Selected Abstracts of Thermal Spray Literature

Reprinted with permission from MATERIALS INFORMATION, a joint service of ASM International® and the Institute of Materials, Materials Park, Ohio, USA and London, England, respectively.

Applications

Acid Resistance

Development of Acid Resistance Coated Composite Materials. [Original Title: Entwicklung Saurebestandiger Schichtverbundwerkstoffe.] An acid resistant multilayer material is described. The material's essential advantages are compared to the established methods of enameling metal surfaces. The basic idea is first to coat the substrate with ZrO_2 to achieve a thermal barrier coating. Next a material is sprayed by APS to form a glassy layer. The total thickness of the coating system is 300 to 400 μm. Due to the thermal barrier coating, the metallic substrate is only slightly heated during the melting of the glassy layer. A number of materials were developed and tested.

W. Kollenberg and J. Decker. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 96-99 [in German]. PHOTOCOPY ORDER NUMBER: 199403-57-0292.

Aerospace

Low Pressure Plasma Spraying—a Product Process in the Aero-Engine Industry. [Original Title: Niederdruckplasmaspritzen—ein Prozess der Serienfertigung im Flugwerktriebsbau.] Among functional coatings are those which only can be applied by low-pressure plasma spraying. A gas-turbine high-pressure vane segment with hot-gas corrosion protection and thermal barrier coating is used to illustrate the planning, testing, and optimization procedures up to production status. It is also shown how problems at this stage arise and how they are solved, and the qualification procedures for the coating process and specific application are outlined. The coating equipment is discussed, and quality assurance and cost efficiency are examined.

M. Gehrmann. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 1-3 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0216.

Aircraft

An Alternative Thermal Spray Method to Plasma Spraying for Aircraft Power. Plant Overhaul. The process of gaining acceptance for arc-sprayed NiAl as an aircraft engine maintenance procedure is discussed. Not only nickel aluminum was considered, but a wide variety of other materials that are currently using the plasma process and the combustion process were requested to be approved using the arc process. The old and new developed materials, economics and the equipment being use are covered. Arc surfacing was found to have a capital equipment cost of 1/5 that of plasma and cost to operate 1/10 of that of plasma. Additionally, the introduction of accessories to augment the use of arc equipment with automation and its flexibility to "quick change" with other thermal spray equipment on robots and traverse equipment is shown.

M.P. Zwetsloot, E.R. Sampson, and M. Thorpe. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 175-180 [in English]. PHOTOCOPY ORDER NUMBER: 199403-58-0233.

Cast Iron

Application of Melt Spraying in Refurbishment of Spare Parts. [Original Title: Anwendung des Schmelzbadspritzens bei der Erneuerung von Ersatzteilen Unter Huttenmannischen Bedingungen.] Procedures introduced at the Ferromont and VSZ plants, Kosice, Czechoslovakia, to refurbish spare parts by APS and electric-arc flame spraying, under in-works conditions, are described. Cast-iron work-roll bolts were machined and welded to remove cracks of 40 μm maximum depth and then refurbished by two-layer electric-arc flame spraying. The resultant coatings showed a complex microstructure, consisting of martensite and finely scattered chromium carbides with a hardness of 602 to 762 HVm. The transport rolls of a dynamo annealing line, in Cr-Ni heat-resistant steel, had accumulated accretions caused by reactions between the chromium oxides formed on the rolls and iron oxides on the treated sheets. APS coatings of various mixtures of oxides of aluminum, titanium, zirconium, and silicon were applied, and that of zirconium, aluminum and silicon oxides provided the most satisfactory coating, with good adhesion strength, low porosity and no subsequent accretions.

P. Slavkowsky. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 175-180 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0241.

Corrosion Resistance

Thermal Sprayed Aluminium Coatings Made of Galvanic Effective Aluminium Alloys for Corrosion Protection of Steel and Aluminium Materials in Maritime Atmosphere. II. The Improvement of Corrosion Protective Layers by Using Sacrificial Aluminium Alloys for Metal Spraying. [Original Title: [Thermisch Gespritzte Aluminiumuberzuge aus Galvanisch Wirksamen Aluminium-Legierungen zum Korrosionsschutz von Stahl und Aluminiumwerkstoffe im Maritimen Bereich. II.] For the improvement of corrosion protection layers, modified Al alloys were necessary which covered not only the surface but also had an electrochemical effect on the base material. The sacrificial anodes, AlZn5 Type 1 and Type 2 with a low corrosion potential and a high activity, were developed and applied by thermal spraying onto steel and Al alloy (AlMg, AlMgMn, AlMgSi, AlSi) surfaces. The corrosion measurements and the testing in the laboratory and in a marine environment using the corrosion rack of Helgoland prove that the thermally sprayed layers of the sacrificial Al alloys are preferred for the long time corrosion protection of steel and aluminum material in seawater.

W. Huppatz, H. Dahmen, and D. Wieser. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 191-192 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0236.

Therrmal Sprayed Aluminium Coatings Made of Galvanic Effective Aluminium Alloys for Corrosion Protection of Steel and Aluminium Materials in Maritime Atmosphere. I. Application Technique to Achieve Optimum Corrosion Protection. [Original Title: Thermisch Gespritzte Aluminiumuberzuge aus Galvanisch Wirksamen Aluminium-Legierungen zum Korrosionsschutz von Stahl und Aluminiumwerkstoffen im Maritimen Bereich. I.] Thermal sprayed aluminum coatings on steel and Al materials become more and more important due to the excellent corrosion protection effect in maritime atmosphere together with a considerable long-term corrosion protection effect. Within the scope of a research project, various Al alloys, in the form of sprayed coatings, have been examined regarding their galvanic efficiency, in order to optimize the corrosion protection behavior. For the production of these coatings the Alucoating procedure has been used as application technique. The report describes this arc spraying procedure, which is developed particularly for the production of Al coatings, as well as about the experience gained in practice.

D. Grasme. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 188-191 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0235.

Development and Applications of Corrosion Resistant Thermal Sprayed Coatings. Polarization studies and immersion testing have demonstrated that type 316 stainless steel coatings applied using the high velocity oxyfuel (HVOF) process are inferior to wrought type 316 alloys. The heterogeneous nature of a coating microstructure results in limited passivity in 0.1 *M* hydrochloric acid. The HVOF coatings, however, show superior corrosion resistance compared to other spray processes tested. HVOF coatings experience the least amount of elemental burnout (reduced oxidation) and have the highest density compared to traditional low-velocity combustion and plasma processes. Further improvements in corrosion current densities were obtained by incorporating deoxidizers into the thermal spray powders. These deoxidizers minimize oxidation at interparticle boundaries. Particle boundaries are active sites for galvanic attack and eventual crevice corrosion.

M.R. Dorfman, B.A. Kushner, A.J. Rotolico, J.A. DeBarro. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag

GmbH, Dusseldorf, 1993, p 171-174 [in English]. PHOTOCOPY ORDER NUMBER: 199403-58-0232.

Damping Capacity

Effects of Thermal Spray Coating on Sound and Vibration. IV. Relation Between Coating Constitution and Damping Characteristics. A series of studies has been carried out to develop high-damping materials, which possess high rigidity and heat resistance, by using a thermal spraying process. The effect of the combinations of thermal sprayed coatings and substrates on the damping characteristics of thermal sprayed specimens was clarified. The substrates used were mild steel and pure aluminum plates. The sprayed coatings used were an Al_2O_3 single layer, an alternatively laminated layer with Al_2O_3 and Ni-Cr alloy, and an Al_2O_3 layer with lead plating. The main results obtained are as follows. A 0.4 mm thick Al_2O_3 single layer coating on the mild steel plate increased the dominant vibration frequency of specimen by 4%. The same coating on the Al plate increased it by 11%. The laminated coating on the mild steel plate lowered the dominant frequency by 3.5%. It is concluded that the thermal spray coating is also effective to modify the vibration characteristics of materials used in industry.

M. Futamata, A. Fuji, T. Owada, Y. Harada, and A. Kobayashi. Cited: *J. High Temp. Soc. Jpn.*, Vol 19 (No. 6), Nov 1993, p 276-284 [in Japanese]. ISSN: 0387-1096. PHOTOCOPY ORDER NUMBER: 199403-57-0327.

Hot Corrosion

Examinations Concerning Hot Gas Corrosion Resistance of Metallic Coatings. [Original Title: Untersuchungen Uber die Heissgasbestandigkeit von Metallischen Beschichtungen.] The corrosion behavior of several nickel-base and iron-base alloys exposed to hot (<1000 ° C) corrosive gases has been examined. Twelve different alloys were exposed to 12 corrosive gases with compositions in the range of 0.2 to 3.0% sulfur, 0 to 1.0% chlorine, 0 to 100 ppm vanadium, and 200 to 400 ppm sodium. The corrosion layers formed by reactions between the alloys and the various gas constituents are described and illustrated. Their formation depends on the elements that diffuse toward the surface of the coating or the material and their affinity for oxygen, sulfur and chlorine to form oxides, sulfides and chlorides. The enthalpies for the formation of oxide protective layers are usually higher than those for sulfide or chloride layers, with the more positive metals being chromium, aluminum, titanium, and silicon, and the more negative tungsten, molybdenum and carbon. Means of calculating corrosion-layer thickness and rate of attack are described.

Th. Steine. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 218-222 [in German]. PHOTOCOPY ORDER NUMBER: 199403-35-0625.

Hydroxyapatite

Quality Assurance for Hydroxylapatite Plasma Spray Coatings on Prosthesis and Implants. [Original Title: Qualitatssicherung bei der Plasmabeschichtung von Endprothesen und Implantaten mit Hydroxylapatit.] Hydroxylapatite coatings applied by plasma spraying on medical implants for human medicine are state of technology. The coating combines the bioactivity of HA with the excellent mechanical properties of metal alloys. The human being, receiver of the implants, governs the quality assurance for plasma sprayed implants. The quality assurance does not cover only the material properties of the coating but also long-term properties of the implant and the quality of the service. A modern quality assurance system for medical products fulfills the requirements of DIN ISO 9001 as well as the requirements of EN 46 001. The quality assurance is explained in detail by means of the examples of development, design of processes and manufacturing.

H.-G. Pfaff and G. Willmann. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 199-200 [in German]. PHOTOCOPY ORDER NUMBER: 199403-22-0265.

Superconductors

Properties of Plasma Sprayed Superconductors on Metallic Substrates. The plasma spraying and the heat treatment of the $YBa_2Cu_3O_{7-\delta}$ and $Bi_2Sr_2CaCu_2O_{8+d}$ coatings sprayed on nickel and on stainless steel with and without diffusion barrier of yttria-stabilized zirconia (YSZ) are discussed. It was found that the superconducting properties of melt textured Ni/YSZ/123 composites are only comparable with the values of 123 annealed under the peritectic melting point, because of the macrocracks in the 123 layer. The superconducting properties of the melt-textured 123 bulk material can only be achieved for thick films on substrates not reacting with the YBCO even after long times under the melt-texturing conditions and which have a better thermal matching to the 123-phase. An enhancement to values of $10^3 A/cm^2$ at 77 K, which is sufficient for applications like magnetic screening of small fields, can be achieved with faster cooling velocities from the melt, if the crack producing stress in the coatings can be reduced. Other materials tested showed a stronger reaction with the 123 phase during melt texturing as the YSZ. The BaO is the strongest reacting part of the Bacuprate melt. Only MgO seems to be a good material, but not in direct contact to nickel-base alloys.

W. Aschern, P.C. Splittgerber-Hunnekes, D. Stover, H. Hemmes, and H. Rogalla. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 285-289 [in English]. PHOTOCOPY ORDER NUMBER: 199403-33-0134.

Composite Coatings

Plasma Spraying of Tauboride Alloy Reinforced by TiC Particles. The coating processing by plasma spraying from tauboride NiCrBTi alloy powders with additions of titanium carbide was investigated. To form the high content of tauboride crystals in the coatings, the gas atomized metallic powders are preferable for spraying. The NiCr scales added to the powder prevent thermal decomposition of the carbides during spraying. The coating resistance to abrasive wear increases with increasing TiC-particle content in sprayed powders from 5 to 35 wt% in the case of low-pressure plasma spraying, but has the negative effect for air plasma sprayed coatings. Underwater plasma spraying is possible for the dense and fine structure tauboride coatings and for processing the coatings with high carbide content.

P. Vityaz, A. Verstak, S. Sobolevsky, E. Lugscheider, P. Jokiel, K. Yushchenko, and G. Pursche. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 36-40 [in English]. PHOTOCOPY ORDER NUMBER: 199403-58-0032.

