Safer coke making

This article highlights the impact of manless coke oven machines on the health and safety, efficiency and productivity of coke making operations. The automation of coke oven machines is essential not only for improving the working environment – characterised by heavy dust emissions, high heat and demanding physical labour – but also for enhancing productivity. By **Oana Niculita***

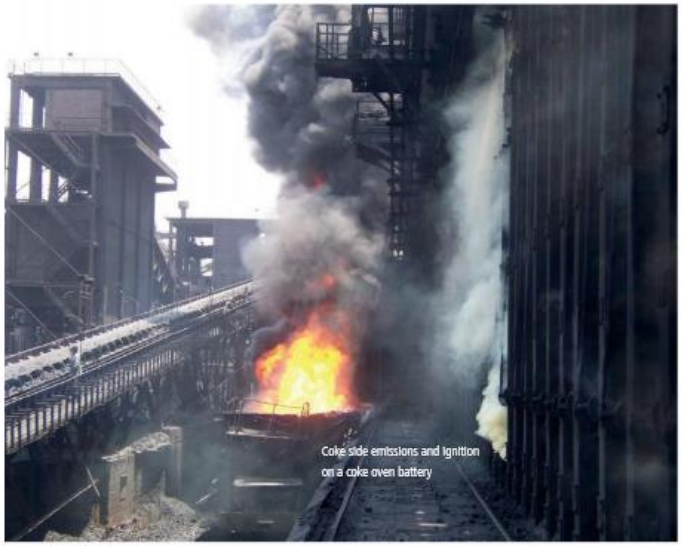
AUTOMATION systems are increasingly important for coke plants, where most processes comprise of complex sequences of dangerous operations: ovens that heat coal to up to 1,200 °C, moving machinery, massive steel doors for locking the ovens, and gases that can ignite or cause cancer.

The human aspect

The processes of coke making are energy intensive and comprised of hazardous operations which cause accidents, acute injuries or fatalities. Deadly accidents in coke oven plants continue to be a reality all over the world. According to information provided by the Indian Ministry of Steel, 74 workers were killed between 2014 and 2017 in accidents in various plants across the country. On the other side of the world, online records of the OSHA in the USA show 16 fatal accidents on coke oven batteries over the past 30 years; most of them involving employees crushed between heavy equipment or burnt in hot coke ovens.

Coke-oven emissions are proven to be human carcinogens based on evidence of carcinogenicity [IARC 1984, IARC 1987]. Workers at coking plants and people who live near have a high risk of exposure to coke-oven emissions and were found to be at an excess risk of mortality from cancer of the lungs, bronchus, trachea, kidney, and prostate. In August 2012 the UK Government officially introduced the legal entitlement for coke oven workers to Industrial Injuries Disablement for primary carcinoma of the lung.

Historically, most previous efforts to improve the working conditions for coke oven workers focused on enforcing safe work procedures, working conditions and environmental regulations. COSHH/OSHA regulations for coke oven facilities set up permissible exposure limits, engineering controls for charging and pushing, work practice controls and compliance programmes to reduce emissions, protective clothing and equipment, hygiene safety, medical surveillance practices, employee information and training, hazard awareness and recordkeeping.



Coke side emissions and ignition on a coke oven battery

Stringent environmental control legislation worldwide has pressured coke plant operators to improve techniques for emissions control. The European Union sets out two directives for coke plant operation: "IED Directive" (EU, 2010) on industrial emissions and the "Air Quality Directive" (EU, 2008), which address the conditions for plant operation and sets standards for emission control. These directives also stipulate that the "best available technique" (BAT) be applied for certain industrial plants in order to achieve environmental standards.

With the significant developments achieved in the area of "zero emission" coke oven machinery technology, all machines can now be equipped with environmental control modules that enable them to capture all emissions occurred during charging, pushing, levelling and quenching operations. Charging emissions can be eliminated by operating modern screwfeeder charging cars. Smokeless- and spillage-free charging is achieved by installing, for example, JMH's specially developed stainless-steel telescope assemblies. Innovative emission control systems installed on the pusher machine and on transfer cars, designed to satisfy the toughest environmental regulations, are extremely efficient at containing coke dust and smoke. Door leaks and emissions are eliminated with the use of high-pressure water jet door cleaners and mechanical frame cleaners, which are considered the best available technologies for achieving zero emission coke oven doors.

