Performance of innovative high-temperature coatings after exposure in a pilot plant burning biomass

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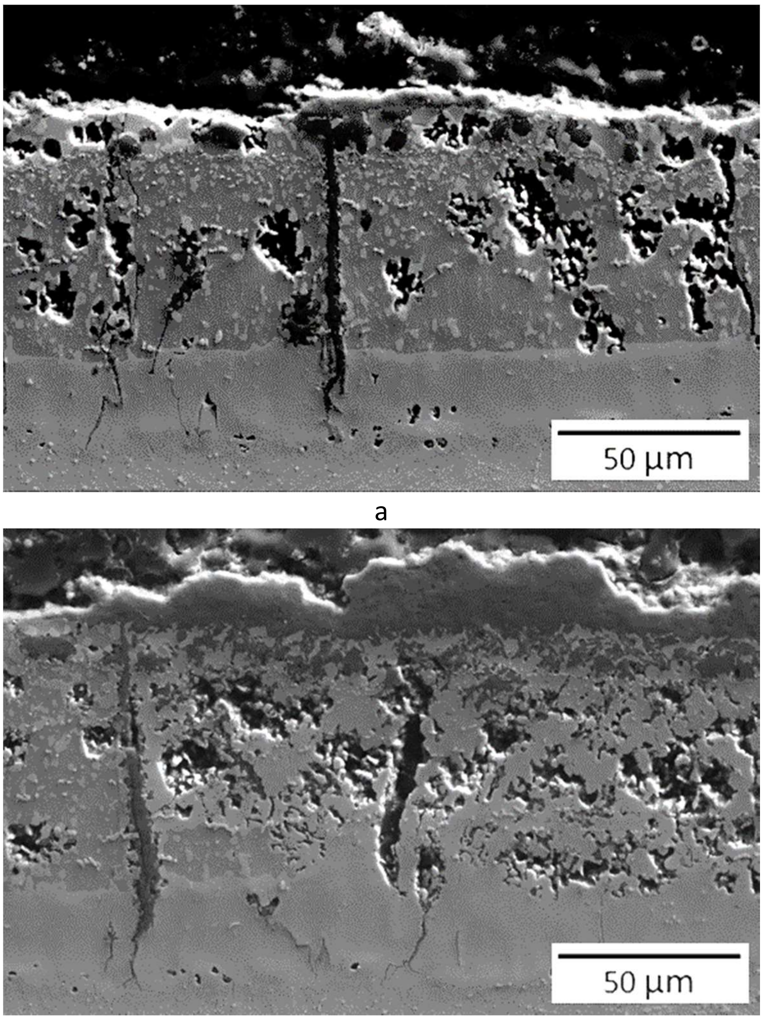
To increase the efficiency of biomass power plants, the operating temperature must be raised with a consequent increase in corrosion rates. New materials and/or coatings are required, and testing is needed to evaluate the corrosion resistance of these new materials under various and very complex atmospheres resulting from the different types of available biomass. However, there is no general agreement regarding the methodology to carry out biomass corrosion tests, which can allow realistic ranking of materials and coatings. A 0.5 kWth simple pilot plant based on fluidised bed combustion was implemented allowing constant fed of biomass pellets. Several alloys with and without coatings were tested at 600-620º C for 1000 h while burning eucalyptus forestry residues pellets. The results were compared to those obtained in a laboratory test carried out under KCl deposits and a model atmosphere containing H_2O, O_2 and N_2. Newly developed Super VM12 ferritic steel was tested with and without coatings, which included slurry aluminides, modified FeCr and NiCr based alloys deposited by HVOF and weld cladded IN625. In both the pilot plant and the lab, uncoated Super VM12 showed a very high degree of corrosion, and evidence of a high extent of spallation, whereas all coatings exhibited protective behaviour at different levels. In general, it was observed that the degree of corrosiveness in the plant was similar to that obtained in the lab and in all cases the coatings protected the substrate. For instance, according to the results of both pilot and lab scale tests, weld cladded IN625 (~700 µm) showed a low degree of corrosion in both environments whereas the best behaved HVOF deposited coating was a 325 µm hard steel alloy modified with Al, that from the initial stages developed an approximately 50 µm corrosion product layer which appears to be protective as no significant thickness variations were observed. On the other hand, the slurry coatings showed non uniform degradation in the pilot plant. Indeed, in some areas typical microstructure changes could be detected due to interdiffusion with the substrate, as well as the development of voids. In addition, some degree of widening of the through thickness cracks originally present in the coating was observed (Figure 1a). These cracks self-healed by forming Al-rich oxides which are protective. The coating exposed in the lab shows a lower amount of voids when comparing with the pilot exposed specimen (Figure 2). Other zones of the coating showed important degradation of the aluminide phases after exposure in the pilot plant (Figure 1b). The causes of the difference in behaviour were analysed and will be discussed.



a

b

Figure 1. Microstructure of two different zones of the slurry coating after 1000 h of exposure in the pilot plant.

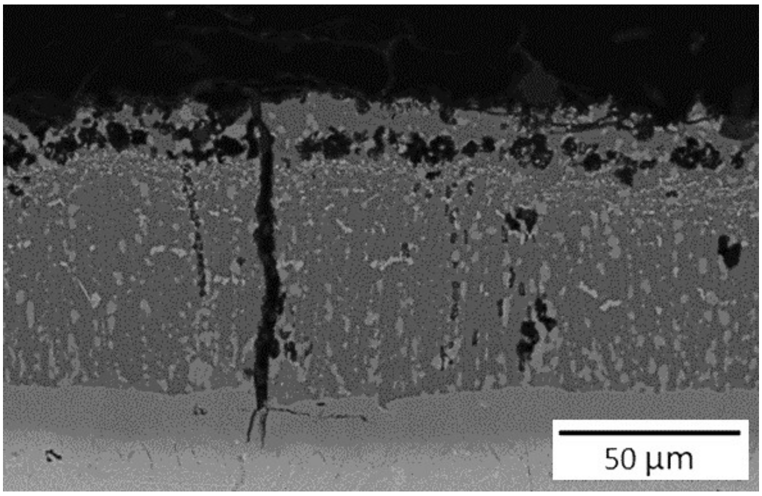


Figure 2. Microstructure of the slurry coating after 1000 h of laboratory exposure.