High Temperature Chromium Carbide Reinforced Metal Matrix Composite Coatings for Turbomachinery Applications. A novel process utilizing the high-velocity Gator-Gard plasma spray system has made possible a new generation of chromium carbide metal matrix composite coatings. These coatings, in comparison to conventional plasma sprayed coatings, have a higher as-sprayed hardness and can be heat treated to generate thermally stable structures. These coatings were deposited on a nickel-base substrates and were characterized using optical microscopy, x-ray diffraction, wear resistance, and other physical properties. Where appropriate, comparisons to a standard plasma sprayed coating are made. Based on the findings of this study, the following conclusions are made regarding the two Gator-Gard applied chromium carbide coatings. Gator-Gard applied coatings have superior physical and mechanical properties compared to conventional air plasma sprayed coatings. Wear resistance is significantly enhanced by isothermal aging of the G-G coatings at 540 °C for 4 h, whereas isothermal aging of a conventional air plasma sprayed chromium carbide coating does not show this effect. The increase in hardness in the G-G coatings is hypothesized to result from a transformation of chromium carbide to chromium oxide.

P. Sahoo and R. Raghuraman. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 296-300 [in English]. PHOTOCOPY ORDER NUMBER: 199403-57-0304.

Composites

Manufacturing of Metal Matrix Composite Materials Using Prepreg Technology. [Original Title: [Herstellung Langfaserverstarkter MMC Mittels Prepregtechnik.] For the fabrication of short-fiber strengthened metal matrix composites (Al_2O_3short fibers in aluminum-matrix), the infiltration technique of preformed fiber-prepregs proves to be successful. This study describes the procedure for laboratory-style MMC-fabrication with carbon-fibers as reinforcement component and the AlSi12 alloy as matrix. The influence of the process parameters and their optimization on the properties of testable MMC samples is shown. Above all, the long-fiber strengthened MMCs are gaining importance in machine and automotive construction as high-strength and very stiff lightweight materials. Their advantage lies in their low, fiber-content-dependent, thermal expansion coefficient, which, just as strength and Young's modulus, depends on the fiber orientation. Adapted to the demands of the application, heat-resistant components capable of bearing high loads can be fabricated.

J. Rahm, D. Dietzschold, and G. Leonhardt. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH,

Dusseldorf, 1993, p 423-426 [in German]. PHOTOCOPY ORDER NUMBER: 199403-62-0411.

Control

Expert System

The Advisory and Information System BIThS. [Original Title: Das Beratungs- und Informationssystem fur Thermisches Spritzen BIThS.] Based on a grouping of knowledge representation forms transformed into computer programs, and on experiences with an expert system for thermal spray material selection, an advising and information system for thermal spraying was developed using the hypertext system TOOLBOOK. Primarily an ergonomic graphic interface was designed. Further hypertext functions such as complex associations, database and expert system calls and dynamic graphics were used. This way the system BIThS was developed, containing the basic knowledge about thermal spray procedures, successful applications, coating materials, and the productive power of parts that were coated by thermal spraying. BIThS can be used by planning and designing engineers for information acquisition about thermal spraying, as well as by factories and experts to accumulate and save their knowledge.

U. Sander and W. Queren-Lieth. Cited: Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 371-374 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0257.

Corrosion

HVOF Coatings

Corrosive Wear Properties of Some HVOF-Sprayed Coatings. The corrosive wear properties of some HVOF-sprayed coatings were measured. AISI 316, St52 or St37 steel were employed as a base material. Coatings consisted of AISI 316, Inconel 625, Inconel 718, and Hastelloy C and were characterized in terms of hardness, oxide contents, microstructure, and porosity. It was found that Hastelloy and Inconel coatings give good protection against corrosive wear for at least a short period of time. The weight loss of these coatings was comparable to that of the uncoated AISI 316 and controlled mainly by mechanical damage of the passive layer. AISI 316 coatings, however, suffered a much higher corrosive wear rate and the contribution of corrosion was also higher. This was attributed to a lack of a spontaneous oxide layer on the surface.

J.-P. Hirvonen, A. Mahiout, and J. Likonen. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 276-279 [in English]. PHOTOCOPY ORDER NUMBER: 199403-31-1223.

Zn and Al Materials

Corrosion Behaviour of Zinc, Aluminum and ZnAl Sprayed Coatings in Short Time Corrosion Test. [Original Title: Zum Korrosionsverhalten von Zn-, Al- und ZnAl-Spritzschichten im Kurzzeit-Korrosionsversuch.] The corrosion behavior of zinc, aluminum and ZnAl-alloy 85/15 as-sprayed coating on steel in the salt-spray test, Kesternich test with SO_2 and condensed-water test is described. It was found, that Zn is necessary for a good corrosion quality. The adhesion of arc sprayed coatings is better than flame sprayed.

W.-D. Schulz. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 364-365 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0255.

Diagnostics

Conical Nozzle

The Analysis of Particle Speed and Specific Enthalpy Distribution Along the Radius of Sprayed Spot When Operating With a Conical Nozzle. The effect of conical nozzle on the distribution of specific enthalpy and particle speed along the sprayed spot radius while spraying by gasothermal burner has been investigated. Technically pure nickel with particles size of 56 to 61 μm has been used for spraying. The use of conical nozzle has been shown to decrease specific enthalpy gradient along the sprayed spot radius. Under equal power values of gasothermal flow overall power of heat flow towards the substrate while using conical nozzle can be twice decreased in comparison with traditional method of gasothermal spraying, the power of particles heat flow being simultaneously increased.

V.V. Kudinov, V.I. Kalita, D.I. Komlev, and O.G. Kopteva. Cited: *Fiz. Khim. Obrab. Mater.*, (No. 9-10), Sept-Oct 1992, p 82-85 [in Russian]. ISSN: 0015-3214. PHOTOCOPY ORDER NUMBER: 199403-58-0364.

Heat Flux

Study of the Heat Flux Transmitted by a DC Ar-H_2 Spraying Plasma Jet to a Cold Substrate. The properties of plasma sprayed coatings depend strongly on the temperature distribution within the coating and the substrate during spraying, distribution controlling the residual stresses. Among other parameters the heat flux from the plasma jet represents between ⅓ and ⅔ of the total flux received by the coating and substrate. It is thus of primary importance to measure it vs. the different spraying parameters: torch diameter, gas flow rate and nature, arc current, spraying distance. This is the purpose of this paper. A calorimeter made of a central probe surrounded by a cylindrical one has been constructed. When the stationary state is reached, the two power levels P_1 and P_2 measured allow one to calculate, iteratively, the heat flux profile assumed to be Gaussian. These heat fluxes have been determined as a function of the spraying distance, the electrical power level, the flow rate of the plasma gases, their nature and the nozzle diameter of the torch. The reduction of the plasma flux imposed to the substrate by the use of an air barrier blown orthogonally to the plasma jet and the presence of carrier gas have also been studied. All the data obtained have been correlated to the studied parameters.

F. Monerie-Moulin, P. Fauchais, F. Gitzhofer, and M. Boulos. Cited: Conference: Thermal Plasma Applications in Materials and Metallurgical Processing, San Diego, California, USA, 1-5 March 1992, The Minerals, Metals & Materials Society (TMS), Warrendale, PA, 1992, p 125-138 [in English]. PHOTOCOPY ORDER NUMBER: 199402-57-0191.

Plasma Systems

Diagnostics of Thermal Spraying Plasma Jets. DC plasma spraying is a fast-growing technology that has diffused progressively from aeronautic and nuclear industries to others. This is due to the increasing need for thick coatings with more and more sophisticated properties and also to a better control of the coating qualities and reproducibility. These results have been obtained thanks to a better understanding of the involved phenomena with the development of the diagnostic techniques that are summarized in this presentation. The way the plasma jet is formed is recalled and the consequences for its behavior (piston flow, turbulences, and surrounding atmosphere pumping) described through fast camera and CARS experiments. The effect of the arc fluctuations on the spectroscopic temperature measurements is emphasized. The possibility to use these fluctuations to determine at least the axial velocity of the jet is commented. A comparison between spectroscopic and enthalpy probe measurements is presented as well as the limitations of Rayleigh technique to measure temperatures <6000 K. The statistical methods to measure in flight the mean particulates number flux (by laser fluxmetry), velocity (by laser anemometry), diameter (by laser scattering), and surface temperature (by two color pyrometry) is discussed together with their limitations. The way to determine the temperature and species density of the vapor surrounding the particulates in flight is also presented. Then the techniques enabling one to determine the velocity, diameter and surface temperature of an unique particulate in flight are commented. The means to follow the temperature evolution of a flattening particulate and of the beads and passes generated during spraying is described.

P. Fauchais, J.F. Coudert, M. Vardelle, and A. Vardelle. Cited: Conference: Thermal Plasma Applications in Materials and Metallurgical Processing, San Diego, California, USA, 1-5 March 1992, The Minerals, Metals & Materials Society (TMS), Warrendale, PA, 1992, p 31-54 [in English]. PHOTOCOPY ORDER NUMBER: 199402-57-0188.

Environmental Control

Pollution of the Environment During Thermal Spraying. [Original Title: Umweltbelastungen Beim Thermischen Spritzen.] During the thermal spray processes, emissions of noise (up to 145 dB(A) for plasma and arc systems), radiation within the range of UV-IR (e.g., UV-emission power of 700 W for APS) and pollutants in form of gases (NO_x, O_3, carbon monoxide, CO_2) and powders (e.g., nickel, chromium) occur. The emissions, in particular for APS-processes under different parameters, are described and explained. The emissions of technical plants often lead to strong emissions at the working place. Therefore, extensive measurements in a typical spraying room are

carried out. Over and above that, the possible effects on employees (e.g., state of health) and environment are described.

H.-D. Steffens and R. Lauterbach Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 69-73 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0295.

Erosion

Stellite

Erosion Protection for Steam Turbine Blades Using the Stellite. [Original Title: [Erosionsschutz fur Dampfturbinenschaufeln Mittels Stellitieren.] Water drops in steam vapor produce progressive wear appearance at the inlet and outlet edges of end stage blades of low pressure steam turbine rotor. Suitable methods for passive protection of the blade surfaces should contribute to delay and compensate the loss of material caused by erosion and the subsequent contour damage of the turbine blades. The coating of blade outlet edges with a Stellite-6 layer is considered to be inexpensive. Compared with other processes the expenditure to execute the protection zone is lower. During a 12-month period approximately 1600 end stage blades of 210 MW low pressure rotors had been reconstructed. In doing so, besides the replacement of the blade inlet edge, the thermal spray coating for the outlet edge protection had been used on massive Stellite-6 bars welded to the blades.

W. Storch and H. Bick. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 184-187 [in German]. PHOTOCOPY ORDER NUMBER: 199403-55-0405.

Feedstock

Adsorption characterization

Characterization of Spraying Powders and Coatings by Adsorption. The determination of the specific surface area of thermal spray powders of different chemical nature (iron, titanium, Fe-Cr, Al_2O_3, TiB_2, CrC_2, WC-6Co) using N and krypton as adsorptives has demonstrated that N shows a stronger adsorbent-adsorbate interaction than Kr. If greater amounts of powder are used, the experimental error can be diminished and correct results can be obtained. Nitrogen seems to be the better choice than Kr. But this requires equipment which is able to measure also small decreases of pressure with a high accuracy. The air plasma sprayed free standing deposits obtained from these powders show, as a rule, weak absorbent-adsorbate interaction for both adsorptives. In this way, a determination of specific surface areas by adsorption leads to incorrect results. The investigation of thermal spray powders and coatings by adsorption will continue in combination with mercury porosimetry.

L.-M. Berger. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 348-350 [in English]. PHOTOCOPY ORDER NUMBER: 199403-22-0270.

Aluminum

Spray Deposited Aluminum Alloys. Spray deposited aluminum alloys have been developed over a number of years. The achievement of such alloy development is highlighted with respect to yield strength, fracture toughness, stress-corrosion cracking resistance, and high temperature strength. It is shown that in all these respects spray deposited Al alloys (i.e., Z618, 7075, and NZ13) can have distinct, if limited advantages. Improvements in properties are limited by the solidification rate which is slow compared to other means of rapid solidification.

M.O. Speidel, O. Beffort, and R. Machler. Cited: Conference: International Conference on Aluminum Alloys: New Process Technologies, Marina di Ravenna, Italy, 3-4 June 1993, Associazione Italiana di Metallurgia, Milano, Italy, 1993, p 69-75 [in English]. PHOTOCOPY ORDER NUMBER: 199402-54-0245.

Basalt

The Basalt Powder for the Plating of the Metallic Surfaces. The characteristics and requirements of basalt powders and the thermal spraying process are described. The nature of the coatings obtained on steel, cast iron, and bronze and their applications for corrosion protection and wear resistant applications are also dealt with.

P. Cornelia and C. Dan. Cited: Conference: Advances in Materials and Processes, Bombay, India, 16-19 Feb 1992, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, India, 1993, p 565-569 [in English]. PHOTOCOPY ORDER NUMBER: 199403-57-0284.

Borides

Microstructure and Some Properties of the Plasma Sprayed Coatings of Composite Powders Containing Boron Carbide. The results presented confirm that the diffusion reaction treatment of Fe and Cr powders with boron carbide produces powders containing iron boride and chromium borides. Chemical Ni plating of the produced powders has a good influence on the decrease in the porosity in coatings. Plasma spraying with boride phases mixed with self-fluxing alloys on the Fe and Ni matrix alloys one to obtain thicker coatings of comparably lower porosity than coatings obtained only from borides covered with nickel. Erosion wear tests show that for the glancing angle of 30° coatings containing iron borides have high abrasion resistance. For the angle of 60° complex coatings obtained from the powders containing boron carbide, chromium borides and NiCr10SiB alloy have high resistance. The results of the wear resistance of coatings are comparable with coatings obtained from the powder 45 VFNS in spite of the fact that the coating structure has high porosity.

