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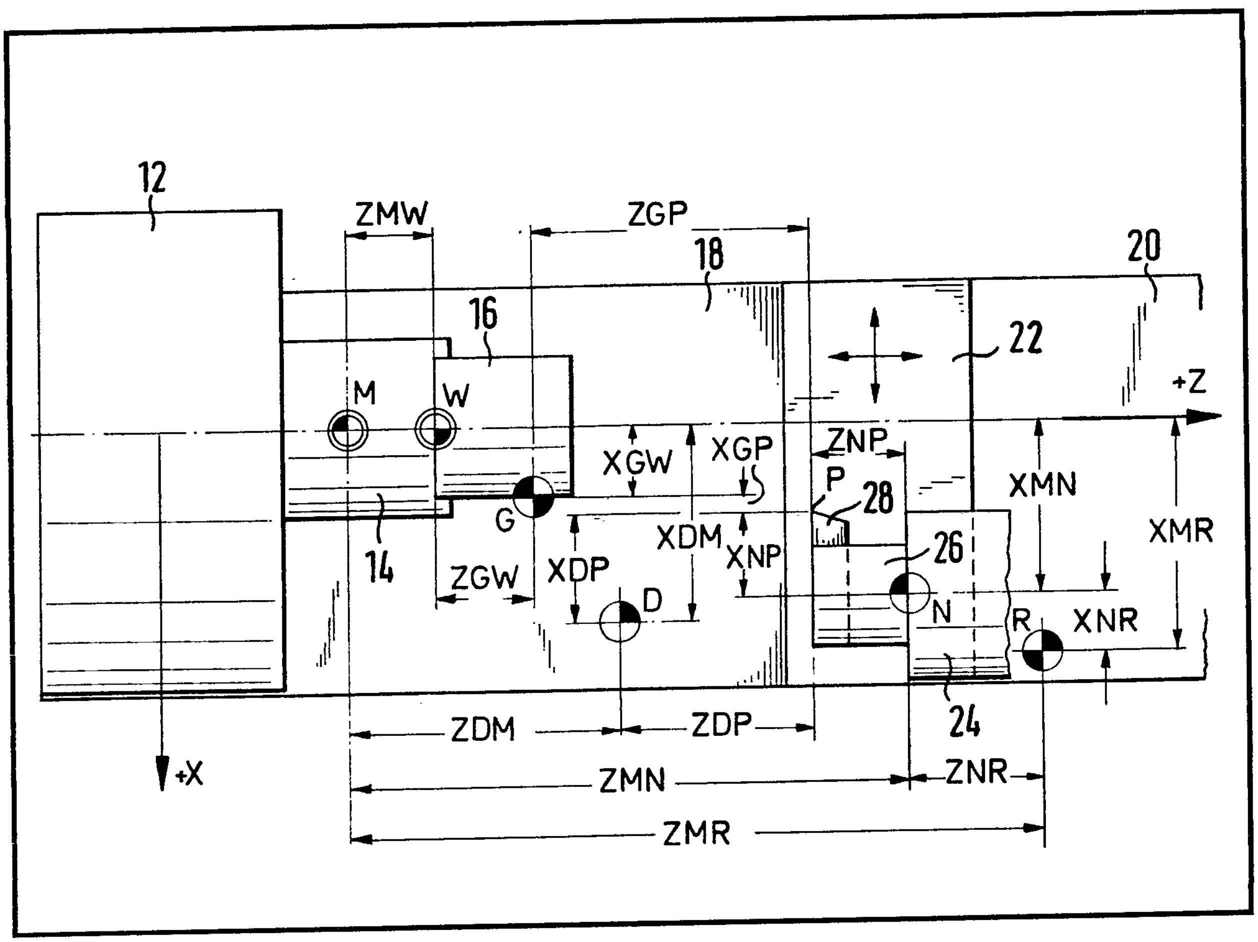
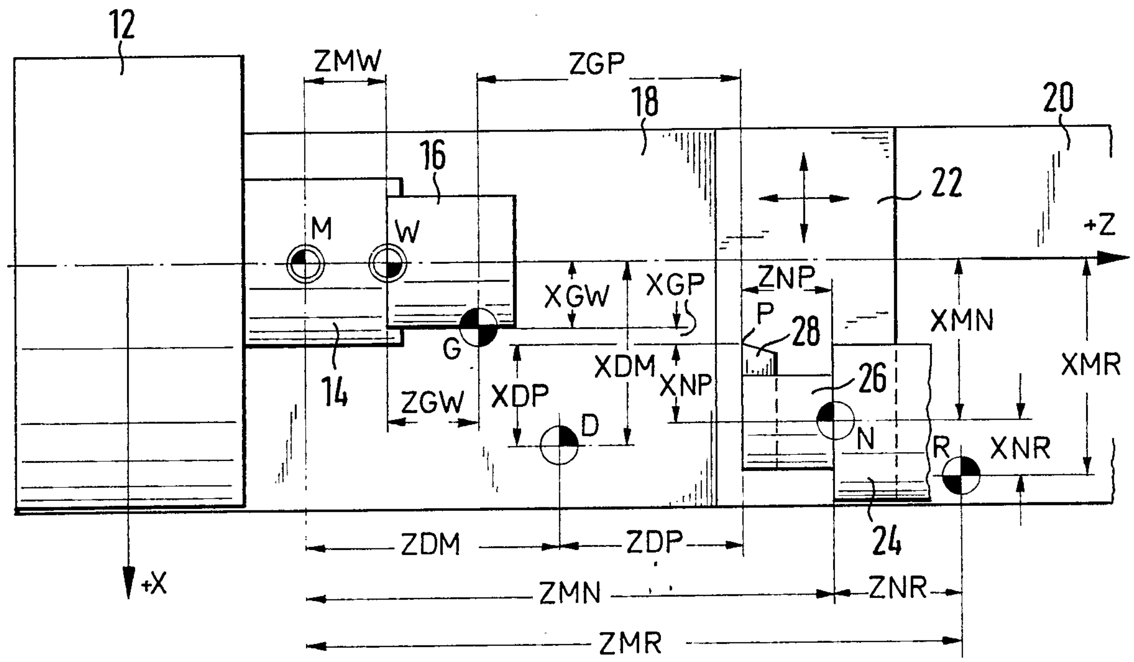
(54) Determining tool tip position

