Analysis of Fireworks accidents in sivakasi

R.Manikandan[1]
M.E
Department of Mechanical Engineering,
Kalasalingam University,
Krishnankoil-626126,
E-mail: rmanikandan198@gmail.com

Dr.S.Rajesh[2]
(Industrial Safety Engg Associate professor.
Department of Mechanical Engineering,
Kalasalingam University,
Krishnankoil-626126,
E-mail: p.ganasen@klu.ac.in

Abstract:

In generally all industries, accidents are occurred and fatality rates increased day by day. Particularly in sivakasi many number of accidents are occurred in fire workers alone than other industries. Fireworks crackers made of Al, Mg, S and KNO3. These chemical powders are hazardous in nature, very sensitive and when exposed to heat and humidity it leads to decompose. Here I proved sensitiveness of the chemical powders using friction and impact sensitivity test. Climatic condition is also fixing the accident rate. The various hazardous process are involving like mixing the chemical powder, filling the mixed powder tube, drying the chemical mixture for making the crackers. During this process, accidents are occurred and carelessness of the workers,(i.e.) mishandling of chemical powders exposed to mechanical sensitiveness fire may occur. So, the main aspire of this study was evaluate the causes of fire and explosion. So here I have collected all accidents statistics and founded its root causes. Finally I will give safety remedial measures for preventing the accident and make safe environment in fireworks.

Keywords: Fireworks accident analysis.

1. Introduction

Sivakasi is a large manufacturing centre, gratitude to its innovative and work cognizant people. It is a arid and warm region. Sivakasi is well recognized all over India for its industries like Fireworks, Match Industries, Printing Industries. In fact the whole country depends on Sivakasi for its supply of fireworks and matches. India is the second largest producer of fireworks after China. In sivakasi more than 90% to India's overall fireworks production. The fireworks industry in Sivakasi is worth between Rs 800-1000 crores.

Fireworks in Sivakasi

There are nearly 983 fireworks factories giving a job of more than 70,000 employees and about 1 lakh indirect such as paper tube making, wire cutting, box making in the country side. About 20-25 workers pass away each year in fire accidents in this industry[1]. Fireworks are display that uses hazardous material to create fantastic displays of light, noise and smoke and used for aesthetic, cultural and religious purposes.

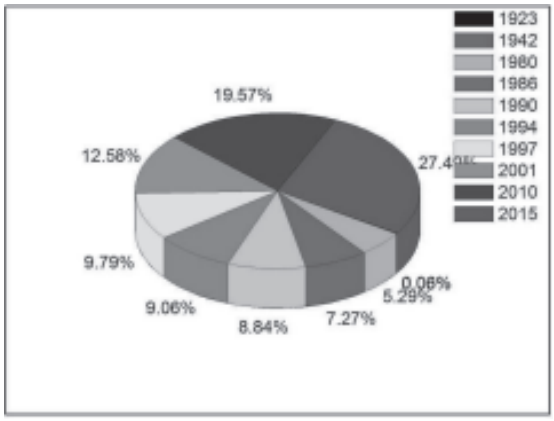


Figure.1Fireworks in sivakasi (Ref.19)

As in any manufacturing industry, Fireworks units also have accidents taking place in the worksite. To decrease the risk of accidents, safety procedures are to be maintained strictly inside the manufacturing areas. The Pyrotechnic

compositions used for fireworks are a mixture of fuel, an oxidizer, binder, colorants and other material with special effects.

The pyrotechnic compositions can occur exothermic reaction in the storage process, generate gases heat. If the heat cannot be discharged promptly, it will accelerate deflagration, which will increase the possibility of the accidents.

The different chemicals using are sulfur, aluminum powder of different grades, barium nitrate, potassium nitrate, sodium nitrate, strontium nitrate, dextrin, charcoal, aluminium powder, PVC, magnesium powder. All of these chemicals are hazardous in nature and very sensitive. So we should handle the powder carefully.

The manufacturing processes in the fireworks industry can broadly be classified into seven stages.

- Mixing of chemicals.
- Filling the chemicals
- Fuse making
- Fixing the fuse
- Drying the chemicals
- Wrapping/Labelling the product
- Packing
- Storage

.

