

Description

The invention is based on a machine tool with cam gear, particularly for punching and shaping the connection pins of integrated circuits, with the features given in the precharacterizing clause of Claim 1.

Prior art

Such a machine is known from DE-PS 35 44 087 and DE-A-3 103 525. In the known machine, the tools are driven by a cam gear which has two driven cam plates located on the same axis. A freely rotating roller is in contact with the end face, designed as the cam track, of each of the two cam plates. Each of the two rollers is supported at the end of a two-arm lever which transmits the deflection of the roller caused by the rotating cam track to a tool half, or to a holder for it, which is located at the opposite end of the lever. The two levers are connected together by a tie-rod on whose ends the two levers are pivotably supported.

So that the rollers remain continuously in contact with the cam plates, they are pressed or pulled by frictional connection onto the cam track formed by the end face of the cam plates; this is generally effected by springs. The preloading forces applied by the springs must be larger than the forces arising during the acceleration and braking of the tools in order to ensure that the rollers do not lift from the cam plates. A disadvantage of these preloading forces, on the other hand, is that they make the driving more difficult because they have to be overcome when the tools are driven, so that a correspondingly strong and heavy drive motor is required. Another disadvantage arises from the fact that the torque to be provided by the drive motor for the actual machining process carried out by the tools is increased by the torque which is required to overcome the preloading forces acting on the rollers; in consequence, the response threshold of an overload clutch provided in the drive train to protect the

tools from damage in the case of overload has to be increased in an undesirable manner. Another disadvantage consists in the fact that a device for preloading the rollers by springs prevents a displacement of the lever, desirable per se, parallel to the driving shaft of the cam plates; such a displacement capability is desirable to adapt the machine tool to different machining tasks.

In order to avoid the preloading forces, it is known to guide the roller in a groove on the cam plate (grooved cam gear) or to guide a pair of rollers on both sides of a bead on the cam plate (beaded cam gear) instead of on the end face of the cam. For the same follower motions as those of a cam gear in which the roller runs externally on the end face of the cam plate, however, grooved cam plates and beaded cam plates have a large diameter, so that a greater mass inertia occurs in the cam gear; this is undesirable because the machine can only be stopped more slowly or the driving forces and braking forces become large and wear increases. The acceleration and braking forces of the tool halves and the clamping devices carrying them generally occur in the direction of the tool motion. They are particularly disadvantageous in the case of a rapid reversal of acceleration because the mass inertia due to the tools and gear elements and occurring in the direction of the tool motion excites the machine frame and the workpiece holder to vibrations, in some cases at a high excitation frequency. In order to counter the excitation of vibration, it is known to displace the apex of the reversal of acceleration in the direction of the starting acceleration so that the braking deceleration is reduced - but with the disadvantage that the starting acceleration is increased.

In DE-PS 35 44 087 there is, furthermore, an indication that the return of the tools can be controlled by cams or cam plates but without positive information on how this has to be done and whether it has an influence on the vibration behaviour.

The disadvantages mentioned are particularly serious in the case

of machines for punching and shaping the connection pins of integrated circuits, because this work must, on the one hand, be carried out with great accuracy, particularly in the case of circuits which have many pins because of a high integration density, and on the other hand, a rapid working cycle is desirable for low-cost manufacture but factors opposing this are the mass inertia, the tendency to vibration and an increase in wear. The tendency to vibration is particularly serious because the punching and shaping work on the delicate connection pins can only be carried out with the desired precision and the machine tool can only be controlled and monitored by means of a camera for pattern recognition and pattern measuring devices if the integrated circuits are still and the tools do not vibrate. The integrated circuits which, initially, are still suspended with their connection pins in pre-punched metal strips (so-called lead frames) tend to vibrate if the connection pins are separated from the lead frame in one operational step and the integrated circuits are then further processed suspended in the lead frame on only four thin bridges.

Statement of the invention

The object of the present invention is so to arrange the tool drive in a machine tool of the type mentioned at the beginning, in particular in a machine for punching and shaping the connection pins of integrated circuits, that it can be operated with a small mass inertia by means of low drive torques and braking torques and, at the same time, the tendency to excite vibrations in the tool holder (clamping plate) and the frame is reduced.

