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CERAMIC COATING COMPOSITION

Howard D. Flicker, North Miami, Fla., assignor to Aircraft Plating Inc., Miami, Fla., a corporation of Florida

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ABSTRACT OF THE DISCLOSURE

A ceramic coating particularly for cermet-bonding with heat resistant metal alloys used in fabricating aircraft and spacecraft parts that are subject to high temperatures combustion products and frictional heat, the coating being able to withstand thermal shock and high temperature heat to at least 2100° F. without cracking, chipping or spalling. The coating can be used in repairing previously coated aircraft or spacecraft parts without dis-assembly thereof by simply brushing or spraying the coating material on as a mixture and fusing it in place with portable means such as an oxy-acetylene torch.

As applied the coating essentially comprises:

Constituent:	Weight percent
Silicon dioxide	40–60
Aluminum oxide	15–25
Sodium tetraborate (hydrous)	25–35
Lead monoxide (yellow)	4–7
Silicon carbide	½–1½
Potassium nitrate	2–3½
Nickel powder	¼–1
Sodium hydroxide	2–3
Ammonium carbonate	½–2

or

Optical crown glass of soda-lime type	40–50
Silicon dioxide	12–20
Titanium dioxide	12–20
Aluminum oxide	5–12
Boric acid	½–2
Magnesium oxide	½–2
Bentonite	1–4
Potassium nitrite	⅛–¾
Aluminum powder	⅛–¾
Lead oxide	3–5
Sodium pyrophosphate	¼–2
Fire clay of high temp. type known as Norton No. 1162	5–15
Sodium hydroxide	¼–3

in which all of the constituents are present in finely divided form. Any inert liquid vehicle that will evaporate prior to fusion of the coating can be used to make more convenient application of the coating possible.

The foregoing abstract, because of its brevity and required presence as an information retrieval aid is not to be interpreted as a definition of the principles or scope of the invention disclosed in this document.

BACKGROUND OF THE INVENTION

Most of the heat resistant refractory or ceramic coatings in current use on metals subject to high temperature are based on frits. Generally, in this context, a frit consists of a mixture of particulate material that has been melted together at about 2400 to 2600 degrees F. This frit is allowed to cool, is broken up and melted onto the part to be coated. Such frit is a brittle, glassy material which has low ductility and is relatively non-adherent with respect to the base metal. Accordingly, manufacturers of

conventional frit usually recommend that coatings no thicker than 0.5 to 1.5 mils be applied using their frit.

With the advent of space exploration and supersonic air travel, metallurgists have developed heat resistant steel alloys and alloys primarily based on more exotic metals such as titanium which retain strength at the high temperatures associated with jet engine and rocket engine combustion and exhaust chambers and passages, and which are durable in spite of such temperature cycling as occurs on the skin of the vehicle due to friction with the atmosphere when traveling therethrough at high speed, alternated with periods when the vehicle is either not in use, not passing through an atmosphere or is traveling relatively slowly. Some of such exotic alloys have thermal expansion characteristics on the order of 10^{-9}. With further development in the jet engine, where parts operate at elevated temperatures, it has been found that for every 100° F. increase in heat at which the engine can operate, an increase in efficiency of about 12 percent is realized. Consequently there has been a constant investigation into means of enabling the engines to run at higher temperatures. One of the areas investigated is the coating of hot section parts so that the high strength base metals could be protected from oxidation, reduction, stress, corrosion, sulfuric and nitric acid attack and the erosion from particles in the gas path area. It has been found that a good ceramic is one of the better coatings to perform the above protective functions. Most ceramic coatings do spall off, are subject to vibrational cracking and have little adhesion to the base metal.

SUMMARY OF THE INVENTION

Accordingly, there exists a hitherto unsatisfied need for ceramic coatings that will protect the base metal they cover, which are ductile, strongly adherent, which can be applied in thicker, successful coatings than can conventional frits, for instance on the order of .5–10 mils without chipping or spalling, are easier to apply than frit-based coatings and which have a low coefficient of thermal expansion, near that of the base alloy. The present invention provides such improved ceramic coatings.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

According to one embodiment of the invention, the coating as applied essentially comprises a mixture of finely divided particles of the following:

Constituent	Weight percent range	Typical preferred example, weight percent
Silicon dioxide	40–60	47
Aluminum oxide	15–25	15
Sodium tetraborate (hydrous)	25–35	25
Lead monoxide (yellow)	4–7	5.0
Silicon carbide	½–1½	1.5
Potassium nitrate	2–3½	2.5
Nickel powder	¼–1	0.5
Sodium hydroxide	2–3	2.5
Ammonium carbonate	½–2	1.0

These constituents are pasted with a volatile inert liquid vehicle and applied by brushing, spraying or other conventional ceramic coating application techniques to a base metal such as high temperature heat resistant steel alloys and fused in place. The fusing step can be carried out in a furnace having a non-oxidizing atmosphere or, especially for the repair of installed parts, the coating can be applied by brushing or spraying on the region to be repaired, while the part remains assembled or installed, for instance in an aircraft engine, and fused in place using an oxy-acetylene torch or similar focusable, local-heating means.

