United States Patent [19]

Mullin et al.

[11] **3,869,834**

[45] **Mar. 11, 1975**

[54] **COATED ABRASIVE ARTICLES HAVING A SURFACE DEPOSIT OF FLUOROCARBON PARTICLES**

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[22] Filed: **Sept. 16, 1968**

[21] Appl. No.: **762,315**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 672,992, Oct. 5, 1967, abandoned.

[52] **U.S. Cl.** **51/295,** 51/298, 51/307

[51] **Int. Cl.** **B24d 3/34**

[58] **Field of Search** 51/295, 298, 307, 308, 51/309

[56] **References Cited**

UNITED STATES PATENTS

3,042,508 7/1962 Haigis et al. 51/298

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[57] **ABSTRACT**

The invention is directed to abrasive articles having a surface deposit comprising an accumulation of fluorocarbon particles, which may be loosely applied or densely compacted on the surface. Processes for making such articles are also described in detail.

8 Claims, No Drawings

COATED ABRASIVE ARTICLES HAVING A SURFACE DEPOSIT OF FLUOROCARBON PARTICLES

This application is a Continuation-in-Part of patent application entitled "Abrasive Article and Method for Its Production," Ser. No. 672,992 filed Oct. 5, 1967, now abandoned.

BACKGROUND OF THE INVENTION

The invention relates to improvements in abrasive articles such as abrasive belts (or any configuration of coated abrasive articles) and grinding wheels. More particularly, the invention relates to such devices having a fluorocarbon surface deposit.

Definitions

For the purpose of this discussion, the term "fluorocarbon" is defined to means polytetrafluoroethylene, polytrifluorochloroethylene, polymers and telomers containing tetrafluoroethylene, and trifluorochloroethylene. These materials are sold under various trade-marks, several of which are Teflon, Kel-F, and Vydax.

Additionally, for the purpose of this discussion, the term "face" when referring to abrasive articles is used to indicate the surface and the abrasive article intended to perform the abrasive functions.

"Loosely applied" shall mean a loose accumulation of particles that are almost non-cohesive and not deliberately packed.

DESCRIPTION OF THE PRIOR ART

Grinding is fundamentally a cutting process. The cutting action of an abrasive belt or a bonded abrasive wheel is performed by abrasive particles which present a multiplicity of tiny cutting edges to the workpiece. A criterion of grinding efficiency is the ratio of work ground compared to the wear of the abrasive articles that perform the grinding action.

Due to heat and friction during the grinding action, the abrasive cutting points gradually become dulled and eventually stop cutting efficiently. In a bonded abrasive wheel, as individual particles are dulled or are torn out, new abrasive points come in contact with the work. In a single layer abrasive device, such as an abrasive belt, when the cutting points are worn and stop cutting efficiently, the belt must be replaced. Any technique that will lengthen the efficient cutting life of an abrasive particle is a significant improvement.

The treatment described in this invention increases dramatically the life and efficiency of abrasive articles.

OBJECTS OF THE INVENTION

It is an object of the invention to provide an abrasive article which avoids the limitations and disadvantages of previous abrasive articles of the type described.

It is yet another object of the invention to provide a surface deposit for abrasive articles which is responsible for outstanding improvements in performance efficiency and life of the abrasive article.

It is yet another object of the invention to provide an abrasive article which substantially reduces the deleterious friction effects of the non-cutting surface in contact with the workpiece.

It is still another object of the invention to provide a method of making a fluorocarbon deposit on abrasive articles.

It is still another object of the invention to provide an easily displaced low-friction deposit or coating for abrasive devices.

It is another object of the invention to provide an abrasive article which reduces and eliminates deleterious grinding effects.

It is yet another object of the invention to provide a method and structure for obtaining outstanding beneficial results from the treatment of abrasive articles with fluorocarbon.

The novel features that are considered characteristic of the invention are set forth in the appended claims. The invention, itself, however, both as to its organization and method of operation, together with additional objects and advantages thereof, will best be understood from the following description of a specific embodiment.

Grinding is fundamentally a cutting process. The cutting action is performed by abrasive particles and more particularly by a very small portion of the abrasive particle, usually the leading edge. Contact between the particle and the workpiece other than at the cutting edge tends to build up heat due to friction. In other words, while the contact between the abrasive particle and the workpiece other than at the cutting edges is nonproductive, this friction contact greatly affects the grinding action adversely. For example, the workpiece may be damaged by excess frictional heating. The abrasive particle is prematurely worn. Power used to overcome friction is wasted.

An important grinding criterion is the ratio of work ground in comparison with the wear of the abrasive device, defined commonly as grinding efficiency. Any improvement that will lengthen the life of an abrasive particle adds to the grinding efficiency.

