Safety and Health Improvement in a Cokemaking Facility

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.

This article features a report from one of the recipients of the 2016–2017 Don B. Daily Safety Grant.

Musculoskeletal disorders (MSDs) are a critical issue among steel workers. Historically, high incidence rates of MSDs were reported from steel manufacturing workers due to the nature of the physically demanding tasks many of them perform and the unique occupational environment in which they work.[1,3,5,9–12] This year, with the help of the Don B. Daily Safety Grant, the authors were able to form a research team to investigate the MSD risks among steel manufacturing workers and explore the existing and potential interventions that are currently used or could be used in reducing these risks.

The facility that the authors visited was a cokemaking plant. Coke is one of the most critical materials used in the blast furnace. More than 90% of the total coke production is dedicated to blast furnace operations. During steelmaking, coke is used as a fuel and as a reducing agent in smelting iron ore in a blast furnace. The main part of this particular cokemaking plant consists of a battery with approximately 100 adjacent coke ovens. Raw coal is poured in these ovens by a larry car and then leveled by coke oven machinery. The coal is then baked at high temperatures for long periods of time to remove impurities. When coking is finished, doors on both sides of the oven are opened by coke oven machinery and coke is then pushed from the ovens and loaded into a quenching car on the coke side of the oven.

With the help of the on-site safety and health professionals at the cokemaking plant, the authors identified two areas that potentially have high risk of MSDs. One is in the coke production site and the other is in the maintenance shop. In both locations, some issues have been identified and addressed with interventions, and there are also further improvements that can be made.

Safety and Health Improvement

Coke Production Site — Degassing dampers are located on the top of the oven batteries, and their purpose is to control oven emissions. A degassing damper is operated using a hydraulic cylinder and sensors are used to assess the position of the damper (Fig. 1a and 1b).

In the cokemaking plant studied, strains and sprains from opening and closing stiff/stuck damper arms used to occur quite frequently. These musculoskeletal injuries resulted in restricted duty and days away from work cases. When opening and closing damper arms, workers need to push up and pull down on the damper arm in order to create an opening for gas to flow. For the cokemaking facility that the authors visited, the number of opening and closing actions exceeds 2,700 times per day and is close to one million times per year. When damper arms are tough to open and close, employees have to use excessive amounts of force. An ergonomic assessment indicated that the force to move a stiff damper arm sometimes exceeded 50 lbs. Clearly, the heavy physical exertion caused the high incidence of injuries (Fig. 1c).

The safety and health professionals of this plant aimed to significantly reduce the risk associated with

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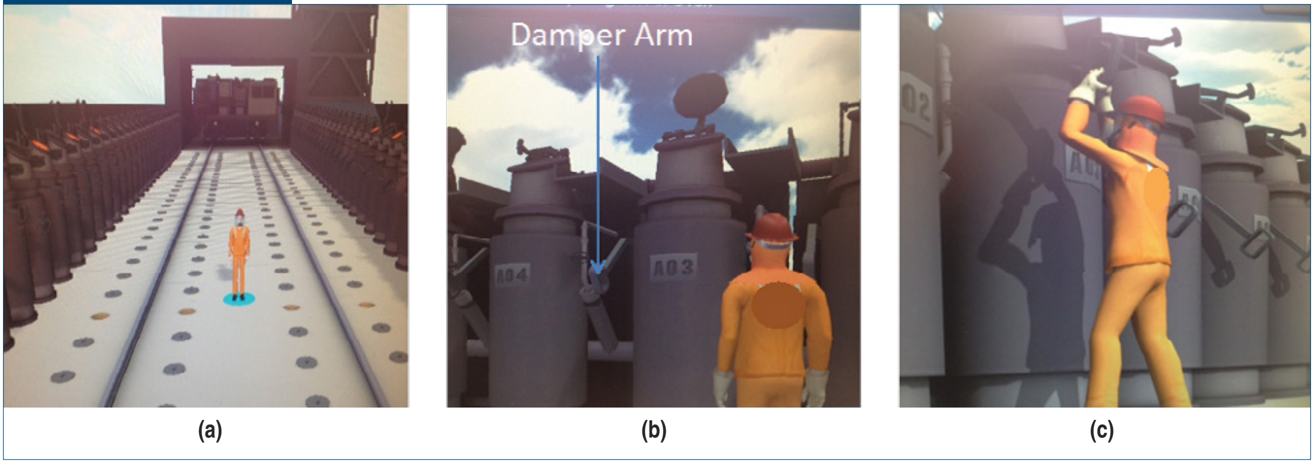
Figure 1



An overview of coke oven batteries (a), damper arms (b) and worker's arm posture when exerting high force on stiff/stuck damper arms (c).

the damper arm operation and to maintain a healthy, safe workforce. To tackle the problem, an initial survey was conducted during a battery outage. Damper arm activation was ranked on a scale of one to three based on its difficulty to operate. A communication system was used to broadcast survey results inside the facility and provide a medium for providing feedback to and from employees. This technology enables real-time display of the stiff and stuck damper arms on television monitors, which helps inform employees (Fig. 2); employees are also able to provide inputs to the system, which updates immediately. Work orders are also generated through the system after stiff and stuck damper arms are identified. Managers must ensure damper arms that need to be repaired are properly maintained in a timely manner.

