Why Do Some Casthouses Have Catastrophic Explosions While Others Do Not?

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Abstract

Literature has failed to address why catastrophic explosions occur with more frequency in some regions than in others. This gap in knowledge is detrimental, leading to workplaces in certain regions needlessly suffering from explosions that result in significant production losses. Additionally, countless workers are injured or killed due to these incidents. This paper will review the two primary types of molten metal explosions, highlighting recent casthouse explosions and discussing the root causes of each incident. We will examine the factors contributing to these explosions, including the physical and chemical conditions that lead to such events.

Our analysis will argue that in some regions, the high frequency of explosions is directly related to a lack of awareness and education regarding molten metal safety. We will explore how insufficient training, inadequate safety protocols, and a lack of regulatory enforcement contribute to the prevalence of these dangerous incidents.

Furthermore, this paper will provide a comprehensive blueprint for workplaces on how to prevent catastrophic explosions. Failure to be aware of and educated about the causes of molten metal explosions will inevitably result in future casthouses experiencing similar catastrophic events. Therefore, this paper emphasizes the critical need for increased awareness and education to prevent such tragedies and ensure the safety and well-being of workers in the industry.

Keywords: Molten metal Explosions, Safety awareness, Casthouse safety.

1. Introduction

Molten metal explosions of varying degrees of severity have occurred from the very beginning of our industry. These explosions damaged equipment, stopped production, injured and killed workers. Aluminium companies acknowledged that their business was at stake if they could not control this hazard.

Though many aluminium companies researched molten metal explosions. One company, Alcoa pioneered research on this topic and dedicated considerable manpower and resources for decades investigating this hazard. Alcoa scientists were the first to author public scientific papers detailing their work. One of their earliest works “Explosion of Molten Aluminum in Water – Cause and Prevention” by Alcoa scientist George Long in 1957 is still relevant today. Mr. Long’s research and the decades of subsequent research studies from Alcoa provided our industry the knowledge on how metal explosions occur [1]. In response, aluminium companies installed engineering controls and revised worker training to mitigate the risk of molten metal explosions in the workplaces. Now many aluminium companies do not experience molten metal explosions. If they do occur, they are Force 1 in size and Force 3 explosions that can destroy a workplace occur in a majority of industry rarely occur.

Unfortunately, catastrophic molten metal explosions are still occurring. Why is that? This author believes they occur because of a lack of awareness and education to this hazard. Many workplaces believe their processes and machinery are safe because they have had no (severe) incidents in the past. It is when a catastrophic explosion occurs that they determine the processes and machinery that they thought were safe were unsafe. It was just by luck that an incident did not occur. This paper will provide the reader with the foundation on why explosions happen and how to prevent them.

It is our sincere hope that for some readers our paper will provide them new knowledge and awareness to molten metal explosions and make their workplace safer.

2. Why Do Explosions Occur?

Explosions occur when water reacts with molten aluminium on a bare substrate of concrete, steel, or stainless steel. There are two reactions, physical or chemical that can result in an explosion.

Physical reaction explosions are common with all molten metals (e.g., brass, copper, steel). Where molten metal covers water, the water molecules expand exponentially in size propelling the molten metal away. It should be noted that the water does not necessarily mean visible water (e.g., puddle of water and/or wet floor). The water can be present in a molecular form and invisible to the naked eye. This is most found with the presence of chemical salts.

Chemical salts enter our workplace by fluxes. Salts also enter on the soles of workers' footwear if rock salt is used on the roadways during winter in colder climate. Chemical salts attract moisture which can result in an explosion upon contact with molten metal. This can also occur with hand and furnace tools that are not properly preheated prior to inserting into a molten bath.

There is no physical change in the metal in this type of explosion. If 100 kg of molten aluminium explodes in a physical reaction, there would be 100 kg of solidified aluminium spread about. There are additional hazards depending on where the molten aluminium lands. Does it land on a combustible (e.g., wood pallet, cardboard box) and start a fire. Does it land on a worker resulting in an injury or fatality.

Chemical reactions are where aluminium chemically bonds with oxygen in water (H_2O) releasing Hydrogen in the form of energy. In the aftermath of a chemical reaction explosion the workplace is covered in a fine white powder of aluminium oxide. Scientists have determined that 1 kg of molten aluminium in a chemical reaction will result in an equivalent of 3 kg of tnt in force. In the earlier example of 100 kg of molten aluminium in a chemical reaction would generate 300 kg of tnt in force. There would be no solidified metal left, only white aluminium oxide powder.

$$2Al+3H_20 \rightarrow Al_2O_3+3H_2 \quad (1)$$

The Aluminium Association has administered a molten metal incident reporting system for the past forty years that defines the different explosions as Force 1, Force 2, and Force 3, which are characterized as follows (Guidelines for Handling Molten Aluminum, 2016 [2]).

9. References

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