The various phase changes and reactions which occur

within the coatings particularly at high temperatures during fusing, are not fully understood. It is known that silicon dioxide, the major constituent, will withstand temperatures up to 1710° C. (3110° F.). Aluminum oxide melts at 2050° C. (3722° F.). During the fusing process, the sodium tetraborate in the mixture breaks down into sodium oxide, boron and boron oxide. The boron diffuses into the base metal and provides a bridge to the boron oxide. The sodium oxide and boron oxide are binding agents which tend to hold the remainder of the mix together. Sodium oxide also provides gloss to the finished product. Lead monoxide also performs a similar function as sodium oxide combining, however, with the heavier elements. It, too, provides smoothness and brilliance. Silicon carbide has extremely good oxidation reduction characteristics along with the ability to provide wear resistance. Potassium nitrate is an oxidizing agent which attacks the base metal to give the ceramic a better bond and to provide pathways for the boron, nickel, lead and sodium to alloy with the base metal. Nickel, as a metal, is included to create a cermet condition. Sodium hydroxide removes any trace organics and assists the potassium nitrate in its action. It breaks down into sodium oxide on fusing. The ammonium carbonate prevents cracking of the coating in its preparatory stages so that a smooth coating results. Percentages of each composition may vary within the ranges noted to condition the mix to the base metal so that the cermet bond which is set up will be uniform and not spall off.

According to a second embodiment of the invention, the coating as applied essentially comprises a mixture of finely divided particles of the following:

Constituent	Weight percent range	Typical preferred example, weight percent
Optical crown glass of soda-lime type	40–50	44
Silicon dioxide	12–20	15
Titanium dioxide	12–20	15
Aluminum oxide	5–12	7.0
Boric acid	½–2	1.0
Magnesium oxide	½–2	1.0
Bentonite	1–4	1.5
Potassium nitrate	⅓–¾	0.3
Aluminum powder	⅓–¾	0.2
Lead oxide	3–5	4.0
Sodium pyrophosphate	¼–2	1.0
Fire clay of high temperature type, such as Norton No. 1162	5–15	9.0
Sodium hydroxide	¼–3	1.0

Optical crown glass of the soda-lime type is typically made from:

	Weight percent	
	Range	Typical example
Constituent:		
SiO_2	70–75	72
Na_2O	12–18	15
K_2O	0–1	0
CaO	5–14	9
Al_2O_3	0.5–2.5	1
MgO	0–4	3

The coating according to the second embodiment of the invention can be applied and fused in place as outlined in regard to the first embodiment and will perform similarly thereto as respects ductility, toughness, excellent resistance to spalling, chipping, cracking, oxidation, reduction, stress, corrosion, sulfuric and nitric acid attack and

to erosion from particles in the gas path, for instance of an aircraft jet engine part.

Volatile inert liquids which can be used to form the powdered coating mixture into a paste or slurry form that will stick to the metal to which it is applied sufficiently well to allow conventional coating application methods such as spraying, brushing, troweling, doctoring and wiping to be employed, are exemplified by the aqueous phase of sodium silicate, ammonium silicate or water.

Typical of the base metals to which the ceramic coatings of the invention can be successfully applied and fused include: low carbon steels, stainless steel, heat resistant alloys such as Hastelloys, Inconels (trademark) or other alloys of iron, nickel, cobalt and chromium base materials.

Typically, an aircraft engine part composed of nickel based alloys cannot be placed in an environment that will for any extended time subject it to surface temperatures in excess of about 1800° F. However, the same part coated with a 2 mil fused coating according to the first embodiment of the present invention, will satisfactorily withstand presentation to a gas stream passing over the coated surface of about 2500 feet per second at about 2,000° F. Similarly, the same part coated with a 2 mil fused coating according to the second embodiment of the present invention will satisfactorily withstand presentation to a gas stream passing over the coated surface at about 2500 feet per second at about 2500° F.

It should now be apparent that the ceramic coatings according to the present invention fill the need of providing means for more economical running of aircraft engines and other metallic parts which are subject to high temperature heat, friction and corrosion by extending the useful life of such parts and raising allowable encountered environmental temperatures.

Because modifications of the invention are possible without departing from its principles, the invention should be understood as encompassing all such modifidations as are within the spirit and scope of the following claim.

I claim:

1. A fusible coating composition for coating heat resistant metal alloys essentially consisting of:

Constituent:	Weight percent
Silicon dioxide	40–60
Aluminum oxide	15–25
Sodium tetraborate (hydrous)	25–35
Lead monoxide (yellow)	4–7
Silicon carbide	½–1½
Potassium nitrate	2–3½
Nickel powder	¼–1
Sodium hydroxide	2–3
Ammonium carbonate	½–2

all present in finely divided form.

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DAVID KLEIN, Primary Examiner

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