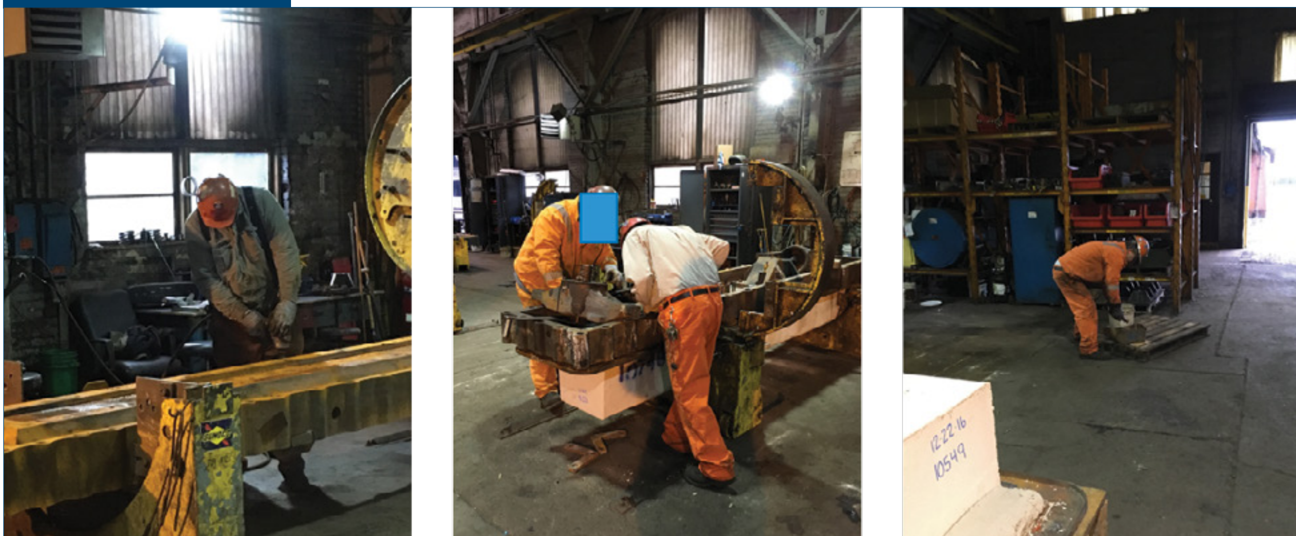
In this cokemaking facility, there have been zero musculoskeletal injuries on these batteries due to stiff and stuck damper arms since the communication system was implemented. In terms of plant operations after the installation of the communication system, maintenance of damper arms was more efficient (i.e., issues are reported in real time), more effective (i.e., work orders are generated when the system is updated) and more cost-effective (i.e., the asset is maintained in good working condition and employees remain injury-free). Moreover, implementing this communication system has provided a novel form of feedback and an opportunity for engagement among workers. Also, the system has helped to create a more proactive and less reactive environment by allowing work orders to be generated as issues were reported. Finally, the system has allowed maintenance to occur more quickly, which contributed to reduced, or even eliminated, injury potential.

Figure 2

A steel worker stands in front of the communication system display.

Maintenance Shop — The cokemaking process includes carbonization of coal to high temperatures in the absence of air to concentrate the carbon. This process is performed by baking coal inside coke oven batteries and it is called byproduct cokemaking. Byproduct coke ovens are typically long, narrow bridge chambers grouped together in batteries to conserve heat and space. Each battery consists of a pusher side, a top side (to charge coal) and a coke side. The pusher and coke sides of a battery can be closed using oven doors. These coke oven doors are intended for locking the chambers of the coke oven on both the coke and pusher sides of the battery to control heat and emissions. As this process includes extremely high temperatures, it is possible for doors to become very dirty, have broken latches, bent keepers, cracked chuck doors and several other issues that require maintenance. In general, door maintenance is performed in position when only minor repair is needed. When more complex repair is needed, the coke oven doors

Figure 3



(a) (b) (c)

Working with the manual vibrating gun (a), and awkward postures observed at the site (b and c).

