STUDY ON A SELF-EXPLOSION IN AN ASPIRIN PRODUCTION FACTORY

دراسة عن انفجار تلقائي بمصنع انتاج الاسبرين

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الخلاصة — يتناول هذا البحث دراسة ميدانية لحادث انفجار وقع في أحد المصانع المنتجة لمادة الاسبرين في جمهورية مصر العربية والذى أدى الى خسائر فادحة في المعدات والأرواح . وقد حدث الانفجار في أحد أقسام المصنع حيث يتم تجفيف عجينة الاسبرين وبالتالي صعود بعض الأبخرة القابلة للاشتعال . وقد ساعد عدم وجود نظام ملائم للتهوية على تكوين مخلوط متفجر في هذا القسم أدى الى الانفجار المروع قيد البحث . ويقدم البحث دراسة تفصيلية لتحديد الأسباب التي أدت الى الانفجار وتقييم للخسائر الناجمة عنه والاجراءات الواجب تطبيقها وتنفيذها لتفادي مثل هذه الحوادث في المستقبل .

ABSTRACT - The study at hand deals with a field study of an explosion that had taken place in an Egyptian Aspirin-Production-Factory. An explosion that has resulted in utter losses in both equipment and personnel. It had taken place in a Drying Aspirin Paste Department in which self-ignitable gases inevitably evaporated. Furthermore, the lack in proper ventilation system had helped in forming an explosive mixture in that department, thus leading to the terrible explosion under investigation.

The present paper gives a detailed account of the reasons of the explosion and an evaluation of the losses incurred and the measures to be taken to avoid such accidents in the future.

1. INTRODUCTION

Self-explosions may result from ignitable gases, liquids or solid materials by means of chemical interaction, exposition to heat, an electric or an electro-magnetic charge, friction or hammering.

Some gases and vapours ignite when they themselves or their mixtures approach the point of ignition which is usually expressed by means of a quantitative percentage of gases or vapours in the air[1] .

There are some gases that interact with each other with a view to forming a mixture of ignitable gases, although by nature they are not liable to ignite by themselves. As an example, Chlorine, which is not liable to ignite, forms an ignitable when interacting with Terebinthine, Ether, Ammonia or Hydrogen [2]. There are other gases that form ignitable mixtures when combined with oxygen alone in the air, or explode when exposed to heat. The main reason being that the gas atoms are in constant random movements. It is also known that the speed of atoms is in direct proportion with the increase in temperature, resulting in quick hitting among these atoms. The hitting of the ignitable atoms with oxygen atoms in the proper mixture usually leads to a fearful explosion. The proper mixture means the mixture in which the energy resulting from the hitting of atoms approaches the point of self-ignition.

2. THE PRODUCTION PROCESS THAT HAD LED TO THE EXPLOSION UNDER STUDY

A) The Production Process

The production process that resulted in the fearful explosion is the Aspirin production process. This process passes through different stages, one of which is the dry of the aspirin paste. It is the stage that caused the explosion. In general, the production process is divided into several stages, which are:

The First Stage: Preparing aspirin paste sufficient to produce 500,000 aspirin tablets. The mixing process of the elements takes place in the mixers situated in chamber 1 or 2 as illustrated in Fig. 1. The paste is made up of the elements mentioned in Table 1.

The Second Stage: The paste is removed into a drying oven either in chamber 1 or 2, where it is left for a period of 8 to 12 hours at 40 °c until it fully dries.

The Third Stage: After drying, the paste is ground in a tablet mill and then the tablets are compressed by special machines to form convex tablets with a diameter of 10 mm. Then the tablets are wrapped or sealed in sterilized containers.

Table 1 Aspirin Past Composition

Element	Weight or Volume
Acetyl Soliaylic Acid	162.5 kg
Lactose	25.0 kg
Hydrognated Castor-oil	2.0 kg
Acetone	20.0 lit.
Alcohol	20.0 lit.
Starch	25.0 kg
Seliconized Materials	6.5 kg

B) Notes on The Production Process

Out of the investigation, notes on the production stages must be taken into account:

1. Although chambers 1 and 2 are devoted for the drying process of the aspirin paste, they are utterly far from being well prepared for this purpose and lack the simplest industrial safety regulations. Each of the two chambers contained a drying oven with a fan that draws the air out of the chamber into the oven and to be drawn out once again to the chamber after absorbing the poisonous vapours and gases out of the aspirin paste. This has led the workers to escape, during operating the ovens, although each chamber is larger than 500 m^3.

2. It would have been possible to avoid this deficiency by applying the standard industrial safety regulations in such cases. On the contrary, the supervisor of the drying process did not bother and so decided to move the drying process to another room without workers, thinking that nobody will be harmed by the poisonous vapours while drying the paste. He thought that in so doing, he had overcome the problem.