216 fatalities and 63 are severely injured from 1994 to 2008. It shows that most accidents were caused by in excess of gunpowder put in at one time and accidents resulting from carelessness while making fireworks. Unsafe acts and unsafe conditions are the main reasons for these accidents[1]. 127 persons were died and 69 persons were injured in fireworks industries accidents during the period from 2010 to 2012. It shows that the workers are unaware of the dangers in the chemicals they are handling. Unsafe acts and unsafe conditions are the main reasons for the accidents[2]

. In fireworks units have accidents taking place in the worksite. So, to reduce the potential accidents, safety rules are to be followed strictly in the manufacturing areas.[3-4] The various process involved in the fireworks manufacturing are chemical mixing to packing.[5-6] Xu-Lin Chenet al, analysed 351 patients having burns caused by gunpowder explosions in a fireworks factory were admitted to center from 1 January 1987 to December 1999 and the clinical notes of 339 patients. Various aspects of fireworks accident cases and causes of explosions were recorded.[7] Analysis of ballistic behaviour of gun powder and flash powder of firework chemicals with different particle size have been carried out. When using a nano size particles it greatly influence of environment and makes less emission to surrounding.[8] Change the particle size of the chemical composition from micron level to nano size, the volume of mixture used will be greatly reduced without affecting the performance of the crackers. To make a free environment, nano size powders are to be used in fireworks. but, the major risk in using nano size powders is that it is a fire hazard.[9] The ground-level pyrotechnics causes air pollution which could be a health hazard.SO2 exposure exceeded the threshold for bronchoconstriction in asthmatics and metals are Ba, Sr and Cu, as well are respiratory irritants, were at levels exceeding ACGIH occupational exposure guidelines.[10] The main causes for fire/ explosion in these work places is the sensitiveness to impact and or friction. It had been experimentally established. This paper suggests many necessary safety precautions to be followed in the manufacture of flash compositions.[11] Accidental death involving the explosion of professional fireworks in an apartment is described. The examination of the scene permitted to study several effects of the explosion on various building structures where the victim was found. The external examination of the victim exposed to various injuries and extensive shrapnel wounds. The autopsy examination showed that the entire surface of lungs showed blunt injuries and the liver showed tearing of parenchyma and multiple cavities.[12] 157 cases (92 retrospective, 65 prospective) with injury due to fireworks presenting to the Department of Plastic Surgery at KEM Hospital between 1997 & 2006 were studied. The reason behind the accidents is misuse failure, device failure, personal failure and innocent victims etc were studied.[13]

Occupational health and safety is about preventing people from hazardous work environment.[14] Working with chemical or in a industry poses various skin diseases, asthma, allergies, irritant contact dermatitis and death.[15] All risks in the workplace must be identified and assessed for control measures.[16] Workers had cases of chronic headaches, dizziness and ulcers due to high level of exposure of Manganese during the manufacturing process. Workers didn't wear masks or gloves while working, and hence source of entry of the metal into the body and make a asphyxiation problem.[17] The main environmental factors influence on pyrotechnic component thermal decomposition are temperature and humidity. Thermal decomposition may occur early when the pyrotechnic powers are exposed to humidity.[18]

Accident in Fireworks

Each and every year accident rate was increased abruptly. In 2001 -2002 only 7 accidents are occurred, 7 peoples were died. but 2010-12, 127 peoples were died. this is for needs of crackers for everyone and lacking of safety measures.

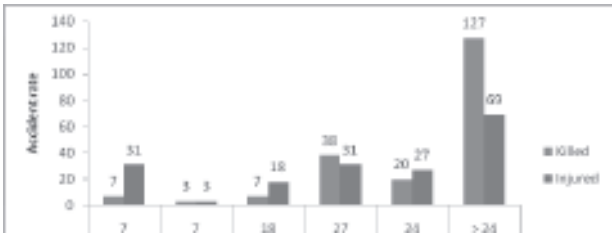
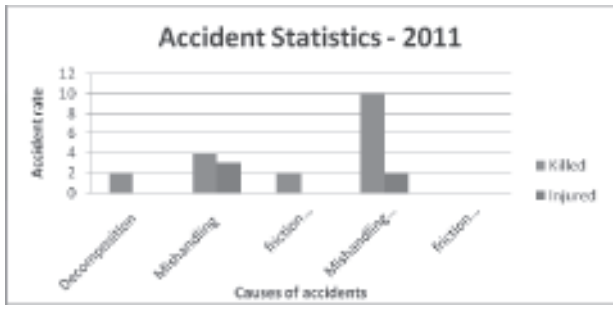


