AVTRON MANUFACTURING, INC.
QUALITY SINCE 1953
7900 E. PLEASANT VALLEY ROAD
INDEPENDENCE, OHIO 44131-5529
TELEPHONE: (216) 642-1230
FACSIMILE: (216) 642-6037
E-MAIL: avtron@avtron.com

Tube Mill DC Drive Upgrade Project

Current economic pressures and decreasing budgets require manufacturers to get additional productivity out of existing equipment and control systems. Reliability and productivity improvements were required at Timken's No. 5 tube mill (see Figure 1).

An economically feasible plan to improve productivity, install diagnostics and remove obsolete equipment was needed. The upgrade was completed in several stages in order to achieve these results without incurring lengthy downtime.

Figure 1 – Timken's #5 Tube Mill in Operation

Significant Problems

An aging electrical drive and control system on Timken's No. 5 tube mill was causing unwanted and expensive downtime. Eventually, the overall productivity and machine efficiency began to decline to an unacceptable level.

Economic pressures were also dictating changes in machine operation, such that the existing drives and process control systems would not keep up with the changes any longer. A plan was required that would minimize capital equipment expenditures and would not need a lengthy machine downtime schedule to implement.

Charting a Course of Action

Ultimately, a plan that solved the following specific problems was needed:

1. Provide a path for replacement of obsolete drive regulators on critical sections.
2. Reduce the high cost of service of existing drive components.
3. Stop catastrophic drive failures on critical machine sections, thus decreasing downtime (Phase 1).
4. Provide Class I fault protection on critical machine drives.
5. Provide diagnostics for future troubleshooting and improvements.
6. Bring productivity and efficiency ratings back to acceptable levels.
7. Counteract rising utility costs while continuing current production rates.
8. Respond to market demands in production orders so that different grades and sizes of tube could be run.

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Planning for Success

Given that there were several serious issues with the line to address, the overall project being reviewed here developed into three major parts:

1. Upgrade of the Elongator and Piercer drive regulators and the Elongator SCR bridge hardware.

This portion of the project involved the removal of the existing Westinghouse regulator circuits (see Figure 2), while keeping the drive cabinet, contactors, motor feeds and 3,000-hp motors on both sections. Each section was then retrofit with an Avtron AFM firing module, which controls the existing equipment, fires the SCR bridge and has full communication capability with the other Avtron drives (see Figure 3).

Figure 2 - Existing Westinghouse Regulator

Figure 3 – Avtron Retrofitted Regulator

Since the Elongator drive was experiencing catastrophic faults, its SCR bridge was replaced with a new Avtron bridge, fully rated for the 3,000-hp motor, with 200 percent extended overload capability. Since the Piercer SCR bridge was still functional, it was retained during this phase of the project and retrofit with the AFM. Also added to the Elongator and Piercer drive was a high-speed DC breaker, giving full Class I fault protection to the section.

Due to the size of the shunt field windings on each of these motors (70 A), each of the field supplies for these sections was replaced with new ones. An Avtron AFS module, 3- phase field supply was installed at the same time. These field supplies, like the AFMs, include full

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communication capabilities with the other added drive components.

High-speed diagnostics for each of the units was supplied by an Avtron Performance ViewTM graphic trending and event history recorder.

Necessary PLC code and automation changes occurred as well. Since the PLC existed on the line prior to the drive upgrade, careful coordination between Timken and Avtron occurred to alter the PLC code required to run the drives, while retaining existing software for the unaffected portions on the mill.

With the upgrade, the drives now include a high-speed network that allows for the control parameters to be passed from the PLC, instead of being hardwired from I/O with the old system.

2. Upgrade of drive communications architecture.

During the Phase 1 implementation listed above, the PLC system communicated with the drive system through a third-party communications gateway. Due to time constraints on the original project, industrial Ethernet at the drive level was not possible, so a gateway was installed to complete the implementation on time.

Once software and hardware designs were complete, this phase of the project included the addition of a high-speed industrial Ethernet network directly into the Avtron AFMs and AFSs. This then allowed for the removal of the third-party gateway device, and a free-flowing direct network connection to exist between the Modicon PLC and the Avtron units.

