Experimental characterization of pulsed arc under water

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The topic of this work is the study of a 10 milliseconds underwater pulsed arc. These types of electric arcs are used in several industrial applications such as electro hydraulic forming, crushing, blasting and so on.

For these types of applications, the arc can be ignited either by applying over voltage between the electrodes leading to the propagation of an ionization front and the creation of a conducting channel or using a copper wire as a fuse element between the two electrodes. In both cases, the birth of a plasma channel expanding inside a water vapour bubble can be observed.

There is only a limited amount of information available on the arc under these conditions and it is necessary to understand the thermal plasma's physical properties, the arc's electrical characteristics and the different sources of loss in order to properly understand and optimize the electro-hydraulic conversion process.

Industrial applications use this rapid energy deposition process in order to generate underwater shock waves and use this electro-mechanical conversion shape or break up materials. Indeed, the rapid increase of temperature and pressure within the plasma channel, generates a primary shock wave and, later, a mechanical wave with the expansion of the plasma bubble.

The aim of our work is to characterize the plasma generated, which is located at the interface of the pulsed power and mechanical topics. Generally, studies analyse the energy efficiency by observing the electro-mechanical ratio. The plasma is rarely characterized.

In this work, we will prospect several kinds of measurements: determination of the plasma temperature with a high temporal resolution based on time-resolved emission spectroscopy measurements, high speed visualization of the plasma expansion, electrical characterization of the plasma column and cathode and anode sheaths. An energy balance will be proposed including electrode and radiation losses. The methodology of the spectroscopic analysis will be provided. This work was done with an arc duration of about 10ms. It is longer than characteristic times of these application (<1ms) but it allowed us to build our experimental setup in simple configuration before changing the time scale in order to observe shorter discharges

with rapid slow rate during the first half period. Eventually we would like to provide a complete characterization of the plasma for several time scales and determine main parameters in order to increase performances of the associated process. To complete this study, we have also developed a magneto-hydro dynamic model that we will try to validate with our experimental setup.

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