This object is achieved by means of a machine tool with the features given in Claim 1. Advantageous further developments of the invention are the subject matter of the dependent claims.

In the machine according to the invention, the rollers of the two levers respectively run externally on a cam track on the end face

of at least one cam plate but the contact between the cam track and the roller is not ensured by mechanical preloading by means of a spring but by the fact that each cam track is associated with a second cam track rigidly connected to it, the cam profile of this latter cam track being complementary to that of the first cam track, and that each of the two levers carries on one of its arms not only one freely rotating roller but two freely rotating rollers which are offset relative to one another in the peripheral direction of the cam track and, in fact, preferably at a 90° position relative to one another relative to the axis of the cam tracks, and of these two rollers, one roller rolls on one cam track and the other rolls on the second cam track complementary thereto, this second cam track having a corresponding offset relative to the first cam track. Because of the complementary configuration of the cam tracks, it is possible - without preloading forces - to force the two rollers of a lever to have continuous contact with their cam track pair. The advantage of this arrangement is that for a given follower motion, the smallest possible cam plates can be used and, because of this, the mass inertia is low; it is also possible to keep the drive torques small because preloading springs are avoided. The amplitude of vibrations to which the machine can be excited is correspondingly small.

The second rollers are located with their axes near to (and preferably on) a normal to the direction of motion Z of the tool halves which passes through the axis of the cam tracks. The use of two rollers offset relative to one another in the selected arrangement for each lever has the great advantage that the forces occurring during acceleration and braking are no longer introduced into the machine frame exclusively parallel to the direction of motion of the tool but are divided into two directions. The acceleration forces during the return motion (return stroke) - which are particularly critical to the excitation of vibrations - and the braking forces during the working stroke are deflected, in accordance with the invention, in a direction extending transverse to the tool motion. The

starting acceleration during the working stroke and the braking deceleration during the return stroke, on the other hand, occur in the direction of the tool motion. The tendency to excite vibration and the vibration frequency are reduced by the division of the forces into different directions, and this is particularly so in the preferred case that a guide device for the tools, which is preferably a plate or a block, or a clamping plate carrying them, extends horizontally and, in consequence, the tool motion also takes place horizontally and the two first rollers of the two levers are correspondingly supported in a plane parallel to the guide device or to the tool clamping plate below the latter; in this case, the two rollers of the levers conduct a substantial part of the forces downwards into the frame and into the machine base so that a resultant force directed obliquely to the tool motion is introduced into the frame at the bearings of the two levers during the acceleration phase in the return stroke and during the braking phase in the working stroke. That part of the forces which is introduced downwards into the frame and into the base causes less excitation of machine vibrations due to the mass of the frame and of the base. The machine is therefore characterized by very smooth running, which is an important advantage in view of the high accuracy requirements in micro-engineering. Smooth running is also a condition for high working speeds. At the same time, smooth running means less wear and permits the use of a camera for pattern recognition and pattern measurement.

It is useful for the stationary part of the cam gear, on which the levers are supported, to be a tie-rod. The tie-rod is preferably formed by the tool clamping plate itself. This has the advantage that the clamping plate is only subjected to tensile load. It is therefore not deformed during the pressing and printing operations but is, on the contrary, stretched by the tensile forces. This is very beneficial to precise support of the workpieces to be machined and to precise guidance of the tools, which is a substantial advantage in micro-engineering processing such as is necessary on micro-electronic components.

The fact that the levers are joined articulately near the tools, preferably directly at the clamping plate, has the further advantage that an optimally compact tool and gear arrangement is possible and this is further supported by the fact that, in accordance with the invention, the second roller of each lever is located near the tools, preferably just below the clamping plate or even in a recess in the clamping plate. In consequence, the levers are very short and have low inertia.

In accordance with a further preferred feature of the invention, the second roller of each lever, which is located in the immediate vicinity of the tools or of the clamping plate, is smaller than the first roller. This is possible because it does not have to transmit the higher processing forces, because these are transmitted from the other two first rollers located diametrically opposite to one another.

