C12 A Potential Metallographic Technique for the Investigation of Pipe Bombings

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The goal of this presentation is to discuss a potential method for identifying the explosive fill used in a pipe bomb by examining collected fragments using standard metallographic techniques.

Three common pipe materials, ASTM A53 low carbon steel, AISI 304L stainless steel, and 6061 aluminum, were shock loaded using five high explosives and three propellants. The explosives used were ANFO, nitroglycerine-based Dynamite, flake TNT, C6 detasheet, and composition C4, the propellants studied were 4F black powder, Red Dot smokeless powder and, in the case of A53 steel, Turbo Fuel A (Jet A). The post-blast microstructure, microhardness and, in the case of the steel tests, macrohardness were examined for each test. Additionally, X-Ray diffraction (XRD) was preformed on the 304L fragments to determine the amount of a martensite induced by a shock, and high-pressure liquid chromatography (HPLC) was run on residue collected from 6061 fragments to detect the presence of the test explosive in the post-blast residue.

The explosives ranged in detonation velocity from a few m/s, for the black and smokeless powders to over 8 km/s for C4. This induced a pressure in the steels ranging from essentially ambient pressure to over 45 GPa, and a range of essentially ambient to 35 GPa in the aluminum. Significant amounts of shock heating were also seen in each material at the high end of the detonation velocity and pressure range in these tests, with a maximum temperature rise of over 200^{o}C in the aluminum and low carbon steel and a maximum temperature increase in the stainless steel of around 120^{o}C. The discrepancy in temperature rise in 304L as opposed to A53 and 6061 can be attributed to the low value of the empirical constant (s) and high value of the bulk sound speed (C_0) for 304L, which dictate the shape of the Hugoniot, and the response of the material to shock loading. The 304L Hugoniot exhibits less concavity than the A53 and 6061 Hugoniots, meaning less work is lost in heating the material.

There was a strong correlation between the microstructure of fragments and the detonation velocity and pressure of the explosive used. This trend being that there was more material flow and grain damage, in some cases even recrystallization, as the detonation velocity of the explosive and the pressure generated in the material increased.

Material hardness showed a sharp increase, followed by a plateau as the shock pressure and explosive detonation velocity increased. This trend was observed in all the materials, although material softening due to shock heating recovery and recrystallization was seen in aluminum in the pressure and velocity range studied.

X-Ray diffraction patterns were used to calculate the amount of shock-induced martensite present in the post-blast microstructure of 304L fragments. This property showed the same trend as did the hardness data, namely a sharp increase in microstructure with shock, followed by a plateau as pressure increased. A decrease in martensite formation due to shock heating was not observed over the pressure range studied.

These studies were done in the hope that a metallographic method could be developed for the investigation of pipe-bombings. While many of the results in this work are qualitative in nature, the trends seen are definite and promising. With further study, these methods could be quantified and applied to the field of forensics as a powerful investigative technique.

Pipe Bombs, Metallography, Forensics