Innovative design of lathe collet opener mechanism

Innowacyjny mechanizm otwierania tulei zaciskowej tokarki

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The article presents innovative lathe collet opener mechanism design. In the proposed solution collet is screwed into the spindle to prevent mutual sliding of these elements. By such attachment the opening and closing of the collet does not cause any longitudinal movement of the workpiece which enhances the accuracy and repeatability of the workpiece clamping.

KEYWORDS: collet, design, lathe, spindle

Numerically controlled lathes are among the fastest growing categories of machinery. One of their most important components are spindle, bearings and drive system. The integral element of the spindle is the collet which anchorage the material during machining [4].

In today's world where high quality, speed and accuracy are the highest values, precise fastening and handling during machining process are essential to meet the above requirements.

Mass production requirements also imply that high opening and closing speeds of the collet, as well as the high accuracy and full repeatability of the workpiece fixing position, are crucial requirements. High quality also means that the object should be fixed in such a way as to exclude the possibility of displacement to the fixing system and its damage by the surface of the collet or any chips that would enter between the collet and the workpiece [7].

In the currently used constructions, the lathe collet are slidably mounted in the spindle. Its rear part is screwed into a pipe or rod connector situated concentric in the spindle. The other end of the connector is connected to a pneumatic or electric actuator to move the collet inside the spindle [1, 3].

The opening and closing of the lathe collet takes place by actuating the actuator, which by means of the connector moves the collet. The collet cone co-operates with the corresponding conical surface in the spindle, thus extending the collet from the spindle to allow it to open simultaneously. This movement in the initial period of time, until the friction between the lathe collet and the machined material or part stops, causes it to move simultaneously relative to the lathe spindle and may result in inaccurate alignment [8].

Description of the construction

The mechanism was designed in Autodesk Inventor Professional. This is a parametric program that allows 3D parts design. In this program is possible to assembly them into assemblies and ready-made machines.

The program has a number of features that facilitate the design process of the machine, such as collision components analysis, kinematics and dynamics analysis that control component collaboration, finite element strength analysis [6, 9].

The base of the structure is the spindle [5], which allows the collet to be screwed in such a way that it cannot move longitudinally to the spindle (fig. 1). The above solution also allows opening and closing of the collet which does not cause material to move which is a unique feature of the proposed mechanism [8].

Fig. 1. Lathe spindle with collet

Figures 2, 4 and 5 show the design of the collet clamping mechanism. The closing of the collet (2) is carried out by means of a sliding element (3) which moves on the spindle (1), and is supported by six springs (7) operating in the holes in the spindle. The stiffness and springs preload have been designed to obtain the correct closing force of the collet clamping [2]. The sliding element is moved by a yoke mechanism, the lever (5) is rotating on the pivot (8) mounted in the lathe head body, and the lever is supported by two springs (10) preventing friction between the slider and the yoke mechanism during workpiece machining. The pusher (4) is connected to the lever with pins (6). In addition, the collet closure slide is secured against rotation relative to the lathe spindle by two positioning screws (9) [8].

In the closed position, the sliding element exerts a closing force on the collet, adjusted by the springs (7). In the open position, the spring resistance is overcome by the yoke mechanism. By moving the sliding element, the collet closure force disappears and the material in the collet can be moved or the finished piece can be removed [8].

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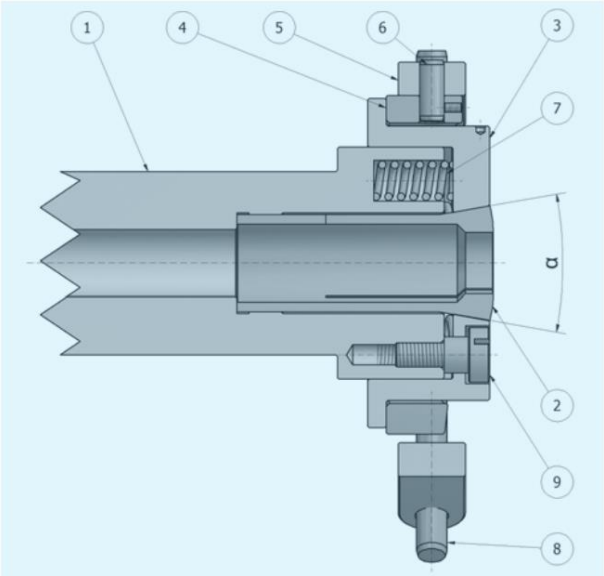

