Hazards are ever-present in the steel plant environment, and a heightened awareness and emphasis on safety is a necessary priority for our industry. This monthly column, coordinated by members of the AIST Safety & Health Technology Committee, focuses on procedures and practices to promote a safe working environment for everyone.

Comments are welcome. If you have questions about this topic or other safety issues, please contact safetyfirst@aist.org.
Please include your full name, company name, mailing address and email in all correspondence.

Many electric arc furnaces (EAFs) have been designed and manufactured at a time when the safety standards for people and facilities were different. Adapting these furnaces is a challenge that takes several years of work with many possible solutions, while also maintaining the standards of production.

At Tenaris, this has been achieved with the following points in order to have a more predictable, sustainable, and safe operation for people and facilities:

- Early water leak detection.
- Remote furnace tapping.
- Remote furnace sealing.
- Automatic additions.
- Furnace confinement.
- Revision of the furnace with camera.
- Functional safety.
- Safety in loading.
- Hydration of refractory.

Early Water Leak Detection

The most important point of safety for an EAF is to take care of an explosion before it happens. One common explosion is that which occurs because of a water leak inside the EAF. This type of explosion is unexpected and could occur in any moment and could have very serious consequences.

Besides preventing the leak, early detection is key to avoid those explosions. A system was developed that monitors the flow of water and utilizes integration vectors to avoid false alarms.

The entire system has eight circuits: five 2-inch circuits (two in the central vault circuits and three in the pairs of injectors) and three 8-inch circuits (one in the vault, the panels and elbow).
Remote Furnace Tapping and Sealing

Operators are put further away from the facility in order to minimize the risk by decreasing the probability of occurrence. A system of cameras and remote controls was installed at Tenaris to take the operators far away from the furnace (in the main cabin). The tilting valve box and the emergency tilting box were also brought into the main cabin.

The sealing system was developed internally and was customized for the furnace at Tenaris.

Automatic Additions

Twelve silos are already at the plant, and three additional silos were installed. The installation was incremented by installing carbon silo, special lime (resulfurized steelmaking) and nickel silo.

The challenge was to find the place in order to reach the tapping on time, because of the carbon ad, and find the precision that is needed in this material.

Furnace Confinement

The furnace confinement system avoids the free circulation of people all around the furnace and blocks the doors in operation moments such as scrap charge, and also in case of emergency (water leak alarm).

Several corridors with protections and doors with safety locks were also installed. A human-machine interface (HMI) was developed to control the access to the EAF plancher. This will also indicate to the operator any emergencies and invasions to the barriers zone, first as a warning and then fully stopping the EAF.

The system has five buttons to block the EAF’s movements (tilting and vault), and electrical signals to indicate emergencies of charge moments.

Revision of the Furnace With Camera

In order to conduct a safety check of the condition of the EAF, a system of cameras was installed in order to cover the whole surface of the furnace. The cameras are positioned every 120°. A shutter system was developed to close down a door and protect the housing and the camera. It shutters closed when the scrap charge is about to happen.

There is also a Wi-Fi-enabled tablet to send the image to the crane operator.
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Figure 5
View of the furnace.

Figure 6
Automatic addition screen to help with precision.

Figure 7
New silos installed at Tenaris.

Figure 8
Layout of oven 4.

Figure 9
3D rendering of the corridors at Tenaris.
Functional Safety

The full platform-EAFs have their center of gravity toward negative angles, but when opened, this center of gravity changes dramatically, and the structure needs more support. This new point supports the weight, avoiding the whole furnace collapsing. The elephant foot is support for a tilting lock and the new system assures that the lock is put in with redundant sensors, safety valves and programmable logic controller (PLC) safety. When the PLC detects incongruity of sensors or any other failure, one cannot move the vault or directly command the valves.

Safety in Loading

The other risky aspect in terms of explosions in an EAF — in addition to the water leaks — is the scrap load. Keeping it under control is a key aspect in the safety of the furnace operation.

Several things have been added to improve the process and achieve a solid operation:

- Charge traceability.
- Suppliers’ characterization.
- Increasing the control (pickers).
- Integrated camera system.

Burns Harbor Hot Strip Mill — Software was developed and installed that brings information to the crane operator via tablet in the form of “recipes” according to the kind of steel being produced, the next scrap bucket, etc. In addition, the operator enters the real scrap that they put in, according to the availability, in order to have the report and the history of each bucket.

Supplier Characterization — Thanks to this traceability, suppliers can be characterized when there are issues of quality or safety, and make a note of them.

Increasing the Control (Pickers) — It is key to separate the scrap into non-ferrous, copper, tin, non-metallics, etc.

This is an activity that has to be done before shredding the scrap, in order to produce a better load.

Integrated Camera System — It is very important to search the scrap to identify that which could be problematic. An integrated system was installed that lets one see the entire scrap yard and review the bucket.

Hydration of Refractory

To prevent an EAF perforation, Tenaris focused on three points:
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- Increase the quantity of thermocouples onboard the furnace.
- Refrigerated panel tracking.
- Software to detect an atypical behavior of the temperature of a thermocouple (machine learning).

**Increasing The Quantity of Thermocouples On Board of The Furnace** — A number was chosen from 24 to 39, increasing mainly the hydration thermocouples that are located in the beginning of the floor of the furnace.

**Refrigerated Panel Tracking** — The information was organized in L2 panels, in order to have a better...
EAF scheme (king pin, elephant foot and tilting cylinder).

System scheme for the EAF.

HMI screen in the main cabin.

Productions program of the EAF.
traceability of the life of each panel, and make preventive changes to them. This will also detect problems in the operation.

Software to Detect Atypical Behavior of the Temperature of a Thermocouple (Machine Learning) — With the data science workers at Tenaris, a software was developed, which is capable of learning and comparing the behavior of each thermocouple with its neighbors. It will also alert if this behavior is atypical. There are 10 different levels of risk that increase or decrease depending on the behavior of each thermocouple and its neighbors.

Conclusions

After several years of hard work, Tenaris has a safe operation for their people and facilities. The amount
of energy that is used in an EAF forces one to keep most variables under control to have a sustainable operation. To reach the result needed, it is necessary to work as a multidisciplinary team, which involves many areas such as operation, maintenance, engineering, safety and environmental, data science, IT and automation.