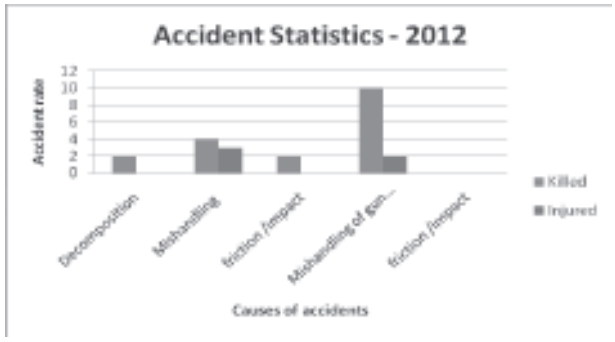
Figure 2 Accident strategy in fireworks

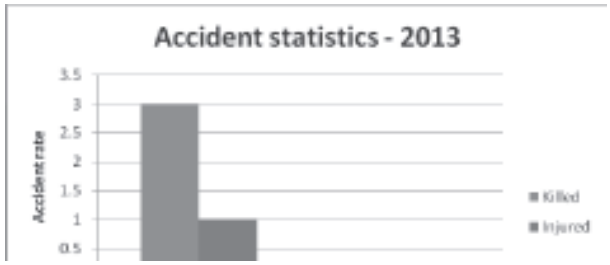
The accident data are collected from the Chief Inspector of Factories, Chennai for the period 2010 to 2012. The number of fatalities during the period was 127 which involve 30 factories.

One hundred and twenty seven persons were died and sixty nine persons were injured in fireworks industries accidents during the period from 2010 to 2012.

Petroleum and Explosive safety organization (PESO) annunally released the report for all explosive industry include fireworks accident. Here I have plotted graph using PESO datas.







S. No.	Sample	Limiting Impact energy (Joules)	Limiting Friction sensitivity (Newton)	Explosion type
1	Gun Poweder	17.265	……	Sensitive
2	Green Strar (Powder)	7.848	252	Very sensitive

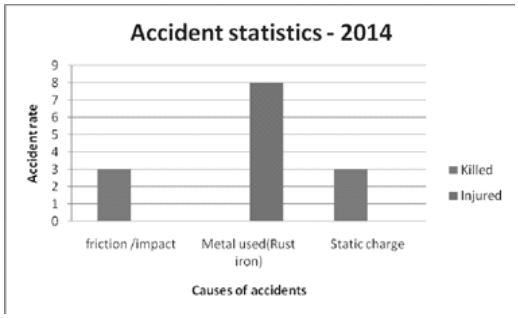


Figure 3 PESO Accident report – 2011-2014 Causes of accident

From the PESO report, In fireworks many accidents are occurred due to

- Mishandling of chemical powder
- Mixing the chemical powder
- Filling
- Friction
- Impact
- Static electricity.

Due to the carelessness of the workers chemical powders are fall into the floor and exposed to frictional contact into the floor fire may occur. By conforming that here I have carried out impact and friction sensitivity test for different chemicals alone and mixed chemical powders like gun power and fancy stars. The result shows that when the chemical power are in separate fire hazardous is less than mixed chemical powder. The experimental is given below.

Table .3 Impact sensitivity test for gun powder (Powder)

S.No	Height (metre)	Trail					
		1	2	3	4	5	6
1	0.4 to 0.88	X	X	X	X	X	X
2	0.9	✓	✓	✓	✓	✓	✓

- Explosion X – No explosion

Limiting impact energy (E) = mgh

M = 2Kg , g = 9.81m/s2, h = 0.88

E = 2 X 9.81 X 0.88

= 17.2656Joules

Table.4 Sensitivity test for green star & gun powder

From the above experimental test the fireworks chemicals are hazardous in nature.

Safety measures

The following safety measures should be followed by the workers and its supervised by the occupier and safety officer in inside the fireworks unit for mitigate the accidents.

