Accidental spillage of incandescent liquid cast-iron from torpedo wagon
Period 2014-2016
Italy

THE ACCIDENT AND ITS CONSEQUENCES

The accidents occurred inside two blast furnace plants of an integrated cycle steel making plant where the reduction process of iron minerals takes place with the production of iron-carbon alloys called cast-iron and a secondary material called slag. The reduction products are evacuated through the opening of a casting hole located in the lower part of the blast furnace (melting pot). Then they are collected in a main casting channel, coated in refractory material, where spontaneous stratification of the liquid cast-iron (heavier) from the slag (lighter) takes place. A siphon barrier located at the end of the main casting channel divides and canalizes the reduction products in two casting channels (cast-iron channel and slag channel).

Furthermore, during the ending phase of the casting cycle or in case of shutdown for maintenance, the cast-iron flow, evacuated from the bottom of the blast furnace to empty the melting pot, is conveyed from the main casting channel in a draining channel that ends with a draining hole. The melted cast-iron is loaded in torpedo wagons placed on specific railroad tracks. Such wagons are located at a level lower than the casting floor. Then, depending on the nature of operations, the torpedo wagon can be placed either under the tilting opening (two railroad tracks with two adjacent torpedo wagons) or under the draining hole (one railroad track).

The tilting system consisting of a balancer connected to a tilting pot that allows the continuous outflow of cast-iron from a torpedo wagon to another until the end of casting phase.

In this report two accidental events are evaluated: one occurred during the draining phase of the liquid cast-iron into the torpedo wagon through the draining hole (18 cm diameter) and the other occurred during the casting phase of the liquid cast-iron in the torpedo wagon through the tilting system. During both events, accidental spillage of the liquid cast-iron on the ground occurred.

These events generated an emission of airborne particles of reddish dust visible outside the plant.

THE ORIGINE AND THE CAUSES

Draining channel

Draining operations are carried out at every ending phase of the casting cycle, that is once a week. This operation involves emptying the melting pot of the residual liquid cast-iron and performing ordinary maintenance operations, during which the conveying systems are scraped from the solidified residual cast-iron. The draining cast-iron may flow at different speeds depending on various factors which can be either different viscosities of the fluids or obstacles created by chilled cast-iron cakes.

The difference in speed mentioned above caused different falling configurations from the draining hole to the torpedo wagon inlet. Further problems occur also because the chilled cakes, previously formed by the liquid cast-iron splashes on the vertical surfaces of the structure, cause flow deviation resulting in spillage on the surrounding ground surface outside the wagons themselves. Yet, another problem is the accidental detachment of the terminal structure of the draining channel. This problem occurs because of mechanical and thermal wear and tear generated by the cast-iron flow.

Tilting

The transfer of the liquid cast iron through the tilting system generates a considerable stress on the tilting-arm. This can result in its breaking and consequently in spillage of cast-iron overflowing from the torpedo wagon. Another cause of spillage has been identified as the chilled cakes collapse from the tilting into the torpedo wagon resulting in the overflowing of the cast-iron.

A further cause of cast-iron overflow and spillage on the ground has been identified in the formation of partially chilled cakes on the torpedo inlet edge which partially obstructs or blocks the tilting system.
FOLLOW-UP ACTION TAKEN

The emergency operations consisted in quickly cooling the surface of the spilled cast-iron with water cannons to prevent its horizontal expansion on the ground. The accelerated cooling generates a surface crust on the spilled cast-iron which mitigates the dust diffusion into the atmosphere. It was not possible to aspirate the emission of dust with the filtration systems on the casting floor because of the height and width of its diffusion.

In the post-emergency phase, the removal operations of the solidified cast-iron and the restoration of the former operating conditions were carried out. Therefore, some management measure was carried out. Before starting the casting and draining processes, an initial check of the correct operation of the plugging machine (provided with a big syringe that quickly shoots a mixture of refractory resins into the casting hole), was implemented. In fact, in case of emergency, the plugging machine must be ready to stop the casting or draining flow as soon as possible. Moreover, training of the operators has been rescheduled to increase their skills in the process control. In addition, maintenance activities of all parts of the cast-iron conveying structure were increased and rescheduled.

Finally, a groove was carved into both railroad tracks so as to inform the machinist on the correct position - under the cast-iron hole - where the torpedo wagon has to be stopped.

Draining channel

During the emergency phase, the operators immediately left the area hit by reddish emission of dust coming from the lower ground level. The plugging machine was immediately activated to close the casting hole of the blast furnace. Firefighters rapidly cooled down the spilled cast-iron on the ground and extinguished any fire outbreaks with water cannons.

In the post-emergency phase the former draining hole has underwent some structural changes. Indeed the empty area of the vertical discharge channel was filled with refractory cement to convey the cast-iron in a longer obliged pathway hence, reducing the gap from the draining hole to the torpedo wagon inlet.

Tilting

The emergency procedures activated for the accident occurred in the tilting system were the same as the ones performed for the draining channel accident.

In the post-emergency phase an additional management measure was adopted. The handling arm of each tilting system was punched and uniquely identified with an ID number so as to place it back in its own tilting system once the weekly laboratory mechanical check has been performed. In addition to a visual check of the torpedo wagon when it uploads, an automatic radar system has been set. It warns that the torpedo wagon is about to be filled up to ¾ of its volume.

Finally, the maintenance activity of the tilting system has been increased in order to guarantee the removal of all the residual chilled cast-iron cakes. This activity is performed to avoid flow deviations on the tilting pot due to the solidified cast-iron cakes. It also prevent the chilled cakes from sticking onto the handling arm, therefore creating mechanical overweight or cracking during the hot-cold cycles.

LESSONS LEARNT

Before 2012, these accidental events occurred occasionally and the company focused the correcting measures on controlling the related risks for operators. Since 2012, however, the increase of media attention on relevant accidental events of this industrial plant resulted in significant increase of social, environmental and safety concerns.

Therefore, the plant operator analysed in detail the structural and mechanical causes of the accidents in order to minimize the occurrence of the described events. This decision was taken because of environmental authorities pressure. Moreover, the plant operator carried out further technical modifications to optimize the transfer of the liquid cast-iron, reviewed operational procedures of management and maintenance and increased training for operators.

In conclusion, over the last years, the plant operator realized the importance of environmental concern, for minor accidents as well as for major ones, due increased media attention and, consequently, social commitment. Therefore, the outcome of this situation is that three different stakeholders (authority, media and local citizens) control in different ways the environmental and safety issues of the plant operation.