L. Swadzba, P. Liberski, and F. Binczyk. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 355-357 [in English]. PHOTOCOPY ORDER NUMBER: 199403-58-0254.

Ceramics

Ceramic Oxide Powders for Gas Thermal Spraying. Some technologies have been worked out that allow production of powders of various chemical compositions, required dimensions, and microstructure. The technologies rest on thermal treatment of starting components taken in a certain ratio in the form of soluble salts. When devising the technologies, special attention was attached to production of powders of a preset size fraction distribution. Introduction of alloying additions into chromium and aluminum oxides changes properties of both powders and coatings. Thus, for example, introduction of titanium oxide in chromium dioxide decreases losses of oxygen and has a favorable effect on the coating quality. Besides, titanium dioxide lowers the temperature required for synthesis of a powder with a preset size fraction distribution.

N.F. Seliverstov, V.A. Ryabin, M.Ya. Berezhneva, A.B. Chudinov, and Yu.S. Borisov. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 442-443 [in English]. PHOTOCOPY ORDER NUMBER: 199403-54-0290.

Cermets

Cr_3C_2-NiCr Cermet Coatings Using Some HVOF, APS and VPS Processes. Properties of Cr_3C_2-NiCr alloy cermet coatings applied by various coating processes are investigated and compared. The coating processes used were atmospheric plasma spraying (APS), low pressure plasma spraying (VPS), Plasma Technik continuous detonation spraying (CDS), Jet Kote (JK), Metco Diamond Jet (DJ), and detonation gun spraying (DGS). The properties that were investigated were the microstructure of cross section, micro-Vickers hardness, abrasion wear resistance, and thermal shock resistance of each coating. The following results were obtained: VPS sprayed coatings have a higher hardness and better wear resistance than coatings applied with other processes. Among the HVOF process sprayed coatings, CDS sprayed coatings had the highest hardness and best wear resistance. Most coatings exhibited good results in the thermal shock test; however, VPS and CDS/H_2 sprayed coatings did not have good results.

J. Takeuchi, A. Nakahira, and G. Barbezat. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 442-443 [in English]. PHOTOCOPY ORDER NUMBER: 199403-58-0217.

Chromium Diboride

Production of Titanium—Chromium Diboride Powders for Plasma Spraying. I. Tests of metallized-powder coatings (copper) for adhesion to steel showed a relatively high adhesion strength amounting to 40 MPa for (TiCr)B_2 and 43 MPa for CrB_2 . The findings attest to the beneficial use of metallized powders as compared with starting powders, the advantages being an increase in hardness by 18 to 20% and in wear resistance by a factor of 1.8 to 2.6. The results obtained are explained primarily by compacting of particles (porosity decrease) in the plasma jet during metallization and also by a lower

interaction between the titanium-chromium diboride particles and the base element of self-fluxing alloys.

A.S. Nechepurenko, E.A. Knyshev, and N.A. Klinskaya. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 255-256 [in English]. PHOTOCOPY ORDER NUMBER: 199403-58-0243.

Fe-Al-Me

Exothermic Metallic Composite Powders on the Base of Nickel and the Self-Decomposition Products of the Fe—Al—Me—C Alloys for Plasma Spraying. Composite powder mixtures of 50% Ni powder, 5% aluminum powder and 42% of one of two self-decomposing Fe-Al-Me-C powders were formulated. It was found that the exothermic reaction in the Ni-Al mixtures takes place in two stages. The first exothermic effect occurs in the solid state and it is connected with the diffusive formation of the Ni_2Al_3 compound. The second exothermic effect begins when the Al + $NiAl_3$ eutectic is melted at the temperature of approximately 630 °C. The molten areas in the mixture are an ignition factor of the exothermic reaction between the eutectic and the nickel powder that probably gives the Ni_3Al compound formation. The partial or total replacement of the Al powder in the mixture with the self-decomposition powder (containing from 35 to 45 wt% Al) leads to the occurrence of an additional (third) exothermic effect on the DTA curve. Preliminary results of plasma spraying of new exothermic composite mixtures containing Ni, Al, iron, chromium and molybdenum, showed that it was possible to obtain coatings with good applied properties.

A. Gierek, F. Binczyk, R. Przeliorz, and B. Formanek. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 253-255 [in English]. PHOTOCOPY ORDER NUMBER: 199403-58-0242.

Graphite-Metal

Obtaining And Properties of Me-Graphite Cladding Powders for Gasothermal Deposition. Structure and properties of cladded graphite powders with double copper-nickel shell obtained by means of chemical and electrothermal cladding. Technology of obtaining Cu-Ni-graphite powders having two types of structure (graphite-Ni-Cu and graphite-Cu-Ni) was tried out. Particles were shown to retain after cladding the form essential for initial graphite and the thicknesses of layers about 3.3 to 10 μm. Their technological properties correspond to the conditions of gasothermal spraying. A possibility is noted of the use of these particles as lubricating coatings under impact loading of 5 to 15 MPa and slip rate of 1 m/s.

I.N. Gorbatov, V.A. Pashchenko, N.N. Zaets, S.V. Karpenko, A.E. Terent'ev, and I.S. Martsenyuk. Cited: *Fiz. Khim. Obrab. Mater.*, (No. 4), July-Aug 1992, p 97-101. ISSN: 0015-3214. PHOTOCOPY ORDER NUMBER: 199403-57-0396.

High-Nitrided Steel

Thermal Spraying of High-Nitrided Steel Material. [Original Title: Thermisches Spritzen von Hochaufgestickten Stahlen.] High nitrogen, austenitic steels up to 1.2 wt% have a high strength and toughness in combination with high resistance against pitting corrosion, general abrasion corrosion, and crevice corrosion. The aim of this R&D project was to apply these properties on surface coatings by using thermal spray processes. The first results are presented. Steels 316L without and with 0.61 wt% nitrogen content were deposited on St37 by arc spraying with an arc jet system. As atomizing gases, air and N were used. The coating characteristics were evaluated with respect to: N content, oxygen content, porosity, and hardness. The relationship of these properties to the selection of the atomizing gas and the chosen materials was investigated. The spray process was evaluated by the deposit efficiency.

Ch. Karsten, H. Krings, K. Ebert, C. Verpoort, and H. Witulskic. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 23-27 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0219.

HVOF Processes

Cermet Materials for HVOF Processes. [Original Title: Cermets fur das Hochgeschwindigkeits-Flammspritzen.] Results of investigations concerning Top-Gun-HVOF-sprayed coatings are discussed. Several types of agglomerated and sintered WC-Co- and Cr_3C_2-NiCr-powders were investigated for their deposition efficiency during the spray process, coating surface roughness, bond strength, and coating hardness in comparison to HVOF-sprayed WCCoCr and WCCrCNi coatings. The listed coating properties underline the importance of these cermet powders as materials for wear resistant coatings sprayed by HVOF.

J. Beczkowiak, J. Fischer, and G. Schwier. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 32-36 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0220.

Ni-Based Alloys

Powders of Nickel-Based Alloys With Laves Phases for Gas Thermal Spraying. Structures, methods of formation, and properties of powder coatings based on nickel alloys containing Laves phases are considered. The coatings are distinguished by high hardness, chemical inertness in corrosive media, and other valuable properties. Materials of such a type are used for gasothermal spraying of wear- and corrosion-stable coatings. The materials are described containing nickel, cobalt, molybdenum, chromium, silicon (of triballoy group) obtained by components alloying in protective medium with subsequent crushing and classification of the powders. Laves phase content can be changed from 30 to 85 vol% depending on future material application. annealing with diffusion zone formation or coatings melt off were carried out to enhance coatings adhesion to substitute.

I.N. Gorbatov, L.K. Shvedova, A.E. Terent'ev, S.V. Karpenko, and S.V. Nagornyi. Cited: Fiz. Khim. Obrab. Mater., (No. 9-10), Sept-Oct 1992, p 86-89 [in Russian]. ISSN: 0015-3214. PHOTOCOPY ORDER NUMBER: 199403-58-0365.

NiAl

Production of Reactive Sintered Nickel Aluminide Effort over three months was directed at increasing manufacturing capacity (ball milling) and improving product quality. Orders for powder have increased, mainly for plasma spray powders. NiAl is an excellent coat between a metal and a ceramic, and its use instead of cobalt should extend operating range for carbide tools. The feather phase in the sintered Ni_3Al was identified to be a nickel-rich phase nucleated on the grain boundaries with 10 wt% aluminum composition. The ductile to brittle temperature of powder extruded NiAl was found to be between 500 to 600 °C, and shows a 50% elongation at 600 °C.

R.M. Cooper. Cited: Fifth Quarterly Technical Progress Report, 22 Feb 1993-22 May 1993. ISSN: 0097-9007. PHOTOCOPY ORDER NUMBER: 199402-54-0195.

Spheroidization

A Mathematical Model of the Spheroidization of Porous Agglomerate Particles in Thermal Plasma Torches. A mathematical model of the melting and vaporization of porous agglomerate particles in thermal plasma torches is presented. The change in the particle density between the solid/porous state and the molten/nonporous state means that not only may the particles undergo significant volume changes during melting, but also that the physical properties characteristic of the molten state are retained during subsequent resolidification. In effect, the particle properties are no longer simple functions of the thermodynamic state of the particle and become dependent on the previous melting history. The physical properties of the agglomerate particles are calculated using concepts from the theory of porous media, while the temperature distribution within the particles is calculated from an enthalpy equation. Sample calculations are presented for agglomerate alumina particles injected into the plume region of a dc torch and into the fireball of an inductively coupled rf plasma torch.

J.W. McKelliget. Cited: Conference: Thermal Plasma Applications in Materials and Metallurgical Processing, San Diego, California, USA, 1-5 March 1992, The Minerals, Metals & Materials Society (TMS), Warrendale, PA, 1992, p 337-349 [in English]. PHOTOCOPY ORDER NUMBER: 199402-57-0192.

Material Properties

Adhesion

AES-Investigation of the Boundary Layer of Metallic and Metal-Ceramic Layer Composites. [Original Title: AES-Untersuchungen der Grenzflachen Metallischer und Metall-Keramischer Schichtverbundwerkstoffe.] The adherence mechanism of arc sprayed Ni layers on steel St37 and of plasma sprayed Al_2O_3 on oxidized Ni, both accomplished in air, are investigated. Nickel particles still adhering on the substrate after the sprayed layer has been separated from the substrate are examined. The best adhering coatings show Ni-Fe layered structures at the boundary regions, whereas less adhering coatings reveal narrower diffusion zones. The investigation of the

back sides of the separated Al_2O_3 layers and the Ni substrates provides information about the adherence mechanism. It is determined by diffusion between Al_2O_3 and NiO which has grown on the substrates during a preoxidation step. The best adhering layers show broadest diffusion zones, whereas thickest NiO regions with highest lateral distribution remaining at the sprayed Al_2O_3 layers after separation from the substrates show highest concentrations.

H.D. Steffens, H. Jenett, and S. Bredendiek-Kamper. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 444-446 [in German]. PHOTOCOPY ORDER NUMBER: 199403-57-0314.

Adhesion Tests

Current Analysis of Hitherto Adhesion Test Methods for Thermally Sprayed Coatings. [Original Title: Kritische Bewertung der Heute Ublichen Testverfahren zur Bestimmung der Schichtaftung.] At present, various test methods for evaluating the bond strength are available in industry and research. All these methods offer several minor or decisive disadvantages that influence the results. The main criteria for a bond strength test are listed, and the different methods are explained and compared to each other.

W. Milewski. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 258-260 [in German]. PHOTOCOPY ORDER NUMBER: 199403-22-0268.

Ceramic Coatings

On the Properties of Thermally Sprayed Oxide Ceramic Coatings. Al_2O_3, Al_2O_3 + 3-40% TiO_2, TiO_2 and Al_2O_3 + 40% ZrO_2 coatings were deposited by atmospheric plasma spraying (APS) and detonation gun spraying (DGS) on low carbon steel substrates. The coatings were evaluated by optical microscopy, microhardness measurements, and x-ray diffraction. Moreover, wear resistance of the coatings was evaluated by rubber wheel sand abrasion and particle erosion test methods. Detonation gun sprayed coatings showed more homogeneous microstructures and somewhat higher microhardness values than corresponding plasma sprayed coatings. Small additions of TiO_2 (3%) improved both the abrasion and erosion wear resistance, whereas 40% TiO_2 decreased significantly the erosion wear resistance of both APS and DGS coatings. The abrasion and erosion wear resistance of the TiO_2 coatings deposited by DGS was significantly lower than with the other DGS coatings studied. Al_2O_3 + 40% ZrO_2 coatings showed the best abrasion wear resistance of both APS and DGS coatings, but the erosion wear resistance of these coatings was lower than that of the Al_2O_3 and Al_2O_3 + 3% TiO_2 coatings. The best abrasion wear resistance of the studied coatings was obtained with DGS Al_2O_3 + 40% ZrO_2 and Al_2O_3 + 3-40% TiO_2 coatings which showed even lower wear rates than bulk Al_2O_3. The best erosion wear resistance was obtained with DGS Al_2O_3 + 3% TiO_2 coating, but it was clearly lower than that of the bulk Al_2O_3. In general, detonation gun sprayed coatings showed significantly higher abrasion and erosion wear resistance than corresponding plasma sprayed coatings.

