

Foam Grenade: Throwable Active Fire Protection Device

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Abstract:- Nowadays, fires in complicated areas like Confined spaces, tank tops, oil spills, high rise fires, and all the petrochemical Industries are both difficult and dangerous to extinguish. Going too close to flames and combustion products can be fatal. To meet today's need for a rapid and very safe way for extinguishment of fires in an area that is hard to be approached by the conventional methods, foam grenade is proposed. It offers the highest level of safety to the workers, the public, or firefighters in extinguishing the fire.

Traditional methods have the potential to cause severe burns and toxic effects on the human body. Traditional methods also required prior knowledge and training for any kind of operation, they also require maintenance in periodic duration but Foam Grenade is free from both.

Small fires that produce a high risk to life by expanding exponentially or that cannot be extinguished by First Aid Fire Extinguishers, can be extinguished by foam grenade. It is a throwable foam extinguisher ball that can extinguish A and B class of fire by forming a layer of foam over the surface after busting and cutting off the oxygen by smoothing effect and it also uses cooling effect.

Keywords:- Innovative Foam Extinguisher, Chemical Based Extinguisher, Oils and solids Fires Extinguisher, Throwable Active Fire Protection Device, Extinguishment by Smothering, Fire Ball Extinguisher, Fire Safety Extinguishing Device, Fire Extinguisher.

I. INTRODUCTION

A large number of people lose their lives or become seriously injured because of fires. According to World Health Organization (WHO) statistics, fire-induced burns cause more than 300,000 deaths annually and more than 95 percent of these deaths occur in low- and middle-income countries (LMICs) [1]. Studies indicate that large fires have occurred in buildings with no or substandard fire alarm systems. Surveys conducted also indicate that at least 75% of fires are preventable [2] [3]. Also at Petroleum Industries, petrochemical processes completed mainly through a series of physical, chemical reaction, and its main raw materials

and products are in liquid and gaseous components which are almost toxic, flammable, and corrosive [4]. This creates a high risk to workers and can cause harm to the surroundings including fatalities of people. Fire & explosion accident can be caused by tank lightning and static fire, tank, and pipeline leakage fire, explosion, fire ignited, the impact fire, boiling liquid evaporate vapor explosion (BLEVE), vapor cloud deflagration, physical explosion, an explosion of energetic materials and so on, mainly in the form of pool fire, jet fire, and fire flows [4].

Moreover, for extinguishment of such fires fire fighting is essential. Firefighting is dangerous work. Each year, approximately 80,000 firefighters are injured and about 100 firefighters lose their lives in the line of duty. Firefighters face multiple dangers in the course of their work; they encounter toxic fumes, dangerous products of combustion, high radiant heat loads, and a chaotic work environment. Despite the myriad dangers, the leading cause of line-of-duty death among firefighters is a sudden cardiac event, accounting for approximately 45% of duty deaths [5]. And all the traditional fire fighting methods requires skills.

When the fire extinguishing media comes in contact with the human body, it causes severe difficulties like Contact with the solid carbon dioxide gas for more than a second or two without the proper protection may cause skin injury because of rapid and profound cooling, leading to localized cold injury and cellular destruction. Numbness develops because of the inactivation of nerve sensation. Frostbite following exposure to cold gases is an occupational hazard [6] [7] [8]. Inhalation of monoammonium phosphate and sodium bicarbonate can cause mild irritation to the nose, throat, and lungs and results in symptoms like shortness of breath and coughing. Dizziness and headache are also possible [9] [10]. Similarly, several health hazards are associated with different fire extinguishing media, as the fire fighters or workers or normal people have to get exposed to the extinguishing media.

Considering all these points and overcoming them, this research paper is proposed that is, 'Foam Grenade: Throwable foam extinguisher ball'. Form Grenade can be used at all locations, which promotes the risk of A-class and B class of fire. Any individual with zero training can use

Foam Grenade. One can extinguish the fire from a very long distance just by throwing this device in the fire. This reduces the risk of fire and hence becomes the best option as compared to traditional fire extinguishers.

A major application of Foam Grenade comes under the extinguishment of small fires at any petrochemical industry or industries that deals with flammable liquids or solids, and in regular household use. It can rapidly extinguish any Pool fire in case of an oil leak or oil spill. Foam grenade can be used in the protection of households, rooftops of storage tanks, or at Rim seals so that it will be perfectly suitable in case of fire.