Fig. 2. The mechanism of the collet opener

The lever of the yoke mechanism is connected by means of a steel cable in the armor with an auxiliary subassembly (fig. 3). It consists of a body (1) to which the electromagnetic actuator (2) is bolted. To increase the impact force of the actuator is used a lever mechanism (3). Additional functions of the auxiliary subassembly are to regulate the cable tension and clear the clearance of both components by means of a screw element (4) with a counter nut (5) to prevent uncontrolled unscrewing. The subassembly additionally includes an auxiliary spring (6) which introduces a constant pre-tension in the steel cable to prevent its disengagement from the retaining seats.

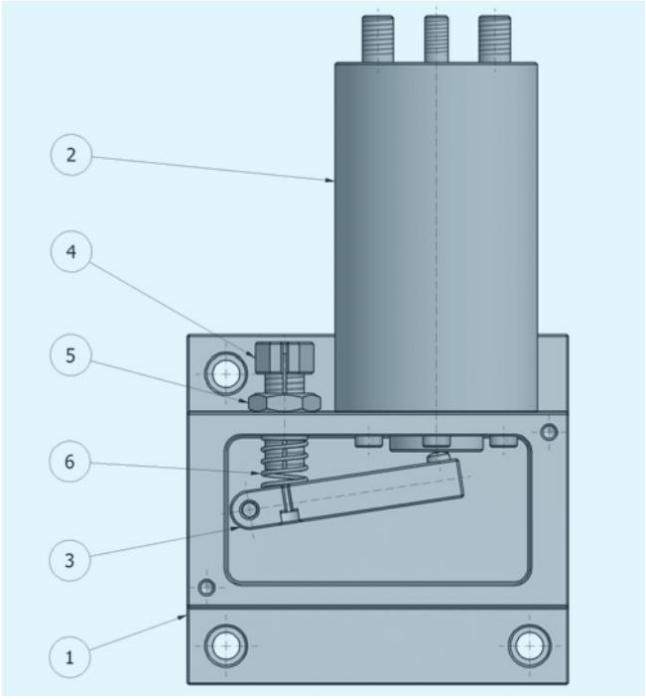

Fig. 3. Actuator subassembly mechanism

Principle of operation

Figure 4 shows the clamping mechanism in the closed position. In this position, the sliding element (3) gripping the collet (2) exerts a locking force adjustable by means of appropriately selected springs (7) by mutually co-operating conical surfaces of the collet and the sliding element. The spring force is calculated according to the following formula 1. The expected force of the sleeve clamp (F_t) is linearly dependent on the angle (α) of the cone of the collet. The following formula is given in a simplified form that does not take into account friction between the elements. The resulting error is small and is less than 10% due to the constant lubrication between the cooperating surfaces.

$$F_o = F_t \cdot \mathrm{tg}\frac{\alpha}{2}$$

where:
F_o – the operating force of the collet exerted by the spring, F_t – the clamping force of the collet on the workpiece, α – cone angle of the collet grip.

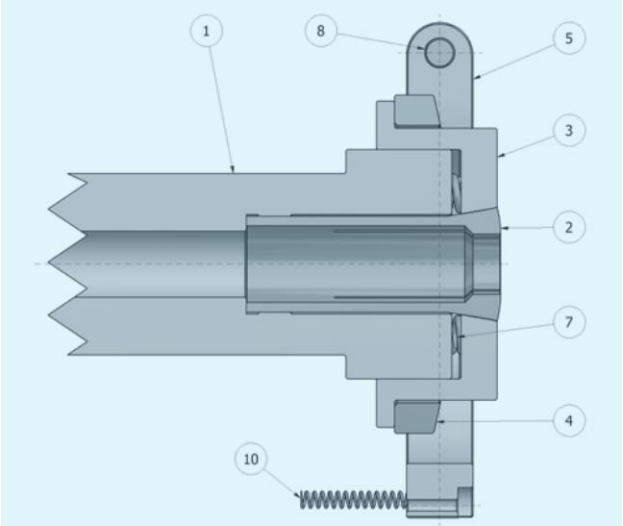

Fig. 4. Collet mechanism closed

Figure 5 shows the clamping mechanism in the open position. In this position the spring resistance is overcome by the yoke mechanism, which is moved by the force (F) from the auxiliary mechanism. By moving the collet clamping element, the collet closing force disappears and it is possible to move the material in the collet or to remove the finished piece.

