

FIRE IN INDUSTRIAL FACILITIES FROM THE ASPECTS OF FACILITY SAFETY AND EMPLOYEES HEALTH

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Abstract: This paper presents an overview of industrial fire research with an emphasis on the three branches of industry: the wood-processing, textile and waste processing. The paper also presents the most common causes that can cause fires in industrial facilities. Also, a proposal of measures by which the fire protection of industrial facilities can be improved and thus reduce the risk of fires or explosions is given.

Key words: industrial fire, fire protection, explosion, waste

INTRODUCTION

Fire protection in industrial facilities is a complex problem, because in addition to the problem of burning of the materials, there is also the possibility of explosions, which especially violates human safety and the impact of fire on the environment. The activity of an industrial facility also raises a special issue of fire protection because it is not possible to extinguish fires of all types of combustible substances with the same type of extinguishing devices. What makes industrial fires characteristic is the great material damage that they can cause, as well as the large emission of harmful gases that adversely affect the environment. Considering that there is a large number of machines, means of transport, combustible substances (raw materials, lubricants, paper ...) in industrial facilities, the possibility of a fire is very certain. The most common causes of fires in industrial plants are:

1. Flammable dust - is characteristic of food, wood processing, pharmaceutical, textile and metal processing industries,
2. Heating and sparking during welding and grinding - typical for the metal processing industry,
3. Improper handling of flammable liquids and gases - these fires, which often occur in chemical plants, and can be catastrophic. One of the common sources of ignition in liquids is static electricity that can occur during fuel spills,
4. Machinery and equipment - faulty equipment and machinery are also causes of industrial fires. Static electricity that occurs in moving parts is a common cause of fire.
5. Faulty electrical installations - Faulty installations cause sparks, overheating or electric arcs, which can be a common cause of fire.

OVERVIEW OF THE MOST COMMON FIRES IN INDUSTRIAL FACILITIES

Fires in the wood processing industry

In the wood processing industry, the greatest risk for the outbreak of fire represents wood dust. Wood dust is a by-product that is created during wood processing, and because the dust particles are barely visible to the naked eye, it represents a great threat to fires and explosions as well as to the health of employees. Explosions and fires caused by igniting a mixture of air and wood dust (dust clouds) are common in wood processing plants. In the paper published by Krentowski, 2015 [1], the explosion of an industrial facility (hall) for the production of plywood and board material caused by self-ignition of a mixture of wood dust and air was analyzed. (Fig.1). The main reason for the occurrence of an explosion is the inadequate ventilation of the machinery used in the process of forming the chipboard. Due to the accumulation of dust in the part of the building (corridor) there was the creation of highly flammable mixture of wood dust and air, whose self-ignition occurred damage that has spread to other parts of the building. Explosion produced an increased air pressure and the shock wave due to an object which is made of prefabricated reinforced-concrete structures have suffered significant damage. In addition to the mentioned explosion, due to the creation of a high temperature which damaged the parts of the structure, additional damage was caused by

the cooling of the elements of the mentioned structure during the fire extinguishing. The deficiency of adequate human oversight of industry control systems has further increased the extent of damage and financial losses.

A similar danger is present in the production of renewable energy sources generated by the processing of biomass - briquettes and pellets. The paper done by Ennis (2016) [2] analyzes the main threats in this type of production, where the leading one is the heat generated due to the storage of wood chips, which is the main raw material for fuel production, as well as the hazards that can occur during transport. The paper also presents measures that can prevent the outbreak of fires and explosions, as well as recommendations based on standards in this area.