Decades of research and development in engineering enabled coke oven machines to achieve zero emission performance, but the key capability with the highest impact on human health and safety is the ability to remove personnel from hazardous areas. Automation technologies can be applied to coke oven machinery for the purpose of controlling their operation and reducing the need for human operators. Automation has proven to have the greatest impact in terms of personnel safety and environmental control; also improving overall productivity and efficiency of the coke making operation, reducing cost and energy consumption and increasing stability of the operations.

Pre-requisites, requirements and components

The necessity to man coke oven machines has been eliminated with the introduction of mechanisms to carry out all the necessary functions including automatic positioning. Fully automatic 'manless' operation involves the incorporation of all necessary mechanical control and communication equipment on the machine to enable remote control with no operator on board. To provide this, a co-ordination PLC and supervisory system is installed in the battery control room. The master PLC and wireless LAN control each coke oven machine so that monitoring and taking emergency procedures from the main control room is possible.

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The monitoring team in the control room can operate each individual motion of the machines from their replica operator interface.

Components of a manless automated system

In simple terms, to operate manless, a coke battery requires: Manless-capable coke oven machines, a data communication system between the machines and the control room, a co-ordinating system for a link between the machines and Level 2 system and a Level 2 System for developing a pushing/charging schedule.

Illustration of a high-level control room operating manless equipment

The data communication system between machines and the control room is one of the fundamental aspects to ensuring a successful manless coke oven plant. The LAN/Wi-Fi connection should be reliable enough that it doesn't affect the day-to-day operations of the coke oven machinery. All machine PLCs should also communicate with a central PLC, which identifies the machines used in production, ensures all are aligned to the same oven and all machine interlocks are healthy, generating a push-permissive command.

While manless automation is made possible using advanced electrical control systems, it is essential that all mechanical equipment operates efficiently and in a reliable and repeatable fashion in order to maintain manless operation. Effective maintenance is needed to ensure that the coke oven machines and the required infrastructure for manless operation are operating in a very reliable way.

The age of the equipment is not an impediment for manless introduction or upgrade. Over the past decade JMH has introduced manless capability worldwide to equipment that had been in operation for more than 30 years. The project of upgrading an existing facility to manless operation starts usually with reusing the existing control systems and structure, upgrading existing HMIs, code standards, mechanical or electrical control equipment if needed. For JMH, every manless project begins with an expert site inspection that will estimate the gap between existing mechanical, electrical and hydraulic facilities and the requirements for manless. The site gap analysis is an in-depth engineering assessment that provides a clear understanding of the condition of the existing equipment and identifies the upgrade works necessary to upgrade the machines to a fully automated condition, so that they operate in manless mode, without people.

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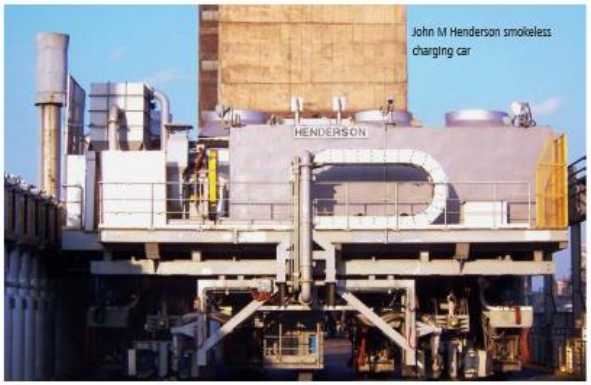

John M Henderson smokeless charging car

Automatic positioning and oven identification system

One of the most important functions of "unmanned" machines is them having the ability to know exactly where they are positioned at any time and be able to transmit that information to the battery control room. The JMH automatic positioning system is a magnetic device consisting of a reader head mounted on the machines and transmitter heads mounted on each oven, bunker and maintenance position. It is a contactless system and provides guaranteed alignment accuracy of 3mm.

