Advanced Safety Technology for Hot Metal Cranes

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Material Handling

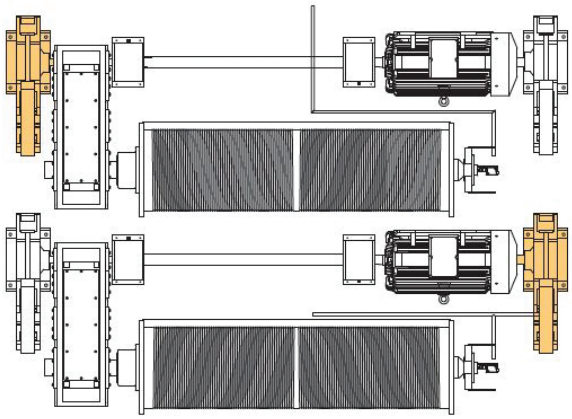
In the steel industry, specifically hot metal applications, where work environments are hazardous, keeping operators safe is essential. Recent advances in overhead material handling technology offer many options to enhance the safety and operation of hot metal cranes. Technology solutions include AC inverter control, reporting crane operation information, contactor controlled crane monitoring, end of travel limits, collision avoidance, and power outage backups. This paper will discuss the conditions required for each technology solution and how they can improve hot metal crane environments and operations.

No Load Brake Hoist Motions — AC Inverter Control

AC inverter controls, in particular closed loop controls, used with encoder feedback are microprocessor-based and can perform a variety of functions at once. In hot metal crane applications, this results in a drive's ability to check the integrity of both the hoist motor and hoist motion holding brakes to confirm they are fully functional before beginning hoist operation. If a problem is detected with either the motor or the brakes, the drive detects this issue and safely shuts down, potentially preventing an incident.

Alternating Brake Checks

Further enhancements to the hoist motion brakes can include the ability to alternately check the brakes during the lifting process. At the end of each run sequence, the drive checks the status of one brake in a dual-brake setup, then checks the second brake. If a problem occurs with either brake during the check sequence, the drive signals that the particular brake is experiencing a problem that needs to be addressed. This reduces the risk of potentially dangerous events that may occur due to malfunctioning braking equipment.



The best option for automatically detecting a failure in the drive train is Drive Train Discontinuity Detection—commonly known as Snapped Shaft Detection—a feature that monitors the drive train on non-mechanical load brake hoists. If there is a disconnect between speeds on a drive train arrangement with one encoder on the motor and a second encoder at another location, the drive can shut down and close the drum brake to prevent a load from falling. This reduces the potential of a load drop, minimizes the likelihood of damaged equipment, and improves safety in the work environment.

On hoist designs, where there are two motors that share loading, each motor is controlled by its own individual variable frequency drive (VFD). If one motor were to fail, it is possible to operate the hoist and lower the load with the single remaining motor under light load conditions. This eliminates the load being suspended in the event of a failure. The load can be set down safely and the source of the failure can be determined quickly, minimizing downtime.

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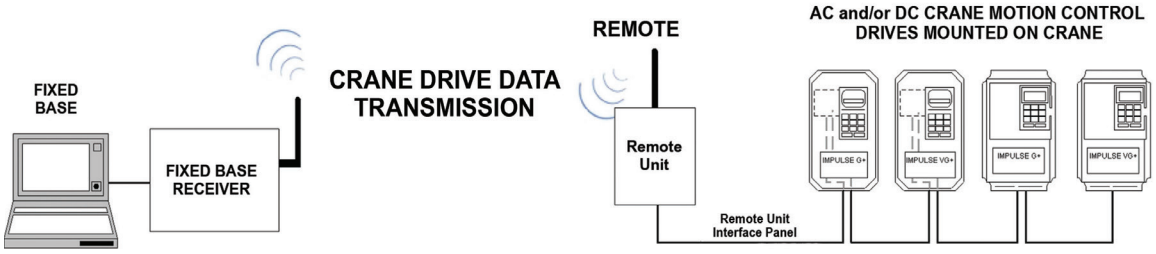
Load sway issues on traverse motions, specifically trolley and bridge, can be improved by limiting the actual swing of the load. This can be accomplished by tying all of the crane motions together (hoist, trolley, and bridge), where the hoist drive provides the trolley and bridge with location information. The trolley and bridge then control the acceleration and deceleration rates to effectively limit the load sway. This can stabilize the load during a lift and aids in the prevention of spilling hot metal, which dramatically improves safety for workers.

