(12) UK Patent Application (19) GB (11) 2 050 009 A

(21) Application No **8009179**
(22) Date of filing **19 Mar 1980**
(30) Priority data
(31) **211652**
(32) **19 Mar 1979**
(33) **Dem. Rep. of Germany (DD)**
(43) Application published **31 Dec 1980**
(51) **INT CL^3 G05F 1/10 // B24B 47/20 49/16**
(52) Domestic classification **G3U** BA
(56) Documents cited **GB 1455746 GB 1425066**
(58) Field of search **G3U**
(71) Applicants
VEB Rathenower Optische Werke 'Hermann Duncker', 183 Rathenow, German Democratic Republic
(72) Inventors
Wolfgang Lorenz, Rainer Ortmann, Franz Grunwald, Gerd Boswetter
(74) Agents
Venner Shipley & Co.

(54) Automatic control of grinding pressure

(57) In a method of severing grinding and surface grinding using a diamond grinding tool, an advantageous surface pressure between the grinding tool and the workpiece is continuously maintained during the grinding operation. This pressure is controlled in dependence on the geometrical dimensions and the properties of the material of the workpiece, by the in-feed force adjusting means so as to maintain constant either the current consumed by the grinding spindle driving motor. It is stated that the in-fed speed may also be maintained constant.

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

GB 2 050 009 A

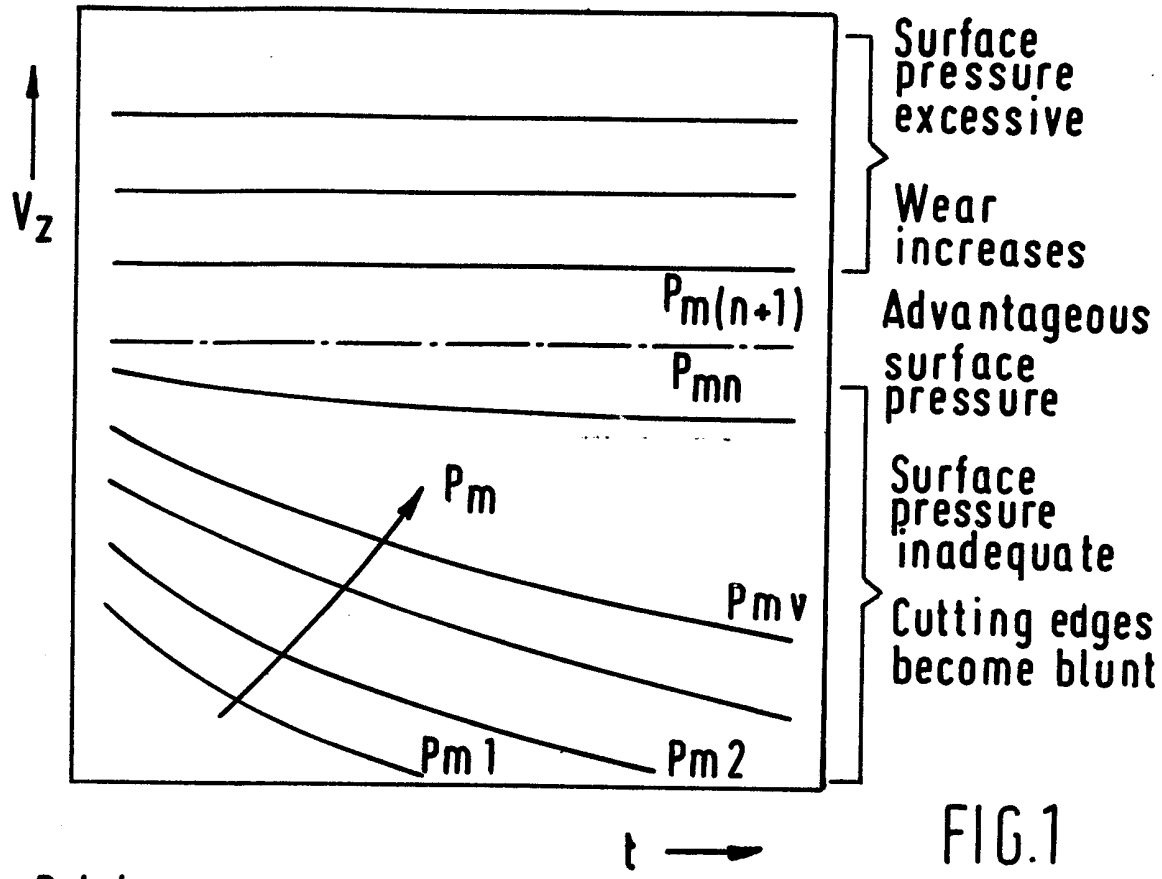
Surface pressure excessive
Wear increases
Advantageous surface pressure
Surface pressure inadequate
Cutting edges become blunt
V_z
$P_{m(n+1)}$
P_{mn}
P_m
P_{mv}
P_{m1}
P_{m2}
t

