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Ceramic material coatings.

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A coating for a substrate, providing a thermal barrier for that substrate, includes a plurality of superimposed layers applied to the substrate. At least some of the layers have a composition containing a proportional amount of ceramic material, and that proportional amount varies between coating layers. The layers are preferably applied by spraying each in succession onto the preceding layer.

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"CERAMIC MATERIAL COATINGS"

This invention relates generally to ceramic material coatings for a substrate, and in particular to the coating of a substrate surface of an article in order to provide the article with a thermal barrier. The invention is applicable to the coating of combustion engine components such as piston crowns, cylinder walls, cylinder heads, valve heads, and exhaust ports to reduce combustion heat loss in an effort to approach adiabatic operation of the engine. It will be convenient to hereinafter disclose this invention in relation to this application although it should be appreciated that the invention is applicable to other coating applications.

Recent developments towards increasing useful power obtained from, and improving the efficiency of, combustion engines have included the manufacture of various engine components at least in part from ceramic materials. Such materials are used because of favourable properties such as low thermal conductivity, high strength, high fracture toughness, high thermal shock resistance, good wear resistance, thermal expansion matching that of steel or iron with which the material is generally used, and a high resistance to erosion and corrosion. One such ceramic material particularly used is partially stabilised zirconia (known as PSZ). Ceramic material may be formed into monolithic engine components such as cylinder liners and piston crowns, as well as being coated onto those components.

Whilst the use of ceramic material has been found to improve engine operation, monolithic ceramic material is relatively heavy and thus can only be used in small quantities without adversely affecting engine operation. In addition, that material is relatively expensive which can lead to increased engine component costs. In any event, a further reduction in combustion heat loss would be desirable in order to further improve engine operation.

It is an object of the present invention to provide a ceramic material coating for a substrate, such as combustion engine components, which may alleviate the foregoing disadvantages of prior arrangements utilising those materials.

With that in mind, the present invention provides in one aspect a coating for a substrate, the coating including a plurality of superimposed coating layers, at least some of the layers having a composition containing a proportional amount of a ceramic material, characterised in that the proportional amount of ceramic material varies between coating layers.

The present invention also provides in another aspect a process for applying a coating to a substrate, including superimposing a plurality of coating layers onto the substrate, at least some of the layers having a composition containing a proportional amount of a ceramic material, characterised in that the proportional amount of ceramic material varies between coating layers.

Preferably, the coating layers are arranged so as to be generally or at least substantially graded relative to each other according to the amount of ceramic material contained in the layer composition. In that regard, preferably, the layers are arranged so that the proportional amounts of ceramic material successively increase from the substrate.

At least one of the coating layers preferably contains less than about 50% by volume of ceramic material. The coating layer immediately adjacent the substrate preferably contains 0% or about 0% by volume ceramic material. This coating layer preferably acts as a bonding or transition layer between the substrate and remaining layers.

At least one of the coating layers preferably contains more than about 50% by volume of ceramic material. The coating layer outermost from the substrate preferably contains 100% or about 100% by volume ceramic material.

The coating layers preferably have a composition density that varies from layer to layer in accordance with their proportional amount of ceramic material. In that regard, preferably, the layer density increases with increasing amounts of ceramic material so that the coating preferably has a density gradient that increases outwardly from the substrate.

The same ceramic material is preferably used in each of those coating layers in which it is present. The coating layer compositions containing less than 100% ceramic material preferably contain a filler material in a 100% balance amount. That filler material is preferably compatible with the ceramic material, and is preferably a metallic material.

Each of the coating layers are preferably approximately the same thickness. Moreover, those layers are preferably of a consistent thickness throughout their extent.

Preferably, each coating layer is applied by spraying onto the substrate or preceding layer. Each layer composition is preferably prepared to a powder state and then heated to melt for spraying. Suitable thermal spray apparatus is preferably provided to enable coating application.

In one preferred embodiment of the present invention, the coating includes at least three coating layers. In this embodiment, the layer immediately adjacent the substrate contains about 0% ceramic material, the outermost layer contains about 100% ceramic material whilst the or each intermediate coating layer contains an amount of ceramic material between about 0% and 100% by volume. In this embodiment, three intermediate layers may be provided, successive layers containing about 25%, 50% and 75% of ceramic material by volume.

In one preferred embodiment, the ceramic material is a zirconia material. That ceramic material may be fully or partially stabilised zirconia material. That ceramic material may be a yttria zirconia material.

In one preferred embodiment, the coating layers containing less than 100% ceramic material contain a balance amount of filler material of any suitable metal or alloy thereof. In that regard, the material may be nickel-chromium, although nickel or chromium, or other metals or alloys thereof, may be equally suitable depending on the composition of the substrate and nature of the ceramic material. The substrate may generally comprise a metal, such as steel or iron and alloys thereof.

