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— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

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(54) Title: ALUMINA ZIRCONIA ABRASIVE GRAIN ESPECIALLY DESIGNED FOR LIGHT DUTY GRINDING APPLICATIONS

(57) Abstract: A eutectic alumina zirconia abrasive grain with low to medium toughness for light duty coated abrasive applications such as flap disc or fine grit polishing is produced by controlling zirconia content from 38-43% and by controlling quench rate to get crystal size from 15-20 micrometers.

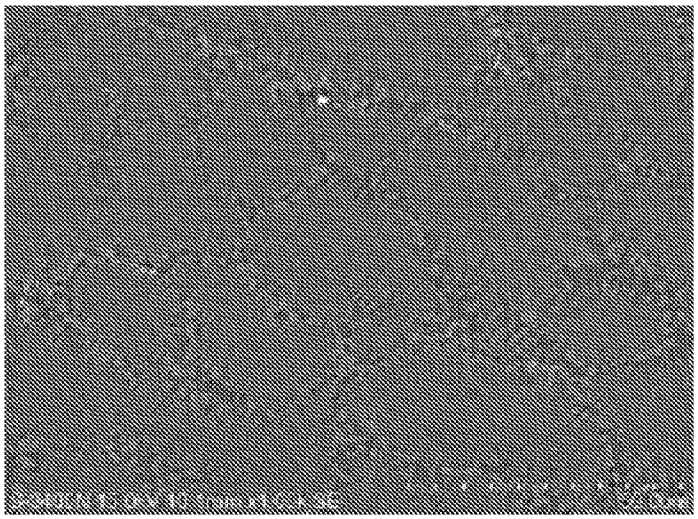

Fig. 1

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ALUMINA ZIRCONIA ABRASIVE GRAIN ESPECIALLY DESIGNED FOR LIGHT DUTY GRINDING APPLICATIONS

Field of Technology

The invention relates to a new eutectic alumina zirconia abrasive grain especially designed for light duty grinding applications such as coated abrasive products for flap disc or fine grit polishing (grit size is below P80).

Description of Related Arts

Alumina zirconia abrasive grain is widely applied in coated and bonded abrasive products such as rail track grinding wheel, heavy duty grinding wheel, abrasive belt and flap disc， due to its self-sharping properties and high toughness.

Alumina zirconia is one kind of fused abrasive grain. It is divided into 2 types: AZ-25 and AZ-40. AZ-25 has excellent wear resistance and consists of primary corundum and alumina-zirconia eutectic crystalline structure. It's suited for heavy duty grinding, snagging and cut-off wheels. AZ-40 has excellent self-sharping properties for good cutting and strong wear resistance. It has uniform, very fine alumina-zirconia eutectic crystalline structure. It is suited for coated abrasive and resinoid grinding wheel.

During the last several decades, many efforts are put on how to increase the grinding performance of eutectic AZ-40 for coated abrasive applications that requires a different balance of hardness and toughness properties. For high pressure and high speed abrasive belt grinding, the AZ-40 grain need high toughness or wear resistance for high cut rate and long service life. A lot of work was conducted to increase the toughness of AZ-40 grain such as reducing the crystal size or modifying its chemical composition.

US 3,891,408 described a method to produce alumina zirconia abrasive grits of very high strength combined with highly desirable microfracture properties. The zirconium oxide in the material is in the form of rods (or platelets), which, on the average, are less than 3000 angstroms in diameter. The abrasive grit is made up of cells or colonies typically 40 micrometers or less across their width. Groups of cells having identical orientation of microstructure form grains which typically include from 2 to 100 or more cells or colonies. In crushing, the material fractures along grain boundaries and cell boundaries. Due to its eutectic structure and small crystal size, the toughness of this kind of abrasive grain was very high. The abrasive produced from this method was very successful in bonded abrasive and high pressure grinding coated abrasive applications such as abrasive belts on

YF polyester backing, but not so successful in light pressure grinding applications for coated abrasive products such as flap disc or abrasive belts with cotton backing.

GB 2,011,880 described an abrasive composition with a co-fused mixture of bauxite and zirconia which had been rapidly solidified and comminuted, the composition containing from 25 to 50 weight percent zirconia, from 49.2 to 74.2 weight percent alumina and from 0.8-2.5 weight percent silica. The method of manufacture comprised fusing a mixture of bauxite and zirconia, cooling the fused mixture to solidify the composition within 3 minutes of the time that cooling to solidify the composition was commenced and comminuting the resulting the cooled mixture to form abrasive particles. The abrasive grain made from this method was surprisingly successful in ASI 1018 cold rolled steel grinding under high pressure for coated abrasive belt (the abrasive grain was coated on polyester backing) and resinoid grinding wheel due to its high toughness, but the application of this kind of abrasive grain on light duty grinding such as fiber disc or flap disc was not mentioned.