FIG.1

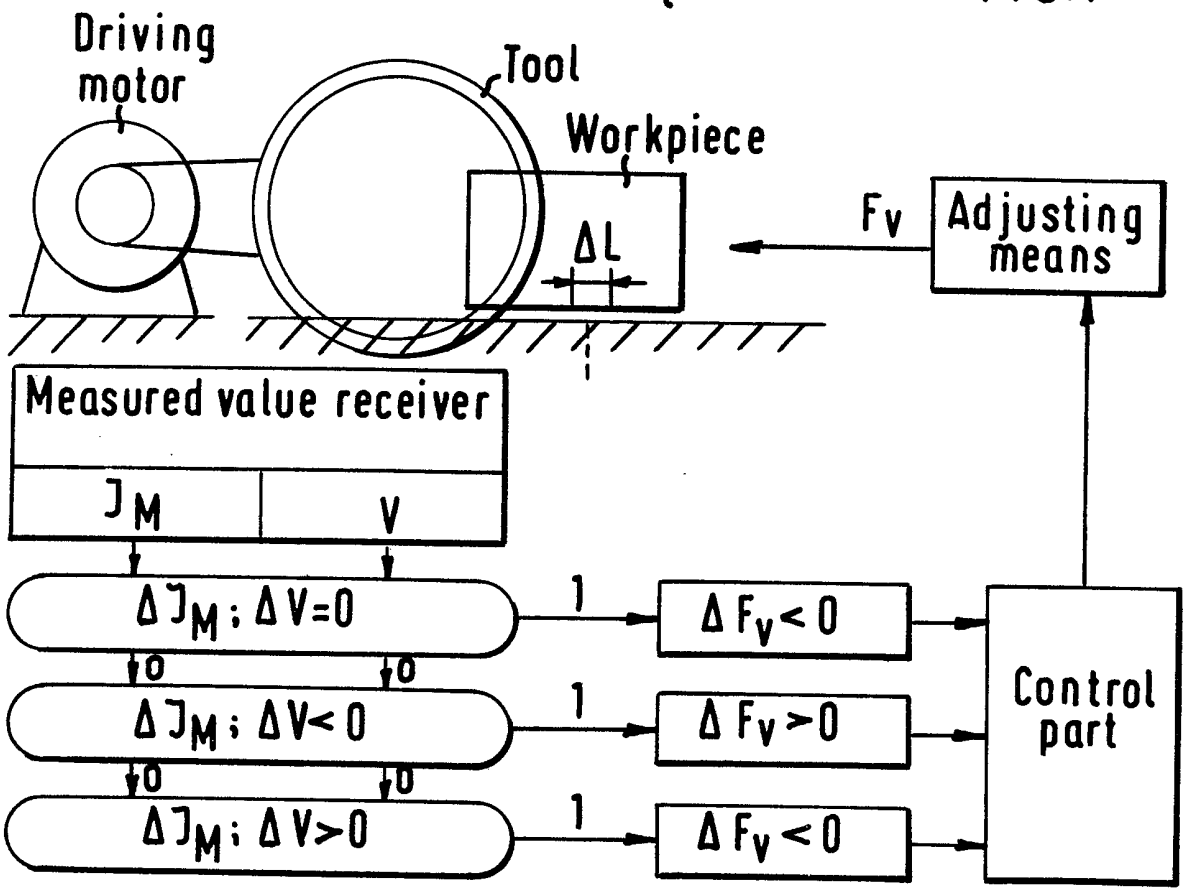
Driving motor
Tool
Workpiece
ΔL
Fv
Adjusting means
Measured value receiver
J_M
V
ΔJ_M; ΔV=0
ΔJ_M; ΔV<0
ΔJ_M; ΔV>0
1
0
$\Delta F_V < 0$
$\Delta F_V > 0$
$\Delta F_V < 0$
Control part