In one preferred embodiment, each coating layer is about 0.005 inches in thickness.

In one preferred embodiment of the present invention, each coating layer is sprayed with thermal spray apparatus utilising plasma flame as the heat source for melting the layer composition. Such apparatus may be constructed and utilised as will be well known by those skilled in the relevant art.

In one preferred form, prior to application of the coating layers the substrate surface to which the layers are to be applied may be appropriately prepared. In that regard, that substrate surface may be cleaned and roughened such as by grit blasting. Following coating of the substrate the outermost surface of the coating may also be treated as desired, for example, smoothed such as by grinding.

The coating of the present invention enables reduction in the quantity of ceramic material used, and as a result a reduction in the overall weight, in the article to which the coating is applied when compared to previous arrangements for providing such articles made at least in part of ceramic material. This is achieved without detriment to the performance of articles, such as combustion engine components, to which the coating is particularly applicable. Indeed, it is believed that the thermal conductivity of the coating may be lower than that of monolithic ceramic material.

The process of providing the coating of the present invention can be conducted utilising existing apparatus and to that extent may not require additional high capital investment. This may minimise the cost of providing articles with the coating of the present invention and thus the cost of those articles themselves.

It is to be appreciated that modifications and/or alterations may be made to the coating and its application process without departing from the ambit of the present invention as defined in the claims appended hereto.

Claims

1. A coating for a substrate, including a plurality of superimposed coating layers, at least some of the layers having a composition containing a proportional amount of a ceramic material, characterised in that the proportional amount of ceramic material varies between coating layers.

2. A coating as claimed in claim 1, characterised in that the coating layers are at least substantially gradated relative to each other according to the amount of ceramic material in each layer.

3. A coating as claimed in claim 2, characterised in that the coating layers are arranged so that the proportional amounts of ceramic material contained therein successively increase from the substrate.

4. A coating as claimed in any preceding claim, characterised in that at least one of the coating layers contains less than about 50% by volume of ceramic material.

5. A coating as claimed in any preceding claim, characterised in that the coating layer immediately adjacent the substrate contains 0% or about 0% by volume of ceramic material.

6. A coating as claimed in any preceding claim, characterised in that at least one of the coating layers contains more than about 50% by volume of ceramic material.

7. A coating as claimed in any preceding claim, characterised in that the coating layer outermost from the substrate contains 100% or about 100% by volume of ceramic material.

8. A coating as claimed in any preceding claim, characterised in that five coating layers are provided, successive layers from the substrate containing at least about 0%, 25%, 50%, 75% and 100% by volume of ceramic material.

9. A coating as claimed in any preceding claim, characterised in that each coating layer has a thickness of about 0.005 inches.

10. A coating as claimed in any preceding claim, characterised in that the ceramic material is a zirconia material.

11. A process for applying a coating to a substrate, including superimposing a plurality of coating layers onto the substrate, at least some of the layers having a composition containing a proportional amount of a ceramic material, characterised in that the proportional amount of ceramic material varies between coating layers.

12. A process as claimed in claim 11, characterised in that each coating layer is successively applied by spraying onto the substrate or preceding coating layer.

13. A process as claimed in claim 12, characterised in that each coating layer composition is initially prepared to a powder state, heated to melt, and then spray applied to the substrate.

14. A process as claimed in claim 13, characterised in that each coating layer composition is melted using a plasma flame heat source.

15. A process as claimed in claims 11 to 14, characterised in that a surface of the substrate to which the coating layers are applied is cleaned and roughened prior to coating layer application so as to facilitate retention of the coating on the substrate.

16. A process as claimed in any one of claims 11 to 15, characterised in that the applied coating is as claimed in any one of claims 1 to 10.

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
X	PATENTS ABSTRACTS OF JAPAN, vol. 7, no. 92 (M-208) [1237], 16th April 1983; & JP - A - 58 15 742 (NIPPON KOKAN K.K.) 29-01-1983 * Abstract *	1-16	C 23 C 4/04 C 23 C 4/12
X	FR-A-1 393 475 (L. DESMAR QUEST) * Claims 1-7; examples 1,2 *	1-16	
X	EP-A-0 075 228 (BATTELLE-INSTITUT) * Claims 1-12; figures 1,2 *	1-16	
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X	WO-A-8 201 898 (CASTOLIN) * Claims 1-15 *	1-16	
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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 29-04-1986	Examiner ELSEN D.B.A.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	



DOCUMENTS CONSIDERED TO BE RELEVANT			Page 2
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X	--- DERWENT, 85-317039 [51], N85-235641; & AU - A - 8 540 544 (REPCO LTD.) 03-10-1985 * Not published *	1-16	
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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 29-04-1986	Examiner ELSEN D.B.A.
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X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			