K. Niemi, P. Vuoristo, and T. Mantyla. Cited: Conference: 7th International Metallurgy and Materials Congress, Vol II, Ankara, Turkey, 4-8 May 1993, UCTEA (Union of Chambers of Turkish Engineers and Architects), Ankara, Turkey, 1993, p 1283-1294 [in English]. PHOTOCOPY ORDER NUMBER: 199402-57-0182.

Cyclic Heat

Influence of Cyclic Heat Stress on the Properties of Plasma-Sprayed Ceramic Coatings. The aim of the experimental work was to study structural and adhesion changes of Al_2O_3 and $ZrSiO_4$ plasma-sprayed ceramic coatings on 11523.0 steel resulting from cyclic thermal stressing. The obtained results enable one to recommend particular material for a given type of stress. It was concluded that, using a suitable interlayer eliminating the corrosion of the substrate due to porosity and compensating different thermal expansion of substrate and coating, the $ZrSiO_4$ coating seems to be more resistant to cyclic thermal stressing up to 800 °C. This conclusion is based on higher initial adhesion and stability of the zirconium coating.

V. Bacova. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 290-293 [in English]. PHOTOCOPY ORDER NUMBER: 199403-57-0302.

Magnetic Properties

Amorphized Plasma Coatings With Special Magnetic Properties. The peculiar magnetic properties of amorphized plasma coatings of alloys $Co_{58}Fe_5Ni_{10}Si_{11}B_{16}$ and $Fe_{40}Ni_{40}B_{20}$ and their differences from amorphous strips of a similar composition produced by quenching of a melt on a rotating disk were studied. It was found that the values of magnetic induction and magnetic permeability of the coatings are 70 to 95% of their level for the amorphous strips. The coatings are also characterized by the higher values of Curie temperature and coercive force. As compared to the amorphous strips, they are characterized by the lower anisotropy of magnetic properties, the higher stability in heating up to 700 to 800 K and the 2 to 25 times higher values of specific electrical resistance.

Yu. Borisov, V. Korzhyk, A. Chernishov, Yu. Kunitsky, and S. Revo. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 290-293 [in English]. PHOTOCOPY ORDER NUMBER: 199403-58-0269.

Residual Stresses

Residual Stresses in Plasma-Sprayed Ceramic Coatings. Investigations were conducted to establish suitable parameters for the production of ceramic-metal composites with a dense, homogeneous, wear- and corrosion-resistant coating. Suitable St37 flat specimens were sprayed using varied production parameters of ceramic coatings with regard to the formation of residual stresses optimum for the respective application. The variation of spraying parameters did not in any case change the state of residual stress of the specimen. Distinct dependencies become apparent with changing spraying distance and coating thickness. The application of the roentgenographic measuring method enabled the state of residual stress in the subsurface zones, which is of particular importance to the wear behavior of coatings to be displayed.

H.-D. Tietz, B. Mack, and L. Pfeiffer. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 205-208 [in English]. PHOTOCOPY ORDER NUMBER: 199403-57-0298.

Stress Analysis in Plasma Sprayed Coatings. [Original Title: Spannungsermittlung in Plasmaspritzschichten.] The development of residual stresses of plasma sprayed coatings during the production process and their determination by using a computer simulation are discussed. The model of the simulation program is described and the results compared with x-ray diffraction stress analysis of copper coatings.

H.-J. Gross, W. Fischer, R. Vassen, W. Mallener, and D. Stover. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 205-208 [in German]. PHOTOCOPY ORDER NUMBER: 199403-22-0269.

Thermal Properties

Laser Induced Micro-Thermography—An Innovative Process for the Control of Coatings. [Original Title: [Laserinduzierte Mikrothermographie—ein Innovatives ZfP-Verfahren zur Prufung von Beschichtungen.] For the improvement of the lifetime of components, more and more coatings are used in order to realize special physical and chemical properties of the surface. The objective characterization of the achieved properties is necessary for the quality control of coatings. The method of thermal wave analysis presented enables the spatial mapping of thermal properties with high resolution. Because the thermal properties of a specimen are influenced by thermal material constants, coating thickness, coating porosity and coating adhesion, it is possible to use this method for quality control of coatings with regard to the mentioned features.

U. Radtke, H.-A. Crostack, P. Peppler, and E. Winschuh. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 360-364 [in German]. PHOTOCOPY ORDER NUMBER: 199403-22-0271.

Thermal Shock

Thermal Shock Behaviour of Zirconia Based Ceramics. The thermal shock behavior of zirconia-based ceramics was investigated. Al-13.5 wt% Si alloy specimens were coated by PSZ using the flame spray process. The samples were heated at temperatures of 150 to 520 °C for 20 min and cooled rapidly to room temperature. The examination showed that PSZ ceramic coatings did not crack on cooling from 500 °C, but the ceramic coating cracked upon cooling from 520 °C.

M. Akcil, H.A. Celik, I. Cevik, and Z. Cizmecioglu. Cited: Conference: 7th International Metallurgy and Materials Congress, Vol II, Ankara, Turkey, 4-8 May 1993, UCTEA (Union of Chambers of Turkish Engineers and Architects),

Ankara, Turkey, 1993, p 1319-1326 [in English]. PHOTOCOPY ORDER NUMBER: 199402-57-0185.

VPS Coatings

Mechanical Properties of VPS-Sprayed Superalloys. [Original Title: Mechanische Eigenschaften VPS-Gespritzter Superlegierungen.] Thermal sprayed coatings expand in modern surface technology. But to the disappointment of the designer the area of responsibility is still valid: The substrate takes the load, the coating protects. Careful measurements of the mechanical properties of VPS-sprayed superalloys have demonstrated the possibility to use them as loaded part of a construction, if the spray powder, the process parameters and the thermal treatment are matched one after another in an optimized way. The key is the change of the powder splat morphology after the deposition into a recrystallized grain structure after the heat treatment. Values of adhesion and strength, gained with new methods of testing, and the possibility of electron beam welding of the sprayed coating with other parts give the evidence and open up new applications for VPS-sprayed coatings.

H. Gruner, T. Schenkel, and N. Voss. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 79-82 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0297.

Material Property Measurements

Evaluation of Basic Properties for Plasma Sprayed Composite Coatings. [Original Title: Bestimmung der Grundeigenschaften fur die Verbundplasmaschichten.] A model describing the main elastic and physical characteristics of plasma sprayed composite coatings was developed. The calculation of the following parameters was made: thermal conductivity, elastic modulus, Poisson's ratio, and thermal expansion coefficient.

V. Kot. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 328-329 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0248.

Microstructure

Study of Macro- and Microstructure Formation in Gasothermal Coatings Particles. With the purpose to control structure of metal gasothermal coatings, formation of micro- and macrostructure of single particles, obtained on crystallizer under collision angles of 20 to 80°, distances of 250 to 600 and substrate movement rate up to 60 m/s, was studied. The investigations were carried out using technically pure nickel. Classification of macro- and microstructure of gasothermal coatings particles based on particles formation mechanism and cooling method is given. Real structure of particles in coatings is described on the base of four main types of particles according the above classification.

V.V. Kudinov, V.I. Kalita, and O.G. Kopteva. Cited: *Fiz. Khim. Obrab. Mater.*, (No. 4), July-Aug 1992, p 88-92 [in Russian]. ISSN: 0015-3214. PHOTOCOPY ORDER NUMBER: 199403-58-0359.

CoNiCrAlY

Microstructural Changes in MCrAlY Coatings on Nickel-Base Superalloy Single Crystals. Changes in the microstructure during heat treatment and thermal exposure of a plasma sprayed CoNiCrAlY overlay coating were observed using electron microscopy. The microstructure was examined following spraying, a diffusion heat treatment, a substrate aging treatment, and thermal exposures of 140 h at 850 °C and 140 h at 1100 °C. The principal changes involved γ' formation in γ due to a decrease in the cobalt:nickel ratio and a reduction in the chromium content, loss of β phase due to aluminum loss during oxidation, and formation of a β-derivative phase.

T.C. Totemeier, W.F. Gale, and J.E. King. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 304-307 [in German]. PHOTOCOPY ORDER NUMBER: 199403-12-0266.

Modeling

Transport Phenomena

Recent Advances in the Mathematical Modelling of Transport Phenomena in Plasma Systems. Major advances made regarding the modeling of transport phenomena in plasma systems are reviewed. Major emphasis is on the modeling of the plumes of plasma torches, electromagnetic and transport phenomena inside plasma torches, and plasma-particle interactions. A number of the important issues involved in each of the three areas are advanced. The issue of model validation is addressed, and the areas where further work would be highly desirable are discussed.

d R.C. Westhoff. Cited: Conference: Thermal Plasma Applications in Materials and Metallurgical Processing, San Diego, California, USA, 1-5 March 1992, The Minerals, Metals & Materials Society (TMS), Warrendale, PA, 1992, p 125-138 [in English]. PHOTOCOPY ORDER NUMBER: 199402-57-0189.

Optimization

Some Problems of Optimization of Thermal Spray Coating Formation. Earlier work concerning stochastic theory application indicated that this approach could be very helpful for thermal spray process (TSP) modeling and optimization. The facilities of this approach mentioned are demonstrated in more detail and its advantages are illustrated using in particular an arc spray process case. Main assumptions included in software to serve the approach are: (A) surface distribution $q^{(d)}$ of the heat flow from gas/plasma jet, the particles' temperature (T_p) and velocity (V_p) distributions as well as distribution of spray pattern approximated by normal laws with standard deviations σ_g, σ_T, σ_v, and σ_p ; and (B) only the case of a flat substrate with thickness H is considered. Reasonable agreement was found between the modeling results and experimental data for arc sprayed carbon steel coatings. These results indicated that the approach and software proposed could be helpful for solving some practical optimization problems such as robot-sprayer optimization problem.

V.E. Belashchenko. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 378-381 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0259.

Methods for Optimizing Strength and Life-Time of Thermally Sprayed Coatings. [Original Title: Methoden zur Optimierung von Festigkeit und Lebensdauer Thermisch Gespritzter Werkstoffverbunde.] Performance of coated compounds is defined mainly by percentage of adhesion, cohesion and abrasion, ruled by the local maximal of strain-amplitude and sensitivity to quasistatic mean-strain as well, especially in the case of "non-plastificable" tops. "Consistency"—adhesion plus contact-force or -geometry—rises, multiplied by 1000 in TC, if compressive strains are made high temperature stable by using tailored heating-cooling strategies. The use of heating-cooling cycles to increase the consistency of CoNiCrAlY/ZrO_2-H_2O_3/Al_2O_3 layered coatings on IN100 is described.

P. Pantucek. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 148-151 [in German]. PHOTOCOPY ORDER NUMBER: 199403-57-0297.

Particle Morphology

Morphology of Thermal Sprayed Particles in Different Spraying Processes Illustrated by the Behaviour of Molybdenum. [Original Title: Morphologie von Spritzteilchen bei Verschiedenen Spritzverfahren am Beispiel von Molybdan.] The morphology of thermally sprayed particles depends on the state of the substrate surface and the characteristics of the sprayed particles at the moment of impingement. Whereas, with a roughened substrate surface and particles already solidified upon impingement, conclusions cannot be reached as to characteristics of the particles, the shape, thickness, and degree of spreading can be deduced with particles sprayed onto a polished surface. In order to compare systematically the changes in specific particle characteristics, e.g., viscosity, thickness, size during flight and during spreading, tests were carried out on the thermal spraying of molybdenum on a polished St37 steel substrate, using arc, wire, and powder-flame, high-speed powder-flame and plasma spraying techniques. The conditions giving rise to the various morphologies identified, e.g., pancakes and flowers, and to crack formation in the individual solidified particles are discussed in detail.

S.D. Haumann, J. Drozek. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf,

1993, p 366-370 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0256.

Patent

Feedstock

A Cable for a Torch Used in Spray Coating and Its Use in Depositing a Quasicrystalline Layer on a Substrate. [Original Title: Cordon Pour Revetement par Projection au Chalumeau et son Utilisation Pour Deposer sur un Substrat une Phase Quasi Cristalline.] The cable comprises a core consisting of an organic binder and a powder or mixture of powders tending to form a quasicrystalline alloy, this core being surrounded by a sleeve of organic material. It also enables the depositing of a quasicrystalline alloy (e.g., an Al-base alloy) on a substrate by producing this alloy in the flame of a spraying device, from commercial powders of quasicrystalline alloy constituents.

J.-M. Dubois, M. Ducos, and R. Nury. Patent: EP0504048, European Patent 11 March 1992, 16 Sept 1992 [in French]. PHOTOCOPY ORDER NUMBER: 199403-58-0300.

