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GA Drilling

ENERGY BALANCE OF PULSED ELECTRIC ARC FOR PLASMA DRILLING APPLICATION

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Fig. 1: Experimental set up used for the measurements.

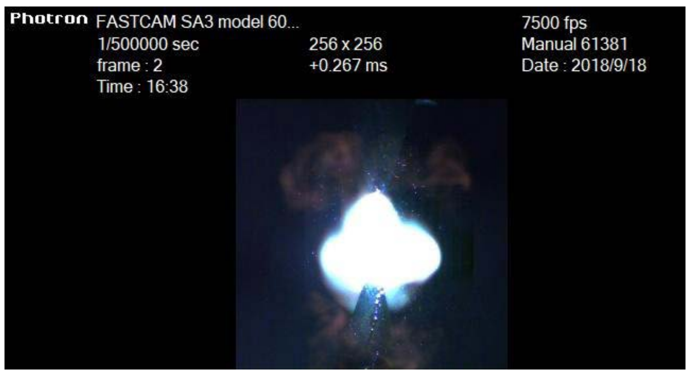

Fig. 2: Discharge as captured by high-speed camera.

Fig. 3: Discharge after binarization.

ABSTRACT

The increasingly diverse range of plasma applications in both research and industry motivates characterization studies aimed at improved understanding of the underlying phenomena. For its employment as a means of rock disintegration in deep drilling, pulse electric arc was investigated, and the energy balance thereof was obtained. Particular attention was paid to the radiative component of the energy output due to its pivotal role in the rock disintegration. The study was conducted using a pulse generator with maximum output current and voltage being 2 kA and 1 kV respectively.

Subsequent analysis was performed by means of optical spectroscopy and a high-speed camera. The share of the radiative component as a fraction of the generator's power output was obtained for a range of input parameters. Thus, the resulting energy balance can be utilized not only for establishing the employability of the pulse generator in plasma drilling, but also for its optimization in terms of maximizing the desired radiative component.

METHOD

Total radiative power output is given as a product of radiative flux and area of corresponding wave surface. The two were established by means of optical emissive spectroscopy and high-speed camera respectively.
Radiative flux was calculated by integration with respect to wavelength. Conversion of intensity curve in arbitrary units to radiative flux curve was conducted by means of prior calibration using a calibration lamp with known power output.
Subsequently, a capture of high-speed camera was analysed. The picture was binarized by setting a threshold, outputting a binary matrix describing pixels. Boundary points of the arc edge were obtained and fitted by a sixth-degree polynomial for convenience. This was geometrically expanded, so as to describe surface assumed by the wave utilizing Huygens-Frensel principle. Corresponding surface area was computed as an area of revolution.
Product of radiative flux and area yielded radiative power, which was normalized by mean energy input, expressing radiation as a fraction of the energy input.

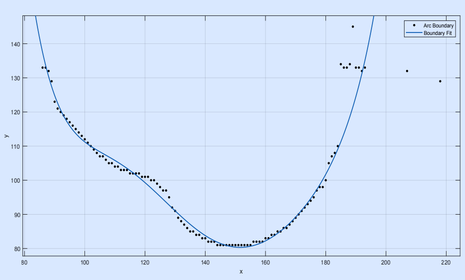

Fig. 4: Boundary points fitted by sixth-order polynomial.

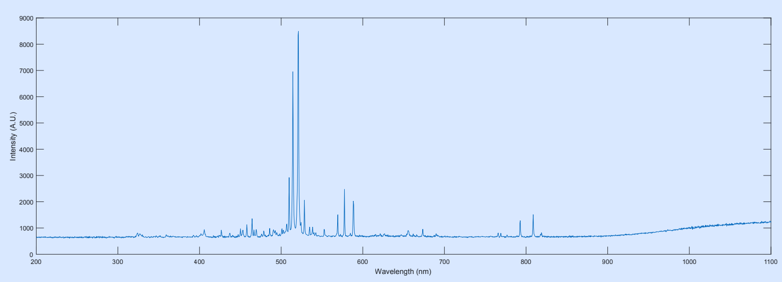

Fig. 5: Full spectrum captured by optical emissive spectroscope.

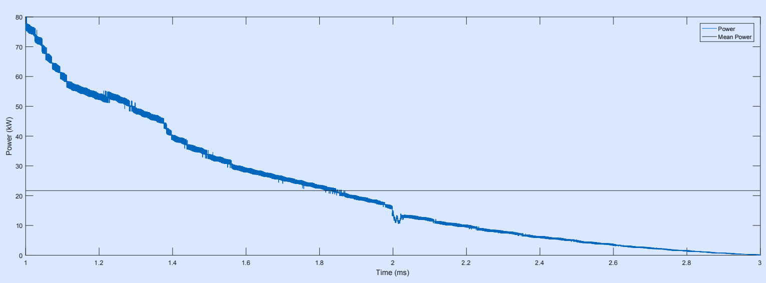

Fig. 6: Power in the measured time sequence.

INTRODUCTION

In order to use plasma arc powered by pulse source for rock degradation, it is necessary to obtain its energy balance. In general, it is assumed that the electric input is converted into heat, radiation, and mechanical impulse. Under expected conditions, visible radiation is thought to be the most efficient way of delivering degradative energy to the rock, thus, it was deemed desirable to establish its fraction on the overall energy output.

CONCLUSION

It was established the percentage of visible radiation on energy input is of order of unity. For the given experimental set up, which utilizes fire-ups using a copper wire, the literature does not provide sufficient data for comparison. However, similar experiments yielded somewhat higher values (~30%) (Bauchire, Hong, Rabat, & Riquel, 2009). Therefore, it was proposed the experiments be conducted using pilot arc to verify the values.

Bibliography: Bauchire, J., Hong, D., Rabat, H., & Riquel, G. (2009). Radiative Energy Measurements of Pulsed High-Current Arcs. ISPC Conference. Bochum: 19th International Symposium of Plasma Chemistry.