GB 2,062,666 described an abrasive grain comprising about 20 to about 50% by weight of zirconia; reduced titanic in an amount on analysis expressed as titanium dioxide of 1.5 to about 10% by weight; total carbon in an amount of 0.03 to about 0.5% by weight; impurities, if any, in a total amount on analysis expressed as the oxides of not greater than 3% by weight; and a balance of alumina. The microstructure of the abrasive grain comprises primary alumina or zirconia crystals embedded in a supporting alumina-zirconia eutectic matrix. The grain may be produced by combining and melting the alumina and zirconia; adding titanic and carbon (excess carbon being required); melting and reducing the titanic under reducing furnace conditions; and solidifying the melt in under three minutes by means of a suitable heat sink material. The abrasive grain has a high toughness and may be used to produce coated abrasive products or bonded abrasive products. The application of this kind of abrasive grain on light duty coated abrasive applications such as flap disc was also not studied in this patent.

It is also known to all the coated abrasive industry that the wear rate of abrasive grain, binder layer and backing substrate of flap disc should have a good match, the best case is that the wear rate of these 3 components should be the same for flap disc grinding application, otherwise the utilization of the whole flap disc is not good. If the toughness of abrasive grain is too high, the wear rate of abrasive grain and binder layer and backing will be different.

So, there is a need to get an abrasive with low to medium toughness so that it has self-sharping properties under low to medium pressure for coated abrasive applications such as flap disc.

Summary of the Invention

It is an object of the invention to provide a method of producing eutectic alumina zirconia abrasive material (AZ-40) which has low to medium toughness for light duty coated abrasive applications such as flap disc. The manufacturing process of this invention includes the following steps:

(1) Electro fusion process: the raw material including alumina, zirconia or high purity bauxite and zircon is fused in an electric arc furnace at a temperature above 2000 ℃. The bed of alumina and zirconia, etc is poured into the bottom of the furnace where a carbon started rod is laid down. A couple of large vertical carbon rods are then brought down to touch and a heavy current applied. They started rod is rapidly consumed, by which time the heat melts the alumina/zirconia mixture, which then becomes electrolytes. Alumina/zirconia mixture is added over 1-3 hours to build up the volume of the melt. Current is controlled by adjusting the height of the electrodes.

(2) Cooling process: After fusion, the melt is then poured into a receptor in which there is non-reactive, non-melting particulate solid cooling media of a material other than that of alumina zirconia (for example, steel balls having a size ranging from 15-50 mm). By using steel balls as the cooling media, the balls can be removed from the solidified material with a magnet. The cooling speed can be controlled by different steel ball size or steel types with different thermal conductivity. For example, the smaller the steel ball size, the faster the cooling process and the smaller the abrasive grain's crystal size and the higher toughness of the grain. The higher thermal conductivity of the steel ball, the faster the cooling process; therefore, the toughness of the AZ-40 abrasive grain can be controlled by the cooling process by changing steel ball size or steel conductivity.

(3) Post fusion process: after fusion and cooling, the material can be crushed and sieved to different sizes. This type of particle reduction method can greatly affect the grain shape. Impact crushers such as hammer mills create a blocky shape while roll crushers create a sharp shape. For coated abrasive applications such as abrasive belt or flap disc, sharp grain is preferred. P24 to P120 is the usual grit size of AZ-40 grain, because when the grit size is smaller than P120, the grinding pressure is low, the AZ-40 grain does not have self-sharping properties under such low pressure, so it has no cost-effective advantage over fused alumina abrasive grain. If we can reduce the grain toughness, the performance of AZ-40 grain will be improved for light duty coated abrasive applications such as flap disc and fine grit (finer than P120) abrasive belt.

Brief Description of the Drawings

Fig.1 is SEM image of abrasive grain made from this invention. The crystal size is about 15-20 micron.

Detailed Description of the Preferred Embodiment

From the above-mentioned cooling process, we know that AZ-40 abrasive grain's toughness can be controlled by cooling speed of the melt. Low cooling speed can get abrasive grain with large crystal size that leads to low to medium toughness. Detailed description of this invention is shown in the following examples.

