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Selected Patents Related to Thermal Spraying

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US denotes U.S. patent, WO denotes World Organization patent, EP denotes European patent, GB denotes Great Britain patent, RU denotes patent of Russian Union, CZ denotes patent of Czech Republic, CA denotes Canadian patent, and JP denotes Japanese patent. Due to differences in databases, not all data are available for each patent.

Applications

Antislip Coatings

Portable Manufacturing Facility for Manufacturing Antislip Flooring and Method of Manufacturing. The present invention provides a truck trailer manufacturing facility for coating workpieces such as metal plates or grating sections with a thermal spray antislip coating that provides a durable, high coefficient of friction surface on the workpieces. The manufacturing facility of the invention includes at least one surface preparation machine and at least one coating machine housed in a truck trailer. The present invention also provides a method of coating a workpiece with the truck trailer manufacturing facility.

US20030175429A1. W.S. Molnar, K.J. Heinl, B.P. Pelto, and J.J. Schulte, Detroit, MI. Issued/Filed: 18 Sept 2003/11 March 2003.

Bond Coats

Diffusion Bonding of Copper Sputtering Targets to Backing Plates Using Nickel Alloy Interlayers. A sputter target assembly including a high-purity Cu sputter target diffusion bonded to a backing plate, preferably composed of either Al, Al alloy, Al-matrix composite materials, Cu, or Cu alloy, and a Ni alloy interlayer, preferably composed of Ni-V, Ni-Ti, Ni-Cr, or Ni-Si, located between and joining the target and backing plate, and a method for making the assembly. The method of making involves depositing (e.g., electroplating, sputtering, plasma spraying) the interlayer on a mating surface of either the sputter target or backing plate and pressing, such as hot isostatically pressing, the sputter target and backing plate together along mating surfaces so as to form a diffusion bonded sputter target assembly.

US6619537. H. Zhang, J. Hart, and A. Bolcavage. Company: Tosoh SMD, Inc., Grove City, OH. Issued/Filed: 16 Sept 2003/12 June 2001.

Elastomeric Covered Roller Having a Thermally Sprayed Bonding Material. An elastomer-covered roller is provided with an improved bond coating for bonding the elastomeric cover to the core. At least one layer of material is thermally sprayed on the core to form a rough surface having a roughness from 400 to 2000 μin. R_a or greater. In a further improvement a denser, less porous layer may be applied next to the core to protect the core from corrosion, followed by a less dense layer applied to the first layer and having a similarly rough surface for good mechanical bonding.

US6616584. B.E. Hyllberg, G.S. Butters, G.T. Squires, and P.J. Kaprelian. Company: American Roller Co., LLC., Union Grove, WI. Issued/Filed: 9 Sept 2003/9 May 2002.

Plasma Sprayed Thermal Bond Coat System. A method for forming a thermal barrier coating system on an article subjected to a hostile thermal environment, such as the hot gas path components of a gas turbine engine. The coating system generally comprises a ceramic layer and an environmentally resistant beta-phase nickel aluminum intermetallic (β-NiAl) bond coat that adheres the ceramic layer to the component surface. A thin aluminum oxide scale forms on the surface of the β-NiAl during heat treatment. The β-NiAl may contain alloying elements in addition to Ni and Al in order to increase the environmental resistance of the β-NiAl. The β-NiAl powder having a size in the range of 20 to 50 μm is applied using air plasma spray techniques to produce a surface having a roughness of 400 μin. or rougher. The ceramic top coat can be applied using inexpensive thermal spray techniques to greater thicknesses than achievable otherwise because of the rough surface finish of the underlying β-NiAl bond coat.

US6607789. J.D. Rigney, M.J. Weimer, B.A. Nagaraj, and Y.-C. Lau. Company: General Electric Co., Schenectady, NY. Issued/Filed: 19 Aug 2003/26 April 2001.

Plasma Sprayed Thermal Bond Coat System. A method for forming a thermal barrier coating system on an article subjected to a hostile thermal environment, such as the hot gas path components of a gas turbine engine. The coating system is generally comprised of a ceramic layer and an environmentally resistant beta phase nickel aluminum intermetallic (β-NiAl) bond coat that adheres the ceramic layer to the component surface. A thin aluminum oxide scale forms on the surface of the β-NiAl during heat treatment. An additional layer of diffusion aluminide may be formed underlying the ceramic layer. The β-NiAl may contain alloying elements in addition to Ni and Al in order to increase the environmental resistance of the β-NiAl. These elements include hafnium, Cr, and Zr and increase the oxidation resistance of the β-NiAl. The β-NiAl is supplied as a powder having a size in the range of 20 to 80 μm. The β-NiAl powder is applied using air plasma spray techniques to produce a surface having a roughness of 400 μin. or rougher. The ceramic top coat, a stabilized zirconia, typically yttria-stabilized zirconia, can be applied using inexpensive thermal spray techniques to greater thicknesses than achievable otherwise because of the rough surface finish of the underlying β-NiAl bond coat. Alternatively, the β-NiAl coat can be used as an environmental coating without application of an overlying ceramic topcoat.

US20030157363A1. J.D. Rigney, M.J. Weimer, B.A. Nagaraj, and Y.-C. Lau. Company: General Electric Co., Schenectady, NY. Issued/Filed: 21 August 2003/26 April 2001.

Combustion Engine Parts, Posttreatment

Thermal Spraying of a Machine Part. The invention discloses a machine part surface, coated at least partly with a coating material by a thermal spray process. Said coating material has been exposed to heat treatment at an elevated temperature and for a time effective to at least partially diffuse said coating material into underlying surface, thereby creating necks be

tween the coating material and the underlying surface. Additionally coating material layers are applied and subject to successive heat treatments of each said coating material layer in order to provide on said machine part surface a plurality of layers of same said coating material (so that the coating material forms necks in contact points between particles and layers in at least said coating. A method for making such coating on a machine part surface is also disclosed.

WO3072844A1. L. Moczulski and M.E. Benzon. Company: MAN B & W Diesel A/S. Issued/Filed: 4 Sept 2003/28 Feb 2002.

Cordierite Glaze

Glaze for Ceramic Superplastic Forming (SPF) Dies. The life of ceramic SPF dies can be enhanced significantly by plasma spray application of a cordierite glaze on the forming surface. The preferred glaze has a coefficient of thermal expansion close to or matching with the ceramic of the die, and, typically, is a 2·2·5 MAS system including 2 to 10 mol.% TiO_2 (or above 8 wt.%).