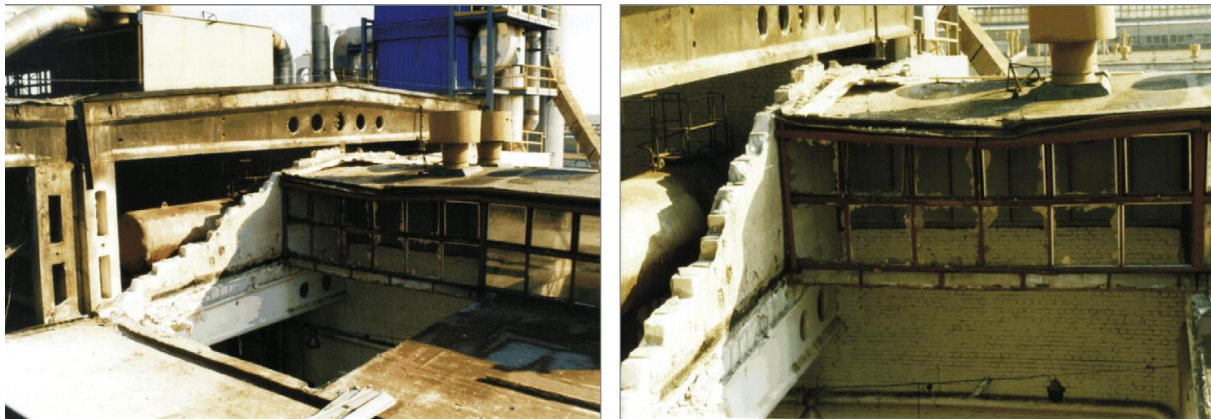


Fig. 1. Appearance of the wood processing industry after the fire and explosion

Fires in the textile industry

Textile production as one of the main branches of industry carries a high risk of fires and explosions. In recent years, there have been more and more accidents in which a large number of employees are injured, especially in Asian countries where the textile industry has experienced the greatest expansion. The textile processing technology itself carries a high risk of creating dust that can be highly flammable, especially in the processing of wool, cotton and other textile fibers in spinning and weaving operations.. In the paper published by Ponnusamy et. all (2019) [3] were analyzed all of the possible conditions that may cause a fire or explosion in the textile industry. It is stated that improper safety measures at work and fire protection can cause great material damage, and in the worst case, the loss of many human lives. (Fig.2). In the paper done by Lina et. all (2011) [4] using the Fire Dynamics Simulator software (FDS) a simulation of a fire was made in a three-storey building with an area of about 12000 m², which is a facility in which textile raw materials are stored and in which further production into the finished product is performed. The analysis of the obtained results revealed interesting facts that can serve as a basis for further research and development of protection rules in the textile industry.



Fig.2 Textile industry facility after fire

In the paper published by Marmo et. all [5] a scenario and results are reconstructed of papers dealing with the subject of 4 fires which occurred in the textile industry with characteristic data related to materials and conditions in which processing was performed. The paper done by Piccinini (2008) [6] analyzes the explosion that occurred in a wool processing factory in Italy. The explosion is a consequence of the ignition of a cloud of dust particles of wool particles, which was most likely initiated by a spark from the lighting system. A detailed analysis revealed that the explosion occurred by burning several layers of dust, the spark caused the dust clouds to ignite, and after that deflagration occurred, which caused an explosion inside the factory.

Fires in the recycling industry

As the awareness of the reuse of material changed, so the recycling industry has progressed and expanded the range of materials that can be processed. Fires in facilities for processing and storage are important economic, social and environmental challenges. Lately, the more frequent recycling of electronic waste (computers, white goods, batteries ...) that represents a high risk and a big waste is imperative to provide adequate fire protection during storage and processing of the same. In paper done by Nigl et. all (2019) [7], a comprehensive analysis of 285 fires in recycling facilities that occurred in Austria over a decade was conducted. As for the places where fires most often occur, in waste processing plants it is in the case of crushing machines, because it is never possible to predict in advance whether there are, for example, old pressurized bottles in recycled metal waste that can initiate a fire or explosion. Understanding the causes of fire in waste management, disposal and recycling, as well as the shortcomings in terms of people's knowledge of this area, which must be constantly upgraded, and mentioned paper emphasizes this.

Research and simulations of fires in the recycling facility that caused serious damage to the warehouse and the recycling facility itself, were conducted within the chapter published by Romano (2019) [8]. Due to the lack of adequate active and passive measures to protect buildings from fire and poor operational warehouse management, it was not possible to prevent the formation of fire. In this regard, it is necessary to establish new criteria for fire prevention in plants of this type. An overview of the characteristic large industrial fires is given in the project report don by Ingason et. all [9]. Deeper analysis of specific fire led to the confirmation of certain data for the mathematical model for calculating the fire spread between buildings affected by the fire. The biggest problem when assessing the risk and danger of fire is the determination of input parameters in the calculation model, and one of the most important is the rate of heat release.

Study published by Ministry of the Environment, Energy and the Sea in France (2016) [10] is based on an analysis of 1100 accidents that occur in the waste management activities and took place over a period of 10 years. Within the aforementioned study identified different causes of causing fire in plants for waste recycling, and some of them are self-ignition temperature, welding places as sources of heat, friction, faulty electrical installations and others.

MEASURES FOR REDUCING RISK OF FIRE OUTBREAKS IN INDUSTRIAL FACILITIES

The main goal when designing an industrial plant is to enable the proper functioning of the production process without great danger to human life and health, as well as the protection of the environment and the facility itself from destruction. Certain laws are defined measures and procedures for fire protection that must be respected.

