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Erosion-corrosion of plasma as sprayed and laser remelted Stellite-6 coatings in a coal fired boiler

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Abstract

Unacceptable levels of surface degradation of metal containment walls and heat exchanger tubing by a combined erosion-corrosion (E-C) mechanism have been experienced in some boilers. The recent use of coatings to protect the heat exchanger tubes of fluidized bed combustor from E-C problems has been suggested by many authors. The laser remelting of the surface coating is suggested as a promising technique to improve its physical properties.

Aim of the present investigation is to evaluate the erosion-corrosion (E-C) behaviour of plasma as sprayed and laser remelted Stellite-6 (St-6) coatings on boiler tube steels in the actual coal fired boiler environment. The cyclic experimental studies were performed in the platen superheater zone of a coal fired boiler where the temperature was around 755 °C and the study was carried out upto 10 cycles each of 100 h duration followed by 1 h cooling at ambient temperature. Coated steels were found to possess higher resistance to E-C than the uncoated steels. The highest degradation resistance has been indicated by the T11 steel coated and subsequently laser remelted.

Keywords: Plasma spray; Stellite-6; Coal fired boilers; Laser remelting; Erosion-corrosion

1. Introduction

It is important to understand the nature of all types of environmental degradation of metals and alloys as vividly as possible so that preventive measures against metal loss and failures can be economically devised to ensure safety and reliability in the use of metallic components [1].

The plausible mechanisms of hot corrosion are fairly well established and any one or more of these mechanisms may be operative in the degradation of a given alloy. At present, methods to minimise the extent of hot corrosion have been identified, however, considerable research effort is needed for a quantitative evaluation of these methods under conditions of interest in the coal-gasification processes [2,3].

Unacceptable levels of surface degradation of metal containment walls and heat exchanger tubing by a combined erosion-corrosion (E-C) mechanism have been experienced in some boilers, particularly fluidized bed combustors by Levy [4]. He proposed that a dynamic surface layer is formed that consists of a mechanical mixture of particles from the boiler gases and oxide scale growing from the base metal. It is constantly being refurbished and removed at a rate that resulted in an essentially constant thickness of the deposit/scale layer during steady state operation of the boiler, thereby loss of sound metal is related to the rate of oxidation of metal.

Wang and Luer [5] reported the recent use of coatings to protect the heat exchanger tubes of fluidized bed combustor from E-C problems and Hocking [6] also suggested the use of corrosion resistant alloys as coatings to protect substrate alloys having good mechanical properties. Hidalgo et al. [7–10] have further discussed the use of plasma sprayed thin anti wear and anti oxidation coatings to take care of the

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Table 1
Composition and particle size of coating powders

Coating powder	Composition (wt.%)	Particle size
Ni-22Cr-10Al-1 Y (Praxair NI-343) (*sprayed as a bond coat of around* 150 μm, *for each coating*)	Cr (22), Al (10), Y (1), Ni (bal.)	−45 μm + 10 μm
Stellite-6 (Eu Troloy)	Cr (19), C (0.7), Si (2.3), Fe (3), Ni (13.5), B (1.7), W (7.5), Mn (1 max.), Co (bal.)	−180 μm + 53 μm

high temperature erosion and corrosion problems in energy generation systems.

The main advantage of plasma spray technique is that it enables a whole range of materials including metals and alloys to be plasma sprayed on to a great variety of substrate types and geometries [11,12]. It is the most widely used technique to prepare composite structural parts providing required mechanical strength properties as well as inhibition of oxidation and other corrosive degradation processes [13].

The residual porosity in plasma spray coatings allows corrosive liquids to penetrate through them. This led to the debonding or spallation of the coatings associated with the accumulation of corrosion products at the coating/substrate interface. Therefore, the coatings may require post-deposition treatments to improve these properties [12,14–17].

Table 2
Process parameters for laser remelting of coatings

Type	Pulsed Nd:YAG laser
Power (W)	300
Pulse energy (J)	6
Pulse width (ms)	12
Repetition rate (Hz)	10
Defocus (mm)	5
Traverse speed (mm/s)	2
Shielding gas	Ar
Tracks overlapping (%)	60

The use of high power laser to remelt the surface coating zone and subsequent surface alloying is an effective way to obtain the required material surface properties [18–20]. It is one of the surface modification techniques to improve the

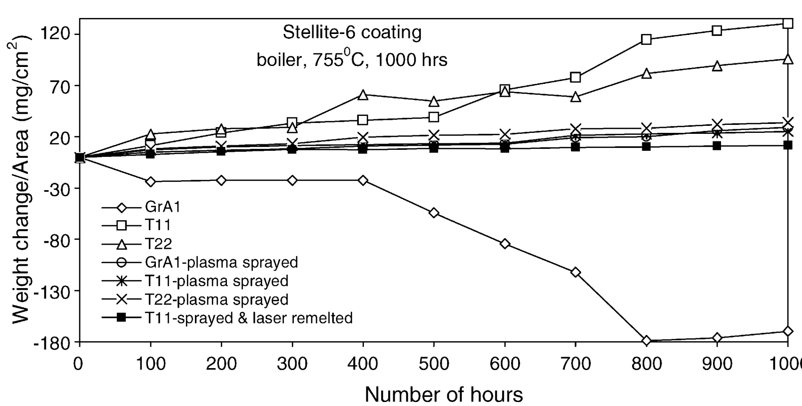

Fig. 1. Weight change plot for uncoated and Stellite-6 coated steels with bond coat exposed to platen superheater of the coal fired boiler for 1000 h at 755 °C.

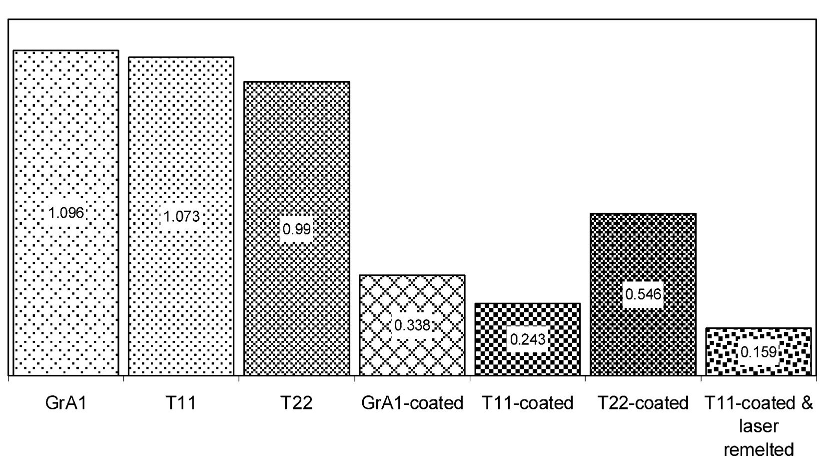

Fig. 2. Bar chart indicating the thickness lost in mm by the uncoated and Stellite-6 coated steels with bond coat after 1000 h exposure to the coal fired boiler at 755 °C.