Engineering Failure Analysis 18 (2011) 855–867

Contents lists available at ScienceDirect

Engineering Failure Analysis

journal homepage: www.elsevier.com/locate/engfailanal

The new parameter to assess cavitation erosion resistance of hard PVD coatings

Alicja K. Krella *

The Szewalski Institute of Fluid-Flow Machinery, Polish Academy of Sciences, ul. Fiszera 14, 80-231 Gdansk, Poland

ARTICLE INFO

Article history:
Received 30 March 2010
Received in revised form 13 October 2010
Accepted 13 October 2010
Available online 26 October 2010

Keywords:
TiN coatings
Cr–N coatings
Cavitation erosion
Fracture
Degradation

ABSTRACT

Most machinery elements are coated with hard coatings to prolong their lifetime and to improve working efficiency. Cavitation test was used as a tool for studies of dynamic impact degradation. Ti- and Cr-based coatings were chosen for investigations. The TiN and Cr–N coatings with various thicknesses were deposited on stainless steel by means of the cathodic arc evaporation method at various deposition parameters. Tests were performed in the cavitation chamber with a system of barricades. Nearly all the TiN and Cr–N coatings have undergone micro-undulation. The first cohesive fractures have occurred on top of the micro-folding and at delamination spots. The analysis of degradation mechanism of thin hard coatings under repeated impact loading has resulted in deriving a new empirical parameter suitable for description of the hard coating cavitation resistance. The derived parameter is proportional to the plasticity index, H/E (defined as ratio of hardness, H, and Young's modulus, E), adhesion force, L_{C2}, ratio of thermal conductivity of the coating to that of the substrate, and inversely proportional to the number of phases in the coating phase composition, the ratio of the thermal expansion of the coatings to that of the substrate and the square root of the coating thickness. The new endurance parameter shows good correlation with the mass loss of all the tested hard coatings indicating a continuous improvement in the erosion resistance with the increase of the new parameter.

1. Introduction

Most equipment is subjected to dynamic local loading during its service. This loading may last only few microseconds or even nanoseconds with the local impact pressure of GPa. The material response to such extreme condition has been a topic of great interest from decades and it is an important research goal nowadays. Material properties shown under static or quasi-static load conditions are different from those manifested under dynamic impact conditions. Material resistance to deformation and fracture under dynamic loading is lower in general than that under quasi-static ones. Therefore, the dynamic loading degradation should be closely examined. Cavitation degradation seems to be the method suitable for simulation of local dynamic degradation and for evaluation of material resistance to the dynamic loading.

Cavitation phenomena occurs in fast flowing liquid, e.g. in water passing a system of barricades which disturbs the flow and causes the rapid pressure decrease below the critic value which is the vapour pressure of a given liquid, e.g. water. Moreover, all liquids contain some dissolved gas, which is the source of cavitation nuclei. If the liquid pressure exterior to a nucleus/bubble of a radius R will be lower than the saturated vapour pressure, the nucleus will be activated and the radius of the bubble will increase. The number and the magnitude of cavitation bubbles depend on the level of the water pressure

* Tel.: +48 58 699 52 35; fax: +48 58 341 61 44.
E-mail address: akr@imp.gda.pl

1350-6307/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.engfailanal.2010.10.002