Kitchen Utensils

Process for Coating Domestic and Kitchen Utensils. Original Title: Verfahren zum Beschichten von Haus- und Kuchengerdatschaften.] The process comprises the steps of forming grooves in a surface of a metallic-base body wherein the grooves have a breadth and a depth of 100 to 400 μm in each case. At least one plasma sprayed layer is deposited on the surface, the thickness of the layer(s) being less than half the depth. Finally, a nonstick layer is deposited on the plasma sprayed layer(s), the thickness of the nonstick layer being smaller than that of the plasma sprayed layer(s).

W. Heinzel. Patent: EP0510546, European Patent 16 April 1992, 28 Oct 1992 [in German]. PHOTOCOPY ORDER NUMBER: 199403-57-0344.

Processing

Process and Device for Spray Deposition of a Coating Material on a Substrate. [Original Title: Procede et Dispositif de Formation de Depot par Projection d'un Materiau d'Apport sur un Substrat.] The spray nozzle is composed of a central part mounted in a peripheral part, the openings for ejection from the conduits of oxyfuel mixture being distributed around the central orifice in at least two series set apart from each other in relation to the main axis of the nozzle, the conduits being advantageously composed of milled grooves on the outside of the central part. The carrier gas contains not 90% inert gas, generally nitrogen, and advantageously 1 to 10% oxygen, the remainder being N, the carrier gas being supplied by an adsorption or permeation air separation unit. The invention particularly relates to the forming of a zinc-based corrosion-resistant coating, e.g., on metal tubes.

S. Suzon, R. Soula, and M. Arnout. Patent: EP0511076, European Patent 21 April 1992, 28 Oct 1992 [in French]. PHOTOCOPY ORDER NUMBER: 199403-58-0312.

Single-Wire Arc

Depositing Metal onto a Surface. In order to deposit metal onto a surface such as a cylindrical surface, an arc spraying method is used with a consumable electrode, a nonconsumable electrode, and a jet of atomizing gas blown through the arc in a radial direction to propel the molten metal of the consumable electrode from the arc to the cylinder wall. The nonconsumable electrode and the atomizing gas jet both rotate about the cylinder axis so that the entire surface can be covered. The supply for the consumable electrode will normally come from a reel that can be stationary such that the consumable electrode does not rotate about its own axis.

A.R.E. Singer, G.I. Davies, and A.D. Roche. Patent: US5245153, USA 7 Oct 1991, 14 Sept 1993 [in English]. PHOTOCOPY ORDER NUMBER: 199403-58-0333.

Exhaust Valve

Exhaust Valve of a Diesel Combustion Engine, and a Method of Making This Valve. [Original Title: Auslassventil Einer Diesel-Brennkraftmaschine und Verfahren zum Herstellung des Ventils.] The basic body of the valve consists of a heat-resistant nickel-base alloy of the Nimonic type. In the region of its seating part it is metallurgically combined with an alloy which is either a Ni-base alloy of the Inconel type or of the NiCrAlY type.

H. Altorfer. Patent: EP0521821, European Patent 16 June 1992, 7 Jan 1993 [in German]. PHOTOCOPY ORDER NUMBER: 199403-61-0304.

Post Processing

Laser Glazing

Influence of Laser Treatment on Structure and Properties of Thermal Barrier Coatings. The Al_2O_3-Ni and ZrO_2-Ni ceramic coatings and coatings obtained by thermal spraying of the ceramic materials with diffusion treatment afterward—chromoaluminizing—were used in the tests. The nickel superalloy with the chemical composition (wt%): Ni-balance; chromium-24; tungsten-14; titanium-0.5; aluminum-0.5; carbon not more than 0.1, was used as a substrate material. The investigation results confirmed an advantageous influence of the laser beam on the structure of the ceramic coatings obtained by the plasma spraying methods. Owing to the laser beam influence, a high adherence of the ceramic coatings to the substrate was obtained, and it allowed removal of the main defect of the thermal spraying. Investigations of the hot corrosion resistance showed that the laser remelting of the ceramic coatings increased their corrosion resistance.

K. Kobylanska-Szkaradec and L. Swadzba. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 321-324 [in English]. PHOTOCOPY ORDER NUMBER: 199403-57-0308.

Structural Change in Plasma-Sprayed Alumina Coatings by Laser Melting. II. On Pulsed Mode Treatment. Structural change in plasma-sprayed alumina coatings on mild steel plates by laser melting was investigated particularly for pulsed mode treatment. Effect of various processing parameters on the structural change were discussed for one-pass treatment. A three-layer structure consisting of melted, heat-affected, and as-sprayed zones was observed in the cross sections of the laser-treated coatings. The depths of both the melted and heat-affected zones depended significantly on the pulse parameters. The treatment increased the Vickers microhardness by 1.6 to 2.0 times, although defects such as cracks, humps, and voids developed in the melted zone. The highest hardness was observed for the thin melted layer with narrow cracks and small humps that was obtained under the conditions of low frequency and small pulse width. These conditions led to a large temperature gradient and rapid cooling the layer, because the sample is heated by a high power density beam in a very short time and cooled appreciably during the subsequent interval between pulses.

C. Takahashi, T. Senda, and S. Amada. Cited: *Nippon Seramikkusu Kyokai Gakujutsu Ronbunshi (J. Ceram. Soc. Jpn.)*, Vol 101 (No. 1177), Sept 1993, p 1027-1031 [in Japanese]. ISSN: 0914-5400. PHOTOCOPY ORDER NUMBER: 199402-57-0172.

Remelting of Metallic and Ceramic Coatings by Means of Laser. Investigations into the laser remelting of flame-sprayed Al and copper coatings with thicknesses of 0.25 to 0.375 mm and plasma-sprayed aluminum-oxide coatings 0.28 to 0.36 mm thick on low-carbon steel and their ensuing wear characteristics are reported. Tests were carried out with a 1000 W laser melting appliance, using a gaseous mixture of carbon dioxide, nitrogen and helium. The sliding-friction and abrasion characteristics of the coatings were determined before and after the laser remelting, and the coatings and the coating/substrate transition zones were examined by optical and electron microscopy. All coatings showed considerable improvements in friction/abrasion characteristics and reduced wear rates. Optimal flame-spraying and plasma-spraying parameters have been evolved from the test results.

K. Takac. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 231-233 [in English]. PHOTOCOPY ORDER NUMBER: 199403-58-0237.

Sintering

Shrinkage of Plasma Sprayed YSZ Thermal Barrier Coatings Caused by Sintering Processes. [Original Title: Volumenverminderung an Plasmagespritzten Warmedammschichten Aufgrund von Sintervorgangen in Teilstabilisiertem Zirkonoxid.] Experience with the development of thermal barrier coatings for aeroengine applications has shown that a decrease in the number of pores accompanied by an increase in the size of the pores occurs with time at service temperatures >1200 °C. Rounding of edges and corners was observed in fracture surfaces. A permanent decrease in length was measured on the dilatometer. The effects observed in connection with the sintering processes known to occur with plasma-sprayed zirconia are discussed. The possible effects of a decrease in volume on the behavior of thermal barrier coatings and ways of suppressing the sintering processes are presented.

Th. Cosack and W. Hinreiner. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf,

1993, p 123-127 [in German]. PHOTOCOPY ORDER NUMBER: 199403-57-0294.

Surface Glazing

Remelting of Thermal Sprayed Component Coatings by High Power Arc Lamps. [Original Title: Umschmelzen von Thermisch Gespritzten Bauteilbeschichtungen mit Hochleistungsbogenlampen.] High power arc lamps have a simple construction and high power output of presently up to 50 kW in the working area. When using these lamps to remelt thermally sprayed layers consisting of self-fluxing NiCrBSi-alloy, test results are obtained. In this two-stage process the layer is flame sprayed first and subsequently remelted or rather secondary compressed in a short-cycle heat treatment. The experiments with a maximum track width of 100 mm and layer thickness of 0.5 and 1.0 mm, respectively, yielded a finely grained layer structure which shows high hardness.

M. Rund and H.K. Tonshoff. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 110-113 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0229.

Process

Fused Coating

Use of Special Gun Systems for Thermal Treatment of Flame Spray Coatings. [Original Title: Einsatz von Sonderbrennern bei der Thermischen Behandlung Flammgespritzter Schichten.] Self-fluxing alloys deposited by thermal spraying are fused to the substrate using an oxyacetylene flame. Depending upon the mass of the workpiece, different torch capacities are required with steady burning flames for gentle heating of the substrate surface. Many applications necessitate special torch designs for reliable and effective fabrication. The report is concerned with the design and construction of special torches and the application of auxiliary equipment for their automatic operation. In addition, energy supply concepts to meet varying torch capacity requirements are set forth.

K. Schumacher. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 103-109 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0228.

High Velocity Processes

Comparison of Plasma and Detonation Sprayed Tungsten Carbide-Cobalt Coatings. The properties of plasma and detonation sprayed WC-Co coatings were compared. The results indicated that the coatings deposited by detonation spraying give the best properties: higher hardness values, lower porosities, and better wear resistance. The improvement in wear resistances is attributed to higher hardness values and smaller amount of porosity plus the fine distribution of carbide particles in the coating. The hardness values of detonation sprayed coatings are generally higher than those of an equivalent coating produced by plasma spraying technique. The particle size in plasma sprayed coatings is coarser than that in detonation sprayed coatings. In addition, the pores are larger, although the difference in porosities in only 1%.

P.L. Kuhanen and P.O. Kettunen. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 100-012 [in English]. PHOTOCOPY ORDER NUMBER: 199403-58-0227.

HVOF

Recent Advances in HVOF-Spraying Using Acetylene and Other Gases. [Original Title: Modernes, Zukunftsweisendes HVOF-Spritzen mit Acetylen und Anderen Betriebsgasen.] The HVOF TOPGUN-system is described. The system can be operated by all fuel gases, e.g., propane, propylene, hydrogen, mappgas, and for high-melting point spray materials using acetylene-oxygen. The patented gas mixing block guaranties the premixing of this combination before the combustion process takes place. The high-pressure development inside the combustion section of the gun at increasing flame temperatures propels the coaxially introduced fine powder particles at supersonic speed onto the substrate surface. This effect results into superior coating quality providing higher hardness, roughness, density, and bond strength. Typical materials for wear and corrosion-resistant coatings are hard metals, oxides, self-fluxing alloys, steel 316, tantalum, superalloys, etc., utilized by TOPGUN process.

E. Huhne, D. Grasme, R. Kroschel, and E. Schwarz. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 47-52 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0224.

High Velocity Oxy Fuel Spraying of Nickel Based Hard Facing Pre-Alloyed Powders. Hardfacing alloys are basically of two types—nickel-base and cobalt-base—and have a unique application in the field of reclaiming machine components. These prealloyed powders contain varying amount of chromium, iron, silicon, and boron to impart different hardness levels to the sprayed coatings. The presence of Si and B forms the low melting point intermetallic phases in the sprayed deposit during fusing. This makes the coating dense and pore free. The conventional method to obtain these coatings comprises two steps, first to spray and then to fuse. The high velocity oxyfuel spraying system allows both spraying and fusing operations simultaneously. This article discusses the results obtained by spraying these powders by both techniques. An attempt has been made to develop structure-property corelationship by evaluating the mechanical and metallurgical properties of these coatings. The coatings have been characterized.

D.A. Karandikar and S.C. Modi. Cited: Conference: Advances in Materials and Processes, Bombay, India, 16-19 Feb 1992, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, India, 1993, p 59-73 [in English]. PHOTOCOPY ORDER NUMBER: 199403-58-0213.

Impact Fusion

Further Developments on the HVIF Process. HVIF (hypervelocity impact fusion) equipment is described. The equipment was designed primarily for spraying powder. The same apparatus can be used to spray wire. Although wire spraying is not an impact fusion process, extremely dense coatings are achieved. However, the oxide content remains high. Examples of 316SS coatings on steel substrate and copper sprayed coatings are shown.

J.A. Browning. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 52-54 [in English]. PHOTOCOPY ORDER NUMBER: 199403-58-0225.

PTA

PTA Surfacing of Nickel Aluminide Powders. The PTA surfacing process was studied with the objective to reach high degree of γ' in the outer layer without obtaining high temperature cracks. The study confirmed the unique mechanical properties of Ni_3Al alloys on low carbon steel also when these alloys were PTA-surfaced. To meet the requirements of a high quality PTA-surfaced coating of nickel aluminide the following must be accomplished: a buffer layer must be surfaced between the substrate and the nickel aluminide; preheating of the buffer layer to ~300 °C; avoid geometries that result in tensile stresses in the coating; and the PTA-parameters have to be carefully optimized.

H. Hallen and C. Herrstrom. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 167-170 [in English]. PHOTOCOPY ORDER NUMBER: 199403-58-0231.

RF Plasma

Melting of Powder by High-Frequency Plasma. [Original Title: Schmelzen von Pulver im Hochfrequenz-Plasma.] The inductively coupled plasma with its advantages, like the large volume, the small flow and particle velocities and therefore the long residence times of particles at the plasma, can be used for the melting and deposition of different materials with high melting points. A simple model for the heating of powders is described and its results are compared with experimental results for plasma spraying of Al_2O_3, SiO_2, nickel and tungsten powders. The possibilities of the use of high-frequency plasmas are discussed.