(57) A method of determining the position of a tool tip P with respect to a tool slide 22 of a numerically controlled lathe includes the steps of storing in the machine's data memory the co-ordinates of a fixed slide reference point R and the co-ordinates of a fixed measuring point D; determining the position of the measuring point by means of a sight through which the operator observes the tool, moving the tool slide so that the tool tip coincides with the measuring point and feeding the positional data of the tool slide in this position to the data memory, whereby the position of the tool tip with respect to the tool slide may be determined.





12
ZMW
ZGP
18
20
16
22
+Z
M
W
ZNP
XGW
XGP
P
28
XMN
G
XDM
26
XMR
14
ZGW
XDP
XNP
D
N
R
XNR
24
ZDM
ZDP
+X
ZMN
ZNR
ZMR

SPECIFICATION

A method of determining the position of a tool tip with respect to a tool slide of a numerically controlled machine tool

The invention relates to a method of determining the position of a tool tip or edge with respect to a tool slide of a numerically controlled machine tool for example a lathe.

It is one of the purposes of the controls of numerically controlled machine tools to determine the paths along which a tool slide must travel so as to move the point or edge of a tool secured to the tool slide into programmed target points on a workpiece. In most cases a plurality of tools are associated with the tool slide or saddle and several of them may be secured to the tool slide, for instance, by being clamped in chucks mounted on a revolving head supported on the tool slide.

