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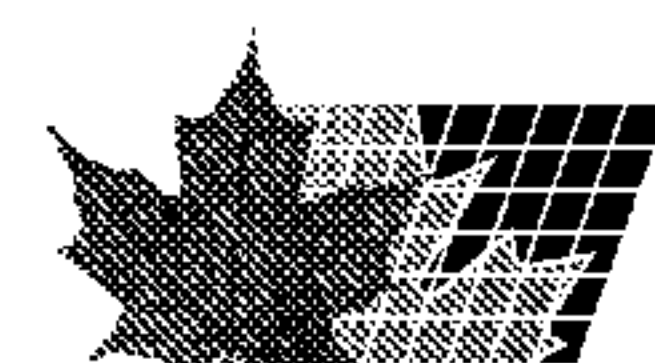
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(54) Title: ROTARY ABRASIVE TOOL

(57) **Abrégé/Abstract:**

Provision of a rotatable abrasive disk having apertures permitting a view of a workpiece surface during the abrading process makes possible the incorporation of a condition sensing mechanism viewing the workpiece surface through the holes and capable of adapting the grinding conditions accordingly.



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(21) International Application Number: PCT/US00/09576 (22) International Filing Date: 10 April 2000 (10.04.00) (30) Priority Data: 60/131,003 23 April 1999 (23.04.99) US 09/522,881 10 March 2000 (10.03.00) US (71) Applicant: NORTON COMPANY [US/US]; 1 New Bond Street, Box No. 15138, Worcester, MA 01615-0138 (US). (72) Inventor: KINISKY, Thomas, G.; 33 Floral Street, Shrewsbury, MA 01545 (US). (74) Agents: DAVIS, Anthony, G., M.; Davis and Bujold, 4th floor, 500 North Commercial Street, Manchester, NH 03101 (US) et al.		(81) Designated States: AU, BR, CA, CN, ID, IN, JP, KR, MX, RU, ZA, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i>
(54) Title: ROTARY ABRASIVE TOOL (57) Abstract Provision of a rotatable abrasive disk having apertures permitting a view of a workpiece surface during the abrading process makes possible the incorporation of a condition sensing mechanism viewing the workpiece surface through the holes and capable of adapting the grinding conditions accordingly.		

ROTARY ABRASIVE TOOL

Background of the Invention

5 This invention relates to the coupling of in-situ measurement devices with rotary abrasive tools. Major advantages in the use and operation of abrasive tools can be gained by real time feedback to the operator or machine tool controlling the abrasive tool. The type of real-time feedback that has major significant are, for example, temperature, surface roughness,
10 workpiece position during the abrading, grinding, or finishing, or surface roughness. Hitherto this has depended on the use of experienced operators or interrupted operations in which the abrading is interrupted more or less frequently for measurement. In this document the term "abrading" is to be understood to refer not only to processes in which substantial amounts of
15 material are removed from a surface but also, and perhaps more importantly, to processes in which the operation is considered to be fine finishing, polishing or lapping.

A rotary abrasive tool has now been devised that can be controlled in a plurality of ways to respond to critical parameters automatically and to adjust
20 the operation in response to variation in these parameters without the need for interruption of the operation.

Description of the Invention

The present invention provides a rotary abrading tool which comprises:

- a) an abrasive disk having holes pierced through the disk at intervals
25 permitting a view of the surface during the abrading operation, the disk being mounted on
- b) a rotatable shaft actuated by a motor; and
- c) at least one non-contact sensor aligned to view and/or measure the condition of a workpiece surface through holes in the abrasive disk as it
30 rotates.

The abrasive disk can be rigid, (that is self-supported), but usually more conveniently it is supported on a backup pad which comprises holes in the body of the pad corresponding in location to those in the disk supported thereon such that, upon rotation, it is possible to view a workpiece as it is
5 undergoing abrasion through both the disk and the backup pad.

Abrasive disks with viewing holes or apertures are known in the art for the purpose of allowing the operator to assess the state of the surface being abraded as it happens. Such abrasive disks are described for example in WO/US96/19191. The present invention goes much further however in
10 adapting a rotary abrading tool not only to view the workpiece surface but also to measure its condition in application-specific ways.

In one embodiment of the invention the non-contact sensor is a laser device adapted to measure the surface finish of the workpiece and/or the distance between the abrasive disk and the surface of the workpiece. Thus in an
15 automated operation such a sensor can, for example, advance the abrasive disk towards the workpiece in a rapid but controlled fashion so as to avoid both delays and workpiece damage resulting from excessively abrupt initial contact. Then, having initiated abrading, the laser can monitor the surface of the workpiece and, through appropriate feedback mechanisms, control the
20 grinding pressure or withdraw the tool when the appropriate surface finish has been generated. Making this a part of the rotary abrasive tool ensures that the abrasive operation is conducted efficiently with a minimum of lost time.

In another embodiment the non-contact sensor is one specifically adapted to
25 measure the temperature of the surface, for example using an infra-red sensor device. This is particularly important when the surface being treated is a painted surface. Modern automobile paints, for example, above a certain temperature determined by the chemistry of the polymer matrix, tend to "ball up", (that is to partially melt or soften and form small balls or globules of
30 polymer), during abrasion. This of course destroys the abrasive function of the disk and it is therefore critical to monitor the surface temperature during

abrasion. The temperature sensing device can be separate from, or incorporated into, a laser sensing device such that both modes of surface condition sensing mechanism are available.

Other non-contact sensors can respond to light waves, (both UV and visible),
5 sound waves and any other desired variety of electromagnetic radiation.

