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CONVEYORS: ART MEETS SCIENCE IN DESIGNING FOR SAFETY

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CONVEYORS: ART MEETS SCIENCE IN DESIGNING FOR SAFETY

The safety and performance of conveyors are critical to an operation's success and personnel are the single most important resource of any industrial operation – conveyor suppliers are therefore incorporating greater functionality into designs that will improve safety, writes **Todd Swinderman**, president emeritus, Martin Engineering.

Conveyors are among the most dynamic and potentially dangerous equipment at a quarrying or material processing site. Even though their safety and performance are critical to the operation's success, the impact of their contribution to overall efficiency is often unrecognised by management and workers alike. Operational basics of belt conveyor systems are too often a mystery to those employees, who have little understanding of the hardware installed and the performance required from the components.

The knowledge gap is understandable. The attention of personnel at a mining or quarrying operation is centred on the processing of the company's main product. The 'care and feeding' of belt conveyors – that is, the adjustment, maintenance and troubleshooting that make a huge difference in safety, performance, and profitability – is typically outside of their expertise. It is not that they don't care about conveyors, but that the ongoing maintenance and service of these systems is often not part of their immediate focus, nor is it within their time constraints.

Protecting the most valuable assets

Personnel are the single most important resource of any industrial operation, and engineers and designers are incorporating greater functionality into designs that will improve safety. Standards continue to tighten, as OSHA and MSHA[1] retain their strong focus on worker safety, driving the need for equipment designs that are not just safe, but *optimised* for safety – that is, designed with safety as a fundamental priority. At the same time, there is increasing pressure for continuous and ever-increasing production.

To reduce hazards in the workplace, operators employ a variety of methods, from requiring the use of personal protective equipment (PPE) to installing the latest and safest equipment designs. When examining the safety of a system, improving efficiency, and reducing risk can be achieved by utilising a hierarchy of control methods for alleviating hazards. The consensus among safety professionals is that the most effective way to mitigate risks is to design the hazard out of the component or system. This usually requires a greater initial capital investment than short-term fixes but yields more cost-effective and durable results.
Experienced engineers often recommend that operators retain an outside firm to examine system requirements and design new equipment around historical issues and specific needs of the application, with an overall objective of Production Done Safely™. Before the drafting phase, designers should establish the goals of reducing injuries and exposure to hazards (dust, spillage, etc.) to increase conveyor uptime and productivity, and seek more effective approaches to ongoing operating and maintenance challenges. Designs should be forward-thinking: exceeding compliance standards and enhancing operators' ability to incorporate future upgrades cost-effectively and easily by taking a modular approach.

Examples of *Eliminate by Design* are longer, taller, and tightly sealed loading chutes to control dust and spillage or heavy-duty primary and secondary cleaners to minimise carryback. By using hazard identification and risk-assessment methods early in the design process, engineers can create the safest, most efficient system for the space, budget, and application. These designs alleviate several workplace hazards, while minimising cleanup and maintenance, reducing unscheduled downtime and extending the life of the belt and the system itself.

Combining safety and productivity

To meet the demands for greater safety and improved production, some manufacturers have introduced equipment designs that are not only engineered for safer operation and servicing, but also reduced maintenance time. One example is a new family of heavy-duty conveyor belt cleaners, designed so the blade cartridge can be pulled away from the belt for safe access and replaced by a single worker.

All images by Martin Engineering

This slide-out belt cleaner is engineered to be accessed safely and replaced by a single worker.

The same slide-out technology has been applied to impact cradle designs. The systems are engineered so operators can work on the equipment safely, without breaking the plane of motion. External servicing reduces confined space entry and eliminates reach-in maintenance, while facilitating faster replacement. The result is greater safety and efficiency, with less downtime.

The track-mounted systems can be serviced quickly and safely, with no reach-in maintenance.

Another example is a revolutionary new belt cleaner design that can reduce the need for bulky urethane blades altogether, an innovative belt cleaning system that has received the Australian Bulk Handling Award in the "Innovative Technology" category for its design and potential benefits. The patented design delivers extended service life, low belt wear, significantly reduced maintenance, and improved safety, ultimately delivering lower cost of ownership.

Unlike conventional belt cleaners that are mounted at an angle to the belt, the unique cleaner is installed diagonally across the discharge pulley, forming a three-dimensional curve beneath the discharge area that conforms to the pulley's shape. The novel approach has been so effective that in many operations, previously crucial secondary belt cleaners have become unnecessary, saving further on belt cleaning costs and service time.

The unique belt cleaner forms a 3-D curve beneath the discharge that conforms to the pulley's shape.