Reporting Crane Operation Information

In hot metal crane applications, it can be useful to communicate crane status to help minimize the risk of equipment malfunctions. Information can be limited to a single fault condition indicator, such as drive fault status, up to a continuous information flow, which could include the start and stop cycle of a particular crane. Crane status can be routed from the crane itself to an indicator light or audible alarm, or via serial communication to a location on the crane. AC or DC VFDs can support programmable output options, including digital, analog, and serial signals. Those signals can activate indicator lights, audible signals, score boards, or HMI interface screens. Outputted communications result in an almost immediate indication of a potential problem, which provides the ability for quick corrective actions. Crane operation information can be relayed onboard or transmitted to a remote location, such as the crane cab, production control room, or centralized maintenance location, usually via an RF signal.



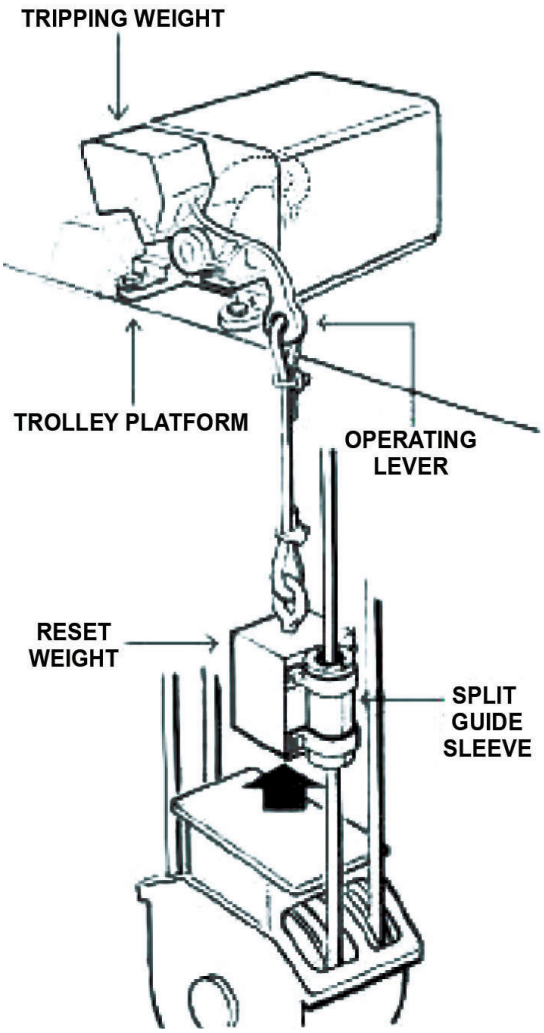
With crane control system data transmission, users do not have to be in close proximity to the crane to detect a possible problem, which means less exposure to the hot metal environment and a shorter response time to resolve an issue.

Monitoring Contractor Controlled Cranes

Contact monitoring can be utilized if a crane motion is controlled exclusively by contactors. The potential exists for issues to develop with respect to the positioning of the contactor control. Additional relay logic and other indications can determine if contactors are fully functional. Contactor position status can be monitored from a base station. If, for example, a contactor fails, contactor monitoring activates a warning device that provides notification of a potential safety issue. The status of the relays, either open or closed, or the brake contactor position, can also be displayed via simple indicator lights or through an advanced PLC and RF signal to a different location, minimizing any safety concerns and improving the likelihood of quickly addressing them.