FIG.3

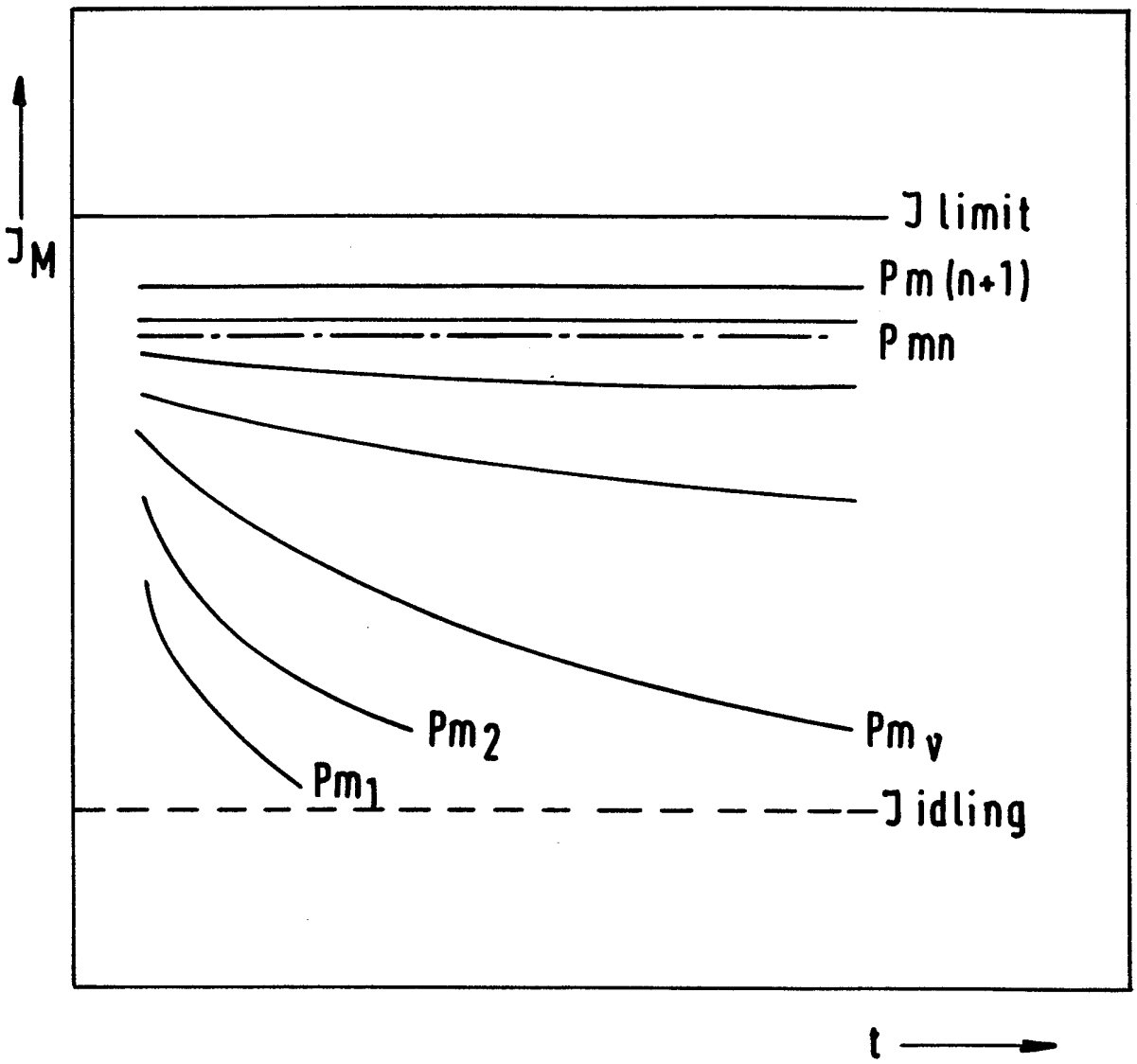

FIG. 2

SPECIFICATION

Method of severing grinding and surface grinding

This invention relates to a method of severing grinding and surface grinding, more particularly using diamond tools, by means of the setting up and continuously maintaining of an advantageous surface pressure between the grinding tool and workpiece in dependence on the geometrical dimensions of the workpiece and the properties of its material.

In severing grindings and surface grinding, more particularly with diamond tools, in the interests of maintaining maximum tool life, continuous self-sharpening, optimum surface quality, minimum machining times and minimum dressing operations, care must be taken to ensure that sharp cutting edges can always be used on the grinding grains disposed firmly in a bonding. This presupposes that, in harmony with the wear on the bonding, fresh cutting edges are produced on blunt grinding grains by the splintering and breakage of grains, and that fresh grinding grains can be used after the grains have become completely worn. The production of a cutting surface condition of this kind is determined mainly by the surface pressure between the tool and the workpiece in the direction in which the material is ground down. More particularly that surface pressure at which a cutting surface condition such as that described hereinbefore can be produced—i.e., fresh cutting edges can be continuously produced on the grinding grains by the splintering and breakage of grains and grains disposed more deeply in the bonding can come into engagement only after complete wear in connection with bonding wear.