Coke plants all over the world are actively making tremendous efforts to improve the quality of the working environment and to optimise operational safety in coke plants. Results show that by reducing the manpower directly involved in coke making production, they are significantly reducing labour costs and process cycle times and improving economic efficiency. Manless coke making is often adopted as a multi-phase approach; with coke operators starting to automate one type of machine in a small-scale project, then gradually extending the concept to other areas.

In the following case studies, the economic effect of coke plant automation is analysed on the basis of manpower, productivity, rate of the operation, energy consumption and environmental protection.

Impact of automating two 40-year-old coke locomotives, Europe

JMH has recently completed the project of applying manless operation to two 40-year-old coke locomotives on a coke battery in Europe. The main objective of the project was removing all personnel from hazardous areas, as potential overrun of the push could have resulted in hot coke covering the locomotive cabin with high risk of operator injury.

JMH has developed a complete automation system, which included controls for the two quench car locomotives as well as for seven battery machines and interconnected areas (guide machines, pusher machines, wharf ploughs, battery control room and quench tower) in order to enable the locomotives to operate in fully automatic mode, without an operator. Safety was ensured by installation of the necessary mechanical protection, suitably designed PLC programmes and machine interlocks.

The project had a significant impact on battery safety and productivity. Firstly, the potential for human injury or fatality was removed and, therefore, approximately 50 operators that could have been exposed to this unsafe area were removed. Secondly, the overall efficiency of the of the locomotive was significantly increased because of the new accurate automatic alignment and positioning system and the less downtime expected with better communications between machines and interlock systems.

Impact of introducing automation on a coke plant in Asia

Between 1990-2000 a coke plant in Asia studied the impact of introducing automatic control systems on coke oven operations in a project aimed at reducing manpower and the cycle times of operation. The economic effects of coke plant automation were analysed on the basis of labour saving, energy consumption, productivity, and environmental protection using data accumulated, such as the amount of coke production, the number of pushing operations, the weight of charged raw material, and annual energy consumption.

In order to automate the overall coke plant, an automatic positioning and control system for travelling cars (pusher, charging car, transfer car and loco) was installed. For safety, travelling car collision avoidance systems and oven door open/close detection systems were implemented in the pushers and transfer cars.

JMH manless transfer car operating in Posco, Korea

As a result of the automation on these areas, the coke plant has achieved a total of US$5.15 million savings annually. The manpower was reduced from 40 to 14 on the battery included in the study. Due to the increased speed of the moving car, the operation cycle time was reduced from 14.36 minutes to 11.38 minutes, increasing the number of pushing operations by 13 times per day. Total energy consumption (Mcal/ton-coke) represented by the sum of fuel, electricity and crude light oil consumed in the coke oven process was reduced by US$390,000 per year.

One of the biggest concerns surrounding the introduction of automation is the impact of jobs for workers and the fear that people may not be needed at all. While these worries are understandable, they are not accurate. Automation will not replace people in the coke making process, because unmanned systems involve human operators in supervisory and monitoring roles. Automation opens further opportunities for existing employees to be trained and expand their own skill set.


Illustration of a high-level control room operating man-less equipment

Initial investment costs are typically the biggest obstacle that will decide whether a coke plant will invest in automation or wait until a later stage. Previous experience demonstrates that the scope of the investment is often overestimated. The site gap analysis is, therefore, key in assessing the initial scope and estimating the business case when considering the implementation of this technology. The returns can be substantial and quite often occur within a short space of time. A multi-phase approach is sometimes the best strategy for adopting automation: start with one type of machine/small scale projects, then include other coke oven machines.

In conclusion, based on several studies and analysis of the implementation of manless operation, automated coke oven machines have a great impact on coke making operations, in terms of personnel safety and environmental control; improved overall productivity and efficiency, reducing cost and energy consumption and increasing stability and regularity of the operations. Automated processes can perform coke making functions in the hazardous environment of the coke oven machinery in a safer manner, more efficiently, more reliably, accurately and at a lower cost than human operators. ■