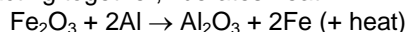


Technical Tales

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Thermite

Over the past 10 years or so, there has been much speculation as to the use of thermite and thermite mixtures in explosives. Traditional thermite is a mixture of iron oxide and aluminium which when reacting together, liberates heat:



Temperatures in excess of 2200°C are quoted in the literature whilst a local supplier of thermite in South Africa claims temperatures exceeding 3000°C. Heat is a form of energy and it has been calculated that the thermite reaction can release 4.0MJ/kg under ideal conditions. Thermites are however, very difficult to ignite but once ignition has occurred, the reaction is self propagating.

Aluminium powder has been used in explosives for many years to increase the temperature of reaction which in turn liberates gases at higher pressure. This component improves the “heave” characteristics of the explosive and adds to the total energy delivered by the explosive. It would therefore appear logical that any component, that can be safely added to an explosive formulation, and which would increase the temperature of reaction, would increase the explosive performance of the product.

The world-wide disposal of aluminium residue, termed dross, is becoming an environmental issue as it is traditionally dumped in landfills. A South African supplier of thermite claims that, via patented technology, they can recycle this residue and convert it into high value-add explosive sensitises and additives for the steel making and water purification industries. This material would also be significantly cheaper than pure aluminium (65% of the cost) and delivers 30% more energy which results in blasting, excavating and processing costs reducing by as much as 30% for mining companies.

In 1999, African Explosives Limited undertook an extensive evaluation of a variety of thermite compositions in various packaged explosives products to ascertain whether the addition of thermite could either:

- reduce raw material costs without affecting product performance (potential savings of nearly R6M per annum) or
- improve the product performance by increasing the amount of energy delivered by the explosive composition.

Tests were done in which the high grade aluminium used in packaged explosives (both the Magnum and Powergel range) was replaced by a thermite mixture. The detonation characteristics of the explosives measured included Velocity of Detonating (VOD), Minimum Initiator (MI) over a period of 6 weeks on ambient and hot (40°C) and energy measurements in the Under Water Test Facility (the “pond”).

For both the Magnum and Powergel products, the addition of thermite to the emulsion caused a decrease in the stability of the product with a corresponding decrease in sensitivity. VOD's, at best, did not change but for the Magnum product, there was a substantial decrease (4.1 decreasing to 3.5kmh⁻¹). The most dramatic decrease was however in the energy liberated during detonation. When comparing the Magnum and Powergel standards (containing regular aluminium) with those containing an equivalent amount of thermite, there was a 24 and 19% decrease in total energy respectively with the major contributor being the decrease in the gas component of energy (27 and 25% respectively). This phenomena was in contradiction to the suppliers claims of **increase** the reaction temperature when thermite was used in the explosive which should have resulted in an **increase** in the gas energy.

A significant area of concern (apart from the decline in energy, VOD and sensitivity!) was the effect that the thermite had on the stability of the emulsion. Samples left in hot storage for 6 weeks became severely crystallised and for one sample, this resulted in the product failing when initiated with a 6D strength detonator. The detrimental effect that the thermite had on

the stability of Packaged Explosive emulsion was duplicated with emulsions used in the Surface and Africa business. Long term stability was severely affected with the emulsions becoming very hard (crystalline) on storage and this was compounded by the effect that the thermite had on the gassing rate and the evolution of ammonia gas when doped with 5% m/m thermite. Analysis of the thermite indicated that the impurities included amphoteric aluminium oxides as well as silica and carbon. The aluminium component of the thermite was often less than 20% metal! The oxide impurities were thought to raise the pH of the oxidiser droplets in the emulsion, causing the ammonium nitrate to decompose (dissociation of NH_4NO_3 to NH_3 starts at pH ~6.5). The basic nature of the thermite impeded the gassing reaction which is acid catalysed and any free acid present was consumed by the presence of the thermite which resulted in extra slow, or no gassing, occurring in the presence of the NO_2^- ion.

In 2002, a report from an independent research organisation claimed that the addition of thermite to Pentolite lead to an overall increase of 56% to the "blast impulse" of the explosive. The inclusion of a mere 5% m/m of thermite lead to a 77% improvement! Based on these results, AEL requested that the supplier produce the best Pentolite/thermite combination for testing to determine whether there would be any advantage in including thermite to their booster composition.

The Instrumented Gap Test (IGT) was used to compare the performance of standard Pentolite boosters with those containing thermite. In this test, a variable length of attenuator is placed between the donor (booster) and acceptor (an ANFEX column) explosives. The greater the length of the attenuator that is used whilst still achieving full detonation of the acceptor column, the better is the booster with regards to its ability to initiate explosives. Testing of a variety of booster configurations indicated that a **400g** booster containing 30% thermite was only marginally superior to a standard **150g** and was **inferior** to a **250g** Pentolite booster. VOD measurements of the explosive compositions showed a significant decrease from 7,620m/s to 7,100m/s (7%) from the Pentolite to the thermite compositions respectively.

Substantial testing of thermite in a variety of explosives compositions has yet to reveal any advantages to using this raw material. All testing undertaken so far has shown that thermite causes emulsions to be less stable, decreases the energy delivered and decreases the velocity of detonation. Addition of the "energetic" material to Pentolite causes a deterioration in the initiation ability of the booster. There are indications that the thermite mixture is more abrasive than standard aluminium powder which could have severe repercussions on the maintenance of plant equipment.

In short, there is no evidence that thermite has any benefits for AEL either for cost reduction or performance improvements.