

SPECIFICATION

TITLE OF THE INVENTION

WORKING TOOL, AND MATERIAL THEREFOR ✓

BACKGROUND OF THE INVENTION

The present invention relates to a working tool material, as well as a working tool such as rotating tool and an abrading grindstone, which is formed from the working tool material.

More particularly, the present invention relates to a working tool material, as well as a working tool which is suitable for cutting, drilling, grinding or polishing: metals such as iron, iron alloy, aluminum, aluminum alloy, copper, copper alloy, titanium, titanium alloy, magnesium and magnesium alloy; or non-metals such as stones, mono- or poly-crystal silicon, ceramics and the like.

Working tools such as carborundum grindstone and an alumina grindstone are conventionally known as this type of the working tool. For example, the carborundum grindstone is a porous block comprised of carborundum abrasive grains coupled together by a binder. However, because the carborundum grindstone is porous, the content of the abrasive grains is insufficient, and the working efficiency is insufficient. Further, cuttings are filled into pores in the porous block to cause a blinding, whereby the workability such as cutting quality is liable to be degraded. Disclosed in Japanese Patent

Publication Nos. 54-4800 and 59-97845 are a buff grindstone made using a fiber glass. However, this buff grindstone has a disadvantage that the fiber glass has a low hardness and hence, the field of application of the buff grindstone is limited. Further, because the buff grindstone is also porous, the working efficiency thereof is insufficient, and a blinding is caused.

It is an object of the present invention to provide a working tool which is capable of cutting, drilling, grinding and polishing a workpiece with a high efficiency, and which cannot cause a blinding in service, and to provide a working tool material which is capable of forming such working tool.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a working tool such as a rotating tool and a polishing grindstone, wherein a large number of grinding grains for applying a working such as a cutting to a workpiece is contained to assure a working efficiency, so that an excellent workability can be always maintained without causing a blinding, and the use of an entwined yarn ensures that the working tool has a strength as high as there is not a possibility that the tool is broken as in the conventional grindstone, and to provide a working tool material for making such working tool.

To achieve the above object, according to a first aspect and feature of the present invention, there is provided a material for a working tool, comprising long fiber glass

properly arranged in the form of an entwined yarn, and a thermosetting resin which contains grinding grains, and which is impregnated into the long fiber glass and cured.

According to a second aspect and feature of the present invention, the working tool material comprises 20 to 40 % by volume of the long fiber glass, 20 to 40 % by volume of the grindstone, and 30 to 50 % by volume of the thermosetting resin.

According to a third aspect and feature of the present invention, the long fiber glass is in the form of an interlaced yarn made as an entwined yarn by blowing of air.

According to a fourth aspect and feature of the present invention, the thermosetting resin comprises an unsaturated polyester resin.

According to a fifth aspect and feature of the present invention, the thermosetting resin comprises an epoxy resin.

According to a sixth aspect and feature of the present invention, the grindstone is at least any one of diamond abrasive grains, CBN abrasive grains, silicon carbide abrasive grains, alumina abrasive grains, zirconia-alumina abrasive grains, and zirconia abrasive grains.

According to a seventh aspect and feature of the present invention, there is provided a rotating tool, which is made into the form of a rotor from the working tool material according to any of the first to sixth features.

According to an eighth aspect and feature of the present

invention, there is provided a polishing grindstone, which is made into the form of a stick from the working tool material according to any of the first to sixth features.

According to a ninth aspect and feature of the present invention, the polishing grindstone has a thickness of 3 mm or less.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is a perspective view for explaining a process for producing a working tool according to the present invention;

Fig.2 is a sectional view for explaining the process for producing the working tool according to the invention;

Fig.3 is a sectional view for explaining the process for producing the working tool according to the invention;

Fig.4 is a perspective view for explaining the process for producing the working tool according to the invention;

Fig.5 is a perspective view for explaining the process for producing the working tool according to the invention; and

Fig.6 is a perspective view of a working tool according to one of embodiments of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

An interlaced yarn made by entwining by blowing of air is used as the long fiber glass properly arranged in the form of the entwined strand. However, the long fiber glass has a large tensile strength, and the working tool made using the long fiber glass has a sufficient strength required for cutting,

drilling, grinding and polishing.

It is preferable that the long fiber glass has a fiber diameter on the order of 3 μm to 25 μm . This is because the fibers presently commercially available generally have the fiber diameter in this range, and it is practically difficult to produce long fiber glass having a fiber diameter departing from this range.