A further feature of advantageous surface pressure is minimum wear on the tool, which can be expected if the surface pressure takes on a value, at which in the direction of increasing p_m values (Figure 1) for the first time a constancy occurs of the volume V_z of material removed per unit of time over the grinding time (p_{mn} in Figure 1)

$$V_z = f(t, p_{mn}) = \text{const.}$$

In dependence on the value of the surface pressure and the properties of the material of the workpiece, the following cutting surface conditions can also occur:

With inadequate surface pressure the cutting edges of the grains become blunt, without the possibility of fresh ones being produced by grains splintering. Consequently, the volume of material removed per unit of time is reduced with the grinding time, and it becomes necessary to dress the tool, and this always has an adverse effect on the grinding coating (lower area of p_m values in Figure 1).

With excessive values of surface pressure the grinding grains are torn out of the bonding before they have finally been used up, and the bonding also becomes worn too quickly. Fresh grinding grains are constantly used, so that wear on the tool increases more quickly in ratio to the volume of material removed per unit of time.

A severing grinding or surface grinding tool should therefore as far as possible be used in such a way that at each phase of the grinding operation the surface pressure is controlled to a value such as to ensure that the volume of material removed per unit of time remains constant. This means (Figure 1) that it takes on the value which is determined by the value of the surface pressure p_{mn}. On the basis of this condition, various dimensions and properties of the material can be taken into account.

Since the width of the grinding wheel and the adjustment and arc of engagement are contained in the definition of the macroscopic surface pressure, instead of the volume V_z of material removed per unit of time, it is possible also to use the in-feed speed v as a criterion for the setting up of the advantageous surface pressure. On the basis of the relationship illustrated in Figure 2, the motor current consumed can also be adduced as a criterion for discovering the advantageous surface pressure. As the cutting capacity of the tool declines, the current consumed by the motor also decreases, while if the cutting properties remain constant, the current consumed by the motor also takes on a value corresponding to the cutting conditions and remains constant. Of course, the current consumed by the motor must not exceed the particular limit of its maximum value.

$$I_{limit} = F\,(\text{Motor})$$

The known methods and arrangements for producing the in-feed in severing grinding or surface grinding machines are of a manual or mechanical nature. If the in-feed is effected manually, in the case of comparatively large workpieces the surface pressure, due to the relatively low muscular forces, may move in the lower zone of the graph (Figure 1 or 2), in which a cutting surface condition is reached which is characterised by blunted cutting edges on the grains. Consequently, cutting efficiency very rapidly declines, and the tool must be dressed. Practical experience with appropriate machines and apparatuses confirms this fact. Conditions of engagement can be better arranged only for small workpieces, although the surface pressure very quickly moves to the upper zone of Figures 1 or 2, meaning that wear on the tool increases. With an uncontrolled manual in-feed, therefore, it is hardly possible to bring the surface pressure to the advantageous value every time.

The mechanical methods of producing the in-feed have a firm, constant in-feed movement which is maintained independently of the workpiece size and material properties. Clearly, even with this method it is very difficult to obtain the advantageous value of the surface pressure every time. It will lie at any place in Figures 1 or 2, in dependence on the workpiece dimensions and kind of material. In this case also it is necessary to

dress the tool frequency or to exchange it prematurely due to excessively rapid wear.

In principle the prior art grinding methods and arrangements use grinding tools based on silicon carbide or corundum, which are substantially cheaper than diamond tools. It is therefore easy to understand that the main emphasis is not laid on the sparing treatment of the grinding discs, but on effecting economic machining, with the workpiece materials remaining substantially constant. The decisive role is therefore not played by the number or sequence of the dressing operations or the exchanging of the grinding wheels, but by the necessary time and expense of the dressing and the precision with which the adjustment is made by the amount of dressing.

Thus, the prior art open and closed loop control systems for severing grinding and surface grinding machines are based on the maintenance of externally given limit values, such as for example, maximum and minimum values of the motor current (German Offenlegungsschrift 2 517 001) or for the grinding resistance (German Auslegeschrift 2 159 876). As a result, technologically optimum conditions are created for very definite machining situations, and these must be redetermined in each particular case.