What is extremely important, opening the collet does not change its position relative to the spindle or material when machining the rods. This allows the high positioning accuracy and full repeatability of the workpiece fixing position.

The numbering of the individual elements in fig. 3 and fig. 4 corresponds to the description of the structure shown in fig. 2.

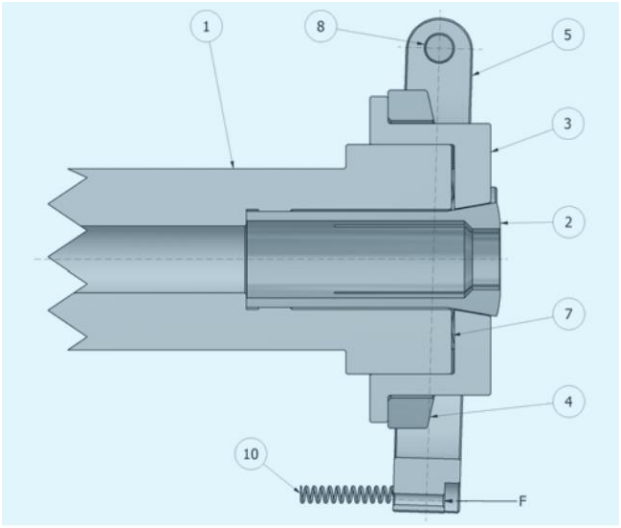

Fig. 5. Collet mechanism open

Figure 6 shows a perspective view of the clamping collet assembly. The figure shows the mechanism in the closed position (1) and in the open position (2).

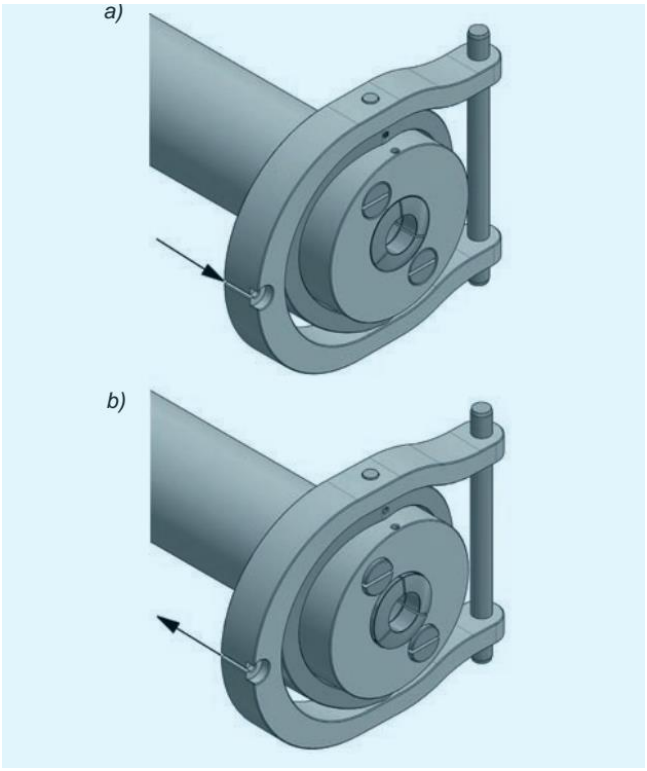

Fig. 6. Perspective view of collet mechanism

Conclusion

The proposed design of the mechanism for opening the clamping collet is characterized by simplicity and compactness of the structure. For this reason, its introduction in subsequent generations of lathes should neither pose major structural problems nor generate additional costs. This is particularly justified by the fact that the proposed project contains fewer components than the currently applied mechanisms for similar tasks.

The structural modifications proposed in the described design of the clamping collet mechanism will not cause excessive retraction of the machining area from the main bearing, which could result in a deterioration in the quality of the workpiece surface and problems in obtaining satisfactory geometry of the manufactured parts.

In the case of serial and large-scale machining, the durability of the machine tool construction is also extremely important. In the proposed solution all components of the clamping unit are characterized by high strength. In addition, the reduction in the number of components limits the potential points of failure.

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