The amount of long fiber glass incorporated is preferred to be on the order of 20 to 40 % by volume. If the amount of long fiber glass incorporated is lower than 20 % by volume, a strength required for the working tool is not obtained. On the other hand, if the amount exceeds 40 % by volume, abrasive grains required for a working such as cutting, drilling, grinding and polishing are not incorporated in a sufficient amount and as a result, it is failed to produce a working tool satisfactorily enabling a working such as cutting, drilling, grinding and polishing.

Examples of the abrasive grains which may be used are diamond abrasive grains, CBN abrasive grains, silicon carbide abrasive grains, alumina abrasive grains, zirconia-alumina abrasive grains, zirconia abrasive grains and the like. Further, the following materials may be used: powders of carbides such as boron carbide, titanium carbide and tungsten carbide; nitrides such as boron nitride and titanium nitride; borides such as zirconia boride, titanium boride and tungsten

boride, or whiskers of silicon carbide, silicon nitride, magnesium oxide, aluminum borate, potassium titanate, and alumina.

The size of the abrasive grains may be in a range of #60 to # 200,000, which enables the addition of the abrasive grains. However, if the abrasive grains have a larger size (i.e., smaller than # 60), a violent sedimentation occurs within a resin cell during impregnation of the long fiber glass with the resin composition containing the abrasive grains and hence, a forming material is not produced successfully. Therefore, the use of abrasive grains having a smaller size (i.e., larger than #80) is preferred.

It is preferable that the amount of abrasive grains incorporated is on the order of 20 to 40 % by volume. If the incorporated amount is lower than 20 % by volume, a sufficient strength for the working tool is obtained, but a sufficient workability such as cutting, drilling, grinding and polishing is not achieved, so that the working tool merely slips on a workpiece. If the incorporated amount exceeds 40 % by volume, the fiber glass serving to provide a strength is not incorporated in a sufficient amount and as a result, a working tool having a satisfactory strength can not be obtained.

The thermosetting resin containing the abrasive grains acts as a matrix for a binder, i.e., the long fiber glass and the abrasive grains. The type of this resin is particularly

not limited, if it is thermosetting, but in general, the thermosetting resin is an unsaturated polyester resin or an epoxy resin.

To produce the working tool material, for example, an entwined yarn made by entwining long fiber glass together by blowing air from the side in a fine tube is used. The entwined yarn is passed through a resin cell in which a thermosetting resin containing a given amount of abrasive grains mixed is accommodated, thereby causing the resin composition containing the abrasive grains to be retained in gaps in the loosened entwined yarn. Then, the entwined yarn of the fiber glass containing the given amount of the resin composition in the above manner is wound around a rotating rotor (which may be cylindrical, rectangular or of flat plate-like shape). In this case, the entwined strand may be wound in a traverse manner, or wound in parallel. Then, a forming material resulting from integration of the entwined strand wound around the rotor and the resin composition containing the abrasive grains is cut in an axial direction of the rotor and spread into a sheet-like configuration. The sheet-like forming material is cut into a size corresponding to the size of the mold. If required depending upon the thickness, the forming materials may be laminated one on another. The resulting forming material is placed into the heated mold, where it is subjected to a heat and pressure pressing and cured.

The working tool forming material produced in the form of a block in the above manner may be cut into the form of a desired rotor, or into a polishing grindstone in the form of a desired stick, thereby producing a working tool.

After the working tool material is formed into the form of the block as described above, it may be formed into a desired shape of working tool. But the working tool material itself may directly be formed into a desired shape of working tool from the beginning.

For the rotating tool, it may be produced in the following manner: First, the entwined yarn is passed through a resin cell in which a thermosetting resin containing a given amount of abrasive grains mixed is accommodated, in the same manner as described above, thereby causing the resin composition containing the abrasive grains to be retained in gaps in the loosened entwined yarn. Then, the entwined yarn of the fiber glass containing the given amount of the resin composition in the above manner is wound around a rotating rotor (which may be cylindrical, rectangular or of flat plate-like shape). In this case, the entwined strand may be wound in a traverse manner, or wound in parallel. The resulting forming material is directly introduced into a mold, where the resin composition is cured on the rotor to provide a molded product. The rotor serving as an axis is withdrawn, and the cured molded product is cut into a suitable thickness.

As described above, the long fiber glass in the form of the entwined strand such as the interlaced strand made entwined by blowing of air has a large tensile strength, and the produced working tool has a sufficient tensile strength of 10 kg to 12 kg/mm² required for a rotating tool for cutting, drilling, grinding and polishing.

Examples

Particular examples will now be described with reference to the accompanying drawings.

