Slurry erosion behavior of thermally sprayed Ni-based super alloys: Review

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Abstract

A good, novel coating composition can protect components surface against corrosive and erosive wear in aggressive conditions. Thermal spraying is a widely accepted method for deposition of protective coatings consisting of metals, ceramics or composites onto any type of substrate material. Coating system that has an optimum combination of hardness and toughness is considered to be an ideal one. In literature, the performance of various tough phases along with harder candidates was already explored by various researchers. The objective of this study is to review the performance of some Ni-based superalloys as coating candidate to combat slurry erosion. The present review article revealed remarkable enhancements in coatings performance with respect to mechanical & microstructural properties along with application of evaluated coating materials.

Keywords: slurry erosion; Ni-based superalloys; thermal spraying.

Abbreviations

<table>
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<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>HVOF</td>
<td>high-velocity oxy-fuel</td>
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<tr>
<td>SEM/EDAX</td>
<td>scanning electron microscopy/energy dispersive X-ray spectroscopy</td>
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<tr>
<td>XRD</td>
<td>X-ray diffraction</td>
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<td>IN-718</td>
<td>alloy -718 is a Ni based superalloy</td>
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Introduction

Among all surface related phenomenons, issue of wear is a serious concern in majority of industrial components. Various forms of wears do exist such as abrasive, adhesive, dry & wet erosion. Slurry erosion also termed as wet erosion, is a phenomenon described by the degradation of components surface under the impact of solid particles entertained in liquid stream. Erosion taking place at impacting velocities > 6-9m/s is known as high velocity erosion while erosion that encounters at low velocities is called low velocity erosion [1-2]. It is serious issue in many industrial applications and the components suffering from slurry erosion in these applications should be diagnosed at early stages to minimize the loss of service & economy. The major areas in which components have to face slurry related issues includes; hydropower plants components, mining industries components, oil & gas industries, and pipelines involved in hydro transportation of solids [3-5]. One possible alternate to combat slurry erosion is the modification of components surface with the deposition of wear resistant coatings by thermal spray
techniques. Thermal spray methods present a progressive approach for the deposition of these coatings with respect to materials, medium of deposition and the thickness achieved when compared to the other deposition processes. During the process stream of high temperature particles (molten or in semi-molten state) is directed towards substrate with specific velocity and upon impacting the substrate these particles flattened in form of disc like shape known as splats. It is clear from the vast technical literature that slurry erosion performance depends upon the composition of feedstock material. However, the final microstructure of the deposited coating depends upon the type of method selected for the deposition of feedstock material. Therefore, one should be intelligent while making selection in order to meet particular need for protective coating [6].

A good, novel coating can protect components surface against erosive wear in aggressive conditions. Coating system that has an optimum combination of hardness and toughness is considered to be an ideal one. Nickel-based superalloys have excellent wear resistance properties, better strength at ambient temperature in addition to high fatigue and creep strength at elevated temperatures. Therefore, this alloy is a candidate choice to combat slurry erosion wear [7-8]. Hence, the objective of this study is to review the performance of some Ni-based superalloy as coating candidate to combat slurry erosion.

Studies related to Ni-based coatings

Ramesh. et al.,[9] investigated the slurry erosion behavior of Inconel-718 coating deposited onto mild steel substrate by using plasma spray technique. Deposited coatings were characterized by XRD, EDAX and SEM analysis techniques. SEM micrographs of the coating cross-section clearly exhibits that developed coating has a thickness of approximately 200µm and bonding between base material and coating was excellent. No visible cracks were seen on coating and it shows a lamellar and dense structure which is typical feature of plasma sprayed technique also reported by many authors [10]. It was found that porosity level reduces and micro-hardness increases with increase in coating thickness. Coating which have a thickness of 250µm has 43% improvement in hardness as compared to uncoated specimen. Authors reported that slurry erosion performance of developed coating was better than un-coated mild steel under all tested conditions. Ramesh. et al.,[11] in another work coated Titania-30wt%In-718 on copper substrate by plasma spray technique. Formation of lamellae and splats were clearly visible in SEM micrographs. Effect of rotational speed, slurry concentration and particle size on slurry erosion performance of developed coatings was investigated. Among aforesaid parameters slurry concentration has greater influence slurry erosion behavior of developed coatings of 100µm thick coating. While particle size influence the slurry erosion performance of 200µm thick coating. It was concluded that with increase in all parameters slurry erosion rate of developed coating increases. However, maximum slurry erosion resistance was shown by 200µm thick coating.

Sekhar. et al.,[12] during their investigations on the theoretical modeling of the slurry erosion wear behavior of HVOF sprayed inconel-titania coatings recommended that for 1000rpm speed and similar slurry concentration levels higher resistance to slurry erosion was exhibited by 200µm thick coatings.

Discussion

Nickel-based superalloys have excellent wear resistance properties, better strength at ambient temperature in addition to high fatigue and creep strength at elevated temperatures and will be a candidate choice to combat slurry erosion wear in many industrial applications. Slurry erosion resistance of materials that can also be improved by adding suitable reinforcements in coatings such as titania, alumina and chromium carbide etc and deposited onto substrate by using suitable deposition method. There is a still wide scope of investigations on slurry erosion wear behavior using thermally sprayed
coatings. Effect of different tribological parameters on slurry erosion behavior was evaluated by various researchers and they come to the conclusion that wear performance relies on physical, mechanical and chemical properties of target material along with type of the erodent used.

In addition to this slurry behavior was also greatly influenced by different parameters like, particle size, slurry concentration and rotational speed. It was concluded that with increase in all parameters slurry erosion rate of developed coating increases. However, increase in coating thickness (up-to 250µm) results in better performance of developed coatings. Moreover, smaller particle size leads to less wear as they don’t have enough significant internal energy to penetrate into the coating and erode wear resistant coatings. The superalloys can be utilized for the deposition of coatings to combat hot-corrosion [13-17].

Conclusion

1. Slurry erosion is a complex serious problem, more importantly in hydro turbine blades and should be diagnose in early stages to minimize economic losses arising from shut downs and maintenance expenses.
2. It has been observed that little attention is given to evaluate slurry erosion performance of Ni-based superalloys in past literature.
3. Slurry erosion performance of substrate having low strength can be enhanced by depositing wear resistant coating.
4. At present, different methods have been recognized to minimize effect of slurry erosion; however, lot of research efforts were still required to apply and examine these techniques.
5. To achieve high thermal efficiencies in modern era it is recommended to use high strength materials that will provide better resistance to harsh conditions. This requirement can be fulfilled if coatings of Ni-based superalloys can be deposited.
6. Outcome of study will be helpful in exploring these materials in actual industrial conditions.

References