Example 1 (comparison example)

A 220 KW single-phase electric arc furnace was charged with 60 kg alumina and 40 kg zirconia, etc. The voltage was set as 70 V and the current was 1500 A. After melting, the material was poured into a receptor containing steel balls with high thermal conductivity. The cooling speed was fast. The crystal size of the AZ-40 abrasive grain was 11-13 micrometers and the toughness of the grain was high.

Example 2 (invention example)

The charging and melting process was the same as example, but the melt was poured into a receptor containing steel balls with low thermal conductivity. The cooling speed was slow. The crystal size of the AZ-40 abrasive grain was 15-20 micrometers and the toughness of the grain was low to medium. The abrasive grains made in example 1 and 2 were applied in coated abrasive products and then converted into flap discs for grinding test. The product structure of the coated abrasive product was as follows:

Backing: cotton backing, 390 grams/square meter (gsm);

Dry make weight: 220 gsm, $CaCO_3$ filled phenolic;

Abrasive grit: 300 gsm P36 semi-friable alumina blended with 400 gsm AZ-40 abrasive grain in example 1 and 2;

Dry size weight: 300 grams/square meter, cryolie filled phenolic;

The flap disc was tested on a 7" pneumatic right angle grinder, the test conditions are as follows:

Work piece: 304 stainless steel;

Grinder speed: 8000 rpm;

Test cycle: 1 minute grinding time

The test results showed that the AZ-40 abrasive grain with low to medium toughness and large crystal size performed much better than AZ-40 abrasive grain with high toughness and small crystal size.

Claims

1. A eutectic alumina zirconia abrasive grain with low to medium toughness, characterized in that, containing zirconia from 38-43% and crystal size from 15-20 micrometers for .light duty coated abrasive applications such as flap disc or fine grit polishing.

2. A method to make abrasive grain described in claim 1, characterized in that, by controlling zirconia content from 38-43%, by controlling quenching rate to control crystal size.

3. A coated abrasive product, characterized in that, it is made by the method according to claim 1.

4. The coated abrasive product according to claim 3, characterized in that, the product is flap disc or abrasive belt with grit size from 80-120 micrometers.

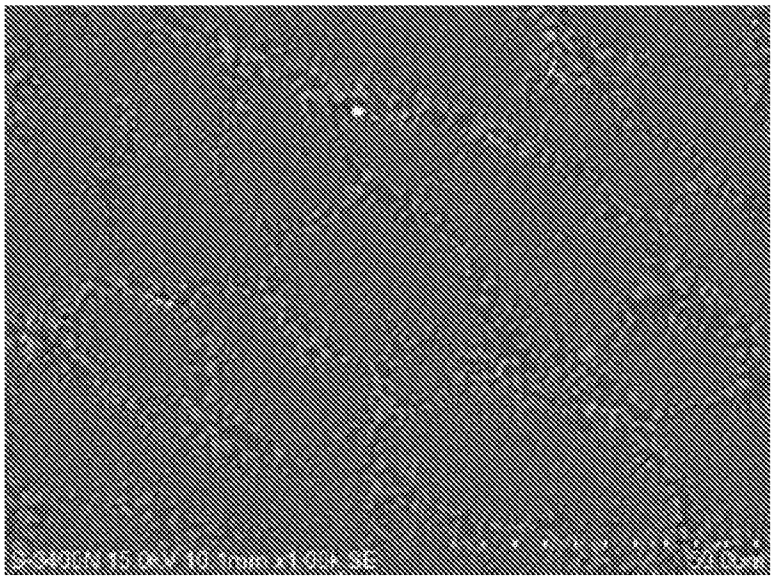

Fig. 1

INTERNATIONAL SEARCH REPORT

International application No.
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A. CLASSIFICATION OF SUBJECT MATTER

C09C 1/68(2006.01)i; C04B 35/48(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C09C 1/-, C04B 35/-

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CPRSABS;CNABS;VEN:NIU YAOWU, WANG SHENGGUO,ZIRCONIUM, GRAIN, QUENCH, COOL, ABRASIVE, GRIT, ZIRCONIA, ZIRCONIUM, GRIND, ALUMINA, ALUMINUM,ALUMINIUM,EUTECTIC, POLISH

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 December 2014	**21 January 2015**

Name and mailing address of the ISA/CN	Authorized officer
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Information on patent family members

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