(Example 1)

First, five entwined yarns of long fiber glass ("Thermo-locked yarn" sold by Nitto Boseki Kabushiki Kaisha, in the name of GBY 042 SP produced by Fuji Fiber Glass Kabushiki Kaisha) were passed through a resin cell containing a resin composition containing the following components, whereby the entwined yarn was impregnated with the resin composition. A resulting bundle of the five entwined yarns 1 impregnated with the resin composition was wound in parallel into a width of 50 mm around an iron rod 2 having a diameter of 3 mm, until the diameter reaches 25 mm, as shown in Fig.1. Reference character 3 in Fig.1 indicates abrasive grains.

Epoxy resin (DER383J produced by Dow Chemical Japan)

100 parts by weight

Tetrahydromethyl phthalate anhydride (HN2200 produced by Hitachi Kasei Kogyo)

80 parts by wieght

Imidazole (2E4MZ-CN produced by Shikoku Kasei Kogyo)

1 part by weight

Alumina abrasive grains (WA#240 made Fujimi Incorporated)

150 parts by weight

Lubricant (BYK-W965 produced by Bigchemi Japane)

1 part by weight

Then, as shown in Fig.2, the resulting bundle of fiber yarns 1 wound around the rod was placed into an iron cylinder 10 having an inside diameter of 30 mm, and rods 20 of an outside diameter of 29.5 mm having a hole 21 of 3.1 mm provided at the center were inserted into the cylinder 10 from opposite ends of the cylinder 10. As shown in Fig.3, the rods 20, 20 on the opposite sides were sandwiched and clamped by a squill vice and then thrown into a curing oven at 120°C and cured for one hour. Thereafter, the bundle of the fiber yarns was withdrawn from the iron cylinder 10, thereby producing a polishing rod 30 having a hole 31 of 3 mm provided at the center, as shown in Fig.4.

The polishing rod 30 was milled into a thickness of 2mm to provide a disk 41, as shown in Fig.5, and a rod 43 made of FRP including a fiber glass having a diameter of 3 mm was fixed in the hole 42 at the center of the disk 41 by use of an epoxy resin adhesive to provide a disk-like rotating tool as shown in Fig.6.

The resulting disk-like rotating tool comprises 30.3 % by volume of the long fiber glass, 23.5 % by volume of the

abrasive grains, and 46.2 % by volume of the thermosetting resin.

The rotating tool 40 was attached to a rotatable polishing device (ESPERT400 produced by Kabushiki Kaisha Nakanishi) to polish an iron mold. The result showed that a very good polished surface was provided. Moreover, the incorporation of the entwined yarn of the fiber glass ensures that the rotating polishing tool is very resistant to fracture, and if the polishing tool was strongly pushed against a surface to be polished to polish this surface, it was not fractured.

(Example 2)

Ten Entwined yarns of long fiber glass ("Thermo-locked yarn" sold by Nitto Boseki Kabushiki Kaisha, in the name of GBY 042SP produced by Fuji Fiber Glass Kabushiki Kaisha) impregnated with a resin composition by passing through a resin cell containing the same resin composition as in Example 1 were wound 612 times in parallel into a width of 276 mm at distances of 12 mm around a cylinder having a diameter of 106 mm. The resulting material was cut axially and opened into a sheet-like shape and further, a cut and opened portion appearing in the form of a slope was cut down to provide a uniform length of 310 mm, thereby producing a sheet of 310 mm length x 270 mm width.

Then, the sheet was placed into a positive mold having a size of 320 mm length x 300 mm width x 30 mm depth and heated to 120°C, where it was pressurized to 100 kg/cm² to squeeze an

extra resin. The sheet was maintained in this state for one hour to perform a heat curing, thereby providing a plate having a size of 320 mm length and 300 mm width and having an average thickness of 4.88 mm.

The plate was cut in a direction of the fibers into a quadrilateral rod by a diamond cutter. The rod was cut to provide rounded rods having diameters of 3 mm.

The produced rotating tool was comprised of 23 % by volume of the long fiber glass, 29.4 % by volume of the abrasive grains and 47.6 % by volume of the thermosetting resin.

This rotating tool was attached to a rotatable polishing device (ESTERT400 produced by Nakanishi) to polish an iron mold. The result showed that a very good polished surface could be provided. Moreover, the incorporation of the entwined yarn of the fiber glass ensures that the polishing rotating tool is very resistant to fracture, and even if the polishing rotating tool was strongly pushed against a surface to be polished, it was not fractured.

