Dragline Retrofit for AC Motion Power

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Abstract

The mining industry is changing rapidly due to mergers, acquisitions and fluctuating market pricing. Successful mining operation in today’s market for coal, minerals, ores, and aggregates demands electrical apparatus that perform every time with maximum efficiency and with consideration for personnel safety. DC motors and motor-generator sets have remained the standard for mining dragline operation since their adoption in the early 20th century. Despite advances, DC technology continues to present significant challenges in productivity, efficiency, safety, and repair. FLANDERS’ completion of the first North American DC to AC Dragline Upgrade successfully eliminates the challenges of DC technology and brings dragline operation into the 21st century.

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Peer-review under responsibility of the Scientific Committee of SYMPHOS 2013

Keywords: Mining; Dragline; AC Retrofit; Advantages; FLANDERS

1. Introduction

With the mining industry changing rapidly due to mergers, acquisitions and fluctuating market pricing, today’s market for coal, minerals, ores, and aggregates demands electrical apparatus that perform every time with maximum efficiency and with consideration for personnel safety. This is especially true in existing mining operations where every payload counts.

Draglines are the workhorses of surface mining operations, and reliable and efficient operation is absolutely critical to success. However, the inherent disadvantages of utilizing DC motors and MG sets can significantly impact productivity and return on investment (ROI).

Today’s DC-powered draglines operate at relatively low efficiency. Additional energy demand is needed due to the high inrush current at MG start-up and significant energy consumption while idling. Commutation limits impact the maximum speed of a DC motor. DC motors and MG sets also require extensive routine maintenance for carbon brushes, commutator, bearings and MG set re-alignment.

Due to the potential of arcing inherent in DC machines, the risk of flashover remains a significant hazard while carbon particulate buildup can lead to catastrophic failure. MG sets also produce a high heat load and ambient noise in the house that can be hazardous for maintenance personnel.

Finally, DC motors and MG set problems are complex to diagnose, and most electrical curricula no longer include DC apparatus troubleshooting and adjustment.

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2. Advantages of AC Draglines

AC technology in mining applications has been proven over the course of a number of years. FLANDERS is the first American company to bring the advantages of AC technology to existing DC draglines.

2.1 Performance

Precision of operator control is crucial for higher productivity. Today’s modern AC drives incorporate insulated gate bipolar transistors (IGBTs) in both the inverter section and the Active Front End (AFE), allowing for precise regulation of the power factor and producing speed control which exceeds that obtainable by DC-powered equipment. AC drives and coordinated AC motors provide enhanced performance capabilities which can significantly reduce cycle times.

2.2 Efficiency

Energy costs strongly impact mining operations’ cost-per-ton. AC drives produce overall efficiencies approximately 12% higher than DC-powered systems and have no high inrush surge at start-up. AC drives consume virtually no power while idling in non-digging situations.

2.3 Safety

Even a minor failure of high-voltage equipment can produce serious injuries. AC drive technology separates the control power from the sealed power section, reducing arc flash exposure and achieving Level 0 arc flash rating. Eliminating exposed commutators removes the risk of shrapnel from catastrophic failure and increases operator and maintenance personnel safety. Liquid cooling of AC drives decreases ambient noise and heat levels in the house. Finally, the down-sized trailing cable—made possible by the lack of inrush at start-up—reduces the risk of physical injuries due to cable handling.

2.4 Productivity

Maintenance time is downtime, and eliminating MG sets removes the need for brush and commutator maintenance. Water-cooled AC drive systems allow placement of the electronics within a sealed enclosure, removing the need for filters and eliminating dirt-related maintenance and failures.

3. The FLANDERS Solution

On behalf of Armstrong Coal Company, FLANDERS combined the expertise of its Engineering Group with advances in AC drives and Active Front End technology to design, build, and commission North America’s first DC to AC Dragline Upgrade.

In 2010, when FLANDERS electrical, mechanical and systems engineers had completed 75% of their first AC dragline upgrade, Armstrong Coal shipped the DC rotating equipment and electronics from a dragline to FLANDERS for evaluation and a repair quote. The DC motors were in poor condition and the MG sets needed replacement. FLANDERS proposed upgrading the machine’s operation to AC power. The FLANDERS team designed, built, and delivered a fully operational AC dragline upgrade that has exceeded the customer’s expectations.