US20030126951A1. D.G. Sanders, M.A. Peterson, D.C. Van Aken, D.T. Weaver, F.S. Miller, and J.D. Smith. Issued/Filed: 10 July 2003/28 Aug 2001.

Electrochemical Cell

Current Collection through Thermally Sprayed Tabs at the Ends of a Spirally Wound Electrochemical Cell. A method of making an electrochemical cell and an electrode stack made thereby. The method includes fabrication of a coating onto selected areas of the ends of the stack by a thermal spray coating process in which the coating is applied to one of the electrodes in the stack without the coating contacting the alternate edges of the other electrode in the stack. Suitable conductive strips, compatible with the substrate materials that make up the electrodes of the cell, can be attached to the thermally sprayed coating layers, or can be embedded into the sprayed materials as they are applied to the electrode stack.

EP0966053B1. S. Oweis, R. Zatorski, G. Chagnon, G. Rigobert, and L. Souliac. Company: Alcatel. Issued/Filed: 20 Aug 2003/10 June 1999.

Electrodes

Energy Storage and Conversion Devices Using Thermal Sprayed Electrodes. Thin electrodes produced by thermal spray techniques are presented, wherein the thermal spray feedstock comprises an active material and a protective barrier coating. In a particularly advantageous feature, the active material feedstock is a metal sulfide, metal selenide, or metal telluride that ordinarily decomposes at thermal spray temperatures or that transforms to a material unsuitable for use as an electrode at thermal spray temperatures. The electrodes find particular utility in thermal batteries.

US20030138695A1. R.A. Guidotti, H. Ye, T.D. Xiao, D.E. Reisner, and D.H. Doughty. Issued/Filed: 24 July 2003/2 Nov 1999.

Electrode for Electrolysis in Acidic Media. Electrode comprising at least an electroconductive support of a titanium-palladium alloy, titanium, tantalum, or compounds or alloys of titanium or of tantalum, an electrochemically active coating, and an interlayer between the support and the electrochemically active coating, wherein the interlayer consists of titanium carbide and/or titanium boride and is applied to the support by flame or plasma spraying. Process for producing these electrodes and their use in an electrochemical cell for producing chlorine or chromic acid.

US20030136669A1. F. Gestermann, H.-D. Pinter, G. Speer, P. Fabian, and R. Scannell. Issued/Filed: 24 July 2003/31 Dec 2002.

Engine Cylinder Coatings

Hypereutectic Aluminum-Silicon Alloy Coating Respectively an Aluminum-Silicon Composite. Copper-free Al-Si alloy or composite material. A hypereutectic Al-Si alloy or Al-Si composite material coating has a heterogeneous structure of an Al solid solution, intermetallic phases such as Mg_2Si, oxides and (1) Si precipitates, (2) embedded Si particles, or (3) Si precipitates and embedded Si particles, the mean size of the primary Si precipitates or embedded Si particles being less than 10 μm, the mean oxide size being less than 5 μm, and the coating being mainly Cu-free; that is, the Cu content is less than 1 (preferably less than 0.1, especially less than 0.01) wt.%. Also claimed are processes for producing the above coatings by thermal (especially atmospheric plasma) spraying with parameters adjusted for formation of oxides. Complete composition of the spraying material is specified.

EP0899354B1. H. Pfeffinger, M. Voit, T. Haug, P. Izguierdo, H. Gasthuber, O. Storz, A. Heuberger, F. Rückert, P. Stocker, H. Pröfrock. Company: DaimlerChrysler AG. Issued/Filed: 10 Sept 2003/17 July 1998.

Coating for Cylinder Friction Surface Part of a Piston Engine. Cylinder running face coating for reciprocating piston engine. A reciprocating piston engine cylinder running face coating consists of a hypereutectic Al-Si alloy or Al-Si composite material that has a heterogeneous structure of an Al solid solution, intermetallic phases such as Al_2Cu and Mg_2Si, oxides and (1) Si precipitates, (2) embedded Si particles, or (3) Si precipitates and embedded Si particles, the mean size of the primary Si precipitates or embedded Si particles being less than 10 μm and the mean oxide size being less than 5 μm. Also claimed are processes for producing the above coatings by thermal (especially atmospheric plasma) spraying with parameters adjusted for formation of oxides. Complete composition of the spraying material is specified.

EP0896073B1. H. Gasthuber, T. Haug, A. Heuberger, P. Izquierdo, H. Pfeffinger, H. Pröfrock, W. Reichle, F. Rückert, P. Stocker, and M. Voit. Company: DaimlerChrysler AG. Issued/Filed: 10 Sept 2003/17 July 1998.

Garnet Coatings

Method for Forming Ceramic Layer Having Garnet Crystal Structure Phase and Article Made Thereby. A method of depositing a coating is disclosed, which method calls for providing a substrate, and thermally spraying a ceramic powder thereon to form a coating. The ceramic powder has a garnet crystal structure phase, and the thermal spraying in turn forms a coating on the substrate that includes a garnet crystal structure phase.

WO03059615A1 and US20030134134A1. M.A. Simpson, D. Billieres, G. Main, and J.-M. Drouin. Company: Saint-Gobain Ceramics and Plastics, Inc. Issued/Filed: 24 July 2003/30 Dec 2002 and 17 July 2003/11 Jan 2002.

Glass Lining

Glass Lining Application Method. A new glass lining application method enables stable, uniform glass lining layers to be applied to large glass-lined instruments composed of a stainless base material, the method including forming a thermal spray treatment layer by applying a thermal spray treatment to a surface of a stainless base material using a thermal

spray material selected from a group composed of a stainless material identical to the base material, Ni metal, Cr metal, Fe metal, Co metal, Ni-Cr alloys, and Fe-Cr alloys, then forming a glass lining layer on the thermal spray treatment layer by means of a glass lining heat treatment using a ground coat and a cover coat, a surface roughness R_z of the thermal spray treatment layer being within a range from 5 to 100 μm, and an open pore diameter being within a range from 3 to 60 μm.

US20030172678A1. Y. Iizawa, M. Shirasaki, and J. Ono. Issued/Filed: 18 Sept 2003/13 March 2002.

Hard Magnetic Coatings

Method for Coating a Support Body with Hard Magnetic SE-FE-B Material Using Plasma Spraying. Method of coating a support body with a layer of hard-magnetic material of the material system SE-FE-B, where the SE component contains at least one rare earth metal and the FE component contains at least one ferromagnetic element, in which method the coating process includes a plasma spraying process in which a molten powder consisting of a precursor of the hard magnetic material to be formed is sprayed onto the support body, several coating phases with heating of the respective surface to be coated, and respective intermediate coating-free phases being provided for each region of the support body to be coated during the coating process, characterized in that the temperature of the support body is increased to a level ensuring recrystallization of a hard magnetic phase of the hard magnetic material at least in a zone directed toward its surface to be coated at least toward the end of the coating process.

