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A Review of Risks to Workers Associated with Fireworks Industry

Dhruv Katoria[1], Dhruv Mehta[2], Dhruv Sehgal[3] and Sameer Kumar[4]

[1]Department of Environmental Engineering, Delhi Technological University Shahabad Daulatpur, Main Bawana Road, New Delhi, INDIA.
[2,3]Department of Environmental Engineering, Delhi Technological University Shahabad Daulatpur, Main Bawana Road, New Delhi, INDIA.

1. Introduction

Fireworks industry is well known to be a hazardous industry. Right from the initial phase of manufacturing till the transportation and storage of fireworks in the stores, risk to life and property is high. The manufacturing process, type of storage and handling are some of the important factors which bear the likeliness of an explosive event taking place.

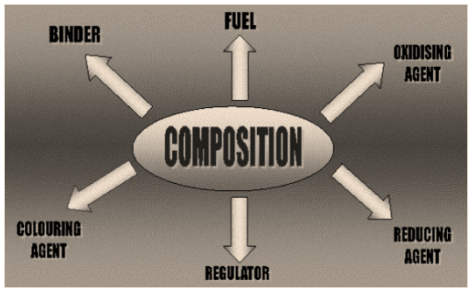
90 percent of Indian fireworks industries are situated in Savakasi, Tamil Nadu and hence the workers there are the most susceptible to injuries. There are around 750 factories and 80000 workers are employed in them. The manufacturing process of assembly is a critical phase where workers come in direct contact with hazardous substances leading to greater like risk. Lead poisoning, ulcers, damage to the central nervous system is some major problems facing these people. Besides unhygienic conditions, improper training lead to greater danger to lives of people. Child labour is a predominant form of employment and leads to loss of lives at an early age. Our paper reviews the hazards faced by workers working in the fireworks industry and provides some mitigation strategies through which these hazards could be reduced.

2. Composition

Fireworks are made of pyrotechnic chemical which are capable of emitting heat, light, sound, gas on ignition. Figure 1. [1] depicts a typical composition of a firework.

Charcoal is the most commonly used fuel in the industry. Oxidising agents are needed to produce oxygen which is required for chemicals inside the firework to burn. Chlorates and per chlorates are mostly commonly used.Reducing agents like sulphur is needed to burn the oxygen produced by oxidising agent to produce got gases. Regulators speed up the process of burning. Colouring agents such as Strontium,

Barium, and Copper provide colour to the fireworks. Binders hold the mixture together.[1]



3. Potential Hazards

3.1 Production Injuries

Manual mixing of chemicals such as fuels, oxidizers, igniters, and sand and special effect chemicals on wooden trays takes place. Here the major causes of accidents are impact, friction, static electricity charges and human errors. Drying of products is done by placing them on specially prepared platforms where accumulation of dust and overheating may cause accidents. After manufacturing of products, they are stored locally where push carts and trucks are used for transportations. During this phase Careless handling, impact loading, over loading and dragging of materials may lead to accidents. [2]

Table 1: Causes of Hazards during manufacturing problems.

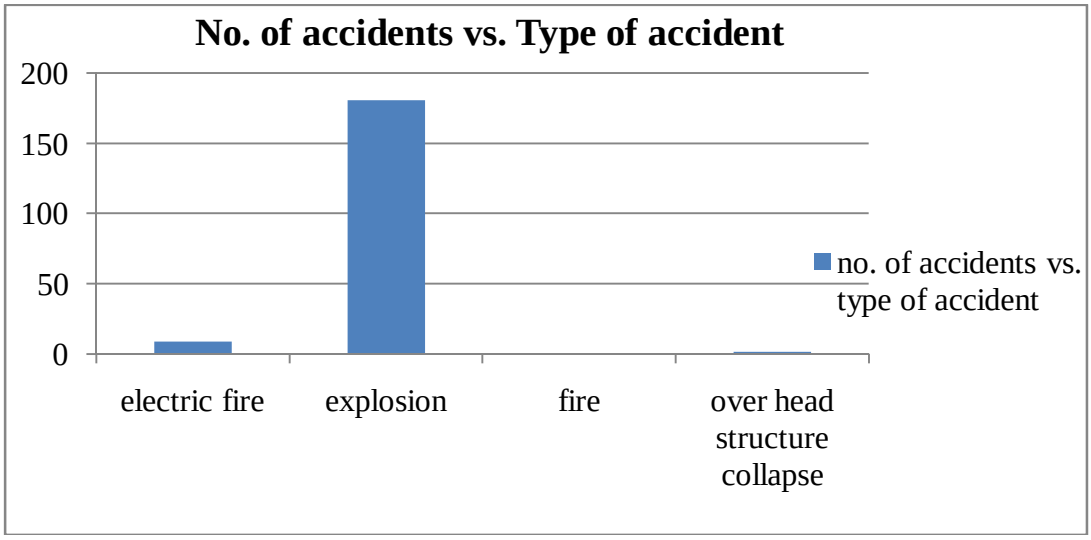
Production Phase	Cause
Manual Mixing of Chemicals	Impact, Friction, Static electricity charges, Human errors
Drying on Heating Platforms	Dust accumulation, overheating
Transportation	Careless Handling, Impact loading Over loading, Dragging of materials

