C52 Pitting Occurrence and Mechanisms in 1018 Steel by Various Explosives

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After attending this presentation, attendees will understand the mechanism and onset of explosive-driven pitting of metals.

This presentation will impact the forensic community and/or humanity by investigating the mechanisms by which explosive pitting occurs.

This study was conducted to observe the pitting and cratering of 1018 steel witness plates, which had been subjected to the detonation or deflagration of an energetic material. Six common energetic materials: ammonium nitrate mixed with fuel oil (ANFO), composition C4, nitroglycerine based dynamite, trinitrotoluene (TNT) flake and two low explosives, black powder and smokeless powder were used in this study. The energetic materials were packed into 2" inch inner diameter schedule 40 steel pipes of varying lengths. The lengths were varied in order to achieve the same TNT equivalent, of 0.81 lbs, for all tests. Each energetic material was tested three times, for a total of 18 tests. The pipes were threaded on one end only, the open ended pipe was secured to a 3" by 3" by 0.25" thick 1018 steel witness plate, which had been ground with 80 grit SiC paper in order to remove surface oxides present after processing. This test setup allowed for direct contact of the explosive with the witness plate. The energetic materials were then hand-packed into the pipes and end caps, which had been drilled out to allow for the introduction of a detonator (for the high explosive tests) or a squib (for the black and smokeless powders) were secured on the threaded ends of the pipes. The test devices were shot at the Energetic Materials Research and Testing Center (EMRTC) at the New Mexico Institute of Mining and Technology.

The 1018 steel witness plates were collected after each explosive test, photographed, and the number of pits found on the surface counted and recorded. The plates were then sectioned to reveal the cross-section, ground using standard metallurgical wet grinding methods to 1200 grit SiC paper, polished with alumina slurries of 5µm and 0.3µm, etched using a mixture of nitric acid and ethanol, and imaged using an optical microscope. After imaging in the optical microscope, the samples were prepared for and taken to the scanning electron microscope (SEM) and again examined. The pit geometry, mainly depth and aspect ratios, was examined, and special attention was given to the areas directly below visible pits, which were scrutinized for any signs of a microstructure which would be indicative of the metallurgical reason for pitting, be it melting, denting, jetting caused by the energetic material, or a combination of the three.

By examining the occurrence and geometry of pitting induced by various energetic materials and the microstructure of the metal samples, theories for the mechanism by which this pitting occurs may be advanced.

Explosives, Pitting, Cratering

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