G. Nutsch and W. Rother. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 239-244 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0240.

Single Wire Vacuum Arc Spraying

A New Spraying Process: Single Wire Vacuum Arc Spraying. [Original Title: Ein Neues Spritzverfahren: Eindraht-Vakuum-Lichtbogenspritzen.] Reactive materials such as titanium and tantalum are not suitable to be manufactured to pure and corrosion resistant layers by atmospheric spraying processes. Up to now this is only possible by vacuum plasma spraying. However, due to the large specific surface of the used powder, oxygen, and

nitrogen are already adsorbed on them in large amounts and will be included in the layer. Therefore, often an unsatisfactory corrosion behavior occurs. The above-mentioned disadvantages of the powder processing vacuum plasma spraying are avoided by using the vacuum arc spraying with a single wire. The spraying material is a cathodic poled wire which is contactlessly led through a nonconsumable water cooled, nozzle. The wire is melted by a high frequency ignited arc burning between the wire and the nozzle. Furthermore, the process gas (argon) effects the atomization of the wire and accelerates the particles onto the component to be coated. The process parameters strongly influence the stability of the process and the resulting microstructure of the deposition.

H.-D. Steffens, M. Wewel, and K. Nassenstein. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 234-237 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0238.

Process Optimization

Examination into the Coating Efficiency. Original Title: [Untersuchungen zum Spritzwirkungsgrad.] The OSU Super Jet System (SJS) is a high speed flame spray system. It can operate with acetylene, hydrogen propane and other liquid gases. A special system makes it possible to regulate the flame temperature, the gas speed and the chemical composition of the combustion atmosphere largely independent with each other. Therefore the Super Jet System is able to produce metallic (e.g. bronzes, copper, nickel alloys, Cr-Mo steels), hard metallic (e.g., WC-Co), and ceramic (e.g., TiO_2, Al_2O_3, $Al_2O_3 + TiO_2$, Cr_2O_3) coatings of high quality. The existence of an optimal powder transport rate is being deduced from the knowledge about the physical mechanism of the heating and the acceleration of powder particles in the hot gas flow. The adhesion rate is used as an example for demonstrating how to optimize the transport rate and for showing that this method can also be used in order to optimize the burner regulation. The adhesion rate and the spraying capacity from the SJS are compared with those of plasma spraying plants.

G. Matthaus and W. Rother. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 269-273 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0244.

Process Simulation

Process Simulation of HVOF-Thermal Spraying Systems. [Original Title: Prozess-Simulation von HVOF-Spritzverfahren.] The optimization process of spraying parameters and systems for new spraying technologies and innovative applications requires extensive experimental efforts. The knowledge of the interdependencies between spraying parameters and final coating qualities is a necessity for the optimization of composite materials. A fundamental understanding of the influence of these parameters is essential to progress also in the field of HVOF-thermal spraying, and process simulation shows promising results. Simulation of parameters for JET KOTE HVOF spraying of WC-Co 88/12 coatings is used to illustrate the principles discussed.

O. Knotek and U. Schnaut. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 138-142 [in German]. PHOTOCOPY ORDER NUMBER: 199403-57-0296.

Processing

Arc Spraying

Combination of Arc-Spraying and Shot-Peening in a Closed Loop Inert Gas System. [Original Title: Kombination von Lichtbogenspritzen und Kugelstrahlen im Geschlossenen Schutzgaskreislauf.] Results of research activities in the field of thermal spraying of CrNi steel 1.4301 corrosion protective layers on St37-2 are reported. A very versatile technique for improving thermally sprayed coatings consists in shot peening. An increase in efficiency can be achieved when shot peening is carried out simultaneously to the thermal spraying. The advantages are: minimizing the porosity, optimizing the particle interfaces, reducing of the surface roughness, inducing of compressive residual stresses, and increasing of the adhesion between substrate and layer. Exposure testing of these compounds in corrosive media showed that the lifetime of the sprayed and peened specimen was three times greater than that of conventionally produced layers. Nevertheless, during the spraying process the reaction of the molten metal with the atmospheric environment leads to the formation of oxides in the layers. These oxidic particles decrease the corrosion resistance of the protective layers. The benefit of the sprayed coatings can be additionally increased by spraying in inert gas (i.e. argon) atmosphere. Due to the lack of reactive gases, the oxide contents of the layers are significantly reduced leading to an improved corrosion behavior of the coatings.

H.-D. Steffens, W. Brandl, and R. Podleschny. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 375-378 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0258.

D-Gun

Preparation, Structure and Wear Properties of Detonation Gun Sprayed WC and Cr_3C_2 Based Cermet Coatings. It is shown that the abrasion wear resistance of detonation gun sprayed WC and Cr_3C_2-based cermet coatings is a complex function of several parameters including the type and composition of the starting powder and the spray parameters used in preparation of the coatings. The results showed that WC + 12% Co coatings with highest abrasive wear resistance were obtained when sintered and spherical powders with a small carbide size were sprayed with a correct gas composition. The microhardness of the coatings did not correlate with the abrasion wear. On the other hand, the phase structure and low porosity seemed to correlate better with the abrasion wear of WC and Cr_3C_2-based coatings. Optimized detonation gun sprayed coatings showed similar wear rates as corresponding HVOF sprayed coatings. The erosion tests carried out with high-particle velocities did not show such a high improvement in wear performance as was observed in rubber wheel abrasion wear tests.

P. Vuoristo, K. Niemi, A. Makela, and T. Mantyla. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 310-313 [in English]. PHOTOCOPY ORDER NUMBER: 199403-58-0246.

Diamond Coatings

Synthesis of Crystalline Diamond Coatings by the dc-Plasma Jet CVD Process. [Original Title: Synthese von Kristallinen Diamantschichten mit Hilfe des Vakuumplasmaspritzens.] The dc-plasma jet CVD process was used in order to synthesis diamond coatings of WC-Co cutting tools and tungsten surfaces. The relationships between the substrate materials, the methane concentration and the substrate temperatures are discussed. Another point of interest is the influence of a mechanical or chemical pretreatment to the nucleation density of the diamond coatings. Dense and 80 μm thick diamond coatings were obtained.

E. Lugscheider, U. Muller, F. Deuerler, and W. Schlump. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 19-22 [in German]. PHOTOCOPY ORDER NUMBER: 199403-57-0288.

HVOF

Characterization and Applications of HVOF-Coatings. [Original Title: Charakterisierung und Anwendung von HVOF-Schichten.] The quality and applicability of HVOF-coatings for wear and corrosion protection depend on their structure and layer properties. Thus it is of great importance for adaption of products to know these properties and the possibilities of their variation. After a short description of specific process advantages, the HVOF-coatings (WC-Co, Hastelloy C4, Stellite 21) are characterized through micrography, and the influence of process parameters, especially of powder characteristics, is discussed. Some examples show the application possibilities. These include reconditioning of machinery used in the paper industry and protection of turbopump and diesel engine components.

R. Altheimer. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 273-276 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0245.

Laser Technique

FeCrAlY Coatings Deposited by Laser Technique for Applications in Gasification Plants. The corrosion behavior of FeCrAlY coatings applied on AISI 310 by both laser cladding (LC) and vacuum plasma spray (VPS) in simulated atmospheres relevant to coal gasification plants are evaluated. The results obtained allow the following conclusions to be drawn: the good corrosion behaviors in simulated coal gasification atmospheres (CGA) at 700 °C of

Fe-Cr-Al-Y claddings and coatings make them suitable for their utilization on components of coal gasification plants; the presence of coal chars has a moderate detrimental effect on the corrosion behaviors of Fe-Cr-Al-Y coatings, and the corrosion of the laser claddings initiates in the proximity of yttria particles that act as preferential sites for subsequent sulfidation of the coating. Thus sulfidation might be avoided by simply removing some surface layers of the coating before exposing it to the environment.

G.P. Mor, F. Uberti, M. Bracchetti, D. D'Angelo, and G.P. Toledo. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 418-420 [in English]. PHOTOCOPY ORDER NUMBER: 199403-58-0268.

Nanocrystalline

Nanocrystalline Vacuum-Plasma-Sprayed Coatings. [Original Title: Nanokristalline Vakuum-Plasma-Spritzschichten.] Nanocrystalline materials can offer superior technological properties such as high hardness and strength combined with higher ductility compared to conventional materials. Vacuum plasma spraying of nanocrystalline powders produced by mechanical alloying is a suitable compacting method resulting in dense coatings or free-standing parts. Chemical composition and the reaction kinetics in the alloy system influence the grain structure in the sprayed coatings. Different iron- and cobalt-base composites were investigated. In contrast to the very resembling spray structures of the coatings, TEM-analyses reveal totally different microstructures, which are used to explain the striking differences in wear behavior after taber-abraser testing. For the best nanocrystalline alloy of the Fe-TiC system, results of different wear testing procedures are presented.)

D.A. Jager, J. Willbrand, and W. Schlump. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 15-18 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0218.

PTA

Factorial Analysis Applied to the PTA Process. The influence of process parameters on PTA deposits of Stellite 6 on mild steel bars was studied. Based on a study of 16 welds, a quarter factorial design has been carried out. It was shown that current and plasma gas have the greatest effect on the dilution and hardness. For the geometry of the deposit, the weld speed was also an important factor.

C. Herrstrom, H. Hallen, A. Ait-Mekideche, and E. Lugscheider. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 409-412 [in English]. PHOTOCOPY ORDER NUMBER: 199403-58-0266.

Plasma-Dual-Powder Weld Surfacing (PZPS) with Powdered Oxide Ceramic Alloys. [Original Title: Plasma-Zweipulver-Auftrag-(PZPA-) Schweissen mit Oxidkeramischen Pulverlegierungen.] The progressively more stringent demands that result from the continuing development of new technology necessitate the use of ceramic materials, especially if tribological, corrosive, and thermal exposure are combined. A further development of the plasma-powder weld surfacing (PPS) method is described; with this technique, two welding powders can be applied in a single manufacturing step. It is thus possible to apply ceramic powders not only by plasma spraying, but also by a welding technique. The two methods complement one another very well, since plasma spraying is applicable up to a required cladding thickness of 500 μm, whereas the PZPS technique is applicable >500 μm.

U. Draugelates, B. Bouaifi, and D. Sommer. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 406-408 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0265.

PTA-Surfacing of Particle Reinforced Hard Alloys Using Composite Powders. [Original Title: PTA-Beschichtungen mit Hartstoffzusatzen im Mikrometer-Bereich Mittels Verbundpulverkonzept.] The possibility of adding different carbide hard phases and the subsequent improvement of the properties of hard alloys is realized by the use of composite powders. Hard phase hard alloy composite powders can be produced by using hard phase material <1 μm. Such powders can be deposited as a coating by plasma transferred arc welding (PTA). Interactions between the composite powder and the welding process were studied. The investigations also included coating comparisons from conventional hard alloy powders to those of the hard phase hard alloy composite powders.

E. Lugscheider, A. Melzer, and A. Ait-Mekideche. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 401-406 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0264.

Plasma Coating with a Pulsed Arc. [Original Title: Plasmabeschichten mit Gepulstem Lichtobogen.] The introduction of pulsed-arc power-input control into PTA buildup welding involves the input of a square-wave current with steep pulses with high rates of current change between the pulse current, which fuses the coating material, and the pause current, which cools and solidifies the weld pool. Tests with a transistorized power source demonstrated the effects of variations in the pulse parameters, their interrelationships, the range of adjustability of the current-time configuration, and the influence of these variations on WC-Co coating quality. Use of the pulsed-arc technique improves weld-pool formation and solidification, producing better mechanical and technological coating properties. Its combination with thermal spraying or laser-beam processing results in a more homogeneous microstructure, reduced porosity and improved coating/substrate adhesion. The low mean-current range of 0 to 200 A enables small-geometry components to be coated efficiently with low power consumption.

J. Fromowicz, A. Ait-Mekideche, and E. Lugscheider. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 394-398 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0262.

Review

Plasma Spraying of the Powder Materials by Means of Air Plasma. Following a brief account of the development of plasma spraying techniques in the USSR, the CIS and, in particular, at St. Petersburg Technical University, the principles and advantages of APS are discussed. High-quality, low-cost APS coatings of metallic (e.g., Ni-Cr-B-Si) and metallo-(e.g., Al_2O_3, TiO_2, Cr_2O_3) powders are characterized by high hardnesses (7 to 19 MPa), relatively low porosities (2 to 8%), and good adhesion strengths (≤35 MPa) and thus are somewhat superior to those produced from argon plasma. Details are reported of the PP-40N industrial APS installation developed by Vereingung Polyplasma in collaboration with St. Petersburg Technical University and other industrial concerns. Applications of APS coatings embrace strengthening of machine and engine components and their protection against wear and corrosion.

V.S. Klubnikin and G. Petrov. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 237-239 [in English]. PHOTOCOPY ORDER NUMBER: 199403-58-0239.