3. The supervisor chosed chamber 5, which had been previously used as a store, only to be furnished now with a drying oven, the like of those used in chambers 1 and 2. It had also been supplied with a fan, thus changing it from a store to a laboratory. The supervisor did not take into account the great difference in size between the chambers originally used for the drying process and the size of chamber 5. The size of chamber 1 is 520 m^3, chamber 2 is 700 m^3, while that of chamber 5 is only 140 m^3 with improper ventilation which results in great dangers.

4. In the morning of the accident, the aspirin paste was prepared in chamber 2 and was removed into chamber 5 to be dried at 10 a.m. The paste was expected to dry at 10 p.m. However, for unknown reasons, the drying oven was switched off and so was the fan at about 2 p.m., only to hear a great explosion in this part of the factory after less than half an hour.

3. THE EFFECTS OF THE EXPLOSION

The explosion took place in chamber 5, extending its damage in a circle of 19 m in diameter. The explosion led to the demolishion of the ceiling which is 25 cm in thickness though was 3.7 m high. Obviously, the explosion began from bottom to top, i.e., from the inside to the outside of the chamber, as shown in Fig. 2. The side walls collapsed, bending the concrete iron bars within the area of the explosion although the thickness of the sidewalls ranged from 25 cm to 40 cm.

The glass of the second floor which includes chamber 5 broke alltogether in addition to part of the first floor glass. The explosion led the doors and windows to fly away, their iron bars to bend and many machines of that department to be destroyed and uprooted from their proper positions. Add to this, the ovens in the direction of the explosion, were displaced in different degrees according to their location from the centre of the explosion.

The explosion had also resulted in the death of five technicians and more than twenty workers were injured.

4. THE POWER OF THE EXPLOSION

According to the explosion equation: $W = A \cdot B \cdot R^3$

Where: W = the explosion weight in kgs.

A = factor depending on the kind of building to be exploded and the kind of explosives used (0.13)

B = factor depending on the way of locating the explosives (0.80)

R = radius of the explosive circular area (19 m)

By substituting the values of A, B and R in the explosion equation, it can be found that the explosives sufficient for causing an equal damage should be of the highly powerful explosives, equivalent to 750 kg to 1000 kg of TNT explosives or Nitroglycerine. This indicates that the explosion, under study, is one of the highly powerful explosions.

5. REASONS OF THE EXPLOSION

The field study of the exploded area and of the damage caused, supported by the opinions of the factory board, has proved that the horrible accident was the result of a self-explosion, resulting from the formation of an explosive mixture of acetone vapour and ethyl-alcohol vapour. Those vapours resulted from the two liquids used in the aspirin paste. Table 2 demonstrates some of the characteristics of these two elements.

The technological and technical faults in chamber 5 have led the gas mixture, which consists of acetone and ethyl-alcohol vapours, to reach the explosion point. Most important among these faults are the following:

1. Switching off the only fan in chamber 5 and the only fan in the oven after four hours of beginning the drying process, has led to the accumulation of vapours arising from the hot oven situated in chamber 5 which is considerably small in size. Consequently, the vapour percentage in the chamber has reached the critical minimum percentage (from 2% to 2.5% for acetone and 3.5% for ethyl-alcohol) which led to explosion.

2. Using the drying oven in chamber 5 violates the simplest industrial safety regulations in the sense that it is inappropriate in size for the drying process.

3. It is worth noting that the factory can benefit by the vapours arising from acetone and alcohol by using them once again. Nevertheless, the factory under study did not take this into consideration. In so doing, the vapours were allowed to accumulate in the production chambers, thus leading to the afore mentioned damages.

Table 2 Some Physical and Chemical Properties of Acetone and Ethyl-alcohol

Property	Acetone	Alcohol
Chemical Composition	$CH_3\,CO\,CH_3$	$CH_3\,CH_2\,OH$
Specific Weight	79	79
Colour	colourless	colourless
Boiling Temperature	56 °c	78.5 °c
Igniting Temperature	535 °c	400 °c
Explosive Limit	2.5% to 13%	3.4% to 19%
Vapour Effects	poisonous & leads to unconscious	its concentration causes suffocation

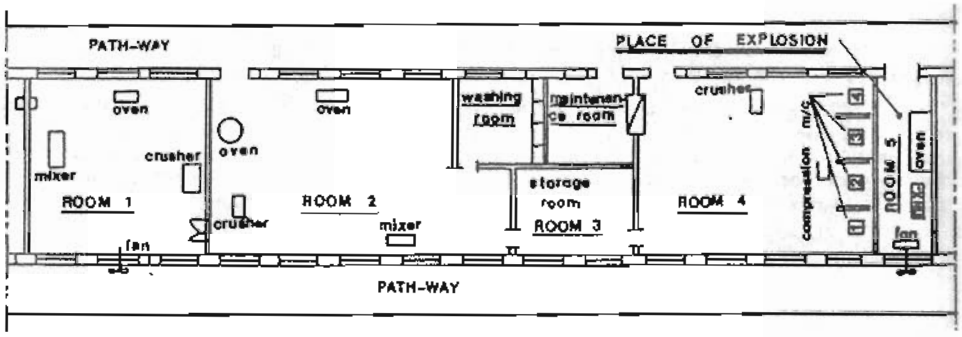

Fig. 1 Schematic Layout of The Aspirin Producing Department.

