Manufacture of Wireless Power Transmission Sheet using Printed Plastic MEMS Switches and Organic Field Effect Transistors

Himanshu Shekhar
Sc 'E' Deputy Director
High Energy Materials Research Lab,
Sutarwadi, Pune – 411 021.
Ph – 020-25869865 (O), Fax – 020-25869316
E-mail – himanshudrdo@rediffmail.com

Introduction

Everybody suffers from gas at one time or the other due to various reasons like swallowing air while eating meals, eating too fast or bacterial fermentation of food. To suppress tummy gas another gas producing universal agent called "ENO" is used. It is not only this form of gas, but gas is useful for various industrial, biological, physical, chemical, economical or defence applications. The article, a comprehensive holistic view of usefulness of gas is taken. A specific defence application in the form of its use in gas generators for cold launch of large inter-continental ballistic missiles (ICBM) is explained. The article gives world view as well as Indian scenario for the cold launch systems for missiles.

Usefulness of gases

Gases are third form of any substance, which does not possess any shape or size and taken shape of the container. It has pressure, temperature and volume, which can be used to do useful work. Gases have some chemical action and can be used as antacids or riot control agents. Gases in some cases possess definite odour, which is used in scented sticks, perfumes and specific applications. Gases are flammable, which makes it useful in domestic cooking, welding, automobiles, generators etc. Gases in solid makes them porous and subsequently foam type reduced conductivity materials can be conceived.

Liquefied petroleum gas or LPG is synonym of domestic cooking applications. Spray for car wash and painting also uses compressed gases. For personal applications, duo-sprays, perfumes-sprays etc uses compressed gas operated systems. Conpressed gases have several other industrial applications. All air-atomization nozzles, humidification system, cooling systems need gases in one form all the other.

Wheels of automobiles use compressed air for better grip and reduced friction. At the same time CNG or Compressed natural gas is used for powering automobiles. During first half of twentieth century, hot air balloons were used for air-transportation. The series ended with the tragic Hinderburg disaster of 6th May 1937, when 35 out of 97 persons on-board died. Recently germany has developed a car, named CLEVER (Compact Low Emission Vehicle for Urban Transport), which operates on natural gas. It weighs less than 400 kg and can run at a speed of 100 kph.

As far as defence applications are concerned, gases are used for almost all the systems. Smoke grenades are used for obscuration, marking, signaling and tracking purposes. Coloured smoke is also used for various signature creation and displays. All gun projectiles, shells and rounds are propelled out of gun-chamber by rapid generation of hot combustion gases behind the projectiles. To enhance range of projectiles, base-bleed concepts are also professed. Rocket propulsion is direct application of gas generation. Combustion of solid propellants in rocket motor chamber generates high volume of hot combustion gases, which is thrown out of the chamber by a small vent resulting in forward motion of rockets.

In fact, the first system in defence field moved by gas generator made their appearance during Second World War, in German combat aircraft with ejection seat in 1944. Propellant cartridge has also been successfully used in the starting of piston-engine aircraft.

Gas generators for Cold Launch of Missiles

Solid propellants are extensively used for propulsion of rockets, missiles and space launch vehicles. In addition, they are also used for attitude correction, small thruster, nose-cone separation, retro and gas generation applications. Solid propellants are shaped in pre-defined ballistic configurations, called grains. Upon suitable ignition, they produce high volume of combustion products at high temperature. Suitable confinement produces high pressure and reaction of expansion though rearward positioned vent propels missiles and launch vehicles in forward direction. Simple configuration, easy design and quick deployment offset minor disadvantages of low energy of solid propellants with respect to liquid propellant and their versatility is proven in many existing missiles and other systems.

The generation of high volume of high temperature exhaust gases from combustion of solid propellant is exploited in gas generator applications.

In civilian application, they are used in crash-bags of cars, where inflation of bags is accomplished with the help of burning solid gas generator charges. In defence and launch vehicles, it has several applications. They are used for gas displacements, control surface unfolding, pressure actuation devices, electrolyte displacement for battery operation and also for cold launch of missiles. For general applications, gas generators are supposed to quickly release a large volume of gases and configuration or shape of gas generating solid pellets is not very important.

