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Title Clearance coatings in lower emission aviation gas turbines: Ytterbium disilicate abradable coatings spraying and combined steam-CMAS performance

Abstract

As efficiency gains are sought within gas turbines through ceramic matrix composites (CMCs), ytterbium disilicate coatings, as both abradable and environmental barriers, are seriously considered to achieve the desired performance. The paper will present a story on plasma spray parameters for developing a range of abradable coatings and their performance in abradable test rigs. It will then present how abradable coatings perform when exposed to steam, molten calcium magnesium alumino-silicates (CMAS) and combined steam and CMAS. Three ytterbium disilicate ($\text{Yb}_2\text{Si}_2\text{O}_7$ or YbDS) abradable EBCs containing 8, 15 and 22 % porosity by area were deposited using atmospheric plasma spraying. These coatings were then exposed to steam, CMAS (35 CaO – 10 MgO – 7 Al₂O₃ – 48 SiO₂ mol. %) and combined steam and CMAS at 1350 °C for 100 hrs. Exposure to steam caused the formation of a thin ytterbium monosilicate (Yb_2SiO_5 or YbMS) reaction layer. Reaction with the CMAS occurred by a dissolution-precipitation mechanism, with a reprecipitated ytterbium disilicate phase and Yb-apatite ($\text{Ca}_2\text{Yb}_8(\text{SiO}_4)_6\text{O}_2$) crystals noted as the only reaction products. After the combined exposure, the CMAS infiltration depth was higher than that observed in the standalone CMAS exposure. Also, an increased amount of Yb-apatite formation was observed within with YbMS reaction layer, and an ytterbium aluminium garnet ($\text{Yb}_3\text{Al}_5\text{O}_{12}$ or YbAG) phase was also observed

Biography

Prof Hussain FASM FIMMM FHEA CEng is a Professor of coating and Surface Engineering at the Faculty of Engineering, University of Nottingham and he holds a prestigious Engineering and Physical Sciences Research Council (EPSRC) Fellowship (£2.1 m) to develop Advanced Coatings for Aerospace Propulsion using artificial intelligence. He is a Co-Director of EPSRC Network Plus IGNITE+ to increase equality, diversity and inclusion in the Energy Sector (£1.25 m) and a Co-Director of the newly launched Centre for Doctoral Training (CDT) in Digital Metal with 4 other UK Universities from the Midlands to train 80 PhD candidates over the next 8 years. He is also one of the founding members of the Marie Skłodowska-Curie Actions Doctoral Training Programme on (Re-MAKE) Refurbishment and Additive Manufacturing Accomplished by Kinetic Deposition with 17 EU partners.

Over the last 20 years, he has built a solid scientific foundation in understanding novel materials processing techniques, especially **thermal spray** and **cold gas dynamic spray**. The process-microstructure-properties relationship is at the heart of his research. His research has directly impacted aerospace, automotive, renewable energy and healthcare sectors. He received a PhD in Materials Engineering from the University of Nottingham in 2010 and a Masters in Manufacturing Engineering and Management in 2007.

He is also recognised worldwide for his suspension and solution precursor thermal spraying to manufacture functional coatings from sub-micron to nanometer range feedstock particles. His team in the EPSRC Fellowship with 20 industrial partners and 7 academic partners are developing new compositions using artificial intelligence and novel processing routes for thermal barrier coatings, environmental barrier coatings, wear-resistant coatings, corrosion-resistant coatings, insulating coatings and functional coatings for electrification.

He is the Director of the Centre of Excellence in Coatings and Surface Engineering at the University of Nottingham, supported by £2.1 m investment from EPSRC and £1 m investment in infrastructure by Propulsion Future Beacon. Total funding since joining the UoN in 2013 is over £17 M (as PI or Co-I). He has published 150 peer-reviewed international journal papers and 2 book chapters on thermal and cold spray research. He has an h-index of 37 with over 4300 citations. He is in the top 2% of cited researchers worldwide for several years, which Stanford University compiled in a database of the top 100,000 scholars.

He is an appointed member of the EPSRC Strategic Advisory Team (SAT) in Manufacturing the Future and Circular Economy and sits on the Special Advisory Group (SAG) on EDI at EPSRC. He is currently an editor of the community's flagship journal, the Journal of the European Ceramic Society, Elsevier and was an Associate Editor for the Journal of Thermal Spray Technology, Springer-Nature, the journal of ASM-Thermal Spray Society (TSS). He also provides input to national and international standards committees as an expert in the BSI STI/40 committee.