EP1161570B1. G. Rieger, J. Wecker, T. Duda, W. Unterberg, and W. Rodewald. Company: Siemens AG. Issued/Filed: 30 July 2003/13 March 2000.

Heat Sink Laminates

Kinetically Sprayed Aluminum Metal-Matrix Composites for Thermal Management. Disclosed is a method for forming a heat sink laminate and a heat sink laminate formed by the method. In the method, a particle mixture is formed from a metal, an alloy, or mixtures thereof with a ceramic or mixture of ceramics. The mixture is kinetically sprayed onto a first side of a dielectric material to form a metal-matrix composite layer. The second side of the dielectric material is thermally coupled to a heat sink baseplate, thereby forming the heat sink laminate.

US20030175559A1. D.T. Morelli, A.A. Elmoursi, T.H. Van Steenkiste, B.K. Fuller, B.A. Gillispie, and D.W. Gorkiewicz. Issued/Filed: 18 Sept 2003/15 March 2002.

Heater Elements

Electrical Heating Elements and Method for Producing Same. A method for the production of a heater element on a target area. A plurality of particles having a specified size range are prepared. The plurality of particles include a metallic alloy, and the metallic alloy includes B. The particles are applied to the target area using at least one of a plasma spray process and a flame spray process.

US6596960. E. Brook-Levinson, V. Manov, Y. Margolin, E. Adar, Y. Sorkine, and V. Volchkov. Company: Advanced Heating Technologies Ltd., Israel. Issued/Filed: 22 July 2003/22 April 1998.

Magnetron Targets

Planar Magnetron Targets Having Target Material Affixed to Nonplanar Backing Plates. Planar magnetron targets are disclosed that include a backing plate that is grooved in the regions where erosion of the target material mainly occurs, thereby permitting greater erosion depth of the target material. The life of the target material may be further extended by employing an in-relief upper surface for the target material. The in-relief surface may be prepared by a number of well-known techniques, which include casting and computer-controlled plasma spray. The target material may be either sprayed on or bonded to the backing plate. For a preferred embodiment of the invention, the backing plate is grooved to create undercut ledges, which retain the target material on the backing plate, even if adhesion between the surfaces of the target material and the backing plate material fails as the result of thermal cycling.

US20030178301A1. D.M. Lynn and M.M. Clarkson. Issued/Filed: 25 Sept 2003/23 Dec 2002.

Metal-Matrix Composite Coatings

Method of Producing Thermally Sprayed Metallic Coating With Additives. The cylinder walls of light metal engine blocks are thermally spray coated with a ferrous-based coating including Al using an HVOF device. A ferrous-based wire is fed to the HVOF device to locate a tip end of the wire in a high-temperature zone of the device. Jet flows of oxygen and gaseous fuel are fed to the high-temperature zone and are combusted to generate heat to melt the tip end. The oxygen is oversupplied in relation to the gaseous fuel. The excess oxygen reacts with and burns a fraction of the ferrous-based feed wire in an exothermic reaction to generate substantial supplemental heat to the HVOF device. The molten/combusted metal is sprayed by the device onto the walls of the cylinder by the jet flow of gases.

US20030152698A1. J.R. Smith, D.R. Sigler, R.E. Teets, L.E. Byrnes, and M.S. Kramer. Issued/Filed: 14 Aug 2003/13 Feb 2002.

Mold Coatings

Composite Articles and Methods and Systems of Forming the Same. Molded articles that have a surface coating, as well as methods and systems of producing the same, are provided. The type of surface coating is selected to provide the article with certain desired properties. In general, the methods involve applying a coating to a mold surface, for example using a thermal spray process, and then molding an article in the mold. The coating is transferred to the surface of the molded article during the molding process.

US20030165706A1. R.C. Abbott and W.A. Glenn. Company: ThermoCeramiX, Inc., Shirley, MA. Issued/Filed: 4 Sept 2003/13 Jan 2003.

Mold Forming by Thermal Spraying

Method of Manufacturing Molds, Dies or Forming Tools Having a Porous Heat Exchanging Body Support Member Having a Defined Porosity. Described are molds, dies, and forming tools comprising: (a) a heat-exchanging body support member and (b) within the support member, a molding cavity portion formed by thermal spraying metallic particles to a desired configuration in the support member. Also described are methods of making a mold, die, or forming tool comprising the steps of: (a) providing a body support member having a controlled and designed porosity that permits the enhancement of the heat transfer ability of said mold, die, or forming tool; (b) configuring a surface of the support member to a desired cavity; and (c) spraying particles to the configured cavity in the support member, thereby producing a mold,

die, or forming tool. Preferably, the materials of construction are metallic and are applied by thermal plasma spraying. The particles may also be ceramics, metal-matrix composites, ceramic-matrix composites, thermoplastic resins, thermoset resins, and composites based thereupon. The controlled porosity of the body of the mold, die, and/or forming tool is as important as the use of thermal spray to subsequently form the cavity.

US20030127775A1 and US6613266. R.R. McDonald. Company: Metallamics, Traverse City, MI. Issued/Filed: 10 July 2003/2 July 1998; 2 Sept 2003/2 July 1998.

Molds and Dies, Spray Forming

Metallic Articles Having Heat Transfer Channels. Metallic articles having heat transfer channels are produced by solidification of molten metallic material about preformed channel defining means such that a solidified metallic deposit having heat transfer channels is formed. The channel-defining means may be in the form of either solid elements (which are subsequently removed to leave the channels) or conduit elements (which may remain permanently embedded in the article). Molds, dies, cores, and other tools for use in molding or casting of plastics and metals are particularly suitably formed by the process, the heat transfer channels being used for cooling of the respective articles during use. The molten metallic material is preferably deposited by spray forming utilizing one or more sprays of molten metallic material.

EP0740588B1. A.R.E. Singer, R.M. Jordan, and A.D. Roche. Company: Sprayform Holdings Limited. Issued/Filed: 10 Sept 2003/20 Jan 1995.