Power

Another trend in large operations is a need for enhanced automation and monitoring, including such tasks as load sensing, belt tracking, cleaner tensioning, and lighting. In most cases, electrical power is supplied only to the conveyor locations where it is needed, such as the drive motor, and is not typically available for general purpose use. In many operations, this lack of available power means that any monitoring of the conveyor must be done by technicians physically walking the length of the structure, which can be a difficult and time-consuming task on long systems spanning difficult terrain.

A more efficient approach is to employ sensors to transmit important data from remote points to a central location where it can be monitored in real time and recorded for later analysis. But intelligent monitoring systems for any conveyor system require power for extended operation. Due to the distances involved, cabled communication systems are not ideal, and therefore wireless communication systems are more advantageous. Options such as solar are not well suited to the general conditions of a conveyor system, as monitoring devices are often required in an enclosed structure without access to sunlight, or for continuous operation during day and night.

A conveyor is driven by a multi-kilowatt motor, and this power is readily available system-wide in the form of the moving belt. The motors driving the belts are typically sized with a considerable power safety factor to account for parasitic loads, such as rolls with damaged bearings, tracking devices (which may work almost continuously), sealing systems, belt cleaners and material changes due to different moisture levels and variable loads. For these reasons, engineers have searched for ways to take advantage of the available kinetic energy of the moving belt to bring power to the specific places where sensors and other devices would provide advantages.

In most conveyor designs, the belt runs on a set of rollers that provide support and guide the belt. The typical conveyor roller is a very reliable device, with key components such as bearings, seals and the "steel can" all well understood in the industry. Product designers theorised that they could draw power from a moving belt by attaching an independent generator directly to one of the rollers. In this way, they felt that power could be drawn from the conveyor without altering the structure of the system or affecting its physical configuration.

Product engineers developed a design to accomplish this using a magnetic coupling that attaches to the end of an existing roller. The outside diameter of the generator matches the diameter of the roll but places the generator outside the normal belt line to avoid the heavy loads and fugitive material that tends to damage existing design attempts. The generator is held in a fixed position by the roll support system but is not normally required to bear any of the material load.

The generator can be employed on virtually any steel roller.

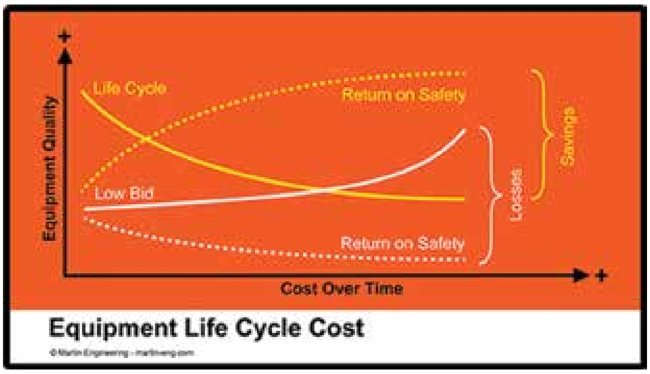
The reliable power supply helps bring a new level of sophistication to conveyors, allowing designers to equip their systems with devices such as weigh scales, proximity switches, moisture sensors, pressure switches, solenoids and relays, as well as timers, lights and even additional safety mechanisms. Wireless communication can be used to transmit directly to a central controller, giving operators a cost-effective way to access data that has not been readily available in the past – and taking another step toward "smarter" conveyor systems.

Low-Bid process and life cycle cost

Although the policy is generally not explicitly stated by companies, the Low-Bid Process is usually an implied rule that is baked into a company's culture. It encourages bidders to follow a belt conveyor design methodology that is based on getting the *maximum load* on the conveyor belt and the *minimum compliance* with regulations using the *lowest price* materials, components, and manufacturing processes available.

Maximising the volume of cargo and minimising the price of the system usually means choosing the narrowest feasible belt, operating at the highest speed possible. This leaves little margin for error and in many cases results in chute plugging, excessive spillage and reduced equipment life.

When companies buy on price, the benefits are often short-lived, and costs increase over time, eventually resulting in losses. In contrast, when purchases are made based on lowest long-term cost (life-cycle cost), benefits usually continue to accrue and costs are lower, resulting in net savings over time.



The return on better design and quality is realised over the extended life and safety of the system.

The art: design hierarchy

To safely maximise production, designers and engineers are urged to approach the project with a specific set of priorities. Rather than meeting minimum compliance standards, the conveyor system should exceed all code, safety and regulatory requirements using global best practices. By designing the system to minimise risk and the escape and accumulation of fugitive material, the workplace is made safer, and the equipment is easier to maintain.