Because the second rollers can be smaller, it is possible to bring the cam tracks closer to the clamping plate, associated with a corresponding shortening of the two levers, which is again favourable with respect to reducing the mass inertia. The low mass inertia, in combination with the drive via complementary cam tracks, has the result that a smaller drive torque is sufficient for the acceleration, and this is lower than the torques purely for processing, so that it is possible to provide an overload clutch with a correspondingly low response threshold in the drive train of the cam gear. In addition, each reduction in the drive torques reduces the forces which can lead to the excitation of vibrations.

Clearance-free coupling between the levers which actuate the tools and the cam tracks is also of importance to low-vibration, precise operation of the tools. The drive of the tools by means of complementary cam tracks again proves satisfactory in this connection, each of the cam tracks being followed by two rollers offset relative to one another in the peripheral direction on one arm of a two-arm lever. Particularly small clearance in the

coupling between the levers and the cam tracks is, in fact, achieved by a further development of the invention in accordance with which the arm of the levers carrying the rollers is branched into a main arm, which carries the first roller, and an auxiliary arm, which is weaker than the first and carries the second roller. The auxiliary arm can be weak in construction because it only has to transmit the forces necessary for the retraction of the tools (return stroke) and these forces are very much less than the forces which the main arm has to transmit during the working stroke. Whereas the main arm has to be rigid, appropriately, the forces occurring, the auxiliary arm can be so weak by comparison that when the rollers are placed on the cam tracks with some pressure, it bends elastically. In this way, the rollers are kept in contact with the cam tracks with absolutely no clearance by using the spring-back of the weak auxiliary arm, provided the position of the pivot pin of the lever is selected relative to the cam plates in such a way that the rollers are continually in contact with the cam tracks under a slight contact pressure. As long as the rollers are in contact with the cam tracks without clearance, an additional vibration excitation due to cam clearance cannot occur and this is ensured for a longer period, the weaker the auxiliary arm of the lever, because the weaker the auxiliary arm, the greater the spring deflection on sprung contact of the roller of the auxiliary arm and the longer the period before the lever has to be readjusted or replaced in order to avoid cam clearance.

The use of cam plates which are followed externally permits a further advantageous development of the invention which consists in the fact that at least the first rollers, which transmit the forces during the working stroke, and preferably also the second rollers, which transmit the forces during the return stroke, are supported in their lever on both sides rather than just one. This makes the lever and roller arrangement particularly rigid and, in consequence, the actuation of the tools and the machining carried out by them particularly precise.

In an advantageous further development of the invention, the levers are supported in bearing blocks which can be displaced parallel to the axis of the cam tracks, preferably along the clamping plate. By this means, the tool stations can readily be adjusted along the clamping plate; the cam plates are, of course, correspondingly displaceable along the shaft on which they are fastened. The levers can be removed, together with their bearing blocks, at right angles to their lateral clamping surface on the workpiece clamping plate for setting up and stripping down.

The cam track and the complementary cam track which are followed by one lever and the cam track and the complementary cam track which are followed by the other lever are preferably coaxial but they could also be located on two separate and mutually parallel axes and be driven synchronously.

The idea of the invention can also be carried over to machine tools in which one movable tool half (male die) works against a fixed tool half (female die) so that only one lever and one pair comprising the cam track and complementary cam track is required. Such a machine is the subject matter of the independent Claim 2.

Ways of carrying out the invention

The attached drawings are used for further explanation of the invention.

Figure 1 shows, diagrammatically, the arrangement of a cam gear and a tool clamping plate with tool clamping devices in a machine tool, viewed in the direction of the drive shaft of the cam gear,

Figure 2 shows, diagrammatically, and partially in section, the plan view on the arrangement of Figure 1 with the clamping plate removed,

Figure 3 shows an acceleration graph,

Figure 4 shows an arrangement as in Figure 1 but with a modified lever shape and

Figure 5 shows, as a detail, the support of a roller in its lever on both sides.

