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Notice for the PhD Viva Voce Examination

Mr Gowtham Sanjai S (Registration Number: 1670092), PhD scholar at the School of Engineering and Technology, CHRIST (Deemed to be University), Bangalore will defend his PhD thesis at the public viva-voce examination on Tuesday, 22 August, 2023 at 2.00 pm in the CDI Conference Room, III Floor, Block V, CHRIST (Deemed to be University), Bangalore Kengeri Campus, Bengaluru 560074.

Title of the Thesis	:	**Synthesis, Process Parameter Control and Performance of Nano Ceramic Coatings for Diesel Engine Applications**
Discipline	:	**Mechanical Engineering**
External Examiner (Outside Karnataka)	:	**Dr N Siva Shanmugam** Associate Professor Department of Mechanical Engineering National Institute of Technology Tiruchirappalli – 620015 Tamil Nadu
External Examiner (Within Karnataka)	:	**Dr Madeva Nagaral** Manager - Design Aircraft Research and Design Centre Hindustan Aeronautics Limited Bengaluru - 560037 Karnataka
Supervisor	:	**Dr Parvati Ramaswamy** Professor Department of Mechanical and Automobile Engineering School of Engineering and Technology CHRIST (Deemed to be University) Bengaluru – 560074 Karnataka

The members of the Research Advisory Committee of the scholar, faculty members of the Department and the School, interested experts and research scholars of all the branches of research are cordially invited to attend this open viva.

Registrar

Place: Bengaluru
Date: 17 August 2023

ABSTRACT

This research work entailed the development of thick plasma sprayed coatings with nano grained microstructure from (a) 8%yttria stabilized zirconia (8YSZ) and (b) α-alumina (α-Al_2O_3) to serve as thermal barrier and wear resistant coatings respectively. Their usefulness was demonstrated in an actual application by employing a single cylinder diesel engine. Plasma sprayable powders were synthesized from commercially sourced nano (<100 nanometers) powders of 8YSZ and α-Al_2O_3 via manual-granulation and spray drying methods which resulted in 50 and 70 grams/batch of powders respectively. Many process variables were applied to obtain free flowing powders with high efficiency in processing. (a) Flowability (b) stability in plasma and (c) coating quality assessments were made to determine their sprayability. Similar flowability (46 to 48 grams/minute) and particle agglomerate size range (50 - 110μ) were obtained in both methods: although spray drying was preferred route due to process efficiency. After lab scale developments, the best parameters were used for further plasma spray powder synthesis in pilot scale spray dryer. The developed powders were plasma spray coated on ~50 μm thick bond coated (commercial NiCrAlY) Al-Si (engine piston materials) and stainless steel (engine gudgeon pin material) coupons which entailed establishment (extensive trials) of suitable plasma spray parameters so as to fabricate >100 microns thick well adherent coatings with nano-grained microstructure.

The challenges caused by unsuitable plasma spray parameters resulting in substrates burning, powder /coating melting, non-adherent coatings etc. were over-come by making small but systematic changes in the spray parameters to obtain them. 8YSZ and α-Al_2O_3 coatings exhibited tetragonal-ZrO_2 & corundum phases (XRD) respectively with average grain sizes between 30 & 50nm (SEM). The top coat thicknesses (cross section metallography & SEM) were up to (a) ~170 μ in 8YSZ and (b) ~ 150μ in α-Al_2O_3 coatings. Deposition efficiency was found to be buildup of 10μm/pass coating thickness that was stable up to a maximum of ~200 μm. Temperature drop of ~40°C across 8YSZ coatings with high thermal shock resistance, VHN numbers (980-1010HV), wear loss (<2%), scratch adhesion tests with <10% indenter penetration at average depths (17.9 -18.8μm), average friction of (3.45 N-3.11N) were determined in these coatings as applicable.

The best plasma spray parameters established via experimentation were employed to spray coat actual engine components (8YSZ on engine piston and α-Al_2O_3 on gudgeon pin). The coated components were mounted on a single cylinder 5HP Kirloskar diesel engine and performances differences were evaluated between baseline engine and modified engine. The engines were run for 100 hours each at maximum load. The 8YSZ coated piston withstood the performance evaluation and exhibited significant (22%) reduction in Brake specific fuel consumption with correspondingly other beneficial outcomes (higher thermal efficiency etc.). Nano α-Al_2O_3 coated gudgeon pin also withstood the test without any deterioration in coating quality. Coating thicknesses were evaluated after 100 hours of engine performance test: small reductions in thicknesses were observed which could be the loose outermost layers (needs addressing). A heat balance sheet that aids the understanding and optimization of the performance of IC engine was prepared.

Keywords: *8YSZ & α-Al_2O_3 nano powders, Spray dryer, Atmospheric plasma spray, nano ceramic coatings, Piston, Gudgeon pin.*

Publications:

1. **Gowtham Sanjai S**, Ratan Pinto, Parvati Ramaswamy, "Plasma Sprayed Nano Refractory coatings". Institute of Physics (IOP) Conference series (Scopus indexed journals), vol. 577, pp. 1-10, 2019.
2. **Gowtham Sanjai S**, Anantha Krishna B, Sreejai Srideep, M Sai Sumanth, Parvati Ramaswamy, "Process Development to synthesize Plasma Sprayable Powders from Nano Alumina Ceramic Powders". Materials Today: Proceedings (Elsevier), vol. 19, pp. 708-714, 2019.
3. **Gowtham Sanjai S**, Sreejai Srideep, Anantha Krishna B, M Sai Sumanth, Parvati Ramaswamy, "Synthesis of Yttria-Stabilized Zirconia Nano Powders for Plasma Sprayed Nano Coatings", Materials Today: Proceedings (Elsevier), vol. 22, pp. 1253-1263, 2020