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FRICITION MATERIAL

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This invention relates to the production of friction material, and particularly to friction material composed in major amount by volume of metal.

More particularly, it is an object of the present invention to provide friction material characterized by its high heat resistant, porous, sintered metal content, making it particularly suitable for high temperature application, such as for industrial, truck, bus, and aircraft clutch or brake elements where high frictional heat is generated.

It is a further object of the present invention to provide a friction element of the character aforesaid composed, in minor amount by volume, of a ceramic friction material such as alumina or magnesia dispersed in a continuous phase or matrix composed of high melting point metal in major amount by volume.

The term high melting point metal as employed herein is understood to mean sinterable metals having melting points of over 2500° F., such as iron, nickel, molybdenum, tungsten, chromium, vanadium, tantalum, boron and columbium, some of which metals, and their combinations or alloys, permit production products having melting points in excess of 4000° F.

Although the process of the present invention employs generally conventional sintering technique, comprising first the formation of molded compacts of powdered compositions followed by disposing the compacts in stacks in an externally heated oven to accomplish sintering, it permits the sintering of metals which are not generally amenable to sintering in such manner.

Such sintering is accomplished herein by combining, in the compacted powder composition, ingredients that react exothermically to produce localized wafer temperatures sufficient for sintering, and which are ignited under conventional sintering temperatures, such as from about 1400° F. to about 1800° F.

The aforesaid reaction comprises a heat initiated exothermic reaction between, for example, aluminum and an oxide of high melting metal such as for example molybdenum trioxide, to form the ceramic friction material aluminum oxide and metallic molybdenum.

It has been unexpectedly found, in accordance with the present invention, that by addition of powdered metallic additives to the foregoing composition in the mixture from which the compact is formed, and in an amount sufficient to provide the final sintered product with a metal content of from at least 50% and up to about 75% by volume, that control of the normally rapid high temperature exothermic reaction is obtained. This also results in elimination of fissures and cracks resulting from volume and temperature changes and permits use of a precompact wafer necessary in preparing friction material by generally conventional sintering technique.

This process or reaction tempering metal additive can be selected for desirable properties in the final product. Thus, nickel added to the following reaction, for example, $\text{MoO}_3 + 2\text{Al} \rightarrow \text{Al}_2\text{O}_3 + \text{Mo}$, will alloy with the molybdenum to provide an oxidation resistant compound, avoiding high temperature catastrophic oxidation associated with unalloyed molybdenum. Similarly, chromium addition to the above reaction will result in a molybdenum-chromium alloy of exceptional value in resistance to thermal shock.

Further, the metallic additive can be selected for other desirable end results. Cobalt, for example, added to the

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reaction: $\text{WO}_3 + 2\text{Al} \rightarrow \text{Al}_2\text{O}_3 + \text{W}$, besides providing a desirable alloy for particular applications, seems to act as a flux aiding the sintering operation. Without the controlling or moderating additive metal the tungsten would melt and the alumina would segregate. With this diluent metal the reaction slows down and forms a uniform sintered composition.

Production of the products of the present invention comprises mixing in powdered form metallic aluminum or magnesium together with a substantially stoichiometric amount of an oxide of high melting point metal, which will be reduced to the metal in the subsequent reaction wherein the first mentioned metals become converted to their refractory oxides. To these is added at least one other high melting point powdered metal additive which does not become oxidized in the reaction, in an amount to provide the final product with a total high melting point metal content of at least 50% by volume, as aforesaid. The particle size of the foregoing powders is in part determined by the desired reaction rate, but also lies within conventional ranges to avoid segregation in handling and molding. Distribution between 200 mesh size to 5 microns has been found most advantageous.

The mixed powders are compacted in the cold by molding in confined shaped molds at pressures of from about 5 to about 50 tons per square inch, to form disc, ring, or other shaped compacts of controlled density, such density also being a factor in the subsequent reaction rate. These molded compacts are then ignited to initiate the subsequent self-sustaining high temperature oxidation-reduction reaction by disposing them in stacks in sintering furnaces of the direct flame, gas and electric sintering or induction heating types.