Life cycle costing should play into all component decisions. Be aware of specifications on project components that state, "Specific Manufacturer Name/Or Equal." Vaguely written "Or Equal" specifications are there for competitive reasons and allow contractors to purchase on price without adequate consideration for construction or performance. Rather, buying on Life Cycle Cost or Engineer-Approved or Equal and anticipating the future use of problem-solving components in the basic configuration of the conveyor provides improved safety and access, without increasing the structural steel requirements or significantly increasing the overall price. It also raises the possibility for easier system upgrades in the future. The ability to accommodate future increases in capacity can also be included in the original design, expanding options and reducing future modification costs.

Conclusion

Engineering safer conveyors is a long-term strategy. Although design absorbs less than 10% of the total budget of a project, Engineering Procurement Construction Management (EPCM) services can be as much as 15% of the installed cost of a major project, additional upfront engineering and applying a life cycle-cost methodology to the selection and purchase of conveyor components proves beneficial. By encouraging the use of the *Hierarchy of Controls* at the planning stage, along with the *Design Hierarchy* at the design stage, the installation of an *Evolved Basic Conveyor* can be achieved. The system will likely meet the demands of modern production and safety regulations, with a longer operational life, fewer stoppages and a lower cost of operation. ■

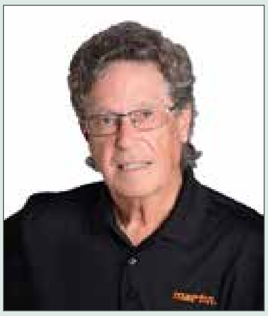
Red, Amber, and Green List for Designing Better Belt Conveyors	
RED LIst	*Procedures, techniques, products, and processes to be prohibited in the Specification and Design stages of a conveyor project.*
	Prevent loading on the transition of the belt.
	Prevent transition of more than 1/3 trough.
	Prevent loading against the direction of the receiving belt.
	Prevent loading conveyor to 100% of CEMA standard cross section capacity.
	Prevent control and sequencing that allows conveyor(s) to run empty longer than necessary.
	Prevent belt identification stamps in top cover.
	Prevent installing equipment in elevated locations without provision of safe access or tie-offs.
	Prevent Component Selection Based on 'Or Equal' Specifications or 'Price Only' Bidding.
AMBER LIST	*Procedures, techniques, products, and processes to be eliminated or reduced as much as reasonably possible. Only allowed with a change in the specification and notice to project owner/manager explaining potential issues and ability to address them in the future.*
	Avoid reversing conveyors.
	Avoid multiple load points on a single conveyor.
	Avoid designs created with the intention to increase capacity in the future by increasing conveyor speed; design the system to accommodate future needs
	Avoid combined vehicle and personnel travelways or uncontrolled exits from buildings into traffic patterns.
	Avoid a site layout that does not allow for safe and efficient delivery, storage, lifting of major components such as pulleys, drives, and belting.
GREEN LIST	*Procedures, techniques, products, and processes to be encouraged in specification and design stages of a conveyor project.*
	Consider ergonomics in the design and access of frequently cleaned or maintained equipment.
	Consider use of pulleys with diameters larger than minimum required for the specified belting.
	Consider access and clearances according to CEMA recommendations.
	Consider the use of design to reduce exposure to hazards.

Rather than meeting minimum compliance standards, conveyor systems should exceed code, safety, and regulatory requirements

References:

1. *After the creation of MSHA in 1977, OSHA and MSHA entered an inter-agency agreement to delineate authority between them.* OSHA has much broader authority than MSHA. *While MSHA is responsible solely for the mining industry, OSHA has jurisdiction over most private sector employers and employees as well as some public sector employees. https://www.bing.com/search?pglt=41&q=OSHA+and+MSHA&cvid=2d628bcf11f449ea84b73dcccd6eab94&aqs=edge..69i57j0l8j69i11004.1272j0j1&FORM=ANNAB1&PC=HCTS 2.*

About the author:



Todd Swinderman earned his BS from the University of Illinois, joining Martin Engineering's Conveyor Products division in 1979 and subsequently serving as VP and GM, president, CEO and chief technology officer. Swinderman has authored dozens of articles and papers, presenting at conferences and customer facilities around the world and holding more than 140 active patents. He has served as president of the Conveyor Equipment Manufacturers' Association and is a member of the ASME B20 committee on conveyor safety. Swinderman retired from Martin Engineering to establish his own engineering firm and currently serves the company as an independent consultant.