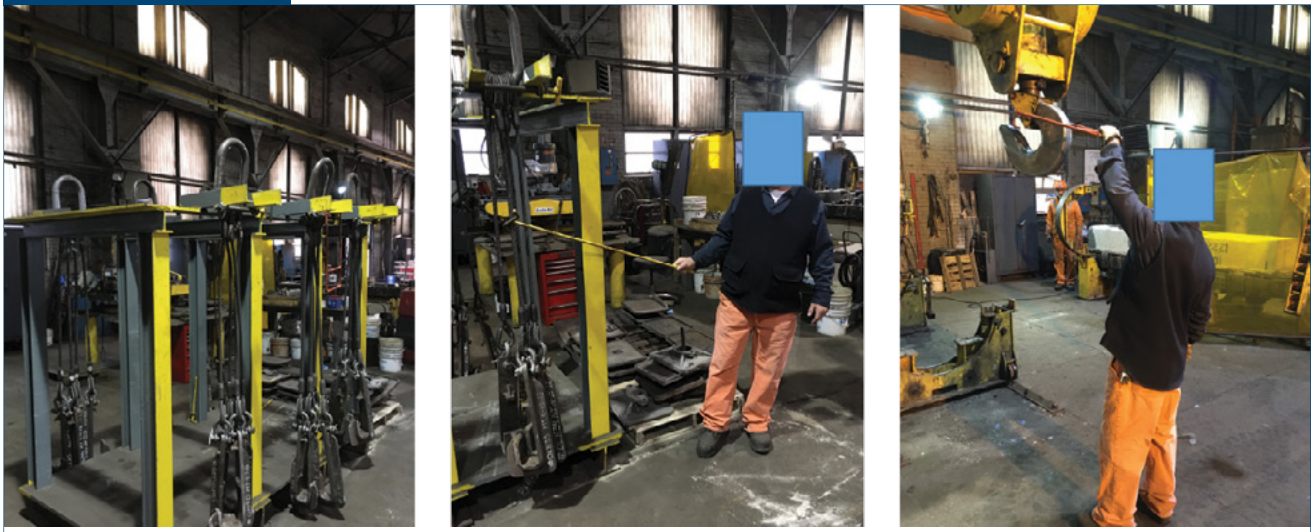
are taken off and moved to the maintenance shop for proper maintenance. This maintenance shop is also responsible for refractory door plug installation and making new doors.

During the site visit, the authors learned about the current safety and health–related challenges as well as existing improvements that workers and safety and health professionals have made over the years. The maintenance shop has around 13 workers who are responsible for cleaning and repairing oven doors for the next use. Through observation, the authors identified a number of physically demanding tasks and risk factors such as repetitive lifting, vibration and awkward body postures, all of which could increase the risk of MSDs development in employees' lower backs and upper extremities.

One of the important tasks performed at this site is cleaning up the screw holes of doors using a manual vibrating cleaning gun (Fig. 3a). During the process of coking, these holes fill with dirt from the fine dust, grease and buildup of materials. The task of cleaning these holes is physically demanding due to the large number of holes (i.e., approx. 40 to 70 holes on each door) that need cleaning. Workers in this maintenance shop also constantly perform forward trunk bending, trunk twisting and side bending when working on these oven doors (Fig. 3b and 3c). It is concluded that awkward trunk postures (i.e., twisting, bending and reaching), repetitive trunk bending and hand vibration received from the vibrating cleaning gun are the main injury risk factors associated with these tasks. Previous evidence suggested that trunk bending is a major risk factor for the development of lower back pain.[6,7,8] Also, the exposure to hand and arm vibration could cause injuries to bones, muscles, and joints of hands and arms.[2]

During the site visit, the authors also identified a number of ergonomic interventions that were developed and implemented by workers and safety and health professionals. The first improvement is a vertical shelf that is used to hang crane hooks and chains used by overhead cranes for moving heavy material and parts such as the oven doors (Fig. 4a). Before adding this intervention to the site, hooks and chains were placed on the ground and workers were required to bend over, lift and carry the parts by hand to attach those parts to the crane. This process involves deep trunk bending and lifting heavy objects. Repetitive bending and heavy lifting have been noted as important risk factors of lower back pain.[4] Therefore, the use of this intervention could reduce the risk of lower back injury. In addition, this task also presents a risk of engaging with the crane hook from a close distance. To eliminate this safety concern, two special hand tools were designed to allow workers to work at a distance from the crane hook. The first tool is a rod that can be used to guide and attach hooks and chains to the overhead crane from approximately 2 feet away from the crane (Fig. 4b). The second tool that the authors observed is specially designed to be used to open the crane hook, allowing workers to work at a distance from the overhead crane, and eliminates direct engagement with the crane hook, which reduces accident risk (Fig. 4c).

Figure 4



(a) (b) (c)

Vertical shelf to hang crane hooks and chains (a), and special tools to guide the chains (b) and to open the crane hook (c).

Discussion and Conclusion

It is clear that jobs and tasks in steelmaking facilities involve identifiable risk factors that could lead to MSDs. Historically, ergonomic redesigns and interventions have been shown to be effective in improving the safety and health working conditions for workers in a number of industries such as manufacturing, transportation, agriculture and construction. In the steelmaking industry, most previous efforts were focused on improving work procedures and working conditions in order to avoid accidents, fatalities and acute injuries. Preventing MSDs and other cumulative injuries has been an area of focus more recently. During the cokemaking facility visit, the authors observed a number of great improvements and smart interventions that significantly improved productivity, reduced injury risk and eliminated safety concerns. However, the authors believe a more comprehensive MSDs risk assessment and systematic redesign of the current job, workstation and tools is still needed. Such effort will help further reduce injury risks and improve working conditions for steel workers.

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