3.1 Built for Purpose

Given the extremely demanding conditions under which draglines operate, FLANDERS recognized from the onset of the project that taking a “built-for purpose” approach to the upgrade would ensure the highest quality and increase the mining company’s ROI while decreasing its Total Cost of Ownership (TCO).

FLANDERS designed the AC upgrade to conform to the existing physical envelope and footprint of the DC machine. The built-for-purpose AC motors were designed as drop-in replacements using the existing couplings and brake assemblies. This approach saved considerable time during the commissioning process. In addition, FLANDERS’ in-house power generation capabilities (both 60Hz and 50Hz) allowed for full load testing of the AC components and setting the operating parameters prior to delivery—another significant time saver.
3.2 Designed-for-Purpose AC Motors

The AC motors for Armstrong’s conversion were designed specifically for dragline application, taking into account all operating parameters: the need for increased torque at drag and peak power at swing speeds; maximum productivity; and long service life.

Specifically, FLANDERS designed-for-purpose AC dragline motors include:

- Copper-barred rotor for increased efficiency and better torque density
- Stainless steel rotor retaining ring that prevents “spin casting” effect
- Complete Class H+ (180° C) insulation system
- Bearing and arrangement using industry-proven design
- Insulated bearings and shaft grounding rings
- Common motor brake components (shoe or disc)

3.3 AC Drive Design

FLANDERS incorporated select power components with high thermal life cycle capability; ease of maintenance and repair by using easy-to-replace common power modules and detailed diagnostics; and improved productivity and machine availability through water-cooled semiconductors to remove the heat from the house and allow cabinets to remain closed and filter-free.

The control power was separated from the sealed power section, reducing the risk of arc flash exposure and achieving Level 0 arc flash rating.

3.4 FLANDERS Quality and Reliability

FLANDERS’ purpose-designed drive systems provide maximum machine availability and are designed for long life operation—up to 175,000 hours/10 million load cycles.

3.5 FLANDERS Total Package

At Armstrong’s request, FLANDERS incorporated motor control centers (MCCs), an operator chair, and a temperature-loop VFD-controlled house blower. A number of additional options can be added to suit the mine operator’s specific needs, including:

- Opportunity for Advanced Control
  - Open system configuration allows for interface of smart instruments, network devices and advanced machine monitoring
  - Control expandability and enhancements
- Communication Between Drive Processors
  - High speed data transfer for control
  - Coordinated operation to dampen or prevent electro-mechanical interaction of motors and gears

4. Field-Proven Performance

Armstrong Coal’s dragline operators have been unanimous in their praise of the upgraded dragline, citing one-touch start-up (no need to start MG sets in the house); the machine’s torque and power; the high degree of coordination between all motions; and smoothness of operation. Armstrong reports that the AC dragline has been working flawlessly with availability in the upper 90% range since commissioning.

5. Conclusion

Given the energy efficiencies, precise control, and increased productivity available through AC dragline operation, mine operators who upgrade from DC to AC draglines stand to realize a quick ROI and ongoing improvements in productivity and safety, decreased cost-per-ton, and decreased total cost of ownership. AC dragline technology is the future of surface mining, and FLANDERS is proud to have pioneered the first DC to AC Dragline Upgrade in North America.
6. About FLANDERS

Over the decades, FLANDERS’ commitment to serving customers’ un-met needs has resulted in technology and engineering breakthroughs and sophisticated manufacturing facilities that enable our team to optimize mine assets by transforming motors, power systems, automation solutions, products and services.

Headquartered in Evansville, Indiana, FLANDERS maintains operations in the U.S., Canada, South America, Africa and Australia with more than 850 employees and almost one million square feet of shop, office and inventory space.

At FLANDERS, we know that our achievements in the past – and those we envision for the future – have been and will be accomplished through consistently following our values and principles and our commitment to listen, innovate, and serve.