ABSTRACT

Thermally sprayed ceramic coatings are more generally used on industrial components for meeting their functional requirements like high strength at elevated temperatures, resistance to chemical degradation, wear resistance and environmental corrosion protection in Engineering components. The design of an engineering component, which basically involves the design of enveloping surface of the components are achieved with some suitable modification techniques. High Velocity Oxy Fuel (HVOF) and Plasma spraying (APS) are more precise to achieve thinner coatings without affecting substrate quality.

HVOF spraying process has been used for thermal spraying of bonding material and plasma spraying process is widely used for the deposition of films, hard materials, such as ceramics on relatively softer substrate. Before deciding on a particular type of coating, it is necessary to look into essential characteristics related to mechanical and tribological properties, in addition to their machinability characteristics for control of surface quality of end products. Hence it has become the end objective of the present work to characterize, to machine for precision and to identify the optimal conditions for the development of ceramic coatings.

The content of the thesis is organized into fifteen chapters. The thesis opens out with an introductory chapter 1, highlighting the importance of surface
modifications. Literature review on different surface modification techniques used for producing high quality coatings are presented extensively in chapter 2.

Chapter 3 deals with the two spraying processes used in the present study namely, HVOF and APS, have been presented with various process parameters, their advantages and applications.

Chapter 4 presents experimental studies conducted which includes preparation of specimen and testing methods to evaluate mechanical, tribological and thermal characteristics of ceramic coatings in addition to their machinability characteristics of the following coating materials namely, Alumina, Alumina-Titania, Partial stabilized zirconia, Zirconia Toughened Alumina and Super-Z alloy. Chapter 5 deals with results obtained from experimental studies and discussion on characteristic evaluation of Mechanical properties (namely, hardness, Bond strength, Porosity, Fatigue strength) and Tribological properties (Wear and Friction) using HVOF spraying process. Besides, the thermal properties namely, Thermal Barrier and Thermal cycling resistance are evaluated. Further performance testing of coated I.C.Engine piston using APS spraying process was also done.

In the chapter 6, a novel technique namely, post-processing method (Microwave irradiation) on the coated surfaces has been applied for improving Mechanical and Tribological properties. The results reveal a remarkable change in the above properties after processing. In order to realize the effect of microwave
treatment, a K20 carbide tool was microwave irradiated and an appreciable change in tool life and the reduction of tool wear were also observed.

The experimental data collected from the precision machining of ceramics such as grinding and lapping were presented in chapter 7. Grindability of ceramic coatings with diamond and CBN grinding wheels has been compared on the basis of grinding forces and surface finish. In lapping, the influence of diamond abrasive size and lapping time on the surface finish has been studied.

Theoretical / Numerical study, using CFD modelling numerical analysis, has been carried out for the optimization of spray process parameters such as standoff distance, gas flow rate, velocity of impinging jet, temperature of the plasma etc. This numerical modeling of Ar-N₂ plasma jet was exclusively done to predict the life of the coating. Also, the effect of plasma jet temperature, velocity distribution and heat exchange to the substrate surface through coatings have been thoroughly discussed in this chapter 8.

Taguchi design approach and ANOVA analysis have also been applied for the optimization of process parameters for Mechanical and Tribological properties like wear and hardness as well as for high temperature engineering applications and their characterization in this regard has been presented in chapter 9. To supplement the above experimental results, a Genetic Programming based approach using Discipulus software was applied to derive a mathematical model of relation of various input and output parameters used in the characterization. This
also helps in the prediction of any output parameters without conducting experiments.

Chapter 11 presents conclusions of entire research work in detail aspects. The chapter 12 and 13 highlight the contributions made out of research work and the future scope of work.