INFLUENCE OF JETS AT SUBZERO TEMPERATURES ON THE BEHAVIOR OF EROSIVE WEAR AND DUCTILITY ON AISI 310 STAINLESS STEEL

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ABSTRACT

The erosive effect of jets on 310 austenitic stainless steel at subzero temperatures was analyzed. Four incidence angles were used under impact of Al_2O_3 particles with average size of 125 µm and a velocity of 20 m s^{-1}. The total exposure time for the tests was 240 s using a novel device with an indirect heat exchanger filled with liquid nitrogen. Also, fracture tensile tests were conducted in accordance with ASTM E8M to observe changes in ductility. A shift in ductile behavior was observed, since at room temperature the highest erosion rate was found at an impact angle of 30°, while at low temperatures it was observed at an angle of 45°, which suggests a decrease in ductility under these conditions.

Surface topography; experiments in tribology; wear; subzero temperatures

INTRODUCTION

Erosion by solid particles is a phenomenon that affects several mechanical components, such as blades, gas turbine walls, pipes, among others, causing the progressive loss of material due to the repeated impact of solid abrasive particles on the surface [1]. Austenitic stainless steels are widely used for subzero temperature applications due to their excellent thermal properties [2].

Under extreme temperature conditions, materials change their behavior against wear phenomena [3]. This work aims to gain knowledge about the ductile-brittle behavior of AISI 310 austenitic stainless steel subjected to erosion tests at subzero temperatures, comparing the results with tensile tests to fracture on the material under the same temperature conditions. The above, due to the limited information on the subject of flows of jet at subzero temperatures related with the ductile-brittle behavior of AISI 310 stainless steel.

EXPERIMENTAL

Solid particle erosion tests were conducted on stainless steel using a device designed to control flow velocity, air stream temperature, and orientation relative to impinging stream. The tester produces subzero jets at -60 ºC by means of a heat exchanger and liquid nitrogen. Abrasive Al_2O_3 particles were used as erodent. The incidence angles used were 30º, 45º, 60º and 90º in the near field. The total exposure time for tests was 240 s. The hardness was monitored after each test, to evaluate its behavior against changes in temperature.

RESULTS

Based on the characterization of wear scars from erosion tests, the primary wear mechanism identified at both temperature conditions was plastic deformation. Furthermore, it was observed that the roughness increased as the impact angle of abrasive particles decreased, both at room temperature and -60 °C. Erosion rates revealed a significant reduction in erosion rates at subzero temperatures. A shift in ductile behavior was observed, since at room temperature the highest erosion rate was found at an impact angle of 30°, while at low temperatures it was observed at an angle of 45°, which suggests a decrease in ductility under these conditions. This change in ductility was measured in the tensile tests at the two temperatures investigated. Additionally, the material hardness slightly increased under low-temperature conditions. Finally, it was observed that AISI 310 stainless steel maintains a ductile behavior even under subzero temperature condition.

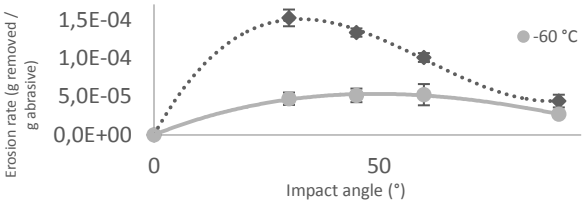

Fig.1 Erosion rates of AISI 310 s.s. under R.T. and -60 °C.

REFERENCES

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[2] Park, Woong Sup, et al. "Strain-rate effects on the mechanical behavior of the AISI 300 series of austenitic stainless steel under cryogenic environments." Materials & Design 31.8 (2010): 3630-3640.