In single layer articles such as abrasive belts, the time lost in replacement which is a frequent occurrence, is an important element of cost. Any improvement, therefore, in the life of an abrasive belt, makes a significant contribution to grinding cost reduction.

Broadly speaking, the abrasive devices, either coated abrasive articles such as abrasive belts, or bounded articles, such as grinding wheels or segments, have a surface deposit that comprises an accumulation of fluorocarbon particles, that are loosely applied or sensely compacted.

In one configuration, the treatment comprises a plurality of layers of fluorocarbon particles. This treatment may be obtained by spray coating with a plurality of layers of suspension or dispersion of fluorocarbon particles in a suitable medium and subsequently removing the medium from the coating.

Generally, particles in suspension are held in suspension by means of a surfactant also called a wetting agent or dispersant. When the suspension is deposited on a surface and the suspending medium is removed, the particles remain on the surface as a coating. The integrity of the coating is maintained by the surfactant which acts to bind the particles together and the particles to the deposition surface. The DuPont T-30 aqueous suspension containing the Rohm Haas Triton X-100 surfactant has been particularly successful as a surfact treatment for cooled abrasives.

A surface was also treated with a coating of a colloidal suspension, Dupont T-42, lacking a surfactant. The coating integrity is preserved by an effect known as

Van de Waals forces acting on judiciously sized particles.

Various other methods of applying the fluorocarbon to the surface of the article, such as painting, may be used.

Alternatively, the coating may be applied dynamically, that is to say, the fluorocarbon treatment is reestablished partially or totally during each grinding pass. This process is useful for single layer abrasive devices, or for grinding wheels where the grinding face wears away and new grinding surfaces are constantly exposed.

The dynamic or regenerating process comprises continuous spraying of an abrasive surface during the grinding operation. The rate at which the fluorocarbon is applied is easily controlled to provide the quantitative limits that will be discussed hereafter.

An alternate dynamic coating process is carried out by moving the abrasive article over a solid fluorocarbon member under sufficient pressure so as to deposit grated fluorocarbon particles on the surface of the abrasive article.

For abrasive belts, or similar single layer abrasive articles, where the treatment is applied to the surface before use, the optimum ratio of fluorocarbon to abrasive grain is in the range of 1/8 to 1/2 by weight. When the treatment is applied during the grinding process by moving the abrasive article over a solid fluorocarbon member or by continuously spraying the ratio of fluorocarbon consumed compared to abrasive loss established as effective is within the range of 0.8 to 1 to 6 to 1 by weight. If the amount of fluorocarbon applied is below the stated minimum, there is a sharp drop-off in performance, particularly with regard to life. On the other hand, if the amount of fluorocarbon exceeds the stated maximum, there is a sharp drop in performance due primarily to the glazing over of the grinding surface by the fluorocarbon. The material flows over the grinding surface and covers the grains of abrasive to such an extent that it interferes with the abrading action.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

EXAMPLE NO. 1:

a 5/8 × 90 inches continuous belt containing 60 grit aluminum oxide was provided with a deposit of a plurality of layers of submicron sized particles from an aqueous suspension of a fluorocarbon. Conventional spraying procedures were used. A precalculated weight of 3.7 grams of tetrafluoroethylene was deposited on the belt. This was accomplished by spraying continuously for 900 revolutions of the belt at 7200 f.p.m.

The water was fully evaporated during the course of developing the deposit. Evaporation could be accelerated, however, by supplying gentle heat to the surface of the coating.

The belt requires no further processing before being used. The performance improvement of these coated belts is quite startling. The rate of stock removal of a coated belt is twice that of an uncoated belt. For a particular application grinding a nickel alloy under identical grinding parameters, at least a three-fold increase in life of the coated belt was observed whereas previously an untreated belt could be used for two to three workpieces the treated belt repeatedly performed well with nine to ten workpieces. In only one case out of 25 tests was it necessary to replace a belt after only six peices were ground. The infeed rate of the fluorocarbon stick against the grinding surface was instrumentally controlled so that a precalculated amount of fluorocarbon would be removed in each cycle. During the course of the grinding operation grated particles of the fluorocarbon were abraded from the stick and deposited on the surface of the grinding surface. Thus as the grinding surface wore, the fluorocarbon deposit was continuously regenerated. In comparison to untreated grinding surfaces a two-to-one improvement in grinding efficiency was obtained with a treated abrasive. A very decided decrease in abrasive wear was noted. The finished workpiece was decidedly and very noticeably cooler.