II. MATERIAL AND METHODS

Foam grenade is a device that consists of two layers/Partitions and each part consists of different chemicals that on reaction produce foam and releases organic and inorganic salts with carbon dioxide gas. When these products are brought in contact with fire the fire

triangle is broken and thus the fire extinguishes. The basic principle which is followed in this process is Smothering and Cooling effect.

2.1. Construction and Materials

This device holds up two different kinds of chemicals and they have to be placed separated, for this reason, two concentric Ball like structure is introduced. One small ball containing one set of chemicals is overlapped by another ball with another chemical. This idea prevents both the chemicals to mix up and start reacting with each other in the earlier stages. The interior ball is of fragile and brittle material (thick Glass or plastic) and the outer ball is of flexible latex layer. The two layers are of different materials because of its actuation process, both the chemicals have to be mixed up. Both the layer's material is non-reactive with its chemical constituent.

A figure for understanding how the Foam Grenade looks like is shown in figure 1 & 2 (not the actual device)



Fig 1&2:- Foam Grenade's 2 layered structure [12] [13]

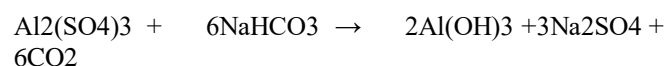
The chemical which is present in the inner section is a solution of alkali and the chemical which is present in the outer section is an acid. Water and a stabilizer are mixed along with these chemicals. The stabilizer is added to make the foam strong, adhesive, and long-lived. When these chemicals react with each other, they form a foam/froth of bubbles filled with carbon dioxide gas.

These chemicals usually are aluminum sulphate ($Al_2(SO_4)_3$) and sodium bicarbonate ($NaHCO_3$). And some sort of stabilizers like Turkey red oil or soap or detergent. The water is present in excess amount.

2.2. Working Mechanism

Foam grenade consists of a fragile core-shell and a flexible outer shell, for this device to work only when both the chemicals mix with one another. For this reason, a strong impulsive force is applied to the Foam grenade. When this force is applied, the flexible outer layer is compressed and the force is transferred to the inner core. As the inner core is brittle after absorbing this impulsive force it breaks into pieces. As a result, both the chemicals mix into one another.

Now when both the chemicals mix with one another they start a violent reaction. Immediately after inner core busting, the foam grenade is thrown over the pool of fire or burning combustibles solids. In the pool of fire, it can float due to buoyancy or if we add heavy chemicals, it sinks. Either it's over the fuel or sunken down it will release its extinguishing media on the burning surface. Also, this is one of its greatest advantages over Fire extinguishing Ball (which uses Dry Chemical Powder as an extinguishing agent, this point is explained in detail later on). The chemical reaction follows in this manner:



AluminumSulfate + Sodium Bicarbonate =Aluminum Hydroxide + Sodium Sulfate + Carbon Dioxide

13% Aluminum Sulphate, 8% Sodium bicarbonate, 3% (Stabilizer) Turkey Red Oil, and Excess Water.

Sodium Sulphate and Aluminum Hydroxide are products of this reaction that have foaming tendency and fire savaging properties. When these two chemicals are combined with water, they form a very sticky and viscous fluid. Now when another product, that is Carbon Dioxide comes beneath it, it starts forming bubbles. All these processes occur at a very fast rate. As a result, a thick layer of strong foam is formed. Just after this reaction begins, the volume inside the flexible layer expands rapidly this causes the layer to stretch and after few seconds it burst and releases all its foam and gases over the burning fire. The mixture of Foam, Water, and Carbon Dioxide extinguish the fire.

2.3. Methods of Extinguishment

When the Foam Grenade Explodes it releases foam and when the foam touches the combustion surface, the evaporation of the fuel is exacerbated by the increase in the total vapor pressure of the liquid surface, resulting in the accumulation of a large amount of combustible gas in the middle of the flame. At the same time, a large amount of

water vapor generated by the heat. Due to all these gases, the concentration of oxygen decreases and thus weakens the fire.

As the layer of foam accumulates, the foam gradually spreads over the oil surface and forms an effective covering layer, which further reduces the burning area and the flame temperature. With the further spreading of foam, the temperature of oil covering by foam is below the ignition point of the fuel, resulting in the extinguishing of a pool fire. During the fire extinguishing process, the foam cover layer can effectively terminate the combustion and prevent the occurrence of re-ignition. And, the combustion is further weakened and extinguished until the entire oil spill or fire is covered by a foam layer. Based on the above analysis, it can be seen that the Foam Grenade mainly reduces the evaporation rate of the flammable liquid and isolates the thermal radiation of flame on the combustion surface through covering and cooling effects, thus achieving an effective fire-extinguishing performance [11].