Neutron Absorbing Coatings

Composite Neutron Absorbing Coatings for Nuclear Criticality Control. Thermal neutron absorbing composite coating materials and methods of applying such coating materials to spent nuclear fuel storage systems are provided. A composite neutron absorbing coating applied to a substrate surface includes a neutron-absorbing layer overlying at least a portion of the substrate surface, and a corrosion-resistant top coat layer overlying at least a portion of the neutron-absorbing layer. An optional bond coat layer can be formed on the substrate surface prior to forming the neutron-absorbing layer. The neutron-absorbing layer can include a neutron-absorbing material, such as gadolinium oxide or gadolinium phosphate, dispersed in a metal alloy matrix. The coating layers may be formed by a plasma spray process or a high-velocity oxygen fuel process.

WO3067608A2 and US20030147485A1. R.N. Wright, D.W. Swank, and R.M. Mizia. Company: Bechtel BWXT Idaho, LLC. Issued/Filed: 14 Aug 2003/3 Feb 2003; 7 Aug 2003/4 Feb 2002.

Piston Rings

Thermal Spraying of a Piston Ring. The invention relates to a piston ring coated with a coating material by a thermal spray process, exposed to heat treatment of said coating material at an elevated temperature and for a time effective to at least partially diffuse said coating material into said piston ring surface or underlying layer of coating material, and an additionally applied coating material layer subject to successive heat treatments of each said coating material layer in order to lay down on said piston ring surface a plurality of layers of same said coating material.

WO3072845A1. M. Aram. Company: Koncentra Verkstads AB. Issued/Filed: 4 Sept 2003/28 Feb 2002.

Thermally Applied Coating for Piston Rings, Consisting of Mechanically Alloyed Powders. The invention relates to a wear-resistant coating used for bearing surfaces and flanks of piston rings in internal combustion engines. The wear-resistant inventive coating is obtained by mechanically alloying powders that form a metallic matrix with hard material dispersoids and lubricant material dispersoids. The coating is then thermally applied to the workpieces, especially by means of high-velocity oxygen fuel (HVOF) spraying. The workpieces coated are bearing surfaces and parts of flanks pertaining to piston rings in internal combustion engines.

US20030180565A1. C. Herbst-Dederichs. Issued/Filed: 25 Sept 2003/3 March 2003.

Solid Oxide Fuel Cells

Solid Oxide Fuel Cell Components and Method of Manufacture Thereof. A solid oxide fuel cell comprises a dense electrolyte disposed between a porous anode and a porous cathode wherein the dense electrolyte comprises doped lanthanum gallate or yttria-stabilized zirconia, the porous anode comprises yttrium-doped strontium titanate, yttrium-doped strontium titanate and Ni, lanthanum-doped ceria and Ni, or yttria-stabilized zirconia and Ni, and the porous cathode comprises doped lanthanum ferrite or strontium-doped lanthanum manganite. The fuel cell may further comprise an interlayer(s) comprising lanthanum-doped ceria disposed between an electrode (anode, cathode, or both) and the electrolyte. An interconnect layer comprising doped lanthanum chromate may be disposed between the anode of a first single fuel cell and the cathode of a second single fuel cell. The anode, cathode, electrolyte, and optional interlayer(s) are produced by thermal spray.

WO3075383A2. S. Hui, X. Ma, H. Zhang, H. Chen, J. Roth, J. Broadhead, A. Decarmine, M. Wang, and T. Xiao. Company: U.S. Nanocorp, Inc. Issued/Filed: 12 Sept 2003/28 Feb 2003.

Spray Formed Seat Inserts

Method of Making Spray Formed Inserts. Method of making seat inserts by thermally spraying bulk material. The method comprises the steps of: (1) preparing a mandrel having an outside dimension not greater than the desired inside dimension of the desired insert, the mandrel having means to provide for separation of the sprayed bulk material from the mandrel, (2) thermal spraying separate particles of one or more types of steel or Ni alloys in the presence of a controlled oxidizing medium to form a bulk composite material on the mandrel with a density of at least 99%, and (3) after cooling the bulk material, removing such material from the mandrel and slicing it into discrete seat shapes for implanting into the final product.

EP0927816B1. O.O. Popoola, L. van Reatherford, R.C. McCune, A.M. Joaquin, and E.L. Cartwright. Company: Ford Global Technologies, Inc. Issued/Filed: 13 Aug 2003/21 Dec 1998.

Thermal Barrier Coatings

Coatings for Turbine Components. An Ir-Nb alloy bond coat is used under a ceramic thermal barrier coating on turbine blades and vanes to improve the life of the thermal barrier coating. Between the bond coat and the substrate is an underlying protective coating that is either a low-pressure plasma sprayed coating such as a NiCoCrAlY alloy or a vapor-deposited coating such as Ta, Ni-Ta, or Re. Heat treatment and preoxidation procedures may be used to form the desirable bonds and materials.

EP0992614B1. M. Cybulsky and T.R. Gibbons. Company: Alstom (Switzerland) Ltd. Issued/Filed: 23 July 2003/27 May 1999.

Method for Thermal Barrier Coating and a Liner Made Using Said Method. A method of applying a thermal barrier coating system to a metal piece having cooling holes angled in a first direction and cooling holes angled in a second direction. The method includes spraying a bond coat on a first surface of the piece at angles with respect to the first and second directions and to a thickness selected in combination with the angles to prevent the bond coat from entirely filling any of the holes. A thermal barrier coating is sprayed on the bond coat at angles with respect to the first and second directions and to a thickness selected in combination with the angles to prevent the thermal barrier coating from entirely filling any of the holes. The method also includes spraying a high-pressure fluid jet from a nozzle assembly through each hole generally parallel to the respective cooling hole.

US6620457. G. Farmer, T.J. Tomlinson, R.W. Heidorn, J.A. Fehrenbach, W.L. Imhoff, and M.E. Rutherford. Company: General Electric Co., Schenectady, NY. Issued/Filed: 16 Sept 2003/13 July 2001.

Process for Producing a Ceramic Thermal Barrier Layer for Gas Turbine Engine Component. An article that is particularly well suited for use as a gas turbine engine component has a metallic substrate and a ceramic thermal barrier layer including a mixed-metal oxide system comprising a compound selected from the group consisting of (1) a lanthanum aluminate and (2) a calcium zirconate, the calcium in which is partially replaced by at least one calcium-substitute element, such as strontium (Sr) or barium (Ba). In addition, the lanthanum in the lanthanum aluminate can be partially replaced by a lanthanum-substitute element from the lanthanide group, particularly gadolinium (Gd). A process for producing such an article comprises providing a prereacted mixed-metal oxide system as described above and applying it to the substrate by plasma spraying or an evaporation coating process.