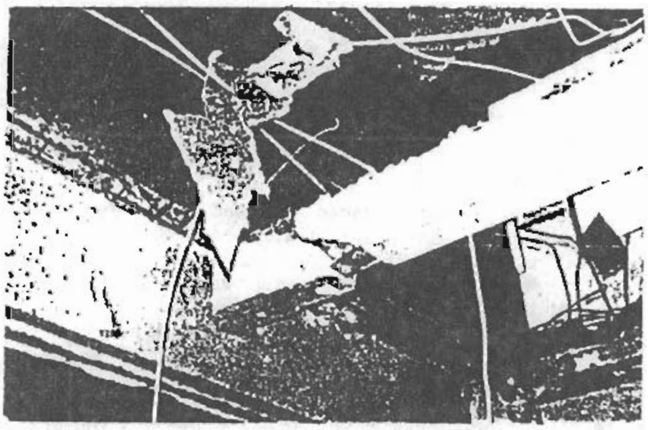

Fig. 2 View for the Damaged Area Inside the Drying Aspirin Paste Department.

6. THE MEASURES TO BE TAKEN TO AVOID SUCH ACCIDENTS

On the basis of the present study, some urgent modifications, necessary for guaranteeing industrial safety regulations and workers's health, have been worked out as follows:

1. The production processes, during which ignitable vapours arise, should be carried out in wide chambers, not less than 300 m^2 in size [3], provided that there should be sufficient ventilation pipes in production chambers for supplying them with fresh air.

2. Vapours arising from ovens or any gases and vapours resulting from any other production processes should be expelled outside the building through pipes. These vapours may be re-used again in other operations, may be rendered healthy through chemical treatment or, if not harmful, may be left in the atmosphere through special chimneys, away from the workers. As for the factory under study, a new system for operating the ovens, has been

advised in the light of this study. Fig. 3 demonstrates the proposed system for sucking air from outside and exhausting produced gases to re-used unit.

3. All chambers in which production process result in gases and vapours must be furnished with appropriate expelling fans, highly-developed fire extinguishing equipment, in addition to gas-leakage-detectors. Industrial safety regulations [4] must be taken into account and so must be the worker's health.

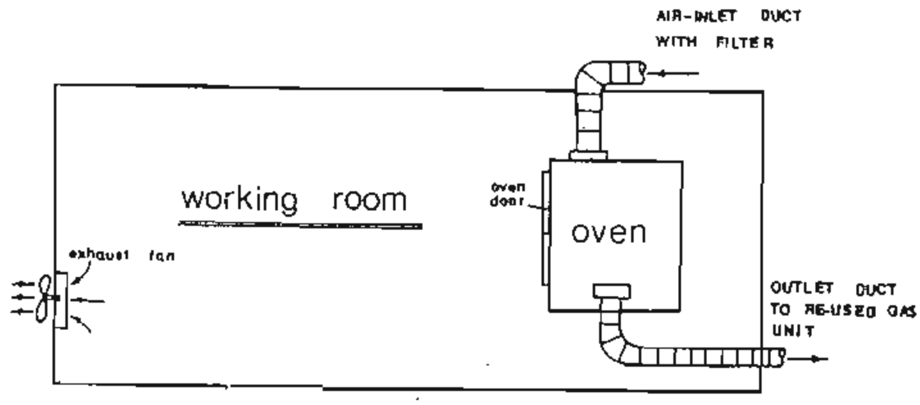

Fig. 3 Proposed System to Operate the Drying Oven

REFERENCES

1. A.H.M. Hamdi, "Fires of Stored Kerosene and Solar". Proceeding of The Seminar on Civil Defence as One of the Fields of Economic Development, Civil Defence Institution, Cairo (Egypt), 6-7 April (1983).

2. A.H. Al-Naggar, "Chlorine Gas and Its Dangers". Proceeding of The Seminar on Civil Defence as One of The Fields of Economic Development, Civil Defence Institution, Cairo (Egypt), 6-7 April (1983).

3. K.A.M. Ibrahim, "Fire and Protective Apparatuses". Proceeding of The Seminar on Civil Defence as One of the Fields of Economic Development, Civil Defence Institution, Cairo (Egypt), 6-7 April (1983).

4. Encyclopedia of Industrial Safety Regulations. El-Ahram Publications, (1980).