It is a condition for making the required calculations of the paths that the position of the tool slide be known exactly at each instant. For this reason, a path measuring system, for instance, in the form of a line scale with corresponding reading head is provided for each axis along which the tool slide is movable. It transmits pulses to a counter unit in accordance with each movement of the tool slide along the respective axis. For gauging of the various path measuring systems, the tool slide is moved to a stationary slide reference point at which the counters are set to zero if the slide reference point at the same time is the neutral point of the machine, or the counters are each set to a certain counting level which corresponds to the co-ordinates of the slide reference point with respect to a neutral point of the machine which differs from the slide reference point. Thus the problems involved in determining the slide positions may be considered solved.

It is another condition for calculating the slide paths required for machining a certain workpiece that the position of the decisive tip or edge of each tool used in the machining process with respect to the tool slide is known and stored in the data memory of the machine tool. This position either may be fixed once and for all or may be measured after securing each individual tool at the tool slide.

In the first of these procedures, instead of being gripped directly by chucks at the tool slide, the tools are clamped by tool holders which are first introduced into a tool adjustment fixture which is separate from the machine and in which the tool tip or edge decisive for the machining is adjusted to an accurately predetermined position with respect to the tool holder. Such pre-adjustment means may comprise a microscope installed on a cross slide arrangement with a measuring system each for each axis. The tool holder with the adjusted tool is then attached in a position which is predetermined exactly with respect to the tool slide. Thus the position of the tool tip or edge with respect to a reference point of the tool at the tool slide is known and may be stored as a fixed datum in the data memory of the machine tool or considered in the machining program. Adjusting the tools outside of the machine tool has the advantage that it can be effected at the same time as machining work is being done, in other words during the productive machining time. Yet the enormous costs for the usually numerous tool holders required and above all the expensive pre-adjustment means are a disadvantage. Furthermore, inaccuracies may creep into the system if the tool holders are not placed exactly in their predetermined position with respect to the tool slide, either as a result of carelessness or wear.

In the second of these procedures, the tools are fixed directly in chucks at the tool slide so as to avoid the cost of tool holders and eliminate errors by inaccurate securing of the holders at the tool slide. In these cases the position of the tool tip or edge with respect to a tool reference point at the tool slide is determined subsequently. In accordance with a known method of this kind, this is carried out by swinging a projector into the working space of the machine tool and moving the tool slide into the stationary slide reference point. The projector includes a screen plate on which the tool tip is to be seen, provided the tool has been secured to the tool slide at no more than a certain adjustment error which depends on the size of the screen plate. The adjustment errors of all tools secured to the tool slide are read on the screen plate one after the other by the operator and fed into the control of the maching tool. However, errors can occur in the reading as well in entering the data into the keyboard, and these errors may not be noticed until after a workpiece has been machined erroneously. Therefore, even skilled adjusters will be careful and work at a correspondingly slower speed in reading and feeding the errors detected into the control system so as to minimise the risk of errors. The considerable amount of time thus involved in determining the position of the tool tip with respect to the tool slide represents idling time of the machine, resulting in a corresponding decrease in the efficiency of the machine. It is therefore an object of the invention to provide a method of determining the position of a tool tip with respect to a tool slide which may be carried out in less time and with less likelihood of erros than previously known methods.

According to one aspect of the invention there is provided a method of determining the position of a tool tip or edge with respect to a tool slide of a numerically controlled machine tool comprising storing in the machine data memory the co-ordinates of a fixed slide reference point and the co-ordinates of a fixed measuring point, moving the tool slide so that the tool tip or edge coincides with the measuring point, and recording in the data memory the positional data of the tool slide at the position where the tool tip or edge coincides with the measuring point, whereby the position of the tool tip with respect to the tool slide may be determined.

Preferably, the position of the measuring point is determined by a sight through which the operator observes the tool.

Preferably, the tool tip or edge is made coincident with the measuring point by means of the sight through which the operator observes the tool.

Preferably, the method is repeated for a plurality of tools associated with the tool slide.

