The Composite Material Based on Synthesized Zirconium Oxide Nanopowder for Structural Appliance

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INTRODUCTION

In order to the widespread use of waterjet nozzles in the practical field, it is necessary to carry out a research related to improving the mechanical properties of parts in accordance with international standards. It is known that carbide nozzles last longer than all other materials when unfiltered water is used, and the rate and type of wear of carbide nozzles depend on the types of bonding and the percentage of carbide [1]. The work investigated the level of wear and defects arising from trails in ZrO_2-CeO_2-SiC tubes.

EXPERIMENTAL/THEORETICAL STUDY

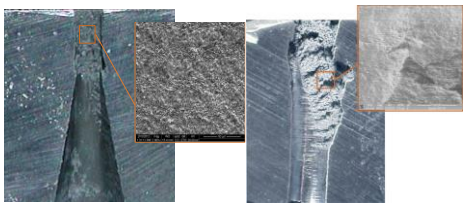
The ZrO_2-CeO_2-SiC system has been obtained by decomposition of fluoride salts; it has been used hydrofluoric acid HF, concentrated nitric acid HNO_3, aqueous ammonia NH_4OH, metallic zirconium and polyvinyl alcohol from Reakhim. Distilled water has been used to prepare solutions.

The particles were obtained as follows: 4 g of a metal zirconium was placed in a 100 ml Teflon beaker, 10 ml of hydrofluoric acid and 10 ml of distilled water were added. After dissolving of the zirconium, 60 ml of distilled water and a calculated amount of polyvinyl alcohol were poured into the resulting solution with continuous stirring. The resulting mixture was stirred for 1 hour, and then 20 ml of aqueous ammonia solution was added and stirred for 30 minutes. The deposition process was carried out at 20, 50, and 80 ° C. The content of polyvinyl alcohol was varied within the mass ratio m (Zr): m (PVC) 1: 0.1, 1; 0.5, and 1: 1. Upon completion, the resulting precipitate was filtered off, washed with distilled water and dried at room temperature for 48 hours. The dried precipitate was then heated in a muffle furnace to 800 ° C (heating rate 100 ° C / h), held for 4 hours, and then the resulting powder was cooled to room temperature.

The material of the carbide tubes consists of tungsten carbide with a binder. The amount and type of bond in the carbide can vary, and both of these variables affect the strength as well as the erosion resistance of the tube. Comparative tests were carried out on tubes made of a ZrO_2-CeO_2-SiC nanopowder mixture. It was found that ZrO_2-CeO_2-SiC tubes are characterized by erosive wear with pronounced uniformity over the entire channel surface and the hole size increases uniformly, while the nozzle still produces a directed jet. In this case, the original outlet diameter increases by 0.1 mm, which leads to a decrease in the jet velocity by 20%. However, the changing of the diameter by the same amount for a tube with a 2.0 mm hole leads to an increasing in flow rate by only 10%.

RESULTS AND DISCUSSION

It is known that in a hard alloy, first of all, the cobalt phase is destroyed and removed, so that the mechanism of wear of the hard alloy tubes includes erosion of the binder in combination with corrosion erosion. Studies have shown that the uniform distribution of the silicon carbide additive in the bulk of the composite, provided even at the stage of obtaining powders, provides a small grain size in the resulting material. It was achieved due to the optimal modes of electroconsolidation to ensure high density, when an increased contact area with a large number of adjacent particles contributes to the high degree of homogeneity of the compact material naturally explains more longer a service life of the developed material nozzles.



a) b)

Fig. 1. The nature of the wear surface of the tube after 80 hours (a) and 110 hours (b) of operation

CONCLUSION

The high durability of the developed ZrO_2-CeO_2-SiC composition under abrasive and erosional effects, as well as the high-speed advantages of the electroconsolidation technology and the possibility of using industrial current without the use of expensive pulse generators, make it possible to reduce the cost of producing hydroabrasive nozzles from ZrO_2-CeO_2-SiC with high technological characteristics.

REFERENCES

1. .D.Wright et. Waterjet Nozzle Material Types. 2003 WJTA American Waterjet Conference, Houston, Texas, August 17-19, (2003).

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