

Cam – clamping device with variable eccentricity

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Abstract. Productivity and quality growth, all together with cost reductions, are the main objectives of modern manufacturing companies. Fixture devices shall facilitate that the workpiece can be changed fast, to have simple construction, to be cheap and affordable, and they have minimal positioning and installation errors. Clamping forces are applied to the workpiece with the help of fixture devices, after being correctly oriented by the application of adjusting forces. In the stage of design, many parameters are taken into account, like strokes and forces necessary, operation time, build simplicity, all which determines the cost of the device. In the field of device design, the main requirements are related to rapid fixing of the workpiece, fixing of more workpieces simultaneously and reducing the effort of labour for the operators. In this paper is presented the research and construction of a circular cam with variable eccentricity used in one this kind of fixture devices.

1. Introduction

The main objective of the companies is maximizing the productivity and quality of their products, minimizing production costs. For manufacturing companies that use metal chipping processes, these objectives are strongly influenced, besides many factors, by fixtures used in the manufacturing processes.

The device is a component of the machine-device-tool-workpiece system, their primary role being the orientation of the workpiece and sometimes of the tools in the meantime of manufacturing. By using fixture devices are being watched the reduction of auxiliary times for fixing the workpiece, thus being used rapid fastening mechanisms and also multiple workpiece fastening [1].

The forces must retain the workpiece oriented all the time in the manufacturing process. The direction the fixing force must be perpendicular on the orientation base of the workpiece that cancels the maximal number of grades of freedom.

In the field of manufacturing processes, there are many studies and different approaches related to fixture device design.

In article [2], it's been analyzed the cams geometrical calculations, calculations related to fixing forces and torques, auto-blocking conditions and contact resistance conditions. In this paper, the discussed solution is changing the eccentric with a cam that has a variable curve that can be designed by the needs of auto-blocking. In the patent [3], it's presented a different model with an eccentric drive cam with variable stroke. Authors [4] are evaluating the efficiency of the manipulation systems, by examining recent development of products, and are elaborating new requirements for upcoming systems. The researchers [5] are focusing on aspects related to the development of integrated computerized manufacturing, the automation of devices design, optimizing the fixing forces. Thus, in the paper [6] they are approaching researches related to the performance of fixtures that can be adapted to advanced production. There are presented design methodologies, studies related finite element

method, optimization, models for simulation, and fixing forces analyzing, and also numerical research and experiments related to the performance of the device.

In this paper is presented the design of a fixing device for a prismatic workpiece, and also the construction of an eccentric cam with variable eccentricity.

2. The fixture design

In the process of design parameters that were taken into account was the ease of use, the length of the stroke, acting time of the fixture, simplicity of operation and the necessary energy for the operation. In this case, it was used a fixture mechanism with an eccentric cam with variable eccentricity which is part of the rapid fixing systems category, having an operation time between 0.6-1.7 seconds.

The device (figure 1) has two workstations for fixing two workpieces simultaneously. It's made from a base plate (1) on which are fixed elements (2) and (3), in which can be found the support (4). The workpiece (5) is placed on the plates (6) and fixed with the lever (7) that is operated by the eccentric cam (8) being moved by the handle (14). For the release, the elements (15) are withdraw manually, and for the undoing of the eccentric cam, the spring (16) is operating the rod (17) which remove the levers.

For adjusting the eccentricity, we must remove the assembly formed from the sleeve (8), disc (9), handle (12), and the toothed coupling(10) which can be repositioned by rotating over a number of teeth around the axle (11), thereby obtaining the desired eccentricity and operating stroke. The adjustment of the handle can be done in a large domain (100-300 mm) by unscrewing the sleeve (14) and by blocking it by a nut (13).