According to a second aspect of the invention there is provided a method of determining the position of a tool tip or edge with respect to a tool slide of a numerically controlled machine tool, in particular a lathe, in the data memory of which the co-ordinates of a stationary slide reference point to be reached by the tool slide are stored and with which a measuring point which is likewise stationary is fixed by a sight means through which the user observes the tool secured to the tool slide and then feeds a command for memorization of measuring data into the control, characterised in that the co-ordinates of the measuring point are stored in the data memory in addition to the co-ordinates of the slide reference point, at least for a certain program, in that the tool slide with the or each tool required for said program is moved into the position, differing from the slide reference point, at which position the tool tip coincides with the measuring point, and in that the positional data of the tool slide in this position are stored.

At first glance it may seem that storing the co-ordinates of the measuring point in accordance with the method of the invention would cause additional expenditure. However, this tends not to be so since it is not required for each individual tool. Instead, the measuring point taken by the sight means, in general, is fixed once and for all, but at least for a greater number of measurements. Thus it may be easy for the operator to apply manual control of the slide drives in order to move the tool slide with each individual tool into a position at which the top or edge of the respective tool will coincide with the measuring point. To this end, the sight means may simply comprise cross hairs. Any line screen may be omitted. Therefore, an operator need not be as conscientious and may still avoid making reading mistakes. He need simply press a key to see to it that the positional data of the tool slide are stored, which are known to the machine control anyway. Thus, the operator, applying the method of the invention, need not operate a data entry keyboard, thus avoiding the possibility of making mistakes in this respect.

Instead of the external adjustment or measuring devices described, the method according to the invention uses the path measuring systems of the machine itself in order to determine the position of each individual tool with respect to the tool slide. The accuracy and dependability of this determination consequently corresponds to the present day high degree of precision and reliability of internal measuring systems of the machine which are part of the state of the art. As there is practically no risk of misreading, the user can determine the position of a great many tools in a very short time without having to exert any particular effort.

The invention may be carried into practice in various ways and one embodiment will now be desribed by way of example with reference to a diagrammatic drawing, which is a diagrammatic plan view of a numerically controlled lathe utilising a method in accordance with the invention.

In the drawing, a headstock 12 of a numerically controlled lathe is shown diagrammatically to support a main spindle 14, with a workpiece 16 clamped to the same, for rotation about an axis, hereinafter designated the Z axis. Further indicated is the bed 18 of the lathe on which a saddle 20 is guided for displacement in the direction of the Z axis. The saddle 20 carries a tool slide 22 which is movable along an X axis perpendicular to the Z axis. A revolving head 24 comprising a number of chucks 26 each having a tool 28 is supported on the tool slide 22. Only one of the chucks 26 with the corresponding tool 28 is indicated in the drawing.

A machine neutral or zero point M is defined in the interior of the machine on the axis of rotation of the main spindle 14 as the origin of a measuring system of co-ordinates. As the machine zero point M is not accessible in operation, a slide reference point R is fixed at a readily accessible location within the travelling range of the tool slide 22, by providing switches (not shown).

The lathe shown is equipped with path measuring systems which are conventional in numerically controlled machine tools. These may include, for example, line scales disposed along the Z and X axes. Gauging of the path measuring systems may be effected by moving the tool slide 22 into the slide reference point R even if a workpiece 16 is grasped by the main spindle 14, as shown.

A tool reference point N is fixed at the tool slide 22 or the revolving head 24 thereof. Based on the machine zero point M, the tool reference point N has distance co-ordinates ZMN and XMN when the tool slide 22 is at slide reference point R. These co-ordinates are stored in the data memory of the lathe.

A workpiece program is provided, as usual, for machining the workpiece 16. In this program, the distance ZMW, which exists between a workpiece zero point W lying on the axis of rotation of the main spindle 14 and the machine zero point M, is fixed. Furthermore the distance ZGW and XGW of a target point G from the workpiece zero point W are also fixed.