US6602553. B. Heimberg, W. Beele, K. Kempter, U. Bast, T. Haubold, M. Hoffmann, A. Endriss, P. Greil, C.-W. Hong, F. Aldinger, and H.J. Seifert. Company: Siemens AG, Munich, Germany and Rolls-Royce Deutschland GmbH, Oberursel, Germany. Issued/Filed: 5 Aug 2003/1 July 2002.

Thermal Barrier Coating Resistant to Deposits and Coating Method Therefor. A protective coating system and method for protecting a thermal barrier coating from CMAS infiltration. The coating system comprises inner and outer alumina layers and a platinum-group metal layer therebetween. The outer alumina layer is intended as a sacrificial layer that reacts with molten CMAS, forming a compound with a melting temperature significantly higher than CMAS. As a result, the reaction product of the outer alumina layer and CMAS resolidifies before it can infiltrate the thermal barrier coating. The platinum-group metal layer is believed to serve as a barrier to infiltration of CMAS into the thermal barrier coating, while the inner alumina layer appears to enhance the ability of the platinum-group metal layer to prevent CMAS infiltration.

US20030157361A1 and US6627323. B.A. Nagaraj, J.L. Williams, and J.F. Ackerman. Issued/Filed: 21 Aug 2003/19 Feb 2002 and 3 Sept 2003/19 Feb 2002.

Thermal Barrier Coating System of a Turbine Engine Component. Method for forming a thermal barrier coating system on a turbine engine component includes forming a bondcoat on the turbine engine component and depositing a thermal barrier coating so as to overlie the bondcoat. The bondcoat is formed by thermally co-spraying first and second distinct alloy powders on the turbine engine component, forming an oxidation-resistant region, and thermally spraying a third alloy powder on the oxidation-resistant region to form a bonding region. The oxidation-resistant region is more resistant to oxidation than the bonding region.

US6610420. A.M. Thompson and W.C. Hasz. Company: General Electric Co., Niskayuna, NY. Issued/Filed: 26 Aug 2003/30 Oct 2001.

Thermal Insulating Material and Method of Producing Same. A thermochemically stable oxidic thermal insulating material presenting phase stability, which can be used advantageously as a thermal insulating layer on parts subjected to high thermal stress, such as turbine blades or such like. The thermal insulating material can be processed by plasma spraying and consists preferably of a magnetoplumbite phase whose preferred composition is MMeAl11 O19, where M is La or Nd and where Me is chosen from among Zn, the alkaline earth metals, transition metals, and rare earths, preferably from Mg, Zn, Co, Mn, Fe, Ni, and Cr.

US6602814. R. Gadow and G. Schaefer. Company: MTU Aero Engines GmbH, Munich, Germany. Issued/Filed: 5 Aug 2003/11 Oct 2000.

Ultrasonic Waveguides

Clad Ultrasonic Waveguides with Reduced Trailing Echoes. Ultrasonic buffer rods are useful for on-line process control of industrial material processes at elevated temperatures. In order to increase the signal-to-noise ratio in the reflected ultrasonic waves revealing the information of the condition of the materials being processed, clad ultrasonic waveguides consisting of a tapered or uniform core and a cladding are proposed. The core is made of a low ultrasonic loss material. Preferably, the cladding has a higher ultrasonic velocity than the core. The cladding may be thermally sprayed over the core. The waveguides are simple, rugged, machinable, and operable at elevated temperatures.

CA2206090C. J.-G. Legoux and C.-K. Jen. Company: National Research Council of Canada. Issued/Filed: 22 July 2003/23 May 1997.

Wear-Resistant Coatings

Thermal Spray Coating for Gates and Seats. A thermal spray powder composition, a coating made using a powder of this composition, and a process for applying the coating. The chemical composition of the powders of the invention comprise a blend of a tungsten carbide-Co-Cr material and a metallic Co alloy.

EP1024209B1. J. Quets. Company: Praxair S.T. Technology, Inc. Issued/Filed: 24 Sept 2003/26 Jan 2000.

Characterization Methods

Porosity Measurement

Method for Preparation of Test Bodies. The invention relates to a method for preparation of test bodies for analysis of porous, preferably thermally sprayed, surface layers, which are incorporated by casting in plastic. The method according to the invention is carried out by placing one or more testpieces of the surface layer in a mold introduced into a vacuum chamber, the pressure of which is lowered, pouring a ready-mixed, liquid casting

resin into the mold containing the testpieces, again letting the air into the chamber, lifting the testpieces out of the casting resin and allowing the excess resin to drip from the testpieces. After that, they are placed in a mold cavity together with the testpieces with a pulverized resin, and applying pressure and heat to the mold cavity for a predetermined period of time, whereupon the test body is ready to be taken out and lapped.

US20030124274A1. S.-O. Stalberg. Issued/Filed: 3 July 2003/27 Jan 2003.

Feedstock

Ceramic Shell Powders

Ceramic Shell Thermal Spray Powders and Methods of Use Thereof. Plasma spraying a substrate using particles having a ceramic coating on a combustible core, which may optionally be burned out before spraying, gives a potential for a thicker more conformable protective coat.

US20030129320A1 and US6602556. S.H. Yu. Issued/Filed: 10 July 2003/1 Aug 2002 and 5 Aug 2003/1 Aug 2002.

Composite Powder for Abradable Coatings

High-Temperature Spray Dried Composite Abradable Powder for Combustion Spraying and Abradable Barrier Coating Produced Using Same. An improved method of forming an abradable thermal barrier coating comprises providing a spray dried powder of M-CrAlY and a solid lubricant, such as CoNiCrAlY-BN. Unlike powders provided for use with plasma spray guns, the powder is essentially free of polyester or other organic fugitive additives provided to increase porosity. The powder is applied using a combustion spray process and results in a M-CrAlY abradable coating that has an average porosity comparable to that of a plasma-applied coating, but with smaller and more uniform pore distribution, and without requiring postapplication heat treatments to remove fugitive materials. Deposition efficiency is also increased.

WO03059529A1. M.R. Dorfman, J. Mallon, and R.K. Schmid. Company: Sulzer Metco (U.S.) Inc. Issued/Filed: 24 July 2003/14 Jan 2003.

Corrosion-Resistant Composite Powder

Corrosion Resistant Powder and Coating. The invention is a corrosion-resistant powder useful for deposition through thermal spray devices. The powder consists essentially of, by weight percent, 30 to 60 W, 27 to 60 Cr, 1.5 to 6 C, a total of 10 to 40 Co plus Ni, and incidental impurities plus melting point suppressants.

WO3074216A1 W.J. Jarosinski and T.L.B. Crim. Company: Praxair S.T. Technology, Inc. Issued/Filed: 12 Sept 2003/19 Feb 2003.