The casing 11 of a cam gear, which is closed towards the top by a horizontal clamping plate 8, is attached to a machine frame 10. The machining tools are clamped on the clamping plate 8. The tools comprise two tool halves 12 and 13 operating in opposition to one another and guided in opposite directions and towards one another in the horizontal direction Z by the tool guide 1. In order to reciprocate them, two two-arm levers 3a and 3b act on them, these levers being supported in bearing blocks 7 so that they can be pivoted about horizontal pins 14, and these bearing blocks 7 are connected to the clamping plate 8 by a tongue-and-groove connection 15 and can be displaced in their longitudinal direction. The respective upper arms 23a and 23b of the levers are connected to the tool halves 13 and 12. The respective lower arms 33a and 33b of the levers branch into two sections which respectively carry at their ends a first larger roller 6a or 6b and a smaller roller 4a or 4b which are in contact with cam tracks which are formed on the end face of cam plates. The cam plates are fastened to a common shaft 5 centrally located below the clamping plate 8. The roller 6a is in contact with a cam plate 22a, the roller 6b is in contact with a cam plate 22b, the roller 4a is in contact with a cam plate 21a and the roller 4b is in contact with a cam plate 21b. These four cam plates could also be replaced by a single plate with four cam tracks on its end face. The rollers 4a and 4b are located directly below the clamping plate 8 and protrude partially into a recess 18 in the clamping plate; relative to the shaft 5, they are also located in an approximately 90° position with respect to the rollers 6a and 6b, which are located diametrically opposite to one another approximately at the level of the shaft 5. The cam track of the cam plate 21a is complementary to the cam track of the cam plate 22a and is offset relative to it by approximately 90° in the

peripheral direction. The cam plate 21b has, correspondingly, a cam track which is complementary to the cam track of the cam plate 22b and is offset relative to it by approximately 90° in the peripheral direction. Because of the type of arrangement selected, the rollers 4a, 4b and 6a, 6b are guided practically without clearance on the cam tracks 21a, 21b, 22a, 22b and the levers 3a and 3b are optimally short.

So that several processes can be carried out simultaneously in the machine tool, three tool positions are provided and, in other embodiment examples, more than three tool positions can also be provided; there are, correspondingly, three groups of cam plates on the shaft 5 supported in the casing walls 9 and these are preferably displaceable on the shaft 5.

The levers 3a and 3b are similar in construction and are symmetrically arranged opposite to one another. The two rollers 4a and 6a (or 4b and 6b) of each lever 3a (or 3b) provide, by interaction with the bearing of the lever about its pin 14, a positive connection to the respective cam plate pair 21a and 22a or 21b and 22b.

In order to keep the mass inertia (and therefore the mass inertia forces) due to the levers 3a and 3b small during acceleration, the levers are made as short as possible, the lower arms 33a and 33b of the two levers being arranged as close as possible below the clamping plate 8 and the rollers 4a and 4b being made small - in any event smaller than the rollers 6a and 6b which have to transmit the machining forces. The small rollers 4a and 4b are only subject to the loads due to the mass inertia forces of the lever 3a or 3b occurring during acceleration and the reduced mass of the moving parts of the tool suspended from it. Because of the arrangement of the rollers 4a and 4b vertically above the shaft 5, the acceleration forces taken up by them, which depend on the cam rise angle, are introduced substantially perpendicularly into the machine frame and on into the ground. Because of the large frame mass involved and the good damping of

the masses at the bottom, the acceleration amplitude is greatly reduced and the machine is therefore no longer so strongly excited to vibration, but on the contrary runs very much more smoothly, which leads, on the one hand, to less wear and, on the other, to increased precision during operation because the workpieces and the tools are more still. The support for the machining forces in the tools is undertaken by the rollers 6a and 6b via the closely adjacent cam plates 22a and 22b, which are wider than the complementary cam plates 21a and 21b. With respect to the machining forces, there is a closed force path from the workpiece via the tool half 12, the lever 3a, the roller 6a, the cam plates 22a and 22b, the roller 6b, the lever 3b and the tool half 13 back to the workpiece. The clamping plate 8 is only subject to tensile load via the pivot pins 14 of the levers and is not subject to any deformation.

