the cone, which is detected by the position switch *29*.

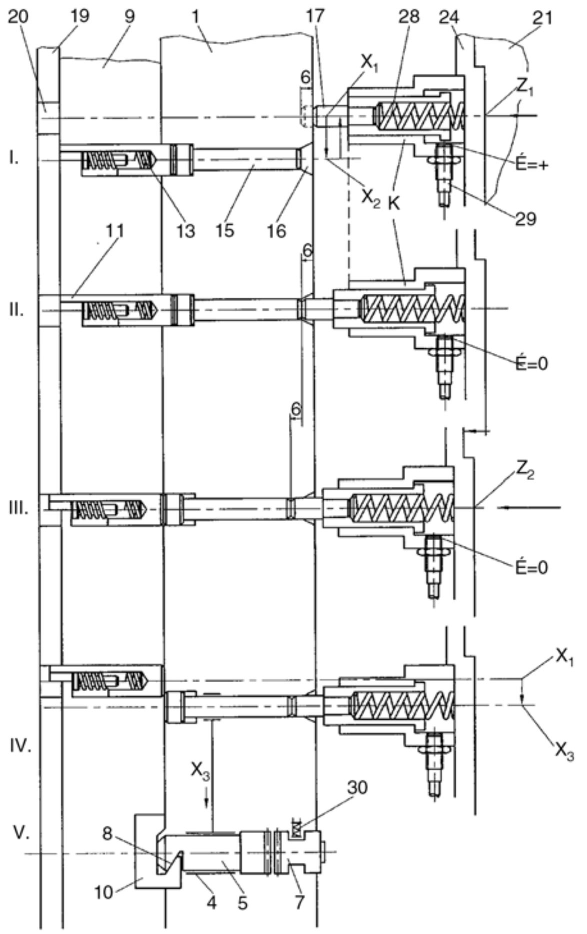

Fig.5. Operation of the coupling mechanism and the chuck

In case of *change-over of the lock* (*III*) through the motion Z_2–Z_1, the base slide pushes the coupling mechanism ahead to the position Z_2, while the coupling stud pushes the lock into the locking hole of the stationary ring by means of the push rod *15*. In this way, the lock couples the control ring to the stationary.

4.2. Precise rotation of the main spindle by movement of the slide

Due to its tangential motion X_3–X_1, the cross slide *21* can rotate the main spindle precisely by means of the coupling stud. The difference between the linear motion of the cross-slide and the curved motion of the push- rod hole is compensated by the hinged connection of the coupling stud.

4.3. Quick jaw replacement (V)

Making the main spindle rotate by 9–10 degrees can be performed with high precision (*Figure 5*). This rotation is required for the chuck body to rotate relative to the control ring to such an extent that the wedge shaped surfaces *8* of the control members *10* fixed to the control ring disengage

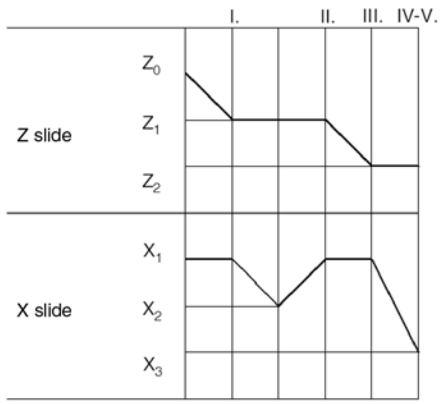

Fig. 6. The switching process to reach position

the teeth of the chuck jaws and the teeth of the coupler, formed in the inner jaws. As a result, all three jaws become released, and thus the *jaws may be replaced quickly*. The falling-out of the released jaws is prevented by the spring-type brakes *30. This system of rapid jaw replacement requires less time and is more convenient than any former solution*. The switching process required to reach the position of the quick jaw replacement is illustrated in *Figure 6*.

A further motion of the machine, the radial motion of the jaws, is also used for stepping the jaws. The jaws can also be moved radially while the workpiece is fastened. This is achieved by the use of the rear drawing cylinder, the main piston of the chuck, through drawing wedges arranged in the chuck. This motion is also used as a component of jaw stepping. In fact, *three motions provided by the machine are used for the jaw stepping*:

- motion *Z* of the base slide,
- motion *X* of the cross slide, and
- radial basic motion of the chuck jaws.

In addition to the driving mechanisms, their measuring, checking and controlling units are also utilised. *There is no need of any modification of the base machine, only the motions must be programmed.*

The driving units of the central drawing head *2* are shown in *Figure 7*.

Adjustment of the outer jaws guided in the chuck body to a different diameter range is performed by stepping all of the three jaws simultaneously. By means of this stepping

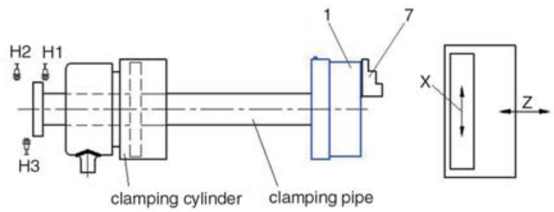

Fig. 7. The driving units of the central drawing head

operation, the jaws may be adjusted to have either greater or smaller diameters.