Other conditions and requirements arise if the properties of the workpiece to be machined or the quality to be achieved necessitate the use of diamond tools. In that case, due to the high value of the grinding tools, dressing operations must be completely avoided, or limited to the minimum.

It is an object of the invention to obviate the aforementioned disadvantages in the use of severing grinding and surface grinding tools by keeping the surface pressure between the tool and the workpiece at its advantageous value during the whole duration of machining, independently of the dimensions or materials of the workpiece, with the object of maintaining maximum tool life, continuous self-sharpening, optimum surface quality, minimum machining time, and minimum dressing operations.

To solve this problem, according to the invention the adjusting means producing the feed F_V is controlled during the grinding operation, in dependence on the properties of the material and the engagement conditions to a value which produces, in the direction of increasing values of in-feed force, for the first time a constancy in the current consumed or in the in-feed speed, a start being made from a value F_{VO} which experience shows to be satisfactory. To meet the demand for an approximation to the first curve of constant motor current and constant in-feed speed, without the latter being exceeded, the control system, starting from the initial value F_{VO}, must meet the following conditions:

With a reduction of in-feed speed and motor current, the in-feed force must be increased

$$\left.\begin{array}{l}\Delta v < 0\\ \Delta I_M < 0\end{array}\right\} \text{ there follows } \Delta F_V > 0$$

With constant in-feed speed and constant motor current, the in-feed force is reduced.

$$\left.\begin{array}{l}\Delta v = 0\\ \Delta I_M = 0\end{array}\right\} \text{ there follows } \Delta F_V < 0$$

With in increase in the in-feed speed and motor current, the in-feed force is also reduced.

$$\left.\begin{array}{l}\Delta v > 0\\ \Delta I_M > 0\end{array}\right\} \text{ there follows } \Delta F_V < 0$$

Advantageously, in the case of comparatively small workpieces, whose dimensions lie in the order of magnitude of ΔL, ΔI_M and Δv are formed from the mean values for I_M and v of two workpieces machined in succession, and ΔF_V comes into operation with each following workpiece to be machined.

This ensures that the control system is always effective for the advantageous surface pressure value, independently of the size, shape and materials of the workpiece.

In order that the invention may be more readily understood, reference is made to the accompanying drawings, which illustrate diagrammatically and by way of example an embodiment thereof and in which:—

Figures 1 and 2 show the dependence of the volume of material removed per unit of time and of the motor current on the grinding time and surface pressure; and

Figure 3 explains the invention in greater detail, taking as an example severing grinding using diamond tools.

A measured value receiving means records at fixed, discreet distances of the value ΔL the course of the in-feed speed and of the motor current and transmits the appropriate information to a logic unit. From there in-feed-producing adjusting member is so actuated that ΔF_V is constantly controlled, either proportionally to Δv and ΔI_M or in constant step widths, in accordance with the control conditions, so that the surface pressure between the workpiece and tool can always be kept at its advantageous value.

CLAIMS

1. A method of severing grinding and surface grinding, wherein an advantageous surface pressure between the grinding tool and the workpiece is continuously controlled during the grinding operation by in in-feed force-controlling adjusting means of a control system, in dependence on the geometrical dimensions and the properties of the material of the workpiece, to a value such as to produce for the first time, in the direction of increasing values of feed force, a constancy in the current consumed by the grinding spindle driving motor or in the in-feed speed.

2. A method according to claim 1, wherein control system meets the following conditions:

if $\Delta I_M < 0$, $\Delta v < 0$ there follows $\Delta F_V > 0$

if $\Delta I_M = 0$, $\Delta v = 0$ there follows $\Delta F_V < 0$

if $\Delta I_M > 0$, $\Delta v > 0$ there follows $\Delta F_V < 0$

3. A method according to claim 1 or 2, wherein in the case of comparatively small workpieces, whose dimensions lie in the order of magnitude of ΔL, ΔI_M and Δv are formed from the mean values for I_M and v of two workpieces machined in succession, and ΔF_V comes into operation with each following workpiece to be machined.

4. A method of severing grinding and surface grinding, wherein an advantageous surface pressure between the grinding tool and the workpiece is continuously controlled by an in-feed controller which is operable to increase the feed force to a value such as to produce, at least initially, a condition in which the current consumed by the grinding spindle driving motor or the in-feed speed are constant.

5. A method of severing grinding and surface grinding, substantially as herein described with reference to and as shown in the accompanying drawings.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1980. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.