In industries such as wood processing, the following procedures must be followed:

- Provide adequate ventilation and drainage of sawdust and dust generated during wood processing in the area of the machines themselves,
- Further drainage and storage of sawdust outside the building with the help of cyclones or silos for sawdust,
- Regularly perform preventive inspection of machines and equipment as well as electrical installations due to the appearance of static electricity and sparks that can be a source of ignition,
- Install early fire alarm systems and automatic fire extinguishing systems of the sprinkler system type (Fig.3).

In industries such as textiles, the following procedures must be followed:

- Provide adequate ventilation of production facilities,

- Regularly maintain the hygiene of the floor of the building due to the deposition of textile dust,
- Prevent unnecessary accumulation of raw materials,,
- Regularly perform preventive inspection of machines and equipment as well as electrical installations due to the appearance of static electricity and sparks that can be a source of ignition,.
- Install early fire alarm systems and automatic fire extinguishing systems of the sprinkler system type (Fig.3).

Due to the specifics of the types of raw materials that are processed within the recycling industry, the guidelines that should be followed are:

- When storage of waste materials that are prone to self-heating, carried out checking temperature and humidity, since it can cause spontaneous combustion,
- Install ventilation systems that reduce the risk of fire by removing various gases and vapors,
- If possible, perform sorting and sorting of waste,
- When recycling metal, pay attention to waste in the form of vessels or pressure bottles, which can cause fires and explosions,
- Install early fire alarm systems and automatic fire extinguishing systems of the sprinkler system type (Fig.3).



Fig.3 Fire detection (alarm system) and sprinkler fire extinguishing system

CONCLUSION

Accidents that occur due to poor fire protection measures can cause great material damage to industrial facilities, and in some cases such events end in casualties. The paper deals with three branches of the processing industry where fires and explosions often occur - wood-processing, textile and recycling industries. What is common for the wood-processing and textile industry is the fact that in both production processes there is a large amount of dust that can create a very flammable and explosive mixture with air. For the recycling industry, it is important to mention that due to the large number of flammable substances that are processed in the process of waste processing, there is a high risk of fire, which is due to self-heating of waste or waste with sufficient and very small ignition source to cause potential fire. The last chapter also provides guidelines - measures that can reduce the risk and possibility of fires in these three industries.

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REFERENCES

- [1] Krentowski, J., Disaster of an industrial hall caused by an explosion of wood dust and fire, *Engineering Failure Analysis*, No.56, pp.403-411, 2015.
- [2] Ennis, T., Fire and Explosion Hazards in the Biomass Industries, *IchemE (Institution of Chemical Engineers) Symposium Series*, No.161, pp.1-9, 2016., Available at www.icheme.org/media/11801/hazards-26-paper-64-fire-and-explosion-hazards-in-the-biomass-industries.pdf
- [3] Ponnusamy, V., Paulraj, P., Palanisamy, S., Kanchana, S.,: Fire safety in textile industries - A Review, *Industria Textila*; Vol.70, No.6, pp.523-526, 2019.
- [4] Lina, C., Wub, M., Tsaic, S.: A Case Study on a Fire Disaster in a Textile Factory, *Applied Mechanics and Materials*, Vol.763, pp.134-139, 2015.
- [5] Marmo, L., Ferri, A., Danzi, E.: Dust explosion hazard in the textile industry, *Journal of Loss Prevention in the Process Industries*, Vol.62, pp.1-11, 2019.
- [6] Piccinini, N.: Dust explosion in a wool factory: Origin, dynamics and consequences, *Fire Safety Journal*, Vol.43, pp.189-204, 2008.
- [7] Nigl, T., Rübenauber, W., Pomberger, R.: Cause-Oriented Investigation of the Fire Incidents in Austrian Waste Management Systems, *Detritus*, pp.1-8, 2019., Article in press.
- [8] Romano, G., Romano, A.: Fire investigation in an Italian waste treatment plant: lessons learned and future development, *Safety and Security Engineering*, Vol.189, pp.113-119, 2019.
- [9] Ingason Tuovinen, H. and Lönnermark, A.: Industrial fires - An Overview, *SP Technical Research Institute of Sweden*, 2010, Available at www.diva-portal.org/smash/get/diva2:962537/FULLTEXT01.pdf
- [10] Overview of accident statistics on waste management facilities, *Ministry of the Environment, Energy and the Sea, France*, 2016, Available at <https://www.aria.developpement-durable.gouv.fr/wp-content/uploads/2017/06/2016-10-11-SY-AccidentologieDechetsVersionSimplifiee-PA-EN-Vfin.pdf>