Investigation of Low Voltage Spark Ignition in Explosion Protection Applications

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Electric sparks pose an ignition hazard in the presence of flammable gas mixtures. Electrical equipment to be used in such hazardous environments must therefore satisfy strict safety requirements, through the use of internationally standardised explosion protection methods. One such method is "Intrinsic Safety", where the output of electrical energy sources is limited so that spark ignitions cannot occur under any usage scenario.

This energy limitation is verified using a stochastic empirical procedure, involving a "Spark Test Apparatus" connected to the output of an electrical energy source. The apparatus consists of a tungsten wire anode and cadmium disc cathode, each rotating against one another creating sparks between them. Both electrodes are enclosed in a test cell containing flammable gas. The connected electrical circuit is deemed intrinsically safe if no ignitions result within a defined number of contact rotations. This procedure suffers from variability and poor reproducibility.

The aim of this research project is to develop a fundamental basis for the intrinsically safe energy limit, reducing reliance on unreliable empirical methods. Although, previous research projects have been undertaken to this end, they were limited to the electrical characteristics of sparks. This project will undertake a more extensive characterisation of intrinsic safety related spark ignitions, specifically those with:

- Low spark energies (approx. 20µJ),
- Low spark voltages (10-60V) and currents (less than 3A),
- Contact conditions resembling the spark test apparatus (ie: approx. 100µm separation between moving cadmium and tungsten electrodes), and,
- A Hydrogen-Air gas mixture.

An additional focus of the research is understanding the causes of uncertainty in such ignitions. Non electrical factors are thought to play a significant role, and include electrode surface conditions (eg. roughness, oxidation and mechanical stresses), and the composition of the gas mixture.

The overall aim is thus a complete characterisation of the ignition process, from spark initiation to chemical ignition. Initial results of this research will be presented. A current theme is high speed photographic investigation of sparks, to establish a relationship between plasma column geometry and

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electrical characteristics. A preliminary outcome of this work is the development of a simplified electrical model of the spark.

Investigations into electrode surface characteristics have also found significant contact erosion and even metal whiskers. Effects of these phenomena on geometric electric field enhancement, and thereby spark initiation have been explored.

Additional optical investigations will be undertaken in the near future. These include plasma spectroscopy based spark thermometry, as well as schlieren imaging for transient and spatial characterisation of the ignition process. The resulting insights into the thermal and chemical processes involved in the spark ignition, together with knowledge of the spark electrical characteristics is an important step towards a better defined intrinsically safe energy limit, based on modelling of the ignition process.

The model based ignition limit will be used to develop an alternative to the Spark Test Apparatus, termed the “Electronic Spark Tester” (EST). This method will verify ignition safety through analysis of an energy source, thereby providing a reproducible result, unlike currently used empirical methods.