Native to each of the Avtron drive/regulator units is a high-speed, fiber-optic Ethernet port, which allows for communication to the automation system PLC. It can interpret direct Modbus TCP messages and simultaneously allow communication between each of the drive units, as well other disparate devices.

Use of the fiber-optic media all the way back to the drive regulators completely eliminates electrical noise and disturbances from the industrial setting these drives sit in and was an ideal choice for integrating into existing cabinets where high-power electrics exist.

Of significance in having direct Ethernet connectivity on the regulators is the ability for the drive system to communicate with other third-party devices directly. Industry acceptance of Ethernet as a standard communication method on the plant floor in the last three to five years has opened the door to allow direct interface with other process control, data acquisition, scheduling or manufacturing execution systems.

Connectivity of such systems together must be monitored by both the IT and engineering departments to ensure safe, secure connections between drive control and mill-wide networks. However, the building blocks for the future will exist in the core infrastructure.

Direct high-speed communication from the drive system to the Performance View diagnostic terminal was accomplished at this time as well, eliminating the need to pass data through the PLC first.

3. Upgrade of the Piercer bridge and associated components.

As time went on, the need to upgrade the Piercer bridge became apparent to Timken. Several issues were surfacing on the drive system:

1. The Piercer bridge was starting to suffer from costly failures, much like the Elongator had previously. Failures of SCRs and fuses began to occur, and in order to alleviate the associated downtime, the current limits in the drive were turned down to protect the bridge. This action was directly reflected in a production decrease with production rates dropping by 15 percent.

2. The rising utility costs associated with natural gas to run the furnace forced the mill to experiment with different heating practices in order to reduce natural gas usage. This in turn altered the properties of the material enough that more current was required out of the bridge to pierce the bar, which it could not supply.
   The discharge rate of the mill had to be decreased (time between tubes increased) in order to adapt to the increased demands on the bridge for each tube pierced.

3. Production issues allowed for the running of experimental material through the mill at reduced cost. This experimental material also drove the temperatures down in the furnace and contributed to the extra load incurred during the piercing process.

Also added to the Piercer drive (like the Elongator) was a high-speed DC breaker, giving full Class I fault protection to the section as well. During this phase, the Thrust Block drive section was also completely replaced with a brand-new static SCR armature drive.

Obsolescence of parts drove this as well. As a result of the newly added drive, required network, PLC and automation issues were also addressed.

These three major project parts evolved into three major implementation phases of the project.

Project Schedule

As previously mentioned, the project broke down into three major parts or stages. The schedule for these stages occurred as follows:

Phase 1 – 2000

Of primary concern to the Timken Co. was keeping unscheduled downtime to an absolute minimum. Regular outages were scheduled on the machine every year during the July 4 holiday.

Due to the catastrophic events occurring on the Elongator drives, a short lead time of 10 weeks was necessary on the initial project from order to delivery of the equipment. This included all engineering and manufacture of equipment and allowed for the July 4 outage to be used for installation and commissioning.

Equipment was delivered on June 30 and was ready for the 5-day outage to follow. All required on-site work was accomplished during the scheduled outage, including demolition of old equipment,

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installation of new, and start-up/ commissioning.

Since the PLC and associated automation software already existed on the mill, the necessary modifications were made prior to the outage. New software was loaded into the PLC during the outage, which reflected the new control strategy of the drive system, using the drive network to pass information back and forth from the PLC. The mill was ready for production on schedule at the end of the outage.

Phase 2 – 2001

Upgrade of the communications architecture occurred on a short 2-day outage at the end of the year. New software and a communication hardware card were required in the drive regulators, but not the PLC. A small effort to alter the configuration of the drives and Performance View diagnostic terminal was required, and occurred without incident.

Phase 3 – 2004

Similar to the Phase 1 requirements, Phase 3 was required for a variety of production and downtime issues already discussed. Also operating on a tight 8-week lead-time schedule, the mill was due for another July 4 holiday shutdown.

Again, it was not possible to install and upgrade the Piercer bridge and replace the thrust block drive section using unscheduled downtime. Six total days of downtime were scheduled for the week prior to July 4.

Engineering and manufacture of required components occurred during the eight weeks, and installation commenced on schedule. New software was loaded into the PLC during the outage, which reflected the new control strategy of the drive system, and the mill was ready for production on schedule at the end of the outage.