EXAMPLE NO. 2

A 5/8 × 90 inches continuous belt coated with 60 grit aluminum oxide was operated at 7200 surface f.p.m. on a belt grinding machine. While the belt was grinding a continuous spray of an aqueous dispersion of a submicron fluorocarbon was applied. The deposition rate was in the range of 0.1 to 1 gram of solid fluorocarbon per minute. The water carrier evaporated prior to its arrival at the grinding interface. This was accomplished by natural evaporation, and by the application of heat.

Particles may also be deposited on a grinding surface by applying a stick of solid fluorocarbon; under pressure, against the grinding surface ahead of the point of contact between the abrasive and the workpiece.

The performance improvement of these coated belts is quite startling. The rate of stock removal is twice that of an uncoated belt. In a particular application under identical grinding parameters, at least a two-fold increase in belt life was observed. The workpiece temperature was observed to be much cooler with the treated belts.

The life of belts under these conditions was less than that of belts in Example 1 because the deposition rate was lower than optimum. Note, however, that the rate of metal removal was still excellent.

The deposit produced in Examples 1 and 3, before contact with the workpiece, is a loose accumulation of fluorocarbon particles. Some compacting takes place during a grinding operation.

The deposit produced in Example 2 is a densely compacted accumulation of fluorocarbon particles since the particles are generated under compressive pressure by abrasive action.

TABLE I

WEIGHT OF METAL REMOVED IN TEN MINUTES

A.	Normal Pressure 4.11 pounds	
	Emralon 310 - Resin Bonded	21.0 grams
	Emralon 312 - Resin Bonded	23.0 grams
	Emralon 320 - Resin Bonded	20.0 grams
	Emralon 323 - Resin Bonded	24.0 grams
	Loosely Applied Fluorocarbon	34.5 grams
	Dry - Control	20.5 grams
B.	Normal Pressure 6.00 pounds	
	Emralon 310 - Resin Bonded	25 grams
	Emralon 312 - Resin Bonded	25.5 grams
	Emralon 320 - Resin Bonded	26 grams
	Emralon 323 - Resin Bonded	*
	Loosely Applied Fluorocarbon	36 grams
	Dry - Control	22 grams

* Belts defective - seam separated

TABLE II

WEIGHT OF METAL REMOVED IN 2.5 MINUTE INTERVALS

A. Normal Pressure	4.11 pounds 0 - 2.5 M	2.5 - 5 M	5-7.5 M	7.5 - 10 M
Emralon 310	9.15	5.25	4.25	3.95
Emralon 312	9.4	5.4	4.7	3.6
Emralon 320	8.4	4.5	3.85	3.45
Emralon 323	9.95	5.5	4.5	4
Loosely Applied Fluorocarbon	15.45	8.05	6.4	6.05
Dry Control	8.1	4.7	4.0	3.6
B. Normal Pressure	6.00 pounds			
Emralon 310	9.9	6.1	5.0	4.1
Emralon 312	12.54	6.7	5.1	4.3
Emralon 320	11.93	5.6	4.5	4.05
Emralon 323	(Defective Belts)			
Loosely Applied Fluorocarbon	15.2	6.3	5.1	4.9
Dry Control	11.25	5.9	4.9	1.91

Comparative performance tests were conducted on resin bonded fluorocarbon treatment taught by the prior art and a treatment comprising of loosely applied deposit of particles as described herein. The resin bond treatment proved to be materially inferior from two points of view. The amount of metal removed in a specified time using a rate bonded fluorocarbon treatment was much less than the amount of metal removed in a similar interval of time using a loosely applied treatment.

Additionally, the life of a belt treated with a loosely applied coating greatly exceeded the life of a belt containing a resin bonded fluorocarbon treatment.

The foregoing is demonstrated in Tables I and II. Tables I and II contain comparative experimental data of a grinding operation using grinding belts with a loosely applied fluorocarbon treatment, a resin bonded fluorocarbon treatment and an ordinary dry, uncoated control belt. The tests were conducted on Waspaloy material at a surface speed of 7,200 ft. per min. Belts treated with loosely applied fluorocarbon were applied, using a spray process in a manner described heretofore. The advantages gained in grinding efficiency and belt life through the use of a loosely applied treatment are quite obvious. (Tables I and II).

Another independent study was made to compare the performance of dry untreated belts and loosely applied fluorocarbon treated belts on Waspaloy and Rene 41 super-alloys. In summary, faster removal rates, longer belt life, and cooler operation were observed with loosely applied fluorocarbon treatment.

Cooler operation preserved surface integrity of the workpiece being ground. High strength, high temperature, nickel-base super-alloys, such as Waspaloy and Rene 41, derived their superior properties through precipitation hardening treatments at specified temperature exposure of these alloys to abrasive machining temperatures higher than the specified temperatures can have deleterious effects on the structure and properties of the alloys. In this connection, ordinary untreated belts produce temperatures of the work piece as much as 550° F. higher than belts treated with loosely applied fluorocarbon.