It has been found advantageous to apply pressure to the compacts during the ignition operation, and this has been most readily accomplished in equipment designed for standard sintered products. Relatively low pressure, such as on the order of 100-250 pounds per square inch has been found satisfactory, since pressure at maximum temperature is assured. This pressure during heating and ignition has a twofold purpose, the first being to obtain desired final product density. For example, the percentage values after the following reactions are the theoretical volume change in the described chemical reaction:

	Percent
$\text{WO}_3 + 2\text{Al} \rightarrow \text{Al}_2\text{O}_3 + \text{W}$	30
$3\text{V}_2\text{O}_5 + 10\text{Al} \rightarrow 5\text{Al}_2\text{O}_3 + 6\text{V}$	28
$\text{Cr}_2\text{O}_3 + 2\text{Al} \rightarrow \text{Al}_2\text{O}_3 + 2\text{Cr}$	13
$\text{MoO}_3 + 2\text{Al} \rightarrow \text{Al}_2\text{O}_3 + \text{Mo}$	29

The applied pressure during this stage thus serves to overcome low density material resulting from such volume shrinkage.

The second benefit of pressure during the heating and igniting stage in the sintering furnace is the ability to therein bond the sintered product to a backing plate or steel core. Pressure applied at the time of ignition insures good contact at elevated temperature most necessary for satisfactory bond.

Since the powdered mix is employed in compacted form, and the period of ignition can be relatively short, protective atmosphere is not critical in many cases. However, when a metal such as aluminum or magnesium is used to reduce a metallic oxide, any oxygen present will readily react with the available surface metal to produce weak, powdery edges. This can be avoided by the use of a protective atmosphere such as carbon monoxide.

Ignition temperature is, of course, a function of the reactants and can readily be determined for each individual mixture. Reduction of a metallic oxide by aluminum will, in most cases, proceed under 1800° F.

The following examples are for the purpose of illus-

tration, but many modifications will be obvious to fulfill specific requirements.

Example I

25 parts by weight of a stoichiometric amount of powdered aluminum and molybdc oxide was mixed with 75 parts by weight of nickel powder, molded to the shape of a friction disc at 10 t.s.i., and sintered at 1400° F. under a pressure of 100 p.s.i. in a furnace. A protective atmosphere of unpurified exothermic gas was employed. The final product, having the composition

	Percent (by volume)
Al ₂ O ₃	32
Mo	8
Ni	60

presented a bright metallic appearance and good strength. A satisfactory bond of the disc to an unplated, wheel abraded steel backing plate was obtained. This material used as friction material element in a brake satisfactorily absorbed 1200 ft.-lbs./in.²/sec. at temperatures well above 1600° F.

A satisfactory product was similarly obtained by adding chromium to stoichiometric proportions of molybdc oxide and aluminum. The molybdc oxide-aluminum reaction has also been employed to sinter iron, ferro-boron, ferro-columbium, vanadium, etc., to give corresponding molybdenum alloys.

Variation in percentages of the metallic additive demonstrated that satisfactory products could be obtained in a range covering final metallic content of from the desired 50% minimum by volume to a point yielding a 75% by volume final metallic composition. Above this point sintering was not complete.

Example II

A powdered compact of the composition

	Percent weight
V ₂ O ₅	16
Al	8
Mo	74

was ignited by direct flame in a sintering furnace under a pressure of 250 p.s.i. to give a final composition:

	Percent volume
Al ₂ O ₃	31
V	12
Mo	57

Similarly, this reaction has been used to sinter tungsten.

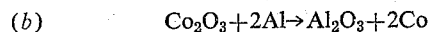
Example III

Other reactions tested are indicated below together with metallic additives that have been used in preparing sin-

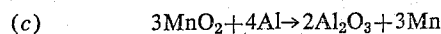
tered metal friction elements in the method previously described:



5 Additives: Mo, Cr, Ni, Fe, Fe/B.



Additives: Cr.



10 Additives: Fe.

I claim:

1. The method of making a high heat resistant, sintered, porous, friction material composition which comprises, mixing (A) a powdered metal selected from the group consisting of aluminum and magnesium with (B) a substantially stoichiometric amount of an oxide of a high melting point metal, and (C) a powdered high melting point metal, cold compacting this mix with pressure to form a handleable shaped compact, then heating this shaped compact to initiate an exothermic reaction whereby said first metal (A) is converted to its refractory oxide and said oxide (B) is reduced to its free metal, said high melting point additive (C) alloying with said free metal and being in an amount to provide a total free metal continuous matrix in the proportion of from at least 50% to about 75% by total volume, with said resulting refractory oxide being substantially uniformly dispersed therein.

2. The process of claim 1 wherein the first powdered metal is aluminum.

3. The process of claim 1 wherein said powders are compacted in a shaped mold at a pressure of from about 5 to about 50 tons per square inch.

4. The process of claim 1 wherein said powdered compact is ignited under compacting pressure in a sintering furnace.

5. The process of claim 1 wherein said powdered compact is ignited under compacting pressure in contact with a solid metal backing plate and united therewith by an in situ formed sintered bond.

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