Using the example of a cam shape K extending over a peripheral angle of 150° , Figure 3 shows, diagrammatically, the variation with time of the velocity V and the acceleration B on a lever between the cam plate and the tool. When a tool half is driven in the direction Z onto a workpiece, the large roller 6a or 6b experiences an acceleration B1 but the braking of the driving-in motion is undertaken by the small roller 4a or 4b and it then experiences the deceleration B2. During the return motion of the tool, in contrast, the smaller roller 4a or 4b is first loaded and experiences the acceleration B3, whereas the braking of the return motion takes place by way of the larger roller 6a or 6b, and this experiences the deceleration B4. Because the small roller 4a or 4b introduces the acceleration forces approximately vertically downwards (direction Ya or Yb in Figure 1) via the frame 10 into the ground and, by this means, makes them almost harmless, only those mass acceleration forces which are transmitted by the large rollers 6a and 6b have to be taken into consideration for vibration excitation in the plane of the clamping plate 8. The time base for the vibration excitation is provided by the time interval between the maxima of B1 and B4. If, however, as in the prior art, the smaller rollers 4a and 4b

were not present, the acceleration forces taken up by them would also have to be taken up and transmitted by the rollers 6a and 6b; they would then also contribute to vibration excitation in the plane of the clamping plate 8 and, in fact, with a time base corresponding to the distance between the maxima of B1 and B2 and of B3 and B4, which is very much smaller than the distance between the maxima of B1 and B4, so that the excitation frequencies according to the invention are lower by a multiple than the excitation frequencies of the prior art, which is very desirable.

It should also be pointed out, as may be seen from Figure 1, that in the arrangement selected for the small rollers 4a and 4b - located centrally above the cam plates and just below the clamping plate 8 - the sideways removal of the levers 3a and 3b at right angles to the clamping surface of the bearing blocks 7 is readily possible, thus ensuring good accessibility to the cam gear and ensuring its adjustment.

The embodiment example of Figure 4 differs from that in Figure 1 in that the arms 33a and 33b of the levers 3a and 3b are branched into a strong main arm 34a or 34b and an auxiliary arm 35a or 35b which is substantially weaker than the main arm 34a or 34b. The main arms 34a and 34b each carry the first roller 6a or 6b for transmitting the forces during the working stroke. The auxiliary arms 35a and 35b each carry the smaller roller 4a or 4b for transmitting the forces during the return stroke. Because the auxiliary arm is very much weaker than the main arm, the auxiliary arm 35a or 35b can spring back somewhat when the two rollers 6a and 4a or 6b and 4b are run on their cam plates under some pressure. Because of the small spring deflection of the auxiliary arm, which does not substantially increase the driving torque, absolutely clearance-free coupling between the cam plates 21a, 21b, 22a, 22b and the rollers 6a, 6b, 4a, 4b is achieved.

As is shown in Figure 5, it is useful for the main arm 34a or 34b

to be configured in a fork shape and to support the roller 6a or 6b respectively on both sides, so that the arrangement made up of lever 3a or 3b and roller 6a or 6b is extremely rigid.

In the embodiment example of Figure 1 or Figure 4, one of the tool halves, for example the tool half 13, can be stationary. The lever 3b and the associated cam plates 21b and 22b are then omitted. This machine also runs relatively smoothly even though the shaft 5 is more strongly loaded on one side.

Commercial application

The invention is particularly suitable for machine tools for the punching and shaping of the connection pins of integrated circuits which are supplied to the machine tool supported in a metallic carrier strip (lead frame).



Claims

1. Machine tool with tools for carrying out punching, cutting, embossing and shaping work, in particular for punching and shaping the connection pins of integrated circuits (ICs), having a frame (10),
having a cam gear, supported on the frame (10), for driving the tools along a guide device (1), and having two driving cam tracks located on parallel axes on the end face of one or more cam plates (21a, 21b, 22a, 22b),
having two two-arm levers (3a, 3b) pivotably supported on a stationary part (8) of the cam gear, the first arms (23a, 23b) of which two-arm levers (3a, 3b) are connected to a respective one of tool halves (12, 13) operating in opposite directions and the second arms (33a, 33b) thereof respectively carrying a freely rotating roller (6a, 6b), of which one (6a) is in contact with said one driving cam track (on 22a) and the other (6b) is in contact with the other driving cam track and both rollers (6a, 6b) are located approximately diametrically with respect to the axis of the driving cam tracks (22a, 22b) and approximately parallel to the direction of motion of the tool (Z), and having further cam tracks disposed on the end face of the cam plate(s) for controlling the tool return,
characterized in that each driving cam track is associated with one of the further cam tracks and is rigidly connected to it and that the further cam tracks have a complementary cam profile to the driving cam track (on 22a, 22b) associated with it and are offset in the peripheral direction,
that the two levers (3a, 3b) respectively carry on their second arm (33a, 33b) a second, freely rotating roller (4a, 4b) which is in contact with the further cam track,
and that the second rollers (4a, 4b) are located with their axes close to a normal to the direction of motion Z of the tool halves (12, 13) and close to the latter, the normal passing through the axis of the cam tracks (on 21a, 21b, 22a, 22b).