3.2 Explosion Injuries

3.2.1Deep wound Impact Injury- The fireworks-related injury caused by gunpowder explosion following work-related accidents is always a compound injury. Due to the high environmental temperature greater than 1000 ◦C resulting from explosions, the thermal injuries are always severe, with large deep wounds.[3]

3.2.2 Inhalation injury- Breathing of hot smoke during burning of material would lead to increase inhalation of carbon monoxide. On entering into the blood stream, increase of carboxyhemoglobin would take place. Continuous increase in carboxyhemoglobin levels would lead to headaches, damage to the central nervous system and eventually death

3.3.3 Intra ocular foreign body-IOFB is any material that penetrates the ocular tissue. On explosion of fireworks, metallic objects like iron, copper enter into the anterior segment of the cornea. This may lead to retinal trauma, cataract formation, glaucoma [4]



This graph shows that most of the occupational hazards are result of explosion which indicates then proper technical care throughout the manufacturing process is not there

3.4 Effects of Chemicals

3.4.1 Potassium Nitrate- When inhaled, it causes nose and throat irritation. Higher levels of Potassium Nitrate interfere with the ability of bloody to carry oxygen leading to headaches, methemoglobinemia and kidney problems.[5]

3.4.2 Potassium Per chlorate- It causes irritation to skin and eyes. Prolong exposure may affect kidney, white blood cells and thyroid.[6]

3.4.3 Aluminum compounds- It causes irritation to eyes and skin. It also causes metal fume fever which is a flu-like illness with symptoms of metallic taste in the mouth, headache, fever and chills, aches, chest tightness and cough. Exposure to fine dust cause scarring of the lungs with symptoms of cough and shortness of breath.[7]

3.4.4Barium Nitrate- It irritates the nose, throat and lungs. Very high exposure to barium nitrate can cause diarrhea, irregular heartbeat, muscle weakness, tremors,

paralysis and even death. It damages the kidney and repeated exposure results in abnormal chest X-ray. [8]

3.4.5 Copper chloride- it irritates the stomach causing salivation, nausea, vomiting, stomach pain and diarrhea. Repeated exposure can cause shrinking of the inner lining of the nose and may cause ulcers and a hole in the bone dividing the inner nose.[9]

4. Case Studies

4.1 Sivakasi, Tamil Nadu

143 male and female workers of a firework industry in Sivakasi, Tamil Nadu were subjects of a hair sample study. The samples were analyzed for presence of trace metal elements. It was found that workers had higher levels of Cr and Mn and the ones having nervous diseases had higher levels of Cr, Mn and Pb. A detailed analysis revealed that female workers had higher levels of Pb and lower levels of Mn as compared to the male workers.

Workers had cases of chronic headaches, dizziness and ulcers due to high level of exposure of Mn during the manufacturing process. Workers didn't wear masks or gloves while working, and hence respiratory tract was deducted as a possible source of entry of the metal into the body. [10]

4.2China

From January 1987 to December 1999, 1000, 351 patients were admitted to hospitals due to gunpowder explosion in fireworks factory out of which 44 died. Patients who died had an average age of 29 years. Half of the patients died within the first week of explosion because of causes ranging from hypovolemic shock to post burn sepis and multi organ failure. 65 patients had inhalation injury.

The most common injuries associated with explosions are fracture of ribs and blast lung injury.[3]

Table 2

Time and causes of death

Causes of death	Time postburn			
	<2 days	3–7 days	8–20 days	21–45 days
Hypovolaemic shock	4			
Multiple organ dysfunction syndrome (MODS)		8	3	
Sepsis		10	14	3
Pulmonary infection			1	1
Total	4	18	18	4

5. Mitigation strategies-

The main variable to control noise level is the particle size of the chemicals. With nano sized aluminium (nAl) particles, the specific surface area increases creating easier ignition and increased burn rates. This will lead to burst the cracker with lesser amount of chemicals with high reactivity. This will also lead to reduce the emission of pollutants during the celebrations.

1) The main causative fireworks were whistles these fireworks should not be carried close to the body. Fuses are highly combustible since they are coated with gunpowder. As a consequence, required whistles should be equipped with safety fuses. They are covered with plastic, thereby allowing ignition only from the tip.[11]
2) The compression of chlorate compositions is in fact hazardous and must be performed in a protected zone.
3) The sensitivity and behavior of the products implemented must be well understood;
4) To the greatest extent possible, it is necessary to substitute hazardous compositions with less sensitive ones;
5) The execution of various activities on the same premises must not be undertaken without first adopting special measures;
6) An individual apparatus must be used to complement the technician's protective gear;
7) Technicians must be made aware on a regular basis of the risks they incur through a well-designed training program.

Though government's rules and regulations regarding the good environment condition for the workers of fireworks industry is a very essential aspect in minimizing the occupational hazards of firework industries still a lot depends on the alertness of the workers regarding their work and they should avoid any kind of carelessness. As carelessness turns to be a sin for the employers in this industry.

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