However, for cold launch of missiles, gas generators have to burn in a progressive fashion and their requirements are quite different and stringent. All vertically launched systems can have either **hot launch**, when missile is fired to move or **cold launch**, when missile is given initial motion with additional auxiliary system. In hot launch of missiles, additional weight, size, maintenance requirement, and initial production cost for the additional power sources is less. The missiles of the hot-launch system also come out of their tubes and are immediately ready to start seeking their targets.

However, this is offset by one major advantage of the cold-launch system i.e. safety. Should the missile engine malfunction while the warhead is armed to detonate during firing, the hot-launch system could be doomed, but the cold-launch system can still eject the missile out of the cell and eliminate or reduce the threat. Another advantage of the cold-launch system is in its low life-cycle cost of the launching tubes: since the engine starts within the tube in a hot-launch system during launches, the tubes of the hot-launch system can only sustain a limited number of launches - after which the tube must be replaced (just like in the large naval guns of obsolete & retired ships). A cold-launch system, in contrast, can last much longer because the tubes are not subject to the extreme heat blasts as are those of the hot-launch system.

The "cold launch" system, first implemented in the R-36M missile, was designed to eject the rocket from the silo with the help of a special Powder Pressure Generator, or PAD (Pressure Actuated Devices). The main propulsion system of the missile would then ignite in midair. Installed in the silo, the PAD generator was capable of sending a 210-ton vehicle up to 20 meters into the air, where the missile's engine would come alive. The "cold launch" technique allowed the deployment of missiles in smaller and cheaper silos without complex exhaust deflection systems required for the R-36 missiles, which fired its engines inside the silo (Gubarev, V., Yuzhnuy Start, Russian, Nekos 1998). In fact china is also developing cold launch gas generating systems for missiles.

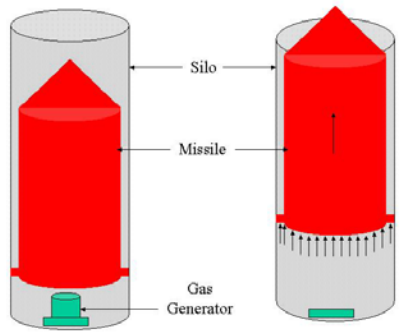


Figure 1. Cold Vertical Launch Missile

Gas generator for cold-launch systems, work on simple piston-cylinder arrangement. Such missiles are stored in silos in vertical position. On combustion of gas generating cartridge, high volume of gases is generated, which lifts whole missile (Figure 1). Later on combustion gases has to compensate for both movement of missile and extra volume created due to movement of missile in the silo. This demands a very high progressivity of combustion. Sometimes mass flow rate has to be made even 5-6 times initial mass flow rate to accomplish this task. Normal solid propellant grains are designed for better neutrality and lesser tail-off, but for gas generating application a highly progressive variation of burning area is needed from propellant and tail-off is not paid much attention. The task is assumed to be complete, when missile goes out of silo and ignited in mid-air.

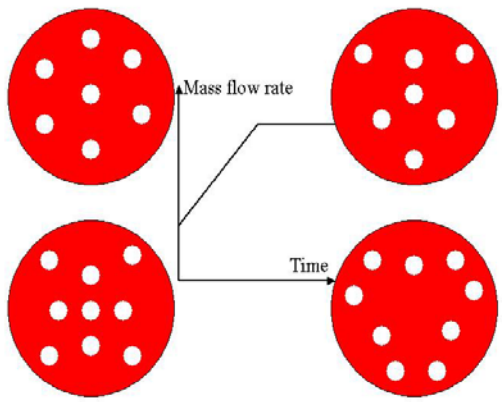


Figure 2. Different Multi-perforated configurations for Gas generators

In general, normal propellant configuration like tubular, star, slotted tube or fin-o-cyl will not be able to meet these requirements of high progressivity. So multi-perforated cylindrical propellant grains (Figure 2) are conceived for such applications. The geometry can be tailored for different progressivity ratio, dimensions and propellant configuration to meet the system specifications and requirements.

Examples of Cold Launch of Missiles

Large missiles are stored vertically in hard silos. Their propulsion may start from silo, but hot combustion gases may make silo-reuse impossible. To compensate this, additional system is needed to bring missiles to above silo and then fire.

