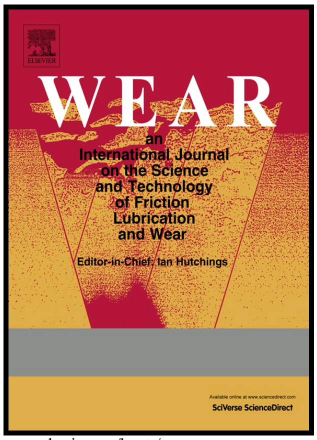
Author's Accepted Manuscript



www.elsevier.com/locate/wear

Cavitation erosion in liquid nitrogen

Matevž Dular, Martin Petkovšek

PII: S0043-1648(17)31139-0
DOI: https://doi.org/10.1016/j.wear.2018.01.003
Reference: WEA102335

To appear in: *Wear*

Received date: 17 July 2017
Revised date: 3 January 2018
Accepted date: 3 January 2018

Cite this article as: Matevž Dular and Martin Petkovšek, Cavitation erosion in liquid nitrogen, *Wear,* https://doi.org/10.1016/j.wear.2018.01.003

Cavitation erosion in liquid nitrogen

Matevž Dular (corresponding author)
Laboratory for Water and Turbine Machines
Faculty of Mechanical Engineering
University of Ljubljana
Askerceva 6, 1000 Ljubljana, SI-Slovenia
E-mail: matevz.dular@fs.uni-lj.si
Phone: +386 1 4771 453
Fax: +386 1 2518 567

Martin Petkovšek
Laboratory for Water and Turbine Machines
Faculty of Mechanical Engineering
University of Ljubljana
Askerceva 6, 1000 Ljubljana, SI-Slovenia

Abstract
Thermodynamic effects in cavitation become significant only when the critical-point temperature is close to the operating temperature of the fluid, as in the case of cryogenic fluids. Therefore, the understanding and the prediction of the cavitation effects in such cases is crucial in many applications - for example the turbopumps for liquid hydrogen (LH2) and oxygen (LOX) in space launcher engines. The new generation of rocket engines will also feature the possibility of re-ignition while in orbit and prolonged period of operation; hence cavitation erosion is becoming an issue at the design stage of the turbo-pumps.
In the study, we show measurements of cavitation erosion in liquid nitrogen (LN2), where cavitation was generated by an ultrasonic transducer. The damage was evaluated on aluminium samples. Special care was given to accurate setting of the operation point – especially the operating pressure, which defines the size of cavitation. We show that it is less aggressive than cavitation in water and that its aggressiveness cannot be described by a single fluid property (for example the most commonly used Brennen's thermodynamic parameter Σ), but by a combination of several (viscosity, density, vapor pressure, surface tension, thermodynamic parameter) – in the present paper we addressed this point by a simple bubble dynamics model with consideration of the thermodynamic effect to qualitatively predict the results of the measurements. Finally, we also compared performance of several other engineering materials.

Key words: Caviation; Erosion; Liquid Nitrogen; Thermodynamic effect

1 Introduction

Optimal operation of turbopumps is crucial for all liquid fuel rocket engines. To reduce weight, these pumps often operate at critical conditions, where dynamic instability and cavitation are unavoidable. In cryogenic engines, the fuel and oxidizer used are liquid usually hydrogen and liquid oxygen at very low temperatures (about 14 and 90 K, respectively). Usually we treat cavitation as an isothermal phenomenon, but this assumption is not valid for such propellants: flows are characterized by a substantial cooling during the vaporization process due to cavitation. This phenomenon delays the further development of cavitation, so it plays a moderation role in