Response surface methodological (RSM) model for optimizing erosion response of WC reinforced SiC ceramics

Shriya E[1#], Divyansh Mittal[1#], Surya D Yadav[2], Sandan Kumar Sharma[1*]

[1]Department of Metallurgical and Materials Engineering, Punjab Engineering College (Deemed to be University), Chandigarh, India
[2] Department of Metallurgical Engineering, Indian Institute of Technology (Banaras Hindu University), India

In this study, erosion performances of SiC-(10, 30, or 50) wt.%WC composites were optimized using the response surface methodology (RSM) method. The hardness to fracture toughness ratio (H/K_{1c}), impingement angle (IA), and WC contents were considered as variables to design a model for estimating the erosion rate (ER) of the composites. The H/K_{1c} values of composites varied from 3.538 for 50 wt.%WC to 4.097 for 30 wt.%WC (~12% improvement) reinforcement in SiC ceramics. The experimentally obtained response of composites against SiC erodent in ambient conditions was further validated using central-composite experimental design (CCD) coupled with the response surface optimization method. Furthermore, statistical analysis of variance (ANOVA) was also used to determine the CCD's suitability and showed a reasonable degree of agreement between the experimental data and the output of the suggested model for SiC-WC composites. The developed models were validated against various experimentally obtained data even beyond the chosen range to produce the models, and results were found significant. From the first model, it was observed that for 30-45º IA, as H/K_{1c} is increased from 3.54 to 3.82, the erosion rate decreased than from 3.82 to 4.09 it increased. Above 45º IA, erosion rate increased with H/K_{1c} till 90º IA. Similarly, from the second design, against normal impingement (90º) of SiC erodent, 25.9 wt.% WC reinforcement in SiC ceramics is best suitable for minimum erosion rate. Furthermore, it was observed that at shallow IA, lower WC % content is beneficial. The models were validated against experimentally obtained erosion rate in the case of monolithic SiC (0 wt.% WC content in SiC) ceramics eroded against SiC erodent in the same experimental conditions. The results extracted from the model agreed with the results obtained experimentally. In agreement with the results, it is concluded that the proposed method and models may be used effectively to predict the wear response of SiC-WC composites.

Keywords: Tribology, Response surface methodology (RSM), Erosion wear, SiC-WC composite

[#]Equal contribution

[*]Corresponding author: sandansharma07@gmail.com