- Storing the pyrotechnic chemicals in separate room.
- Name boards for each process to be displayed.
- Utensils used for one type of mixture should not be used for other type of mixture
- Wear rubber shoes while at work
- Do not carry matches
- Doors are made of woods fitted with non ferrous hinges
- Doors shall be open outwards
- Least quantity of chemical composition in working places (not more than the prescribed limit)
- Room shall be well ventilated to reduce the probability of dust explosion
- Firework products are never to be dragged roughly
- Fire buckets shall be filled with dry sand and never being used for other purpose
- Display safety posture (for uneducated workers)
- All rooms have minimum of two fire exits.
- The doors of any two manufacturing shed should not face each other to prevent the spread of fire in case of explosion.
- Floor should be covered with electrically conducted rubber mat
- Space between the buildings shall be minimum 10 meters
- Space between the drying platforms and other rooms shall be 18 meters
- Distance between mixing and filling sheds shall be 18 meters
- Suitable mound / screen shall be provided around mixing or filling rooms. The mound should be RCC, 22.5 cm thick, or brickwork

with 34 cms. thick and 1.5 to 2 meters from the shed

- Dipped fuse thread should not be overlap each other
- Wooden knob and brass cylinder should only use for making stars (colour balls).
- Wooden hammer should be used for ramming chemicals into the tube of rockets.
- The wastage chemicals are disposed properly.

Reference:

1. N.Rajathilagam et al, Accident Analysis In Fireworks Industries For The Past Decade In Sivakasi
2. Ravi A, Dr.Gandhinathan R, Analysis Of Safety Climate In Fireworks Industries In Tamilnadu International Journal of Scientific & Engineering Research, Volume 4, Issue 12, December-2013 760 ISSN 2229-5518

3). Azhagurajan.A., 2005. Study on explosive waste disposal with a case study on fireworks waste. Journal of Industrial Pollution control 21, 43-50.

4). Brock.H.,1949. A history of fireworks. George.G.Hararap Co. Ltd. London.

5). Chelladurai.A. 1987, Fireworks – Principles and Practice – Tips to an Amateur – Do's and Don'ts. Standard fireworks, Sivakasi.

6). Ghosh,K.N., 1987, The Principles of Fireworks. H.Khatsuria, Sivakasi.

7). Xu-Lin Chen, Yong-Jie Wang, Chang-Rong Wang, De- Lin Hu, Ye-Xiang Sun, Shou-Sheng Li., 2002. Burns due to gunpowder explosions in fireworks factory: A 13-year retrospective study. Burns 28, 245-249.

8) N. Selvakumar et al , Ballistic behaviour of gun powder and flash powder for firework chemicals as a function of particle sizes, www.elsevier.com/locate/measurement Measurement 46 (2013) 3202–3210

9). A. Azhagurajan et al, Impact of nano particles on safety and environment for fireworks chemicals, Process Safety and Environmental Protection92 (2 0 1 4) 732–738

10). Gerry Croteau et al, Department of Environmental and Occupational Health Sciences, USA.Emission factors and exposures from ground-level pyrotechnics, Atmospheric Environment 44 (2010) 3295-3303

11). S.P. Sivapirakasam et al, Hazard assessment for the safe storage, manufacturing and handling of flash compositions. Journal of Loss Prevention in the Process Industries 22 (2009) 254–256

12). Francesco Saverio Romolo et al Department of Anatomical, Histological, Forensic Medicine and Orthopedic Sciences, "Sapienza" University of Rome Viale Regina Elena,336-00161 Rome, Italy, Accidental death involving professional fireworks. Forensic Science International 234 (2014) e5–e9

13).Vinita Puri et al ,Department of Plastic, Reconstructive Surgery and Burns, Mumbai. Firework injuries: a ten-year study. Journal of Plastic, Reconstructive & Aesthetic Surgery (2009) 62, 1103-1111

14).Valerio Cozzani, MichelaCampedel, ElisabettaRenni, Elisabeth Krausmann., 2010. Industrial accidents triggered by flood events: Analysis of past accidents. Journal of Hazardous Materials 15, 501-509.

15). AndrisFreivalds, Alison B. Johnson., 1990. Time-series analysis of Industrial accidents data. Journal of Occupational accidents 13, 179-193.

16).Chelladurai.A. 1987, Fireworks – Principles and Practice – Tips to an Amateur – Do's and Don'ts. Standard fireworks, Sivakasi.

17). Sukumar and R. Subramanian , Trace elements in scalp hair of Manufacturers of fireworks from Sivakasi, Tamil Nadu, The Science of the Total Environment, 114 (1992) 161-168.

18). Xing Qifeng et al, Beijing Institute of technology, China. Study of environmental humidity influence on the thermal safety of the pyrotechnic composition. Procedia engineering 45(2012) 552-557

19). Industrial profile, Potential of industry development.
http://virudhunagar.tn.nic.in/svkindustries.htm