Status of Thermal Spraying in the Aircraft Industry—Trends in Applications and Automated Production Plants. [Original Title: Bedeutung der Thermischen Spritztechnik in der Luftfahrtindustrie—Applikationen—Automatisierte Produktionsanlagen—Trends.] Although the economic and ecological requirements for new developments in aeroengines have not changed for decades, they are constantly being expanded and reformulated. Because titanium and modern superalloys are unable, at one and the same time, to meet the multifarious material requirements and to provide the longest service lives possible, the functional surfaces of highly stressed engine components are protected by thermal spraying. The coatings thus applied to static and rotating aeroengine components for protection against wear and fretting, thermal stressing, hot-gas corrosion, and for repair purposes are comprehensively reviewed. The steady advance toward fully automated thermal-spraying plants and trends in technological development, e.g., plasma torches with axial powder injection and high-speed water-jet removal of coatings, are discussed briefly.

K.D. Borbeck, S. Keller, and K. Reinecken. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 57-61 [in German]. PHOTOCOPY ORDER NUMBER: 199403-61-0278.

General

Thermal Spray Coatings. Thermal spray coatings are surface coatings engineered to provide wear-, erosion-, abrasion-, and corrosion-resistant coatings for original equipment manufacture and for the repair and upgrading of in-service equipment. An overview of flame spraying, arc spraying, and plasma spraying processes is given. The selection of thermally sprayed coatings to preserve the integrity of steels and typical process parameters are described.

H. Herman and R.A. Sulit. Cited: *ASM Handbook*, Vol 6, *Welding, Brazing, and Soldering*, 1993, p 1004-1009 [in English]. PHOTOCOPY ORDER NUMBER: 199402-55-0261.

Spray Parameters

Deposition Efficiency

Effects of Powder Characteristics and Plasma Spray Equipment on Deposition Efficiency of Y_2O_3 (8%)-ZrO_2 Powder. The paper attempts to describe how the equipment and powder parameters affect the deposition efficiency of 7 to 9% Y_2O_3/ZrO_2 plasma sprayed coatings. All the factors studied were found to have an impact on deposition efficiencies. The maximum observed variation on deposition efficiency from these factors is as follows: powder type 62%; particles size 51%; gun type and set-up 49%; and nozzle 22%. A sintered and crushed powder with low fines is described by the equation: DE = 1.38 (10% finer than) + 3.77 where DE = deposition efficiently gives the best deposition efficiency. More work is required to better define what affects deposition efficiency variation.

J.A. Kaniuk, G.A. Graves, B. Neimeier, and H.H. Zender. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 90-92 [in German]. PHOTOCOPY ORDER NUMBER: 199403-57-0291.

Surface Preparation

Investigation of the Effect of Peening on the Corrosion Behavior of Flame and Electric Arc Sprayed Chromium Nickel Steel Coatings. The effect of peening on the corrosion behavior of chromium nickel sprayed steel (X5CrNi18 9) coatings applied to St 37-2 will be investigated. A system will be employed for the production of sprayed coatings that makes possible simultaneous spraying and compaction. The results of aging coated components in moisturized atmosphere containing sulfur dioxide as well as in artificial seawater, are presented in addition to the results of current density measurements of potential. Further, the structural composition, porosity content, adhesive tensile strength, and state of residual stresses will be presented.

H.-D. Steffens, W. Brandl, and R. Podleschny. Cited: Schweissen und Schneiden, Vol 43 (No. 6), June 1991, p E131-E134 [in English]. ISSN: 0036-7184. PHOTOCOPY ORDER NUMBER: 199403-58-0340.

Waterjet

Removal of Thermal-Spray Coatings by Ultrahigh-Pressure Waterjets. [Original Title: Abtragen von Thermischen Spritzschichten mit Ultrahochdruckwasserstrahlen.] The process of thermal-spray coating removal by ultrahigh-pressure waterjet is described. Various coatings (NiCrAlY, CoCrNiW, Al-Si, NiAl, WC-Co, CrC-Ni-Cr) were removed by ultrahigh-pressure waterjet (3800 bar). The influence of various parameters (pressure, flow rate) on the removal rates was studied. The process is compared with conventional methods for thermal-spray removal.

A. Borchert. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 228-230 [in German]. PHOTOCOPY ORDER NUMBER: 199403-57-0300.

Testing

Acoustic Emission

On-Line Quality Control in Thermal Spraying using Sound Emission Analysis. [Original Title: On-Line-Qualitatskontrolle Beim Thermischen Spritzen Mittels Schallemissionsanalyse.] Acoustic emission analysis was being used for quality-control purposes of thermal sprayed coatings in order to gain detailed knowledge of the particle formation while on-line spraying. Through acoustic monitoring it has become possible to receive information on the amount of particles in the spraying stream and on the physical features like mass, velocity, and viscosity of single particles. The results of a secondary examination of the particle velocity and particle diameter are in good correlation with the acoustic investigations. In this way it has become possible to use the acoustic emission analysis as an additional method for the regulation of the process parameters.

H.-A. Crostack, G. Reuss, T. Gath, and M. Dvorak. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 208-211 [in German]. PHOTOCOPY ORDER NUMBER: 199403-22-0267.

Adhesion

Study of a Non-Destructive Method to Evaluate Adhesion of Thermal Sprayed Coatings. The detection of peeling (or delamination) and the measurement of adhesion of NiCr sprayed coatings on mild steel by an ultrasonic method were investigated. The main results are summarized as follows. The peeling, or delamination, of sprayed coatings can be inspected by the ultrasonic method, especially by detecting the bottom echo, B_c. The bottom echo height B_c has a tendency to increase with an increasing adhesion strength. Image displaying methods, that is a two-dimensional scanning graph or a color display, by which the location and shape of peeling and adhesion distribution are able to be visualized, were constructed. An ultrasonic testing method for evaluating the adhesion of sprayed coatings was proposed. The effect of coating thickness on echo height was analyzed and two formulas to correct the ultrasonic data were proposed. Using these formulas, good correlation between the ultrasonic testing data and the adhesion strength data by tensile test was obtained. As a result, it is made clear that the nondestructive ultrasonic method can be applied to the evaluation of adhesion of sprayed coating on a substrate.

Y. Suga, H. Makabe, and K. Makabe. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 201-204 [in English]. PHOTOCOPY ORDER NUMBER: 199403-22-0266.

Microstructure

Preparation and Characterization of Thermal Sprayed Coatings. [Original Title: Praparation und Auswertung Thermisch Gespritzter Schichten.] In contrast to compact materials, nondestructive methods of assessment cannot be applied to thermally sprayed coatings in view of their inhomogeneous structure, due to, inter alia, superimposed or mixed materials, cracks and pores, oxides, etc. Thus destructive ground-section assessment is the only alternative. The criteria that can lead to errors and misinterpretations, i.e., in section preparation (parting, handling, mounting, grinding and polishing, cleaning, and etching), microscopic examination, and assessment, are identified, and the requisite precautions are described. Optical-contrast methods of microscopic examination are recommended, involving (i) sections impregnated with fluorescing mounting material and fluorescence filters, (ii) differential-interference contrast, (iii) darkfield observation, and (iv) polarized light. Examples of WC/Co, NiAl, NiCr6S, and Cr_2O_3 coatings on steel are used to illustrate the concepts discussed.

E. Leistner. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 127-132 [in German]. PHOTOCOPY ORDER NUMBER: 199403-21-0059.

Residual Stresses

X-Ray Diffraction Examinations of Plasma Sprayed Coatings of Turbine Blades. [Original Title: Rontgenographische Untersuchungen an Plasmagespritzten Warmedammschichten von Turbinenschaufeln.] Due to optimizing plasma sprayed thermal barrier coating of turbine blades, the phase composition, and residual stress state of the yttria partially stabilized ZrO_2 coatings were analyzed by means of x-ray diffraction method. The cooling conditions and thermal shock test are described and correlated with phase compositions and residual stresses. Changes induced by thermal shock test are described and discussed.

U. Selvadurai-Lass and H.-A. Crostack. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 318-321 [in German]. PHOTOCOPY ORDER NUMBER: 199403-57-0307.

Sampling Procedure

Application of Miniature Sample Handling System SSam-2 for Investigations on Coated Components. [Original Title: Anwendung des Miniatur-Probeentnahmesystems SSam-2 fur die Untersuchung von Beschichteten Komponenten.] The operation of the miniature surface sampling system SSam-2, used to obtain samples for microstructural analysis, is described. For examination of thermally sprayed coatings on large or poorly accessible components, this sampling system had the following advantages: The thermal and flow properties of the original part will be preserved, which is

often important when dealing with thermally sprayed coatings. The samples removed do not measure >0.8 to 2.5 mm (0.03 to 0.10 in.) thick by 13 to 25 mm (0.5 to 1.0 in.) in diameter. Damage done to the surface of the examined components can be left without repair in many cases. The system allows remote sampling and will work in places otherwise not accessible. By selecting as examples the chromium carbide/nickel-chrome and chromium oxide coatings, it is shown that this sampling system can be used for examination of coated components. As the hemispheric cutter shell is coated with boron nitride, samples can be taken from ceramic oxide as well as from carbidic coatings, without causing cracking or coating separations.

A. McMinn, E. Marshall, H. Krings, and C. Verpoort. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 196-198 [in German]. PHOTOCOPY ORDER NUMBER: 199403-22-0264.

Thermal Barrier Coatings

Testing of Failure Level of Thermal Sprayed Barrier Coatings in Static and Vibrating Bending Stress. [Original Title: Untersuchungen zum Schadigungsverhalten von Thermisch Gespritzten Warmedammschichten bei Statischer und Schwingender Biegebelastung.] Thermal sprayed barrier-coatings are often used in mechanical engine and turbine constructions. In order to detect coating defects due to the manufacturing process or caused by mechanical load, the required testing methods and the critical failure level have to be determined. The paper shows research results that give evidence of the failure behavior of yttria-stabilized ZrO_2 and NiCrAl coatings on GG20, AlSi12, and Inconel 618 substrates, and the failure procedure using destructive and nondestructive testing methods is covered.

H.-A. Crostack and U. Beller. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 196-198 [in German]. PHOTOCOPY ORDER NUMBER: 199403-22-0263

Thermal Barrier

Oxygen Sensitivity

Influence of Oxygen in MeCrAlY-Layers on Durability of Thermal Barrier Coatings. The influence of the oxygen content in the NiCoCAl(Si)Y layers on Ni-base superalloy C61L and Ni20Cr3Al substrates on their resistance to high temperature oxidation and durability of the top zirconia coatings was investigated. It was ascertained that dissolved O, being the source of the coating structure defects, accelerates the diffusion processes in the coatings and thus increases the rate of material oxidation. The continuous silicon oxide films, on the contrary, are the diffusion barriers. There presence has positive influence on the metallic coating oxidation resistance and top ceramic layer thermal shock lifetime.

A. Verstak, A. Ilyuschenko, N. Paschenko, and S. Sobolevsky. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 330-333 [in English]. PHOTOCOPY ORDER NUMBER: 199403-58-0249.

Thermal Spraying Conference

TS93: Thermal Spraying Conference. [Original Title: Thermische Spritzkonferenz.]118 papers selected and abstracted. 45 papers are in English.

Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993 [in German]. ISSN: 3-87155-457-X. PHOTOCOPY ORDER NUMBER: 199403-72-0236.

Torch

Nozzle Geometry

Influence of Nozzle Geometry on Particle Behaviour and Coating Quality in High-Velocity VPS. [Original Title: Einfluss der Dusenkontur Beim Hochgeschwindigkeits-Vakuumplasmaspritzen auf Partikelverhalten und Schichtqualitat.] Laval nozzle heads with different Mach numbers were designed for a VPS torch, where the powder injection takes place within the nozzles. By means of mobile, automated Laser Doppler Anemometry equipment, the behavior of the spray particles within the plasma jets using these nozzles was investigated. The results are compared with those obtained applying standard nozzles. Al_2O_3 with a grain size fraction of –22.5 +5.6 μm served as common test powder. With the new configurations, much higher particle velocities and denser coatings are obtained and the torch power required for spray material melting can be considerably reduced.

R. Henne, W. Mayr, and A. Reusch. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 7-11 [in German]. PHOTOCOPY ORDER NUMBER: 199403-57-0287.

Wear

Alumina

Wear Behaviour of Alumina Plasma-Sprayed Coating on an Al-Cu Alloy. Aluminum oxide was plasma sprayed on the surface of Al-4Cu alloy substrate. The morphology of the coating was studied thoroughly using optical and scanning electron microscopy. The abrasive wear behavior of the alumina coating was examined using the disk on disk method (Taber abraser). The wear rate of the coating was higher at the beginning of the wear tests and depended on the applied load. A linear relationship was observed between the wear rate and the initial surface roughness of the coating.

A. Koutsomichalis, C. Panagopoulos, and H. Badekas. Cited: *Mater. Lett.*, Vol 18 (No. 1-2), Nov 1993, p 19-24 [in English]. ISSN: 0167-577X. PHOTOCOPY ORDER NUMBER: 199402-57-0194.