End of Travel Limits on Hoist Motions

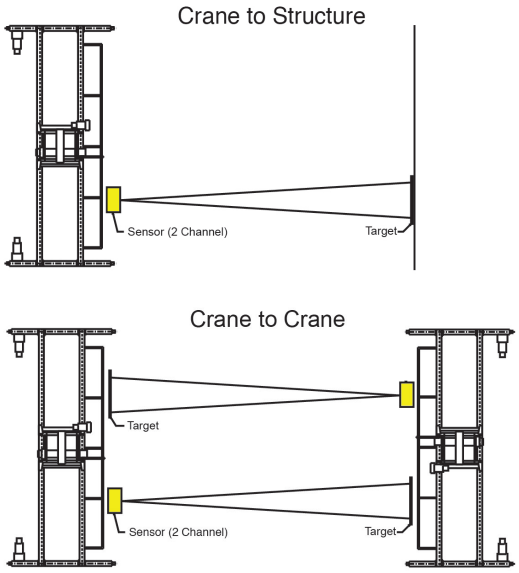
For end of travel limits, limit switches are wired directly into the drive, eliminating a significant amount of wiring on the crane. When wired directly to the drive, limit switch status may be displayed on the drive keypad or display. All hot metal crane hoist motions, according to AIST Technical Report No. 6, section 4.6, must have a power limit switch (PLS) that opens leads to the motor, interrupting power to the motor, to prevent contact of upper and lower sheave blocks. Technology available with VFDs provides additional monitoring and improves response and redundancy to the existing mechanical limit switches that may be in use. Information about the PLS condition can prevent damage to the hoist and in avoiding potential safety issues. DC drive control has the ability to sense a PLS opening. AC drive control can use an "early break" indicator to provide an output designating an open PLS condition.



Mechanical relays may provide audible or visual alarms. With respect to VFD control, use of a programmable digital input and digital output can detect and inform of an end of travel limit switch condition on a hoist. Unique acceleration and deceleration speeds are programmed in the drive, different from normal contactor control. A PLS can back up the VFDs, specifically in closed loop control on hoist motions. A standard mechanical switch can be used and backed up with the programmable limit switch through the encoder pulse count. This information is then relayed to either an on-board or off-board source to indicate the status of the limit switch position, thereby eliminating any concerns about slowdown or stop or the power limit switch condition.

Collision Avoidance for Traverse Motions

Travel limit switches minimize the disturbance of a load suspended on a hoist. It is possible to prevent traverse motions from contacting their end stop functions, minimizing any degree of excessive speed. This can be accomplished with a proximity switch that is backed up with an infrared or laser system. Results can be catastrophic if contact with travel end stop functions were to occur. Another application includes crane-to-crane contact. If multiple cranes exist on a single runway, it is possible to detect, with either an infrared or laser system, a slow-down or stop function. This can be communicated to crane operators so they can be made aware of any operation issues due to a hazardous environment they might not be able to visually confirm.



Power Outage Options

Power outages can be major safety issues for hoist motions because they could leave hot metal suspended in the air, creating a dangerous situation for operators. It is recommended that, at a minimum, a load has the capability of being lowered back to the ground during a power outage, or, under limited circumstances, the crane is able to complete its entire motion. Options in a DC-powered crane include a battery backup for DC holding brakes that, at a minimum, would allow the load to be lowered. If the battery backup is sized adequately, it may be possible to complete a hoist, trolley, or bridge motion's movement. Another option is using a generator with a rectifier, which supplies power to the DC crane and allows the holding brake to open and lower the load and/or run the crane under limited conditions. In the case of AC powered cranes, an AC generator can power the drives in the event of a power outage. Depending upon loading and sizing, the generator may allow the load to be lowered by opening the holding brakes or run the crane under limited conditions.

Conclusion

The above are all advanced solutions to enhance safety on overhead cranes. Depending on the motion's configuration, AC inverter control, reporting crane information, contactor controlled crane monitoring, end of travel limits, collision avoidance, and power outage backups may be used to improve the operation and safety of hot metal cranes. Environments become substantially safer the farther an operator can work away from hot metal and the more safety backup systems that are available within a crane system. A variety of communication options keep operators up-to-date on the status of equipment, while allowing them to be a safe distance from operations.