Both sections of the stepping operation are a combination of two independent motions, one of which is the axial motion of the central drawing head *2* as illustrated in *Figure 1*, and the other is the axial motion of the coupler, which is carried out by the machine through a relative rotation turning of the chuck body.

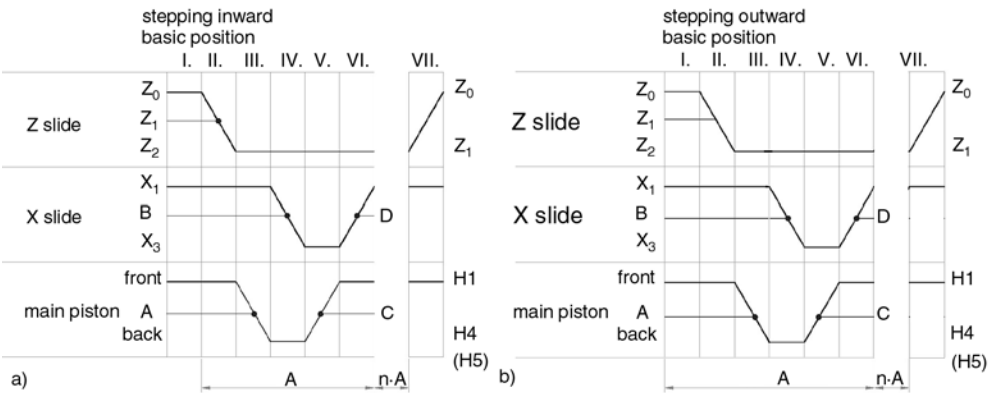

Fig. 8. Chuch jaw adjustment to a) smaller diameter, b) greater diameter

The stepped adjustment of the outer jaws to a smaller diameter comprises the following actions:

A. The central draw head is drawn backwards, whereby the toothed headpieces of the inner jaws *4* in *Figure 1* move into a small diameter.

B. The coupler is drawn backwards, whereby the teeth between the jaws become disengaged. This action requires the right side release and the left side coupling of the secondary locking, and then the relative rotation of the chuck body with respect to the control ring, achieved by the motion X_3 in *Figure 5*.

C. The central draw head is pushed ahead, whereby it pushes all of the three inner jaws to a greater diameter.

D. The coupler is pushed ahead, whereby the teeth of the jaws and become engaged.

This cycle of inward stepping may be repeated any number of times.

Outward stepping can be carried out by executing the above steps in a different sequence, namely B, A, C and D (see *Figures 8*).

The switching diagrams below illustrate the steps of the automatic adjustment of the diameter range of the chuck. *Figures 8 a)* and *8 b)* show the adjustment to a smaller and greater diameter where both adjustments start from an initial position.

For the sake of simplicity, the seeking operation (X_1–X_2; X_2–X_1) illustrated in *Figure 6* is now omitted by assuming the most frequent situation, in which the coupling stud can intrude into the cone even without seeking. In the case of a very low precision machine, the seeking motion could be carried out in position Z_1.

The diagrams illustrate the adjustment of the chuck jaws is carried out by a periodical, synchronised operation of components, the slide motions in x and y directions, and the motions of the hydraulic cylinder operating the chuck.

5. Summary, conclusions

By using only slide motions of the machine supporting the chuck, in addition to the conventional motions of the jaws, this design of chuck provides the following functions:

– positioning of the main spindle,
– precise controlled rotation of the main spindle,
– quick replacement of the jaws,
– automatic jaw stepping.

The need for quick jaw replacement is reduced because of the automatic adjustment to different diameters. The quick jaw replacement is necessary only in specific cases. The actual positions of the jaws are stored in the memory of the control logic.

Adjustment of the jaws may be carried out on the control panel in several convenient ways, including:

– entering the diameter to be adjusted on the control panel,
– selecting the diameter to be adjusted from a series of buttons,
– storing the code of the diameter to be adjusted for the workpiece in the manufacturing program.

These features are not yet available for other chucks. This chuck provides a basis for the future development of the means of production in flexible manufacturing.

References

[1] Chuck for Flexible Manufacturing, Patent PCT/HU2005/000091

[2] Tajnafői, J., Kertész, J., Gaál, J.: Chuck with Automatically Adjusted Jaws and Compesation of Centrifugal Force Patent PCT/HU98/00025.

[3] Tajnafői, J., Gaál, J., Kertész, J., Demeter, P.:Schnelle Automatik bei der Backenumstellung, Werkstatt und Betrieb, 9, 166, 2005.

[4] Tajnafői J., Demeter P., Madarász Lné., Szabó L., A jövő NC tokmányai a rugalmas gyártásban / Chucks of the future in flexible manufacturing, MetalForum, III. 46, 2004.