Ilmenite Powder

Spraying Material for Flame and Plasma Coating. In the present invention there is disclosed a spraying material for flame and plasma coating, especially by a plasma torch with a gas or water stabilization of electric arc and intended for both metallic and nonmetallic substrate materials, as well as for manufacture of self-supporting elements through plasma spraying. The material consists of natural ilmenite particles with moisture content up to 4 wt.% and particle size ranging within 0.01 to 0.315 mm.

CZ0292308B6. K. Neufuss and P. Ctibor. Company: Ustav fyziky plazmatu AV CR, Prague, Czech Republic. Issued/Filed: 17 Sept 2003/20 Dec 2001.

Nanosized Zirconia

Process for Making Nanosized Stabilized Zirconia. A process to produce stabilized zirconia from a solution of zirconium salt and a stabilizing agent. The zirconium salt may include zirconium oxysulfate, zirconium oxychloride, zirconium oxynitrate, zirconium nitrate, and other water-soluble zirconium salts. The stabilizing agent may include calcium, magnesium, yttrium salts of oxides and rare earth oxides. The process is conducted by evaporation of the solution above the boiling point of the solution, but below the temperature where there is significant crystal growth. The evaporation step is followed by calcination to produce the desired nanosized structure. Further processing by sintering may be applied to produce solid structures or by milling and classification to produce material for thermal spray coating.

WO3076337A2. B.J. Sabacky and T.M. Spitler. Company: Altair Nanomaterials Inc. Issued/Filed: 18 Sept 2003/16 Oct 2002.

Powders With Rare-Earth Elements

Thermal Spray Particles and Sprayed Components. Rare earth-containing compound particles of polyhedral shape having an average particle diameter of 3-100 μm, a dispersion index of up to 0.5, and an aspect ratio of up to 2 can be thermally sprayed to form an adherent coating, despite the high melting point of the rare earth-containing compound. A sprayed component having the particles spray coated on a substrate surface is also provided.

US6596397. M. Kaneyoshi and T. Maeda. Company: Shin-Etsu Chemical Co., Tokyo, Japan. Issued/Filed: 22 July 2003/4 April 2002.

Spraying Gas Compound

Gas Compound for Plasma Spraying and Its Application to Refractory Material Plasma Spraying. New plasma forming gas comprises a ternary mixture of helium, argon, and hydrogen. A plasma forming gas, comprising ~30 helium, ~55% argon, and 5.5-15% hydrogen, is new. Independent claims are also included for the following: (1) a thermal spray process employing the above plasma-forming gas and (2) on-site production of the above plasma-forming ternary gas mixture.

EP0924968B1. V. Gourlaouen and F. Remy. Company: L'air Liquide, S.A.; Directoire et Conseil de Surveillance pour l'Etude et l'Exploitation des Procédés Georges Claude. Issued/Filed: 24 Sept 2003/4 Dec 1998.

Spraying Methods, Pre- and Posttreatment

High-Velocity Oxyfuel Wire Spraying

Method of Producing Thermally Sprayed Metallic Coating. The cylinder walls of light metal engine blocks are thermally spray coated with a ferrous-based coating using an high-velocity oxyfuel (HVOF) device. A ferrous-based wire is fed to the HVOF device to locate a tip end of the wire in a high-temperature zone of the device. Jet flows of oxygen and gaseous fuel are fed to the high-temperature zone and are combusted to generate heat to melt the tip end. The oxygen is oversupplied in relation to the gaseous fuel. The excess oxygen reacts with and burns a fraction of the ferrous-based feed wire in an exothermic reaction to generate substantial supplemental heat to the HVOF device. The molten/combusted metal is sprayed by the device onto the walls of the cylinder by the jet flow of gases.

US6610369. L.E. Byrnes, M.S. Kramer, R.A. Neiser. Company: General Motors

Corp., Detroit, MI and Sandia National Laboratories, Albuquerque, NM. Issued/Filed: 26 Aug 2003/13 Dec 2001.

Kinetic Spraying

Method of Producing a Coating Using a Kinetic Spray Process With Large Particles and Nozzles for the Same. A method of depositing large particles having an average nominal diameter of greater than 106 up to 250 μm onto substrates using a kinetic spray system is disclosed. The method utilizes a powder injector tube having a reduced inner diameter and a de Laval type nozzle having an elongated throat to exit end length. The method permits deposition of much larger particles than previously possible.

US6623796. T.H. Van Steenkiste. Company: Delphi Technologies, Inc., Troy, MI. Issued/Filed: 23 Sept 2003/5 April 2002.

Masking

Masking for Engine Blocks for Thermally Sprayed Coatings and Method of Masking Same. A masking for an engine block to be thermally sprayed with a coating includes a head deck mask portion adapted to engage a head deck of an engine block to prevent overspray of a thermally sprayed coating on the head deck. The masking also includes a crankcase mask portion adapted to be disposed in a crankcase chamber of the engine block and engage a lower end of a cylinder bore cavity of the engine block to prevent overspray of the thermally sprayed coating into the crankcase chamber.

US6589605. B.E. Shepley, K.R. Bartle, O.O. Popoola, P.J. Hilton, and R.E. Dejack. Ford Global Technologies, LLC., Dearborn, MI. Issued/Filed: 8 July 2003/26 Feb 2002.

Monitoring of Thermal Spraying

Apparatus and Method for Thermal Spraying. The invention relates to an apparatus and a method for producing a sprayed layer on the surface of a substrate, wherein an admixture material that may have started to melt or is molten is guided onto the surface of the substrate to be coated using a gas or gas mixture, as well as a relevant installation for producing the sprayed layer by means of a thermal spraying method, wherein the installation comprises means for supplying the admixture material or the gas or gas mixture. According to the invention, at least one feature of the thermal spraying process that influences the quality of the sprayed layer and that is responsible for the formation of the layer and its properties, is recorded, evaluated, and assessed, checked, monitored, and/or regulated. Both analog and digital spectroscopic arrangements can be used as optical emission spectroscopic arrangements. The recording, evaluation and assessment, checking, and/or monitoring using the optical emission spectroscopic arrangement can advantageously be used for on-line regulation and if necessary, also for optimizing one or a plurality of parameters responsible for the formation of the layer and its properties.

US20030143318A1. K. Schutte. Issued/Filed: 31 July 2003/31 Jan 2003.