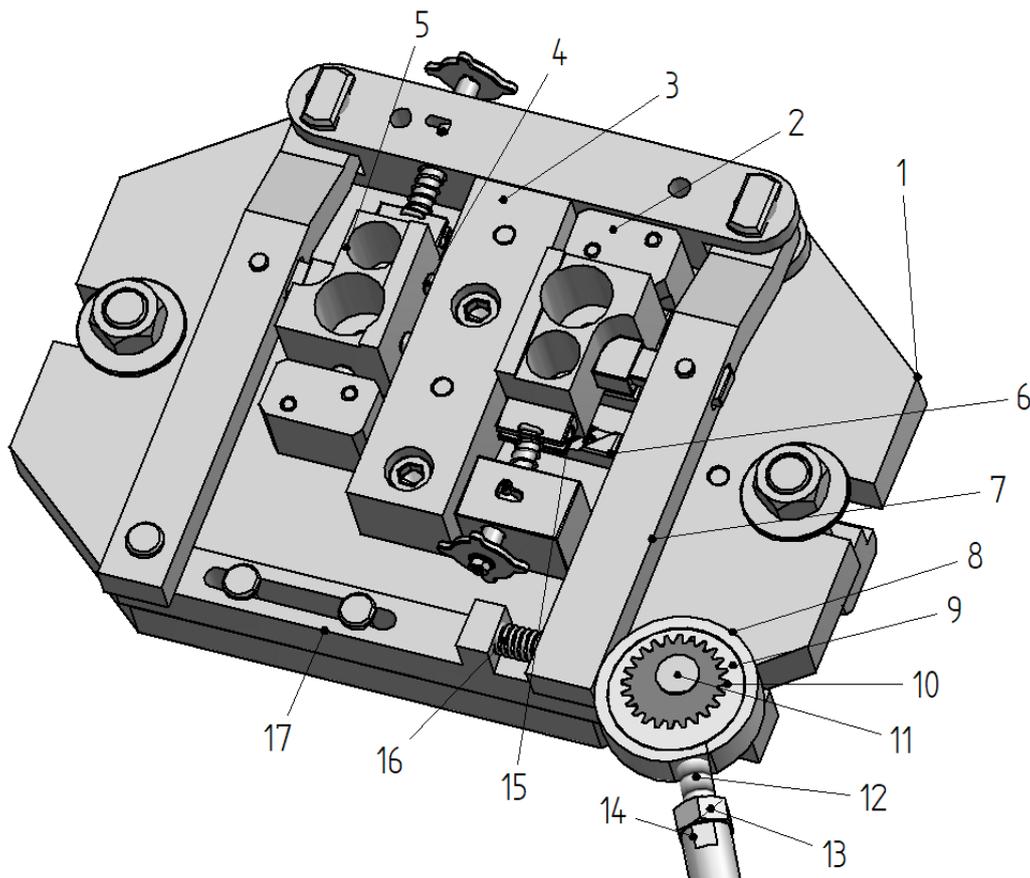


Figure 1. The 3D model of the designed duplex fixture.

The components of the eccentric cam with variable eccentricity is presented in figure 2, and the parameters in table 1. In figure 3 is presented a physical model of an eccentric cam with variable eccentricity.

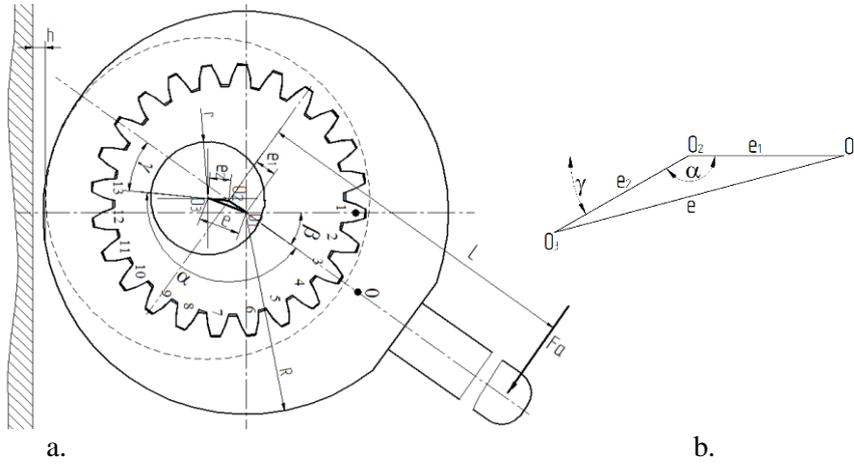


Figure 2. Eccentric cam with variable eccentricity.
a. Functional and constructive elements;
b. calculation of the eccentricity



Figure 3. Physical model of an eccentric cam with variable eccentricity.

Table 1. Constructive parameters of the designed eccentric cam.