Then, rotating tools similar to those in Examples 1 and 2 were made using diamond abrasive grains, CBN abrasive grains, silicon carbide abrasive grains, zirconia-alumina abrasive grains and zirconia abrasive grains in place of the alumina abrasive grains used in Examples 1 and 2 and tested for their characteristic, thereby providing a result similar to those in Examples 1 and 2.

A rotating tool was made using a polyester resin in place of the epoxy resin used in Examples 1 and 2 and tested for its characteristic, thereby providing a result similar to those in Examples 1 and 2.

In the above Example, the rotating tool was formed into a disk-like or rounded rod-like shape, but may be formed into any of a pyramidal shape, a conical shape, a pyramidal conical shape and a truncated pyramidal conical shape. The entwined yarn only acts as a reinforcing element and does not act as a working element such as polishing and hence, the entwined yarn may be oriented in any direction with respect to the rotating tool.

(Example 3)

First, an entwined yarn of long fiber glass ("Thermolocked yarn" sold by Nitto Boseki Kabushiki Kaisha, in the name of GBY 042SP produced by Fuji Fiber Glass Kabushiki Kaisha) was passed through a resin cell containing a resin composition regulated into the following components, whereby the long fiber glass was impregnated with the resin composition. The long fiber glass impregnated with the resin composition was wound in parallel at distances of 3 mm into a width of 138 mm around a cylinder having a diameter of 106 mm by three repetitive runs of forward and backward winding operation to form a total of six layers.

Unsaturated polyester resin (XR301 produced by

Polyurethane Kasei)	100 parts by weight
Percure O (produced by Nippon Ushi)	
	1 part by weight
Alumina abrasive grains (WA#240 Fujimi Incorporated)	
	150 parts by weight

Then, the entwined yarn wound around the cylinder was axially cut and opened into a sheet-like shape with six layers, and a cut and opened portion appearing in the form of a slope was cut down into a uniform length of 300 mm, thereby producing a sheet having a size of 150 mm length $\times$ 60 mm width.

Then, the two sheets were superposed one on the other and placed into a positive mold of 120°C having a size of 150 mm length $\times$ 60 mm width, where it was pressurized to 42 kg/cm² and maintained in this state for 30 minutes for heat curing, thereby providing a plate-like working tool material having a size of 150 mm length $\times$ 60 mm width $\times$ 1 mm thickness.

The plate-like working tool material was cut in a direction of the fibers into five test pieces, as stick-shaped tools, having a size of about 15 mm width $\times$ 50 mm length $\times$ 1 mm thickness by a diamond cutter and was measured for polishability and flexural strength. The result showed a polishability for an iron article and equivalent to that of a #400 grindstone. The result of measurement of the flexural strength is given in Table 1 below.

Table 1

Test piece No.	Size of test piece (mm)	Span (mm)	Breaking load (kg)	Flexural strength (kg/mm ²)
1	15.9 × 50 × 1.0	15	9.1	12.9
2	15.0 × 50 × 1.0	15	10.5	15.8
3	15.3 × 50 × 1.0	15	9.2	13.5
4	14.9 × 50 × 1.0	15	9.1	13.7
5	15.3 × 50 × 1.0	15	13.4	19.7
Average				15.1

As apparent from Table 1, all of the produced test pieces had a sufficient flexural strength.

(Comparative Example)

Under the same conditions as in the Example 3, except that the thermo-locked yarn was not used, a resin mixture comprising only a white molten alumina and an unsaturated polyester resin was used to provide a plate-like working tool material having a size of 150 mm length × 60 mm width × about 2 mm thickness.

The plate-like working tool material was cut, in a direction of the fibers a diamond cutter, into five test pieces working tool material having a size of about 15 mm width × 70 mm length × about 2 mm thickness (because a strength of the material is low, the thickness was set at about 2 mm). Then flexural strength of the test pieces was measured to provide results given in Table 2.

Table 2

Test piece No.	Size of test piece (mm)	Span (mm)	Breaking load (kg)	Flexural strength (kg/mm ²)
1	14.8 × 70 × 2.2	50	7.4	7.7
2	15.3 × 70 × 2.4	50	6.1	5.2
3	15.3 × 70 × 2.4	50	6.3	5.4
4	15.3 × 70 × 2.5	50	6.5	5.1
5	15.2 × 70 × 2.5	50	8.8	7.0
Average				6.1

As apparent from Table 2, any of the produced test pieces had an insufficient flexural strength, as compared with the test pieces in Example 3.