The tool 28 has a tool tip P which is intended for cutting the workpiece 16, the distances of which from the tool reference point N are ZNP and XNP. As described above, in accordance with the known method, these distances are measured or adjusted to predetermined values outside of the machine. Thus, the co-ordinates of the tool tip P with respect to the machine zero point M would be known and, by means of the known co-ordinates of the target point G, the paths ZGP and XGP along which the tool slide 22 must travel in order for the tool tip P to reach the target point G, would be determined.

In view of the disadvantages described of determining the distances ZNP and XNP, in accordance with the known method of the kind in question, the tool slide 22 is not only moved into slide reference point R for gauging the path measuring systems but also into a stationary reference point, which is assumed here to be the same slide reference point R, so that the position of the tool tip P with respect to the tool reference point N at the tool slide 22 may be determined. Furthermore, a measuring point D is fixed by swinging the sight means described in the form of a projector with screen plate into the working space of the machine. Subsequently the distances ZDP and XDP of the tool tip P from the measuring point D are read, as is known, on the screen plate, and these distances are fed into the data memory.

In accordance with the method of the invention, on the other hand, the user guides the tool slide 22 by hand into a position at which the tool tip P coincides exactly with the measuring point D in the sight means. Then both distances ZDP and XDP are zero so that they need not and cannot be read by the user. However, to make the tool tip P coincide with the measuring point D, the tool slide 22 travelled exactly the paths ZDP and XDP, starting from slide reference point R, whereby the path measuring systems of the machine tool itself were given the opportunity to determine these paths or the positional co-ordinates reached upon coincidence of the tool tip P and the measuring point D. As the invention also provides for the co-ordinates ZDM and XDM of measuring point D to be stored in the data memory, the computer of the machine may now calculate the distances ZNP and XNP based on the following simple equations:

$$ZNP = ZMR - ZNR - ZDP - ZDM$$
$$XNP = XMR - XNR - XDP - XDM$$

Thus the paths of the tool slide 22 toward each target point fixed in a machining program are determined for the numerical control, on the basis of the values of ZNP and XNP calculated for each individual tool.

CLAIMS

1. A method of determining the position of a tool tip or edge with respect to a tool slide of a numerically controlled machine tool comprising storing in the machine data memory the co-ordinates of a fixed slide reference point and the co-ordinates of a fixed measuring point, moving the tool slide so that the tool tip or edge coincides with the measuring point, and recording in the data memory the positional data of the tool slide at the position where the tool tip or edge coincides with the measuring point, whereby the position of the tool tip with respect to the tool slide may be determined.

2. A method as claimed in Claim 1 in which the position of the measuring point is determined by a sight through which the operator observes the tool.

3. A method as claimed in Claim 2 in which the tool tip or edge is made coincident with the measuring point by means of the sight through which the operator observes the tool.

4. A method as claimed in any of Claims 1 to 3 which is repeated for a plurality of tools associated with the tool slide.

5. A method as claimed in any of Claims 1 to 4 for determining the position of a tool tip with respect to the tool slide of a numerically controlled lathe.

6. A method of determining the position of a tool tip with respect to a tool slide of a numerically controlled lathe substantially as herein specifically described with reference to and as shown in the accompanying drawing.

7. A method of determining the position of a tool tip or edge with respect to a tool slide of a numerically controlled machine tool, in particular a lathe, in the data memory of which the co-ordinates of a stationary slide reference point to be reached by the tool slide are stored and with which a measuring point which is likewise stationary is fixed by a sight means through which the user observes the tool secured to the tool slide and then feeds a command for memorisation of measuring data into the control, characterised in that the co-ordinates of the measuring point are stored in the data memory in addition to the co-ordinates of the slide reference point, at least for a certain program, in that the tool slide with the or each tool required for said program is moved into the position, differing from the slide reference point, at which position the

tool tip coincides with the measuring point, and in that the positional data of the tool slide in this position are stored.

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