Parameters	Symbol
Disk radius, mm	R
Rotation axis radius, mm	r
Stroke, mm	h
Toothed coupling eccentricity compared to disk, mm	e_1
Axis eccentricity compared to toothed coupling, mm	e_2
Total eccentricity of the disk compared to axis (adjustable), mm	e
Handle length (adjustable), mm	L

If we know the number of teeth z of the toothed coupling, the angle δ , between 2 teeth can be determined:

$$\delta = \frac{2\pi}{z} \quad (1)$$

The adjustment of total eccentricity e can be made by rotating the eccentric disk over the toothed coupling by a number of teeth z_i . The corresponding angle is noted γ (figure. 2, b).

$$\gamma = \frac{2\pi}{z} z_i \quad (2)$$

Knowing the eccentricity e_1 , relative to the eccentric disk and the eccentricity e_2 of the axis compared to the toothed coupling, using the scheme from figure 2, b can be found the mathematic relation for the total eccentricity e :

$$e = \sqrt{e_1^2 + e_2^2 - 2e_1e_2 \cos\left(\frac{2\pi}{z}(z - z_i)\right)} \quad (3)$$

The stroke „h” of the eccentric by rotating an angle β can be determined:

$$h = e(1 - \cos \beta) \quad (4)$$

The property of auto-braking in any point selected in the eccentric must verify the following relationship:

$$e \leq \mu R + \mu r \quad (5)$$

μ – coefficient of friction between the disk and lever and between the coupling and bolt, $\mu=0.16$.

Knowing the clamping force Q made by the eccentric through the length L of the handle, we can find the human acting force.

$$F_a = \frac{Q(e \sin \beta - \varphi) + \mu R + \mu r}{L} \quad (6)$$

$$50 < F_a < 150 \text{ [N]}$$

φ – friction angle $\operatorname{tg}\varphi = \mu$.

3. Numerical study

Numerical studies are simulating the behavior of the eccentric cam for different practical situations: case I: $e_1=e_2=3$ mm; case II: $e_1=e_2=4$ mm; case III: $e_1=e_2=5$ mm;

For the numerical examples were taken in consideration the following values:

- Number of teeth of the toothed coupling: $z=24$ teeth;
- Eccentric disk radius: $R = 30$ mm;
- Eccentric axis radius: $r = 8$ mm;
- Angle between two teeth: $\gamma = 15^\circ$.
- Handle length $L = 100 \dots 300$ mm

In figure. 4 is presented the variation of total eccentricity related to the number of teeth over which the disk rotates compared to toothed coupling in three different situations. It can be seen that total eccentricity e grows as e_1 și e_2 are higher.

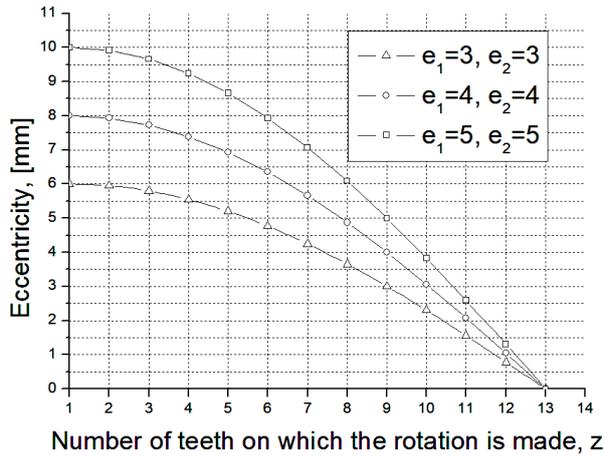


Figure 4. Eccentricity vs. Number of teeth on which the rotation is made, z_i .

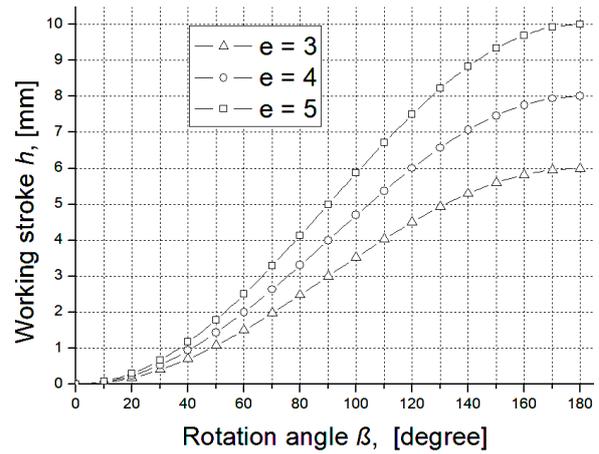


Figure 5. Working stroke vs. rotation angle.

In figure 5 is presented the stroke variation related to rotation angle for three different situations related to eccentricity e_1 și e_2 . We can see that for the same rotation angle, the stroke becomes bigger with the growth of the eccentricities e_1 și e_2 . The variation of the stroke length related to angle of rotation of the eccentric and number of teeth over which the disk is turned are presented in figure 6. The working stroke size increases with increasing the angle of rotation of the eccentric β , and by decreasing the number of teeth over which the disc is rotated relative to the toothed coupling.