2. Machine tool with tools for carrying out punching, cutting,



embossing and/or shaping work, in particular for punching and shaping the connection pins of integrated circuits (ICs), having a frame (10),

having a cam gear, supported on the frame (10), for driving the tools along a guide device (1), and having a driving cam track on the end face of a cam plate (21a, 21b, 22a, 22b),

having a two-arm lever (3a or 3b) pivotably supported on a stationary part (8) of the cam gear, the first arm (23a or 23b) of which two-arm lever (3a or 3b) is connected to a movable tool half (12 or 13) operating in opposition to a second tool half and the second arm thereof (33a or 33b) carrying a freely rotating roller (6a or 6b), which is in contact with the driving cam track, and having a further cam track disposed on the end face of the cam plate for controlling the tool return,

characterized in that the driving cam track is associated with the further cam track and is rigidly connected to it and that the further cam track has a complementary cam profile to the driving cam track associated with it and is offset in the peripheral direction,

that the lever (3a or 3b) carries on its second arm (33a, 33b) a second, freely rotating roller (4a or 4b) which is in contact with the further cam track,

and that the second roller (4a or 4b) is located with its axis close to a normal to the direction of motion Z of the tool halves (12 and 13) and close to the latter, the normal passing through the axis of the cam tracks.

3. Machine tool according to Claim 1 or 2, characterized in that the stationary part (8) of the cam drive is a tie-rod preferably fixed to the frame.

4. Machine tool according to one of the preceding claims, characterized in that the guide device (1) for the tools extends between the latter and the total cam tracks and the second roller(s) (4a, 4b) is(are) located just below the guide device (1) or a tool clamping plate (8).



5. Machine tool according to one of the preceding claims, characterized in that the second roller(s) (4a, 4b) is(are) located at a 90° position relative to the first rollers (6a, 6b) in relation to the axis of the total cam tracks.

6. Machine according to one of the preceding claims, characterized in that the second rollers (4a, 4b) are smaller in diameter than the first rollers (6a, 6b).

7. Machine according to Claims 3 and 4, characterized in that the clamping plate (8) is the tie-rod on which the levers (3a, 3b) are pivotably supported.

8. Machine according to Claim 3, 4 or 7, characterized in that the tie-rod (8) extends horizontally.

9. Machine according to one of Claims 4 to 8, characterized in that the second rollers (4a, 4b) are immediately adjacent to the clamping plate (8).

10. Machine according to one of Claims 4 to 9, characterized in that the clamping plate (8) has a recess (18) into which the second rollers (4a, 4b) protrude.

11. Machine according to one of the preceding claims, characterized in that the levers (3a, 3b) are supported in bearing blocks (7) which can be displaced parallel to the axis of the total cam tracks, in particular along the clamping plate (8).

12. Machine according to one of the preceding claims, characterized in that the arm (33a, 33b) of the lever (3a, 3b) carrying the rollers (6a, 6b, 4a, 4b) is branched into a main arm (3a, 3b), which carries the first roller (6a, 6b), and an auxiliary arm (35a, 35b), which carries the second roller (4a, 4b) and is weaker than the first arm.



13. Machine according to Claim 12, characterized in that the rollers (6a, 6b, 4a, 4b) are in contact without clearance on the total cam tracks by means of pressure.

14. Machine according to one of the preceding claims, characterized in that at least the first rollers (6a, 6b), and preferably also the second rollers (4a, 4b), are supported in their lever (3a, 3b) on both sides.

15. Machine according to one of the preceding claims, characterized in that the total cam tracks have a common axis (5).