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NOISE AND EROSION OF SELF RESONATING CAVITATING JETS

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SYNOPSIS

Self resonating jets have been developed which take advantage of the natural tendency of a jet to organize in large structures. Tests have shown that these jets are both highly erosive and a source of a discrete frequency high level noise. The erosion and noise effects are harnessed for improved cutting, drilling, and cleaning, as well as for sound generation. Simultaneous investigations of the noise and erosion of these jets have been conducted and have shown a definite trend toward correlation. For instance, time evolution of volume removal rates of an impacted surface and RMS readings of a transducer have been found to be correlated. Similarily, shifts in the relative importance of the various frequencies have followed the advancement of erosion. These results could be of great advantage in the determination of the evolution of a jet cutting operation in progress. In this paper jet noise and erosion correlaiton tests will be described and the results analyzed.

INTRODUCTION

Cavitation is mainly known for its harmful effects, namely, loss of performance, erosion, and noise. The usual procedure to prevent these deleterious effects is to avoid the phenomenon by proper design and by limiting the operating conditions. However, attempts to induce and harness cavitation for useful purposes have been increasingly successful. In high-pressure jets, cavitation has for some time now been purposely induced in order to increase their drilling, cutting, and cleaning capabilities[1-2]. The noise associated with cavitation is being used as a means of sensing cavitation when it becomes destructive and, hence, could allow for alleviating its damaging effects. More recently, a more direct utilization of cavitation noise in jets for sound generation was proposed and demonstrated[3-4].

The occurrence of cavitation in the high-volume flows of sodium in fast neutron reactors has prompted the C.E.A. to undertake a large research program on cavitating sodium flows[5]. This was prompted primarily by the importance of the phenomena to the sodium pump development program. Because of the lack of sufficient understanding of cavitation erosion and its scaling laws in sodium, excessive safety margins are presently used for pump design. It is therefore highly desirable to develop techniques to discriminate between erosive and nonerosive cavitation events and flow conditions. Since optical detection of cavitation in sodium flowing at very high temperatures is not feasible, acoustic detection instrumentation (CANASTA) was developed at the Cadarache Nuclear Research Center.

Acoustic detectors and signal processing instrumentation (CANASTA) capable of handling the high-frequency signals created by cavitation has been developed at CEN/CADARACHE. The ability of this instrumentation has been demonstrated using a liquid sodium test loop[6]. However, due to the extremely long time periods required to create measurable erosion in any traditional flow tunnel and therefore in the Cadarache sodium cavitation tunnel, test runs have been expensive and data collection somewhat difficult. In the work described here, erosion due to self resonating cavitating jets is used to gather data which allows discrimination between the noise patterns created by erosive versus nonerosive cavitation. The high erosive capability of these jets which significantly shortens experimentation time relative to a cavitation tunnel was the incentive to conduct this investigation.

In the work reported here, controlled erosion experiments on stainless steel have been conducted. The time evolution of the erosion and the emitted noise were measured simultaneously. The objective was to evaluate the possibility of discrimination between erosive and nonerosive cavitation.

SELF RESONATING CAVITATING JETS

Experimental observations of submerged jets show the tendency of the turbulent eddies in their shear layer to organize in large structures. Excitation of an air jet with periodic acoustic signals produced upstream of the nozzle by transducers or loudspeakers shows a remarkable change of the jet structure into discrete ring vortices when the excitation frequency, f, matches the predominant natural frequencies of the non-excited jet.

The potential of such a phenomenon for suberged water jets was recognized[1-3], and a unique technology was developed related to achieving useful submerged jets having very high amplitude, periodic, oscillatory discharge without using moving parts in the supply system. The passive excitation is obtained hydroacoustically and structures the shear layer of the jet into discrete, well defined ring vortices when the excitation frequency, f, matches the jet's preferred values. This can be obtained by (a) feeding the final jet-forming nozzle with various types of acoustic chambers (for example, Helmholtz chambers or organ-pipe tubes) tuned to

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