Clamping force Q increases with the increase of the number of teeth over which the disk z rotates and towards the ends of the variation range of angle β (figure 7).

Acting human force F_a of the eccentric cam compared to the rotation angle β and number of teeth of the rotation is presented in figure 8. This force decreases with the increasing number of teeth on which the rotation is made, and towards the limits of the rotation angles β of the eccentric.

The human acting force F_a drops by growing the length of the handle L (figure 9).

Related to auto-braking properties in case I in which $e_1=3$ și $e_2=3$ the condition is respected through the entire variation interval of the angle β ($0 < \beta < 180$).

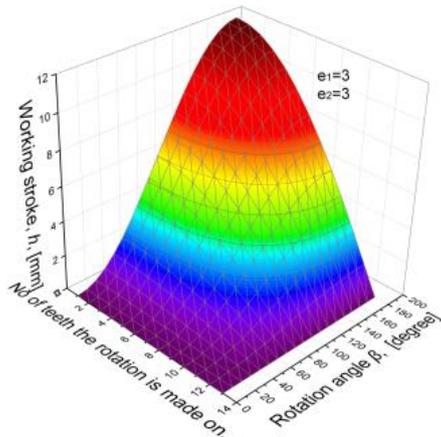


Figure 6. Working stroke (h) vs. rotation angle (β) and number of teeth of the rotation(z).

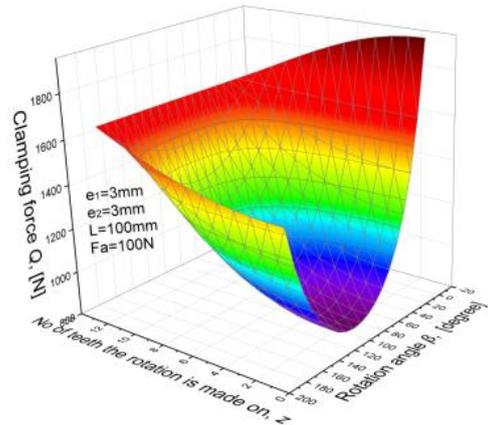


Figure 7. Clamping force (Q) vs. rotation angle (β) and number of teeth of the rotation(z).

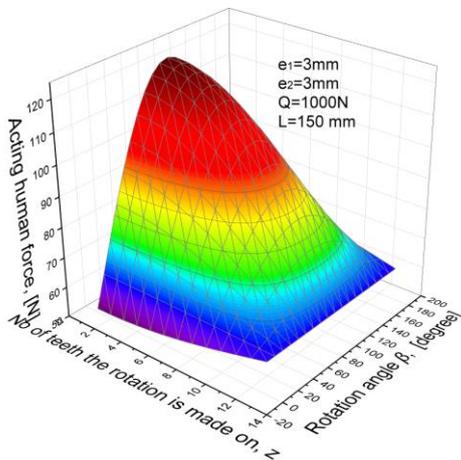


Figure 8. Clamping force (Q) vs. rotation angle (β) and number of teeth of the rotation(z).

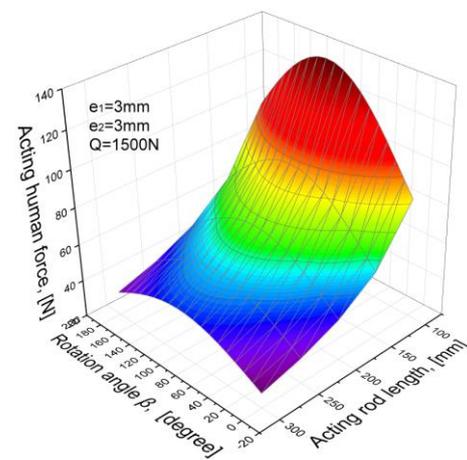


Figure 9. Clamping force (Q) vs. rotation angle (β) and number of teeth of the rotation(z).

4. Conclusions

It has been designed a clamping device that has a mechanism with eccentric cam with variable eccentricity and makes part of the quick clamping devices. For growing the field of use of the device, a circular eccentric has been designed with the possibility to adjust the stroke and eccentricity. The mathematical relations have been determined and numerical studies were done related to the eccentricity variation, stroke length, clamping force, and rotation angle of the disk compared to the toothed coupling.

References

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