Aluminum Substrates

Advanced Coatings for Light Metal Structures. [Original Title: Beschichtungen fur Leichtmetalle und -Legierungen.] The EWISCO-research group, consisting of two German, one Ukrainian and one Byelorussian research institutes, is working intensively on the development of wear resistant coatings for aluminum and its alloys. A wide variety of coatings including ceramic (Al_2O_3, Fe_2O_3, TiO_2), cermet (Al/AlN, Al/AlTi), TiC/SiC reinforced and composite (Al/TiC, Al/SiC) have been studied. This research is carried out in close cooperation with United Technologies Corp. in order to improve the wear and sliding behavior of these light metal alloys, and to broaden its application in industry. The first step has focused mainly on the improvement of the wear properties. Furthermore, self-lubricating properties should be propagated by special additions.

E. Lugscheider, P. Jokiel, K. Yushchenko, Y. Borisov, P. Vityaz, A. Verstak, S. Steinhauser, and G. Schmidt. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 215-217 [in German]. PHOTOCOPY ORDER NUMBER: 199403-57-0299.

Borides

The Wear Resistance of Coatings from Tauboride TiC Powders. The adhesive and abrasive wear resistance properties of TiC (NiCr)- tauboride alloy VPS coatings are investigated. The initial powders were agglomerated with an organic binder or mechanically mixed. Mechanically mixer powders plated with NiCr or nonplated titanium carbide powders was used. The coatings containing 10% of titanium carbide have the lowest adhesive interaction. The growth of TiC content from 10 to 50% vol% in the coatings leads to an increase of their adhesive ability. The coatings with 50 vol% of plated TiC show the biggest resistance to abrasive wear. The TiC particles plated with NiCr lead to higher bond strength between the particles in the coatings. It is the reason why such materials have better wear resistance properties compared to sprayed from mechanically mixed or from agglomerated powder coatings. All the coating properties increase substantially when glass phase powders are added to the powder mixture for spraying.

V. Kot, P. Vityaz, S. Steinhauser, E. Lugscheider, and G. Pursche. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 337-342 [in English]. PHOTOCOPY ORDER NUMBER: 199403-58-0251.

Plasma Spraying of Tauboride Alloy Reinforced by TiC Particles. The results of plasma coatings processing from NiCrBTi tauborides contained alloy with adding of 5 to 35 wt% of TiC particles are presented. The coatings were plasma sprayed in air, vacuum or underwater. The tauboride alloy and titanium carbide phase content changing during spraying, the spraying pa-

rameters influence on the coating porosity, hardness and microstructure as well as the coatings abrasive wear resistance are analyzed.

P. Vityaz, A. Verstak, S. Sobolevsky, E. Lugscheider, P. Jokiel, K. Yshchenko, and G. Pursche. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 36-40 [in English]. PHOTOCOPY ORDER NUMBER: 199403-58-0221.

Flame Spraying of τ-Boride Wear Protective Coatings. [Original Title: Flammgespritzte τ-Borid-Verschleiss-Schutzschichten.] Due to their high hardness and relatively high ductility, τ-boride alloys of the Ni-Cr-B-Ti (τ-boride) system are eminently suitable for wear-resistant coatings and have been applied using plasma-spraying processes. Their deposition by the cheaper oxyacetylene and argon-shielded flame-spraying techniques is described, with particular emphasis on the adequate melting of the particles and the resultant microstructures, bonding stabilities and wear resistances, and on the effects of oxygen on the coating characteristics. The results of tests using both coarse- (63 to 106 μm) and fine-grained (<63 μm) powders with varied spraying parameters are reported and discussed. These coatings showed wear resistances analogous to their plasma-sprayed counterparts and good bonding stability, despite their generally higher porosity. The Ar shielded flame-sprayed coatings showed an extremely high abrasion resistance, but a more marked tendency toward incomplete melting of the particles.

G. Schmidt, A. Rothe, and K.-H. Weichbrodt. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 203-296 [in German]. PHOTOCOPY ORDER NUMBER: 199403-57-0303.

Carbide Coatings

Plasma Sprayed Carbides and Nitrides for Tribological Applications. Plasma sprayed coatings including three carbides NbC, TaC, TiC, and one nitride, titanium nitride, were examined. The different topics were: to optimize the spraying parameters and the kind of powder (sintered or spray-dried); to make a correlation between the wear resistance, the friction coefficient, and the structure and morphology of the different coating materials; and to compare to the behavior of a classical wear resistance coating such as WC/Co. It was found that low-pressure plasma spraying allows low decarburization of denitridation of materials without oxidation. Porosity is quite important but allows a good friction behavior. Coatings show a very low wear rate against steel or alumina. For NbC and TiC, the very weak wear rate is correlated to a low friction coefficient: 0.12 (NbC) and 0.20 (TiC) against alumina pin.

L. Buisson, P. Juliet, and Th. Priem. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 434-437 [in English]. PHOTOCOPY ORDER NUMBER: 199403-57-0313.

Carbides and Nitrides

Plasma Spraying of Special Ceramic Materials Based on Boron Carbide and Zirconium Nitride. [Original Title: Plasmaspritzen von Sonderkeramischen Werkstoffen auf Borcarbid-bzw. Zirkonnitrid-Basis.] Despite the extreme hardness of boron carbide and zirconium nitride, plasma-sprayed coatings of these materials on combustion-engine components, for example, have shown unsatisfactory wear resistance, due mainly to their brittleness; therefore, the effects of adding oxides of aluminum, chromium, and titanium to the matrix materials have been investigated. Discussion of the results of metallurgical examinations and wear tests on the plasma-sprayed coatings obtained reveals the essential requirements for extremely thorough mixing of the powder components to attain suitable grain-size distribution and very careful predetermination of the injection conditions and high-energy plasma-spraying parameters. These multifunctional, reliable coatings show a wear and friction behavior superior to that of conventional oxide ceramic materials.

E. Lugscheider, R. Limbach, P. Pantucek, and J.P. Celis. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 249-252 [in German]. PHOTOCOPY ORDER NUMBER: 199403-57-0301.

Chromia Coatings

Wear Resistance of Plasma Sprayed Cr_2O_3 Coatings. [Original Title: Verschleisswiderstand Plasmagespritzter Cr_2O_3-Schichten.] The application of the plasma sprayed Cr_2O_3 coatings on the functional surface of components to increase their wear resistance is discussed. The suggested methods for testing and experimental equipment used for determination of the wear resistance are described. The Cr_2O_3 coatings were tested using stationary and rotational tubes made of various materials, e.g., low carbon steel, stainless steel, aluminum bronze, gray cast iron, and Cr_2O_3 coating. The conditions used for the testing were as follows: circumferential speed v = 14.8 m/min, and axial pressure p = 0.14 MPa. The criteria of the wear were the decrease of weight in all used materials in grams and a coefficient of friction (μ) between various pairs of selected materials.

O. Ambroz and P. Dobes. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 222-224 [in German]. PHOTOCOPY ORDER NUMBER: 199403-31-1222.

Cr-Si-C System

Wear-Resistant Plasma Coatings of the Cr-Si-C System. Application of exothermic reaction of silicon carbide with Cr for the process of plasma spraying of composite powder Cr-Si-C allows one to produce Cr base carbosilicide coatings that contain chromium carbosilicide and chromium carbides. Adhesion strength of the coatings with steel reaches 46 MPa, porosity is 3 to 5%. Wear resistance of the coatings was studied in abrasive-oil environment, under sliding and reversal friction conditions, and under vibration, with and without lubrication, as was heat resistance over the 400 to 1000 °C temperature interval. These coatings are 10 to 12 times more resistant in abrasive-oil environment than the molybdenum plasma ones at the low friction coefficient and at the low wear of a counterbody (steel). The coatings process sufficiently high heat resistance at temperatures up to 900 °C.

Y. Borisov, A. Borisova, and I. Mits. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 350-354 [in German]. PHOTOCOPY ORDER NUMBER: 199403-57-0309.

D-Gun Coatings

Abrasion Wear Resistance of Detonation Gun Sprayed Carbide Coatings. The effect of starting powder and deposition conditions on the properties of WC and Cr_3C_2-based cermet coatings prepared by detonation gun spraying was studied. Abrasion wear resistance of the coatings was optimized by varying the type of fuel gas, fuel gas-to-oxygen ratio, amount of diluent gas and other equipment parameters. The properties including microstructure, phase structure, microhardness, sand abrasion wear, and particle erosion wear of the coatings were evaluated. The results showed significant variations in wear properties of the coatings depending on the parameters used. The most important parameters were the gas composition and the type and composition of the starting powder. The properties of the optimized coatings are compared with corresponding coatings prepared by HVOF and plasma spraying.

P. Vuoristo, K. Niemi, A. Makela, and T. Mantyla. Cited: Conference: 7th International Metallurgy and Materials Congress, Vol II, Ankara, Turkey, 4-8 May 1993, UCTEA (Union of Chambers of Turkish Engineers and Architects), Ankara, Turkey, 1993, p 1295-1302 [in English]. PHOTOCOPY ORDER NUMBER: 199402-57-0183.

Engine Coatings

Wear Behaviour of Plasma Sprayed Ceramic Coatings: Laboratory Ball-on-Disk Testing. Research is described that is part of a wider program to systematically vary processes and materials, develop an understanding of these variances on the coatings wear behavior, and then to develop advanced coatings systems. The coatings presented were specifically developed for engine applications requiring high wear and good temperature resistance. Different abrasion tests and oscillating tests were performed. The results on pin-on-disk testing and of fretting wear tests are reported. The possibilities of TEM for the characterization of debris are also shown.

S.N. Economou, J.P. Celis, J.R. Roos, E. Lugscheider, and R. Limbach, and R.W. Smith. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 447-449 [in German]. PHOTOCOPY ORDER NUMBER: 199403-57-0315.

Heat Exchangers

Investigation of Wear Mechanisms of Heat Exchanger Tubes under Erosion Conditions. [Original Title: Untersuchung der Verschleissmechanismen an Erosionsbeanspruchten Warmetauscherrohren.] Steam boiler components exposed to incineration fumes are subjected to considerable erosion demands because of fluidized dust and high particle velocities. The erosion conditions can cause high material losses resulting in reduced lifetimes and early repair or replacement of construction components. A protection of components to erosion conditions is essential to minimize maintenance costs and the loss of available production time. It is shown that an

effective protection of steam boiler components exposed to erosion conditions can be achieved by thermally sprayed wear resistant coatings (fused NiCrBSi-type and Cr_3C_2 + NiCr-type, produced by high velocity flame spraying (HVFS)). Erosion measurements were carried out on heat exchanger tubes of a waste heat boiler in a BOF-steel work. Erosion mechanisms were studied under industrial test conditions and in a laboratory erosion test rig. These trials took into consideration uncoated steel specimens and such with coatings of NiCrBSi-type (fused) and Cr_3C_2 + NiCr-type (HVFS). Apart from the erosion rate, the wear mechanisms were studied in detail. By means of SEM methods mechanisms of abrasion and an extrusion forging process (platelet mechanism) were identified. The existence of the extrusion forging process was verified by means of TEM investigations. The experience with coated heat exchanger tubes of a waste heat boiler after two years of operation is also presented.

U. Menne, A. Mohr, M. Bammer, C. Verpoort, K. Ebert, and R. Baumann. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 280-384 [in German]. PHOTOCOPY ORDER NUMBER: 199403-31-1224.

Ni-Cr Coatings

Tribological Performance of Ni-Cr Plasma Sprayed Coatings. [Original Title: Tribologisches Verhalten von Ni-Cr-Plasmaspritzschichten.] On the surface of material samples of case-hardening steel C10 were produced Ni-Cr-coatings by plasma spraying. A few coatings were post-treated with a laser beam or gas flame. The influence of the thermal post-treatment on the tribological behavior is determined using model wear investigations by dry friction. The wear behavior of plasma sprayed coatings is affected by the applied counter body and the type of thermal post-treatment. Metallographic preparations and scanning electron microscopic investigations permitted declarations about the coating composition and the cause of the acting wear mechanism.

I. Haase and R. Franke. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 324-327 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0247.

TiAlX Alloys

VPS-Wear Protection Coatings Made of γ-TiAlX. [Original Title: VPS-Verschleissschutzschichten aus gamma -TiAlX.] By mechanical grinding of γ -TiAl with 2 at.% chromium, respectively, 2 at.% niobium coatings were produced on C45 steel using VPS-technology. These coatings were tested at 550°C on their wear resistance. TiAlNb showed slightly improved properties compared to TiAlCr.

R. Pechloff, B. Friedrich, E. Lugscheider, H. Jungklaus, and P. Jokiel. Cited: Conference: TS93: Thermal Spraying Conference (Thermische Spritzkonferenz), Aachen, Germany, 3-5 March 1993, Deutscher Verlag fur Schweisstechnik DVS-Verlag GmbH, Dusseldorf, 1993, p 385-387 [in German]. PHOTOCOPY ORDER NUMBER: 199403-58-0261.

Photocopies of complete articles are available from the MI Document Service at ASM; please call (216) 338-5151 Ext. 450, for order and price information.