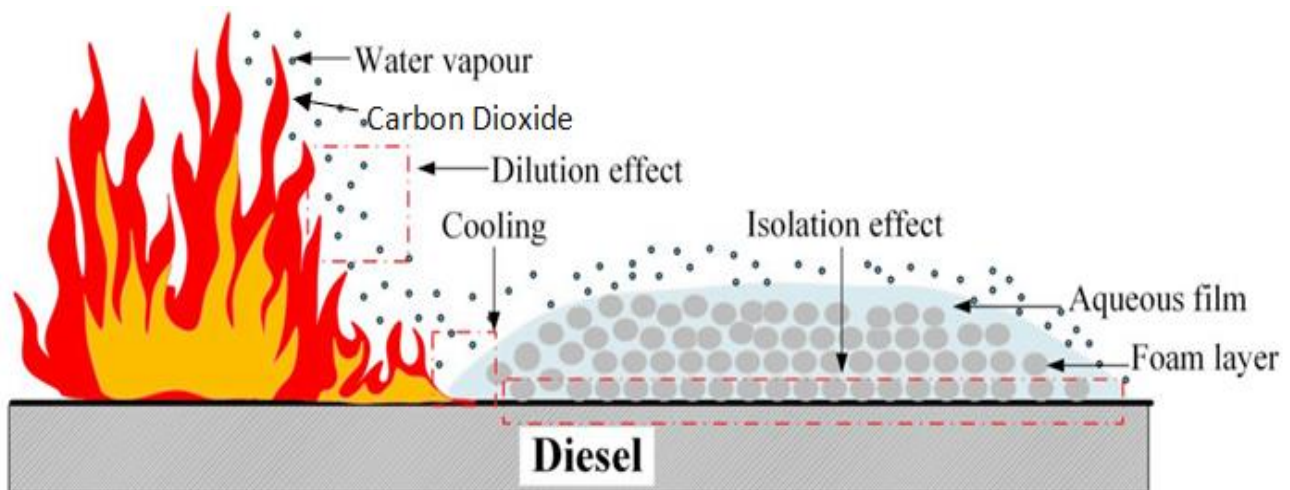


Fig 3:- Schematic diagram of fire Extinguishing Mechanism in pool fire [11]

On class-A type of fire, the major effect is cooling as the water present in Foam Grenade enters the combustible solid and reduces its temperature, hence extinguish the fire. As water have a very high latent heat of vaporization, when it falls on fire it absorbs heat and expands rapidly. When the water is converted into steam after absorption of heat (in the ratio of 1:1600), this steam along with carbon dioxide depletes the concentration of oxygen and helps extinguish the fire.

III. THEORY

After discussing details of foam grenade now it's Important to Understand the Applications and Advantages of this Innovative Foam Extinguisher.

3.1. Advantages

Foam Grenade has a wide range of applications. It can be used over Class A fire (Fire involving combustible solids) and over Class B (Fire involving Flammable liquids and liquefied solids). Foam Grenade weighs soo light that

even children can use it without any complications. There are some places where traditional extinguishers cannot reach or people are not aware of how to use them. Here major application of Foam grenade comes, some of the reasons why Foam Grenade is more useful as compared to other devices are:

- 3.1.1. Being small and light in weight.
- 3.1.2. Actuate just by an impulsive force to extinguish the fire.
- 3.1.3. No need for prior knowledge or specific training.
- 3.1.4. No Inspection and maintenance is required for this product.
- 3.1.5. It provides a fast way to extinguish small fires till proper help arrives.

The revolution of foam grenade offers advantages that exceed conventional methods and affordable solutions.

3.2 Applications

Some location/places where Foam grenade can be used and other Fire Extinguishers cannot reach are:

3.2.1. Extremely dangerous situations

Some places or situations, which possess high risk, are not advised to be approached with first aid fire extinguishers, in such cases Foam Grenade will be perfect for fire extinguishment. As Foam Grenade can be used from a very long distance, people do not have to risk their lives.

One example of such a situation is shown in figure 4.



Fig 4:- Tank fire at petrol pump station [14]

From this picture, we can refer that at a petrol pump station a tank filled with petroleum products eventually caught on fire. Now for extinguishing as a first-aid means it is unimaginable to use a Fire extinguisher and go too close to the tank because there are chances of Boiling Liquid Expanding Vapour Explosion or another sort of mishaps. But if we use Foam Grenade we can easily suppress the fire ensuring safe conditions. If 6 to 7 Foam Grenades are thrown at this situation (few on the floor and remaining inside tank opening) then it can minimize loss until proper help arrives.

