THERMOBARIC EXPLOSIVE TECHNOLOGY

Dr. J. Saji, presently Scientist D at HEMRL joined DRDO in 2003. He is working in the area of High Explosives and related systems. He was associated in the development of Fuel Air Explosive bomb and Thermobaric warheads.

Thermobaric explosives (TBE) classified as enhanced blast explosives are one of the recent advances in the field of high explosives. TBE technology gained interest due to the changing nature of modern day warfare where combatants are frequently fighting from caves, tunnels, bunkers, vehicles and multi-room structures in urban environments. Conventional explosives designed to produce high blast overpressure and fragmentation effects have limitations in defeating targets in hard enclosed spaces like tunnels or caves. The changing nature of warfare has necessitated development of weapons suitable for use in urban or confined environment where target defeat can be achieved without undue collateral damage. In this scenario, military forces world over are looking for ammunition which is insensitive in nature with target specific warheads and improved delivery systems. In line with these requirements, HEMRL has developed the technology of thermobaric explosives which is a critical milestone in the path to development of advanced futuristic weapon systems.

The term "thermobaric" is derived from the capability of generating temperature ('therme') and pressure ('baros') output. The fuel rich thermobaric explosive compositions are capable to create sustained high temperature and longer duration overpressure as compared to conventional high explosives. This nature of output is made possible by using precise combination of fuel and explosives in the composition along with suitable design of warhead. Generally, TBE compositions consist of metal fuel in excess of 30% by weight along with high explosive and binder. Another variant of TBE utilises metallised gelled fuels with a high explosive burster charge. The nature and size distribution of fuel particles are chosen to achieve the enhanced blast and thermal effects. TBE compositions are oxygen deficient in nature and require additional oxygen from air to achieve complete combustion of fuel.

When a thermobaric explosive is initiated, the detonation is simultaneously accompanied by the dispersal of the explosive detonation products and metal fuel in air. The heat generated in detonation ignites the metal fuel mixed with the compressed hot air behind the shock, which leads the blast wave. The hot environment helps in fuel combustion reaction with detonation products and atmospheric oxygen resulting in a sustained pressure wave and a thermal output which damages the target. The wide dispersion of the fuel before combustion makes the initial combustion zone very large in comparison with a standard high explosive blast (Figure 1).

Figure 1. Thermobaric explosive detonation

In confined conditions, the reflections from surfaces enhance the blast pressure and impulse and also provide kinetic support for fuel combustion. Thus, thermobaric materials are optimised to partition the energy release in multiple stages (anaerobic and aerobic) and the total energy output is significantly higher than conventional high explosive compositions. High explosives (HE) typically produce very high overpressure for a short duration whereas TBEs produce a moderate overpressure for a relatively longer duration with an added thermal effect. A typical blast profile of a thermobaric explosion compared to that of conventional HE is shown in Figure 2.

Thermobaric explosive (TBE) compositions are capable to generate high temperature output greater than 1500^{o}C sustaining for hundreds of milliseconds. The enhanced blast and thermal output makes TBE detonation more effective against targets especially in enclosed spaces like tunnel, bunker, field fortifications, underground structures, buildings, machine gun posts, etc. The nature of TBE compositions also makes them a potential candidate for insensitive munitions.

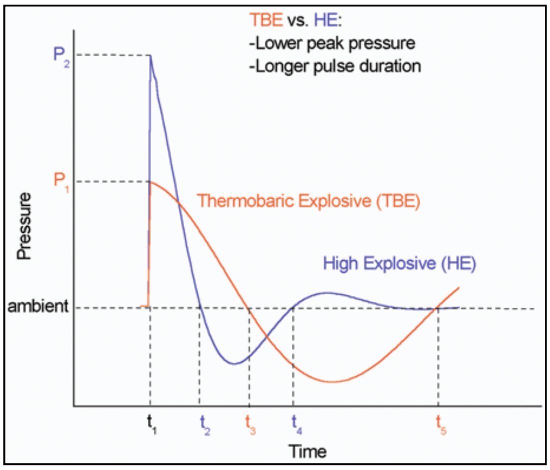

Figure 2. Typical blast pressure profiles from TBE and conventional HE detonation

Responding to the challenges, HEMRL has developed technology for thermobaric explosives which enabled the development of thermobaric ammunition. The indigenous efforts have resulted in development of thermobaric explosive compositions, establishment of preparation process, and performance testing methods. The effect of various parameters like nature and proportion of fuel and explosive ingredients on the performance was studied for optimisation of performance parameters. Selected TBE compositions were prepared and evaluated at scaled up levels for higher calibre warhead applications. Subsequently, the concerted efforts of armament laboratories (HEMRL, ARDE, PXE and TBRL) have resulted in design and development of thermobaric ammunition for gun and artillery applications. In association with Indian Army, DRDO has demonstrated the lethality of thermobaric ammunition for MBT Arjun and 105mm IFG (Figures 3 to 5).

Figure 3. 120mm thermobaric ammunition of MBT Arjun defeating RCC target structure of 500mm thickness.

Figure 4. 120mm thermobaric ammunition of MBT Arjun damaging target tank

The 120mm thermobaric ammunition developed for MBT Arjun was tested in field trials against targets like concrete structure, field fortification and battle tank in which the enhanced effectiveness and lethality was demonstrated. The thermobaric ammunition created extensive damage to the target tank in various attack modes resulting in fire power and mobility kills. The development of thermobaric class of ammunition is a quantum jump in enhancing the lethal fire power of indigenously developed main battle tank.

Figure 5. Thermobaric ammunition of 105mm IFG breaching a brick wall of 400mm thickness.

The development of thermobaric warhead technology is a critical milestone in achieving self-reliance in the field of advanced warhead technology by providing a cutting edge to Indian armed forces over the contemporaries in terms of lethal firepower.