Results

Electrically, the project was a success in all the key required areas, achieving the desired results of the goals of the project:

1. Class I fault protection of main mill motor drives through the use of a high-speed DC breaker.
2. New, state-of-the-art digital regulators installed for the most important sections.
3. New DC bridges installed for undersized, problem-prone sections.
4. Availability of local support is now from Avtron.
5. Availability of spare parts and a reduced dependence on obsolete hardware has been realized.
6. Ethernet addition back to Modicon PLC control loops, allowing for future expansion and communication alternatives.

From a production standpoint, the project was a big success, as it allowed the mill to operate under more efficient conditions than it had in the past. Phase 3 of the project was the most beneficial from an operations standpoint.

One of the seemingly small yet extremely productive additions to the system was the addition of the IIR value from the Piercer drive onto the HMI screens on the production floor. This value is a numerical

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indicator of the thermal heating model of the motor as taken from the drive. This value, when displayed and enunciated on an HMI, gives operations personnel guidance on how fast and how hard they can run the mill before trip-outs of the drive, motor or power stage occur.

By having this value known to them, the operators can and do make adjustments to the speed and discharge rate of the mill so that no unexpected downtime is incurred.

Empowering the operators in this manner to make on-the-spot decisions has also had more far-reaching benefits, including:

1. Decrease in scrap due to surface defects (this is directly related to the operators).
2. Reduced cobbles on the mill.
3. Reduction in maintenance delays for cleanup of cobbles.
4. Reduction in tooling costs for rolls damaged during cobbles.

Of great value has been the addition of the diagnostic tool, Performance View, to the drive system (see Figure 4).

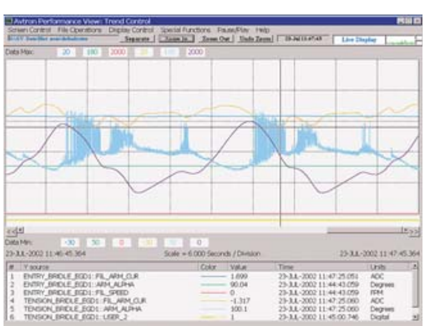

Figure 4 – Avtron Performance View Diagnostic Trending Screen

This type of diagnostic trending package is commonly used by both maintenance and operations personnel alike to serve multiple purposes:

1. Monitor system availability, uptime and efficiency.
2. Establish a baseline of drive conditions under optimal machine process performance.
3. Assist in piece-rate counts on the mill.
4. Aid the operators in troubleshooting process-related issues. Current trends can be viewed in conjunction with the recorded historical baseline to analyze process-related problems.
5. Assist maintenance personnel in determining causes of drive system and mechanical equipment downtime.
6. Current and historical baseline trends can be used to assist in drive and mechanical equipment troubleshooting.
7. Tuning of speed and/or tension regulators is easier.
8. Also used to generate a historical baseline to track system (speed, tension, discharge rate, etc.) response changes over time and to identify opportunities for improving drive system performance.
9. Enable machine analysis to determine potential process or machine improvements for increasing machine uptime or optimization.
10. Training production and maintenance personnel.

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Summary — Project Success

As shown in this paper, production efficiency at the mill has been on a roller-coaster ride the past several years when rolling large-diameter, high-carbon product, but has now returned to a flat, consistent production level.

Mill-wide production output has increased to 27 tons/hour (see Figure 5). Timken is pleased with the success of the project, which has met or exceeded the original goals. The overall success of this project can be attributed in large part to the collaboration and support from both Timken and Avtron before, during and after each major project phase.

Figure 5 – Tube being Pierced on #5 Tube Mill

Timken also acknowledges the benefits of having a responsive drive vendor located a relatively short distance from the mill. This allowed for frequent planning meetings and resolution of problems encountered during the project. It also facilitated quick changes in hardware and software when necessary, as well as fast access to Avtron engineers, technicians and field service personnel. Working with a different vendor farther away would not have offered the same responsiveness and flexibility.

Proximity allowed representatives from Avtron to be at the mill for service emergencies if required. Spare parts were readily available as well. Close cooperation and a clear understanding of the project objectives and scheduling concerns allowed for several different control and operating architectures to be married into one.

This upgrade not only achieved the desired results, but also provides a path for growth and future upgrades to drives that were not in the original scope of work.