Answer on Question #43306 – Engineering – Other

Describe clearly the difference between detonation and deflagration

Solution:

Deflagrations are thermal processes that proceed radially outward in all directions through the available fuel away from the ignition source. As the volume of the reaction zone expands with every passing moment, the larger surface area contacts more fuel, like the surface of an inflating balloon. The reaction starts small and gathers energy with time. This process occurs at speeds depending largely on the chemistry of the fuel--from 1 to 10 meters per second in gasoline vapors mixed with air to hundreds of meters per second in black powder or nitrocellulose propellants. These speeds are less than the speed of sound in the fuel (The speed of sound through a material is not constant, but dependent on the density of the material; the higher its density, the higher the speed of sound will be through it). Deflagrations, then, are thermally initiated reactions propagating at subsonic speeds through materials like: mixtures of natural gas and air, LP gases and air, or gasoline vapors and air; black powder or nitrocellulose (single-base) propellants or rocket fuels. The pressures developed by deflagrating explosions are dependent on the fuels involved, their geometry, and the strength (failure pressure) of a confining vessel or structure (if any). Pressures can range from 0.1psi to approximately 100psi for gasoline: air mixtures to several thousand psi for propellants. Times of development are on the order of thousandths of a second to a half-second or more. Maximum temperatures are on the order of 1000-2000 degrees Celsius (2000-4000 degrees Fahrenheit).

Detonations are very different. While a detonation is still chemically an oxidation reaction, it does not involve a combination with oxygen. It involves only special chemically unstable molecules that, when energized, instantaneously splits into many small pieces that then recombine into different chemical products releasing very large amounts of heat as they do so. High explosives are defined as materials intended to function by detonation, such as TNT, nitroglycerine, C4, picric acid, and dynamite. The reaction speeds are higher than the speed of sound in the material (i.e., supersonic). Since most explosives are roughly the same density, a reaction speed of 1000 m/s (3100 feet per second) is set as the minimum speed that distinguishes detonations from deflagrations. Due to the supersonic reaction speed, a shock wave develops in the explosive (like the sonic boom from supersonic aircraft) that triggers the propagating reaction. Detonation speeds are on the order of 1000-10000 m/s so times of development are on the order of millionths of a second. Temperatures produced can be 3000-5000 degrees Celsius and pressures can be from 10000 psi to 100000 psi. It should be noted that a few materials can transition from deflagration to detonation depending on their geometry (long, straight galleries or pipes), starting temperature, and manner of initiation. Double-base smokeless powders (containing nitroglycerine), perchlorate-based flash powders, hydrogen/air mixtures and acetylene (pure or with air) can detonate under some conditions.

The effects of detonations are very different from those of deflagrations. Deflagrations tend to push, shove, and heave, often with very limited shattering and little production of secondary missiles (fragmentation). Building components may have time to move in response to the pressure as it builds up and vent it. The maximum pressures developed by deflagrations are often limited by the failure pressure of the surrounding structure. Detonations, on the other hand, tend to shatter, pulverize and splinter nearby materials with fragments propelled away at a very high speeds. There is no time to move and relieve pressure so damage tends to be much more localized (seated) in the vicinity of the explosive charge (and its initiator) than a deflagration whose damage is more generalized. Damage from a deflagration tends to be more severe away from the ignition point, as the reaction energy grows with the expanding reaction (flame) front. It is for this reason that identification of an ignition source and mechanism for a deflagration may be more difficult than for a detonation.