(Example 4)

First, ten entwined yarns of long fiber glass ("Thermo-locked yarn" sold by Nitto Boseki Kabushiki Kaisha, in the name of GBY 042SP produced by Fuji Fiber Glass Kabushiki Kaisha) were passed through a resin cell containing a resin composition regulated into the following components, whereby the long fiber glass was impregnated with the resin composition. The long fiber glass impregnated with the resin composition was wound 612 times in parallel at distances of 12 mm into a width of 276 mm around a cylinder having a diameter of 106 mm.

Epoxy resin (DER383J produced by Dow Chemical Japan)

100 parts by weight

Tetrahydromethyl phthalate anhydride (HN2200 produced by Hitachi Kasei Kogyo)

80 parts by wieght

Imidazole (2E4MZ-CN produced by Shikoku Kasei Kogyo)

1 part by weight

Alumina abrasive grains (WA#240 made Fujimi Incorporated)

150 parts by weight

Lubricant (BYK-W965 produced by Bigchemi Japane)

1 part by weight

Then, the entwined yarn wound around the cylinder was axially cut and opened into a sheet-like shape, and a cut and opened portion appearing in the form of a slope was cut down into a uniform length of 310 mm, thereby producing a sheet having a size of 310 mm length x 270 mm width.

Then, this sheet was placed into a positive mold of 120°C having a size of 320 mm length x 300 mm width x 30 mm depth, where it was pressurized to 100 kg/cm² to squeeze out the excessive resin and maintained in this state for one hour for heat curing, thereby providing a plate-like working tool material having a size of 320 mm length x 300 mm width x about 5 mm thickness.

The plate-like working tool material was cut in a direction of the fibers into five test pieces, as stick-shaped tools, having a size of about 5 mm width x 70 length x about 3 mm thickness by a diamond cutter and was measured for polishability and flexural strength. The result showed a polishability for an iron article and equivalent to that of a #400 grindstone. The result of measurement of the flexural

strength is given in Table 3 below.

Table 3

Test piece No.	Size of test piece (mm)	Span (mm)	Breaking load (kg)	Flexural strength (kg/mm ²)
1	4.82 × 70 × 2.79	50	15.1	30.3
2	4.83 × 70 × 2.80	50	16.1	31.8
3	4.78 × 70 × 2.93	50	17.6	32.2
4	4.83 × 70 × 2.78	50	18.5	37.1
5	4.83 × 70 × 2.60	50	14.5	33.4
Average				33.0

As apparent from Table 3, all of the produced test pieces had a sufficient flexural strength.

In this way, according to the present invention, it is possible to provide a rotating tool and a working tool which are capable of cutting, drilling, grinding and polishing a workpiece with a high efficiency and cannot cause a blinding, as well as a working tool material for forming the working tool. The working tool such as a rotating tool and a polishing grindstone can be formed into any shape. Moreover, a working such as cutting, drilling, grinding and polishing is performed by the abrasive grains and therefore, is not influenced by the directional property of the entwined yarn, and the working tool has no directional property to enable a working in all directions.

WHAT IS CLAIMED IS

1. A material for a working tool, comprising long fiber glass properly arranged in the form of an entwined yarn, and a thermosetting resin which contains abrasive grains, and which is impregnated into the long fiber glass and cured.
2. A material for a working tool according to claim 1, wherein said material comprises 20 to 40 % by volume of said long fiber glass, 20 to 40 % by volume of said abrasive grains and 30 to 50 % by volume of said thermosetting resin.
3. A material for a working tool according to claim 1 or 2, wherein said long fiber glass is in the form of an interlaced yarn made as an entwined yarn by blowing of air.
4. A material for a working tool according to any of claims 1 to 3, wherein said thermosetting resin comprises an unsaturated polyester resin.
5. A material for a working tool according to any of claims 1 to 3, wherein said thermosetting resin comprises an epoxy resin.
6. A material for a working tool according to any of claims 1 to 5, wherein said abrasive grains are at least one of diamond abrasive grains, CBN abrasive grains, silicon carbide abrasive grains, alumina abrasive grains, zirconia-alumina abrasive grains, and zirconia abrasive grains.
7. A rotating tool in the form of a rotor made from a working tool material according to claims 1 to 6.
8. A polishing grindstone in the form of a stick made from a



working tool material according to claims 1 to 6.

9. A polishing grindstone according to claim 8, wherein the grindstone has a thickness of 3 mm or less.

10. A material for a working tool according to any of claims 1 to 6, wherein said working tool is a rotating tool, an abrading grindstone or a polishing grindstone.