Plasma Transferred Arc Powder Welding

Method for Coating Materials. Easily oxidized material is hardfaced by plasma transferred arc powder weld deposition. Plasma transferred arc powder weld deposition on easily oxidized materials is carried out using a weld filler material of a CuNi alloy with certain alloy additions. In the process for coating of easily oxidized materials by plasma transferred arc powder weld deposition using direct current (d.c.) or d.c.-superimposed alternating current (a.c.) by the method described in DE 19626941.5, the weld filler material comprises a CuNi alloy with additions specified herein. Preferred composition of the deposit is also specified.

EP0927594B1. M. Dvorak. Company: Castolin S.A. Issued/Filed: 10 Sept 2003/3 Dec 1998.

Posttreatment

Postdeposition Oxidation of a Nickel-Base Superalloy Protected by a Thermal Barrier Coating. A Ni-base superalloy protected by a thermal barrier-coating is prepared by depositing a bond coat layer overlying and contacting the substrate, depositing a ceramic layer overlying and contacting the bond coat layer, thereby forming a coated substrate, placing the coated substrate into a heating apparatus operating with an oxidizing atmosphere, and heating the coated substrate in the heating apparatus to a temperature of from about 1850 to about 2100 °F, for a time of at least about 30 min. A layer of alpha alumina is formed on the bond coat layer, between the bond coat layer and the ceramic layer.

US6607611. R. Darolia. General Electric Co., Schenectady, NY. Issued/Filed: 19 Aug 2003/29 March 2000.

Pretreatment

Treatment of Surfaces Before Thermally Spray Coating Them. Process for processing a surface of a substrate comprises pretreating the surface of the substrate with abrasive containing one or more fluids.

EP0990711B1. P. Heinrich. Company: Linde AG. Issued/Filed: 9 July 2003/10 Sept 1999.

Rapid Prototyping

Method of Directly Making Rapid Prototype Tooling Having Free-Form Shape. A method and apparatus for directly making rapid prototype tooling from a computer model having a free-form shape. The method steps comprise essentially: (a) machining a soft metal tooling base so as to contour at least one free-form surface in conformity with the computer model; (b) cold-gas dynamic spraying the contoured surface to form superimposed impact welded metal particle layers, the layers consisting of at least one thermal management underlayer comprising primarily Cu, and at least an outer wear-resistant layer comprising primarily tool steel.

US6602545. F.Z. Shaikh, H.D. Blair, and T.-Y. Pan. Company: Ford Global Technologies, L.L.C., Dearborn, MI. Issued/Filed: 5 Aug 2003/25 July 2000.

Rapid Prototyping/Spray Forming

Method and Arrangement for Utilizing a Pseudoalloy Composite for Rapid Prototyping and Low-Volume Production Toolmaking by Thermal Spray Form Techniques. Method and arrangement for spray forming an article. The method includes spraying a plurality of metal streams upon a low-heat-resistant model and thereby forming a spray formed article. Each of the plurality of metal streams is composed of moltenized droplets, and as between the plurality of metal streams, each is composed of different constituent elements. In the spray form process, conditions of the metal streams are controlled, particularly around the time that the droplets land, to prevent adverse affects such as melting or burning the master model. The spray conditions are controlled in such a manner that the individual metal droplets forming the metal streams remain substantially segregate. The segregated state is maintained through out solidification so that the resulting spray formed article is composed at least partially of pseudoalloy.

US6595263. G. Grinberg, M.M. Shade, D.R. Collins, and R.L. Allor. Company: Ford Global Technologies, Inc., Dearborn, MI. Issued/Filed: 22 July 2003/20 Aug 2001.

Sealing of Coatings

Method for Sealing of a Coating on a Roll. A press roll such as the center roll of a press or the backup roll of an extended-nip press roll, used in a pulp, paper, board, or finishing machine, has a coating with an intermediate sealed layer. The corrosion resistance and impermeability of the roll coating, particularly of such a coating that is made by thermal spraying, can be improved by way of sealing. The coating comprises a porous outermost surface layer made out of a ceramic or ceramic-metal material applied by thermal spraying and at least one sealed layer situated between the outermost surface layer and the roll mantle.

US6609996. K. Niemi, B. Hellman, J. Wahlroos, and P. Lehtonen. Company: Metso Paper, Inc. Helsinki, Finland. Issued/Filed: 26 Aug 2003/13 Aug 2001.

Spraycasting

Method and Apparatus for Spraycasting. Spraycasting method involves directing an atomized metal or alloy spray from a tundish quiescent chamber at a collector disposed in a spray chamber and in situ evacuating of the spray chamber during spray deposition to a maintain spray chamber gas partial pressure less than about 400 torr. The spray deposit leading-edge region is oriented at a selected acute angle relative to horizontal to improve the quality of the spray deposit by reducing inner-diameter fissure porosity. The collector can be heated in situ proximate the leading edge of the deposit at an initial deposition location. The collector is thermally insulated and capable of accommodating thermal expansion of the collector surface. In addition, the scan rate and distance of a scanning atomizer is slaved to the rotational speed of the collector such that actual atomizer dwell time (spraying time) is lessened as the collector rpm is increased.

EP0852976B1. K.E. Bowen, D.S. Potter, D.A. Cook, D.P. Ingersoll, J.W. van Heest, and R.D. Adair. Company: Howmet Research Corp. Issued/Filed: 13 Aug 2003/5 Dec 1997.

Spray Forming

Spray Forming Bulk Deposits of Allotropic Metal. Method of spray forming bulk metal deposits that replicate a master pattern: (1) casting and solidifying ceramic about a master pattern to form a spraying pattern; (2) after removing the spraying pattern from the master pattern, heating the ceramic spraying pattern to a sustained temperature to effect an isothermal-diffusion-dependent microstructural transformation; (3) while in such heated condition, thermally spraying allotropic metal particles onto the heated spraying pattern to form a deposit having a bulk thickness, the particles impacting the spraying pattern, or previously deposited particles, at a temperature above the sustained temperature of the spraying pattern; (4) holding the deposit on the heated spraying pattern long enough to allow the particles of the deposit to undergo a diffusion reaction that relieves internal stresses due to deposition and solidification; and (5) thereafter gradually cooling the deposit to room temperature to produce a unitary article with essentially no distortion relative to the spraying pattern.

EP0980916B1. P.E. Pergande, G. Grinberg, D.R. Collins, and J.A. Kinane. Company: Ford Motor Co. Issued/Filed: 3 Sept 2003/26 July 1999.

Spraying Diagnostics and Control

Thermal Projection Device. The invention relates to a device and a method for control of the operation of a thermal projection torch, characterized in that the characteristics of the jet and the temperature of the deposit on the piece are measured by means of a camera and a combined pyrometer. The correction to be made to the supply parameters of the torch are deduced therefrom and the corrected parameters are transmitted to the unit controlling the torch.

