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DAMAGE INITIATION DUE TO LIQUID JET IMPACTS ON ZNS

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ABSTRACT

Damage initiation provoked by liquid impact on ZnS is studied through an experimental investigation. A test bench has been designed and manufactured for this purpose. Its calibration and exploitation allow to carry out series of liquid impacts on a specified location with known shapes and velocities. The objective of this investigation is to get a better understanding of crack initiation mechanisms under this specific dynamic loading. Damage initiation models deduced from numerical simulations (both fluid and solid) can be compared to experimental results.

Keywords: liquid impacts, test, damage initiation, ZnS.

INTRODUCTION

Thanks to its unique optical and mechanical characteristics, ZnS brittle ceramic is widely used as window or dome in the aeronautic and defence industries. However, in spite of better mechanical characteristics compared to the other infrared optical materials (ZnSe, Ge, MgF₂, CaF₂), in-flight severe conditions may cause severe damages. Among them, liquid impact due to rainfalls or fog generates a dynamic solicitation causing damages in the periphery of the impact point. Large damages have been widely studied in the literature but the mechanisms explaining crack initiation still remain to be clarified [1-4].

TEST BENCH

The test bench designed for this study, Figure 1, produces liquid jet impacts on specific locations of a sample (1). This type of test bench has been successfully used for water impact and erosion studies [5-6]. Short liquid jets (2) are generated thanks to a drilled disk (named chopper (3)) turning at high velocity (from a few hundred of rpm to a few thousands) cutting a cylindrical continuous water jet. A second disk (not represented in the figure) let only 1 jet out of 300 impacts the target.

The velocity of water jet is managed by the pressure generated by the pump and transmitted to

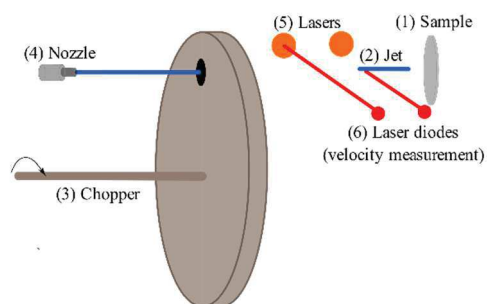


Fig. 1 – Schematic of the test bench.

the nozzle (4). The cut jet velocity is measured thanks to a set of two lasers (5) and photodiodes (6): the water jets cross successively each laser allowing to calculate their velocities. The length of the water jet depends on the chopper rotation velocity.

RESULTS AND ANALYSIS

The current test bench has demonstrated to be able to reproduce damage similar to those observed from the literature [2]. As shown on Figure 2, the damages produced by the test bench show the typical pattern of water impact upon a brittle ceramic: small straight damages initiation which can merge and make a peripheral network of damages around a central undamaged zone. Damage mechanisms are studied through parametric studies (number of impacts, velocity of impacting jets, shape of impacting jets) and a novel damage initiation parameter based on principal tensile stress is proposed based on both numerical and experimental outcomes.

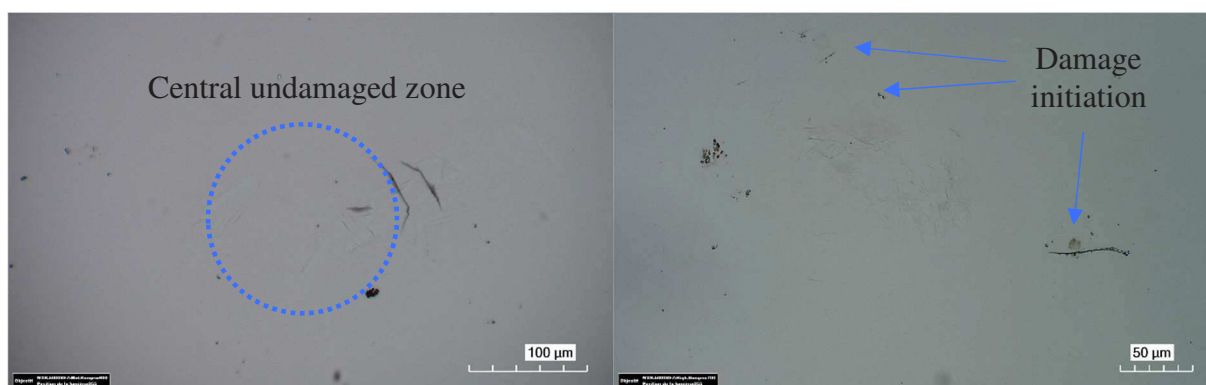


Fig. 2 – Damage produced by the test bench (jet impacts at ~185m/s).

CONCLUSION

The studies carried out have permitted to set up a new test bench able to reproduce damages typical of water jet impacts. Indeed, the forms of observed damages are very similar to the literature and previous damaged samples obtained with another test bench. Parametric studies of impact upon the material allow to propose a new criteria for the damage initiation due to water-drop impact.

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