Throughout this series of tests a loosely applied fluorocarbon treated belts exhibited stock efficiencies of at least two times greater than the efficiencies achieved with untreated belts.

Additionally, the stock removal rates at any given time as reported by the first derivative dG/dt of metal removed with respect to time showed greater metal removal rates with the loosely applied fluorocarbon treatment.

When infeed work pressures were varied, from 2 to 36 psi, the fluorocarbon treated belts were uniformly superior in performance.

It was further observed that at a pressure of 14 psi there was surface straw discoloration on Rene 41 abraded with ordinary uncooled belts. At 21 psi pressure there was discoloration in samples abraded with each type of belt.

When the belt surface speed was varied, superior results were achieved with the fluorocarbon treated belt.

The effect of abrasive machining on the microstructure on superalloys is an important performance parameter since the super-alloys have a tendency to work harden. Waspaloy abraded with a fluorocarbon treated belt exhibited no structural change at or near the surface. Waspaloy abraded with an ordinary untreated belt showed evidence of Ni_3 (AlTi) phases precipitation.

Perhaps the most significant observation was in the area of elastic stresses induced by belt abrasion on the work surface. Elastic stresses can be reliably measured by X-ray diffraction techniques. When the two superalloys were abraded with ordinary untreated belts, under the specified conditions, the changes in surface stresses were tensile stresses induced at the work surface. Abrasion of these same superalloys with belts treated with loosely applied fluorocarbon induced compressive stresses at the surface. Table III summarizes these results.

TABLE III

Surface Elastic Stressed Induced by Belt Abrasion
Stress Measurements by X-Ray Diffraction
60 Grit A10x-Resin Bond-Triple-Flexed
Infeed Pressure = 15 psi
Belt Speed = 3200 SFPM
Abrasion Time = 1 minute
Measured Surface Stresses
(psi)

	Before Abrasion	After Abrasion	
Material	°o	Untreated Belt °R	Treated Belt °R
Waspaloy (R_c 33)	0	+67,000	−107,000
Rene 41 (R_c 45)	−27,000	+46,000	− 68,000
SAE 4140 (R_c 48)	−43,000	0	− 34,000

The possibility of yielding or nucleation of surface cracks which usually result from an accumulation of surface tensile stresses is materially reduced and eliminated. The novel features that are considered characteristic of the invention are set forth in the appended claims; the invention itself, however, both as to its organization and method of operation, together with additional objects and advantages thereof, will best be understood from the following description of a specific embodiment when read in conjunction with the accompanying drawings, in which:

We claim;

1. A coated abrasive device having a surface deposit comprising an accumulation of fluorocarbon particles covering at least that portion of the surface not covered by the abrasive particles and the ratio of the fluorocarbon to abrasive particles on the surface is ⅛ to ½ by weight.

2. A grinding process comprising moving an abrasive device having protuberances of abrasive articles relative to a workpiece for grinding said workpiece and continuously depositing fluorocarbon particles on the face of the abrasive device to form a deposit comprising an accumulation of fluorocarbon particles.

3. A grinding process as described in claim **2** in which the relative proportion of fluorocarbon consumed to abrasive particles lost during a grinding operation is in the range of 0.8/1 to 6/1 by weight.

4. A process as described in claim **2** in which said fluorocarbon applied to the face of the abrasive device is a loosely applied accumulation of fluorocarbon particles.

5. A grinding process as described in claim **2** in which the fluorocarbon coating is produced by abrading a solid fluorocarbon member by the face of the abrasive device.

6. A grinding process as described in claim **2** in which the fluorocarbon is supplied to the abrasive device by supplying a suspension of fluorocarbon particles on the face of the abrasive device.

7. A grinding process as described in claim **6** in which said suspension is sprayed on the face of the abrasive device.

8. A treatment for an abrasive article comprising a substrate containing abrasive particles bonded to the substrate, said treatment comprising a coating of an accumulation of fluorocarbon particles bonded to each other and to the substrate, by means of a surfactant.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,869,834

DATED : March 11, 1975

INVENTOR(S) : George Cruise Mullin, Robert Earle Wetherby, and Victor Oscar Chevalier

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 18, "means" should read--mean--.
Column 1, line 26, "and" should read--of--.
Column 2, line 43, "bounded" should read--bonded--.
Column 2, line 46, "sensley" should read--densely--.
Column 2, line 62, insert "and" after Rohm.
Column 5, line 26, "rate" should read--resin--.
Column 5, line 66, insert "removal" after stock

Signed and sealed this 10th day of June 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents
and Trademarks