WO3072291A2 and WO03072290A2. M. Vardelle, T. Renault, C. Bossoutrot, F. Braillard, and H. Hoffman. Company: Snecma Services. Issued/Filed: 4 Sept 2003/28 Feb 2003 and 4 Sept 2003/28 Feb 2003.

Thermal Spraying Instrument. The invention relates to a device and method for controlling the operation of a thermal spray torch. The inventive device and method are characterized in that an onboard camera and pyrometer are used to measure the properties of the jet and the temperature of the deposit on the part and in that the correction to be made to the supply parameters of the torch is deduced. Furthermore, the invention is characterized in that the corrected parameters are sent to the cabinet that controls the torch.

WO3073804A2 and WO03072292A2. M. Vardelle, T. Renault, C. Bossoutrot, F. Braillard, and H. Hoffman. Company: Snecma Services. Issued/Filed: 4 Sept 2003/28 Feb 2003 and 4 Sept 2003/28 Feb 2003.

Spraying Systems

Arc Spraying Gun

Method and Spray Gun for Arc Spraying. The invention relates to a method and a spray gun for arc spraying. The aim of the invention is to develop a method and a spray gun for arc spraying in order to improve homogeneity and layer adhesion. To this end, according to the inventive method for arc spraying, the ends of two metallic wires are melted in an electric arc, the wires are then transported from wire supply rolls to a melting region, the melted material is projected onto the surface of a workpiece by means of a nozzle system, by supplying an atomizing gas, and the surface of the workpiece is thermally treated at the same time as the material is applied by the nozzle system, by means of a burner. At least one burner is combined with the nozzle system for the heat treatment of the surface of the workpiece.

WO3066233A1. P. Rosa, C. Wanke, W. Pellkofer, A. Sagel, T. Haug, and S. Grau. Company: DaimlerChrysler AG. Issued/Filed: 14 Aug 2003/27 Jan 2003.

High-Velocity Oxyfuel Nozzle Assembly

Nozzle assembly for HVOF Thermal Spray System. A nozzle assembly for a HVOF thermal metallic spray coating system includes an inner tube, a middle tube, and an outer tube that are concentrically arranged about an axis of the nozzle assembly and are spaced to provide annular, concentric gas flow passages for oxygen and gaseous fuel along with a central wire feed passage in an efficient, compact arrangement. A slided nib and plug are fitted to the discharge end at the assembly and defined, together with the middle tube, an annular premix chamber for the combustible gases, and a plurality of circumferentially spaced mixing slots and a downstream mix end portion of the nib where complete mixing of the gases occurs prior to entry into the combustion chamber provided in an air cap. An annular passage between the air cap and outer tube communicates with a high-pressure air source for establishing an envelope of air against the inside surface of the air cap

to serve as a protective barrier layer from the atomized metal.

US20030160109A1. L.E. Byrnes, L.K. Sumner, P.J. Toth, M.S. Kramer, W.L. Oberkampf, R.E. Teets, and C.D. Valerius. Issued/Filed: 28 Aug 2003/22 Feb 2002.

Interior Spraying

Systems and Methods for Coating Conduit Interior Surfaces Utilizing a Thermal Spray Gun with Extension Arm. Systems and methods for applying a coating to an interior surface of a conduit. In one embodiment, a spray gun configured to apply a coating is attached to an extension arm, which may be inserted into the bore of a pipe. The spray gun may be a thermal spray gun adapted to apply a powder coating. An evacuation system may be used to provide a volume area of reduced air pressure for drawing overspray out of the pipe interior during coating. The extension arm as well as the spray gun may be cooled to maintain a consistent temperature in the system, allowing for more consistent coating.

US20030161946A1. K.A. Moore and R.A. Zatorski. Issued/Filed: 28 Aug 2003/11 Feb 2002.

Single-Wire Arc Spraying

Single-Wire Arc Spray Apparatus and Methods of Using Same. Material droplet generator systems utilizing single-wire arc spray apparatus and methods are provided. In some embodiments, the apparatus include a single consumable, first wire electrode fed through a gas nozzle and a nonconsumable, second electrode outside of and proximate a nozzle exit. In some embodiments, the second electrode may have at least a terminal or end portion having an axis that is oriented substantially perpendicular to an axis of the gas nozzle. The first wire electrode may form an angle of 5° or less with the axis of the gas nozzle. Preferably, the first wire electrode forms an anode while the second electrode forms a cathode. In operation, the apparatus and methods produce a narrow beam thermal spray, which, when deposited upon a substrate surface, results in a high-definition spray pattern and coating having distinct boundaries and a controllable thickness.

US6610959. R.R. Carlson and J.V.R. Heberlein. Company: Regents of the Univ. of Minnesota, Minneapolis, MN. Issued/Filed: 26 Aug 2003/26 April 2001.

Spray Gun Nozzle

High-Efficiency Nozzle for Thermal Spray of High-Quality, Low Oxide Content Coatings. The present invention provides a spray gun with associated nozzle attachments for high deposition efficiency for thermal spray of high-quality, dense, low oxide content coatings. The spray guns are used to produce coatings using a thermal spray process, a high-velocity oxyfuel process, a high-velocity air-fuel process, cold spraying, and plasma spraying in which the process is characterized by having an overexpanded flow with a Mach number from about 1.0 to about 4.0 that have passageway section that diverges to the gun outlet. In one embodiment, the nozzle attachment is another diverging section with a greater angle of divergence than the diverging nozzle section. In another embodiment the nozzle attachment includes the aforementioned diverging nozzle attachment section followed by a converging nozzle section having an outlet section through which the thermal spray is emitted.

US20030178511A1. A. Dolatabadi, J. Mostaghimi, and V. Pershin. Issued/Filed: 25 Sept 2003/22 March 2002.

Thermal Spray Gun Internal Liner

Thermal Spray Gun with Inner Passage Liner and Component for Such Gun. A gas cap for a thermal spray gun has a spray passage extending from the combustion chamber to an exit end, and a thermal spray material is fed into the passage. A nozzle component of the gas cap is formed of a tubular inner member in thermal contact with a metallic outer member, such as Cu, that is in contact with a fluid coolant. The inner member is formed of a hard, thermally conductive material, preferably a carbide in a metal matrix, such as tungsten carbide in Co.

EP0807470B1. W.P. Rusch. Company: Sulzer Metco (U.S.) Inc. Issued/Filed: 30 July 2003/6 May 1997.