The Atlas F, the most advanced US missile of the Atlas series, was designed to be stored vertically in "hard" or "silo" sites. With the exception of its massive 45-ton doors, the silos, 174-feet deep and 52-feet in diameter, were completely underground. During the firing sequence, the missile was fueled, lifted by an elevator to the mouth of the silo, and then fired. This is a complex system and needs more power, more moving parts and thereby reduced reliability.

However, Russians developed the idea of gas generator based cold launch systems for missile. Vertically stored missiles are designed to be launched from silo with the help of small solid propellant based gas generators. There are several Russian missiles, which are reported to be using such concepts. RT-21M / SS-20 SABER is a 1.79m diameter,16.49 m long and 37 ton launch weight Russian missile, where before ignition of the first sustainer stage the missile is popped out of the container with the help of a solid propellant gas generator the missile and then first stage sustainer is started. The SS-20 silo also has the capability to be reloaded and refired. Another missile SS-18 ICBM (SATAN) from Russia also employs a cold-launch technique with the missile being ejected from the silo prior to main engine ignition. The special hardened silo was 39 meters deep and had a diameter of 5.9 meters. Yet another one, SS-25 is a cold-launched, three-stage, solid propellant, road-mobile ballistic missile and has the Russian designation RS-12 M, is called `Topol' (poplar tree), and is believed to have the identification number 15 Zh 58 or RT-2PM. The missile is stored and fired from a launch canister that is 22 m long and 2 m in diameter. The missile is cold-launched from the canister, using a solid propellant gas generator.

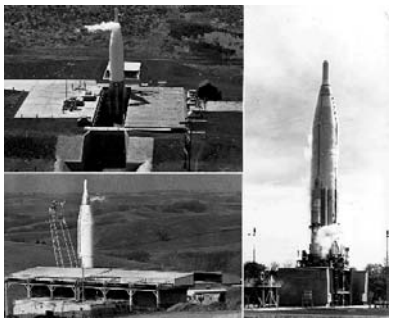
Russian technology is perfected by China also and they also developed missiles with similar vertical launch concepts. DF-31 missile of China has three solid-propellant stages that are believed to have a 16.0 m length, a 2.0 m body diameter, a 42,000 kg launch weight, and 8,000 km maximum range. The missiles are stored, transported and launched from a canister, with a solid propellant gas generator in the base of the canister providing a cold launch. The first stage solid propellant motor is ignited after the missile clears the canister, so that the canister can easily be re-used.

Later on America also adopted this technology for its missiles. The Peacekeeper (designated LGM-118A) is a four-stage intercontinental ballistic missile. The “L” indicates that the missile is silo-launched; the “G” indicates that it is designed to attack ground targets; the “M” indicates that it is a guided missile. The entire missile is encased in a canister in the silo to protect it against damage and to permit "cold launch". Peacekeeper, which was decommissioned in 2003, is ejected by pressurized gas some fifty feet into the air before first stage ignition.

India also has developed cold launch techniques for missiles. Solid propellant hot gas generator is used to launch a missile from canister. DRDO has designed and developed a solid propellant hot gas generator which produces highly progressive mass flow rate. To achieve this, high burn rate non-metalised inhibited composite propellant based on HTPB has been developed. Motor is designed to operate on a pressure range of 15 to 200 kg/cm^2 with factor of safety of 2 to increase the reliability[1].

Conclusion

Gases have multi-dimensional multi-faceted, multi-operational uses. Gas generators exploit one or more of salient features of gas for industrial, commercial, domestic and defence applications. In defence sector, Gas Generators have several applications like Base-bleed units for artillery shells, Smokes for various applications, Cold gases for actuation and recovery operations, and missile components. Missiles uses gas generators for control surface maneuverability and cold launch of vertically located missiles. Propellant grain design is an iterative procedure and unique answer is always a compromise between competing requirements.



ATLAS – F, USA, Elevator Launched

PEACEKEEPER, LGM – 118A, Cold Launch, USA

RT-21M / SS-20 SABER : SS-18 ICBM (SATAN), RUSSIA

SS-25, RS-12 M, “Topol”, 15 Zh 58 or RT-2PM, RUSSIA

Dong Feng – 31 Missile, COLD LAUNCH, CHINA

Figure 3. Vertical Launch of Missiles by Gas Generators