3.2.2. High rise fire

Fires involved in buildings above ground floor possess height, that pressure in normal fire extinguisher can not expel the charge to fire site. Hence the fire remains expanding. But if someone uses a Foam grenade instead, the small fires will extinguish rapidly. One example of such a situation is shown in Figure 5.



Fig 5:- 1st floor fire [15]

From this picture, it is clear that the fire is at such height that normal extinguishers can do nothing. And if someone has to extinguish this fire then s/he have to risk their life by entering this burning building. But by throwing a few Foam grenades from the window fire can easily extinguish.



Fig 6:- Car on fire[16]

3.2.3. Burning Car

If there is a situation in which there is a fire in a car. As shown in FIGURE 6:

In such situations, one can not extinguish the fire if the car is at a remote location, because no one can carry a heavy extinguisher to such far distances. Also is someone who wishes to carry an extinguisher in the car itself will not be possible because it occupies a large space. Before proper help from the fire service will arrive the car will turn into ashes. Foam Grenade occupies very little space and hence can be placed in large numbers even in small cars. Only one or two Foam Grenades will be sufficient for such small fires.

3.2.4. Pool fire

This kind of fire is so dangerous and in seconds it can turn into a disaster, so it's so important to extinguish it in its earliest stage. As shown in Figure 7.

A) when there is a barrier (here water) between fire and firefighters, it can take time to reach the location. Where Foam Grenade can be instantaneously used.

B) closer look at pool fire.

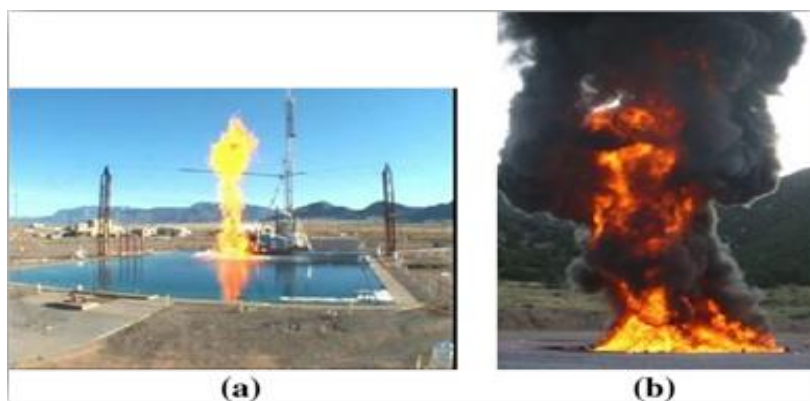


Fig 7:- Pool Fire[17]

IV. DISCUSSIONS

In many situations, Foam Grenade can be lifesaving. It overcomes all the traditional big and heavy Fire Extinguishers. It is small and cheaper.

Fire extinguishing ball that uses dry chemical powder as its extinguishing medium is nowadays trending in fire extinguishing. It uses explosives to expel its extinguishing media. However, it is not suitable at various locations. For example, when a fire extinguishing ball is thrown into a pool of petroleum products, on exploding rather than extinguishing the fire it eventually spread the fuel all over the place and will intensify the fire and it gets fail. Also, if the burning pool is deep extinguishing ball will sink inside the fuel and it will not even actuate. However, at the same place if we use Foam Grenade then the fire will extinguish very easily, as after exploding, it does not produce shock waves and hence no fuel is thrown away.

As we had seen a few examples where this device is applicable, in every situation Foam Grenade will be the best option as a first-aid measure. Besides this situation, it can be used in several other places.

V. CONCLUSION

If this research paper is given consideration, many lives can be saved. Because this device overcomes many drawbacks of other traditional fire extinguishers. It provides long-range protection in a very effective way and has a reach where other devices cannot reach. It is also way safer because fire fighters do not have to deal with the dangerous extinguishing media.

Foam Grenade's idea is innovative and it can replace other first-aid fire extinguishing devices. It can be easily used anywhere especially in the petrochemical industry and households because of its special qualities and easy to use procedure.

As today's trend, people are moving towards simplicity, and Foam Grenade is a very simple and effective Fire Extinguisher. Soon every home, car, or organization may have several Foam Grenades for their protection.

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Note: No one should use this model for their profit without the permission of the author.

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