The abrading disk is conveniently provided with from 3 to 6 apertures located at a uniform radial distance from the axis of the disk. The size of the apertures is preferably large enough to ensure that, when the tool is in use the surface condition sensors are able to receive sufficient data to give a
10 useful reading. The shape of the apertures is not critical but generally round holes are preferred since these afford maximum visibility with minimum disruption to the cohesiveness of the disk under grinding conditions. It is also preferred that sensing devices are located to view through the disk in the radial position on the disk of maximum aperture area.

15 Since the most relevant information relates to the surface of the workpiece actually being abraded, the viewing apertures are preferably located in the radially outer half of the disk since this is the portion that is most heavily used. In some forms of abrasive disk, it is known to remove portions of the circumference of a disk so as to afford a view of the surface right to the edge
20 of the abrasive disk.. Such removed peripheral portions are likewise considered to be "apertures" since they perform the same function as holes in the body of the disk but in a different location on the disk.

The sensor devices operate by transmitting and/or receiving electromagnetic radiation , (the nature of which depends on the condition being sensed as
25 above indicated), through the apertures in the disk. In practice this means that one would synchronize the detection systems to the rotational speeds of the disc and to the frequency of the holes passing the detector system. This ensures that maximum information is received by the sensing device.

Where the disk is rigid, as would be the case for example if the disk were a
30 "flap-disk" in which quadrilateral flaps of coated abrasive material are attached by one edge to a rigid usually cupped disk in overlapping fashion

around one surface of the disk. Such disks generally need no backup pad and are used for grinding down welds or joint lines.

The surface of the abrasive disk can be of the conventional type in which abrasive grain is bonded to a backing material by the usual maker and size coat combinations, with or without a supersize coat conferring special grinding properties or characteristics. However it can also have an engineered surface comprising micro-replicated structures, such as pyramids or lines of parallel ridges, each of which comprises abrasive particles dispersed in a binder and adhered to a backing material.

Finally the surface can comprise a layer of a formulation comprising abrasive particles dispersed in a binder resin and deposited in a relatively uniform layer or in a contoured structure on a backing.

The abrasive particles used can be any of those typically made available for such purposes and range from alumina, alumina-zirconia and silicon carbide in the general purpose grinding area, to diamond, CBN, ceria, gamma alumina, and microcrystalline alpha alumina in the more specialized abrading applications.

The binder component of the abrasive disk can be selected from those known in the trade for such applications. These include thermosetting resins such as phenolic and epoxy-based resins, and radiation-curable resins such as acrylates, epoxy-acrylates, urethane-acrylates resins and similar resins that are curable by visible or UV light as well as electron-beam radiation. Also included are moisture-curable resins.

The means by which the abrasive disk is made to rotate can be any suitable motor means and the whole tool can be a basic adaptation of an angle grinder, off-hand grinder, fixed grinder and the like.

Advantageously the condition-sensing mechanism is linked to control systems on the tool which regulate parameters such as the position of the tool with respect to a workpiece, the force with which the abrasive disk contacts a workpiece and the speed of rotation of the disk. Alternatively or additionally the condition sensing device can be linked to a notification mechanism such

as a light, a bell or a buzzer indicating that a desired end-point or limit condition has been reached. Clearly if the tool is used in an off-hand grinding mode, the linkage is preferably of the notification type.

A preferred application is in the automobile industry wherein automation of finishing processes is well advanced. The rotary abrasive tool of the invention is particularly well adapted to the removal of finish defects where the workpiece is a painted automobile panel. An example of a tool adapted for this application is equipped with two sensors: one a laser device to read out the surface finish of the workpiece as it is polished and to terminate the work when the desired finish has been attained; and the second is a temperature sensor which is set to interrupt or moderate the polishing when the temperature of the surface approaches the point at which "balling-up" of the paint polymer becomes a problem. The preferred disk for the tool has a three round hole pattern with the holes equally spaced around the disk and each is located about two thirds of the radial distance from the center of the disk to the circumference. The diameter of the holes is from about 15 to 30% of the radius of the disk. The abrading surface is conventional for this application and is not critical to the tool itself.

We Claim:

1. A rotary abrading tool which comprises:
 - a) an abrasive disk having holes pierced through the disk at intervals permitting a view of the surface during the abrading operation; the disk being mounted on
 - b) a rotatable shaft actuated by a motor; and
 - c) at least one non-contact sensor aligned to view and/or measure the condition of a workpiece surface through holes in the abrasive disk as it rotates.
2. A tool according to Claim 1 in which the sensor is coupled to means for adjusting the abrading operation in response to the condition sensed.
3. A tool according to Claim 1 in which the abrasive disk is supported on a backup pad having holes in the body of the pad corresponding in location to those in the disk supported thereon such that, upon rotation, it is possible to view a workpiece as it is undergoing abrasion through both the disk and the backup pad.
4. A tool according to Claim 1 in which the sensor is a laser device adapted to measure the surface finish of the workpiece and/or the distance between the abrasive disk and the surface of the workpiece.
5. A tool according to Claim 1 in which the sensor is adapted to measure the temperature of the surface using an infra-red sensor device.
6. A tool according to Claim 1 in which the viewing apertures in the abrasive disk are located in the radially outer half of the disk.
7. A tool according to Claim 1 in which the viewing apertures in the abrasive disk are in the form of portions removed from the circumference of the disk.
8. A tool according to Claim 1 in which the surface of the abrasive disk is engineered to provide a plurality of micro-replicated structures.