Retrofit of Aging Electromagnetic Stirring Power Conversion Hardware

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INTRODUCTION

Electromagnetic Stirring (EMS) is used extensively for continuous casting metallurgical operations. Both primary and secondary stirring operations have been employed for many years now, and the EMS power conversion equipment in many cases is at an age where replacement is necessary. This paper will explore cost effective options for upgrading and retrofitting existing EMS power conversion equipment, primarily targeted at billet or bloom casters.

Overview

The basic principle behind Electromagnetic Stirring (commonly referred to as EMS) is that if an alternating magnetic field is applied to an electrical conductor, the field will induce electric currents in the conducting material. This electrical current will in turn also induce a rotational force within the conductor, and if the conductor itself is molten or fluid, will result in movement within the conductive material. This movement is what is referred to as the stirring that goes on within the strand of a metallurgical casting process. Figure 1 below shows the basic configuration of a steel casting line, with molten steel supplied from the tundish to the mold, where it is then cooled from the outside inward. As the strand passes through the inductive coils, the innermost molten steel is stirred by the rotating magnetic field in the coils surrounding the strand. Desired metallurgical effects (homogeneity) can be varied by varying the current and frequency passed through the coils. Although the basic electrical principles remain the same, physical characteristics of the strand and coils differ widely from caster to caster based on the type, size, and shape of the desired end-product. There are generally three different zones or options for installation of stirrers: at the mold, early solidification zone, or late in the solidification zone. Any or all of these zones are candidates for stirrer placement, and thus power supplies to power them.

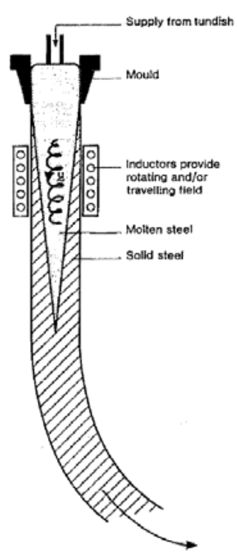

FIGURE 1 – TYPICAL STRAND CASTER EMS COIL PLACEMENT

Over the past 30 years or so, most steel producers have recognized that proper mixing in continuous casters is necessary to improve the overall quality of cast billets and slabs. There are not too many casters in the world today that don't employ EMS. As a result, several generations of power supply equipment have been put in place to achieve this. Many of these power supplies are of the age where replacement is necessary due to a variety of reasons. Since much of the initial research for EMS was done in Europe, many of the vendors of the stirring power supplies are from Europe.

GOALS OF A POWER SUPPLY RETROFIT OR REPLACEMENT

As any organization reviews power converter installation or upgrade project, common considerations must be given to the following issues when selecting hardware and automation projects as follows:

1. Performance Goals – the power converter system must be able to perform the task specified by the required application. This is first and foremost to the proper supply, although there may more than one option that would perform the required tasks. It is up to those specifying the power converter system to understand the application requirements before making any recommendations.

2. Cost Objectives – Secondary to performance goals, are relative initial or capital cost and price objectives. In this day and age, rarely does a mill have excess money to spend on technology that may not be required to do the job. The hardware provided must be specified to properly perform the task, but not at excess cost. Little room for excess exists – value for perceived benefit must be high.

3. Increased Reliability – Issues that go beyond performance and cost objectives that will usually affect the installation from a long-term perspective include:
   - Long term reliability of components
   - Downtime or lost production due to inoperable hardware
   - Time and money spent by maintenance personnel on equipment

4. Service and Maintenance – Long term support by qualified on-site maintenance personnel should also be taken into consideration. Spare parts consolidation and learning curve for maintenance personnel should be taken into account. Key objectives should be:
   - Readily available and reasonably priced spare parts
   - Available support, either by phone or in-person
   - Eliminate costly off-shore service
   - Provide and maintain legible and understandable documentation

A TYPICAL SCENARIO IN AN EXISTING SYSTEM

Problem

An aging EMS power supply and control system on the primary stirrers for Republic Engineered Products' 4-Strand Caster in Canton, OH was causing unwanted and expensive downtime. The system was originally installed in 1995 when the mill was brand new, through Danielli Automation of Italy. Reliability of the components has become an issue, as the equipment could no longer be maintained effectively. Spare parts for the system were extremely hard to find, if at all, and the only service available had to come from Italy. This posed several obstacles to keeping the equipment in operation, including the time change between the US and Europe, and expensive service trips between the two countries. Eventually, the overall productivity and machine efficiency began to decline to an unacceptable level. Economic pressures were also dictating that a cost effective replacement of the supplies be made only during scheduled maintenance outages. A plan was required which minimized capital equipment expenditures and did not need a lengthy machine downtime schedule to implement. Ultimately, a plan which solved the following specific problems was needed:

1. Provide path for replacement of obsolete power supply components.
2. Reduce high cost of service of existing power converter components.
3. Availability of local support for installed hardware and software
4. Provide increased diagnostics for future troubleshooting and improvements.
5. Bring productivity and efficiency ratings as well maintenance costs back to acceptable levels.

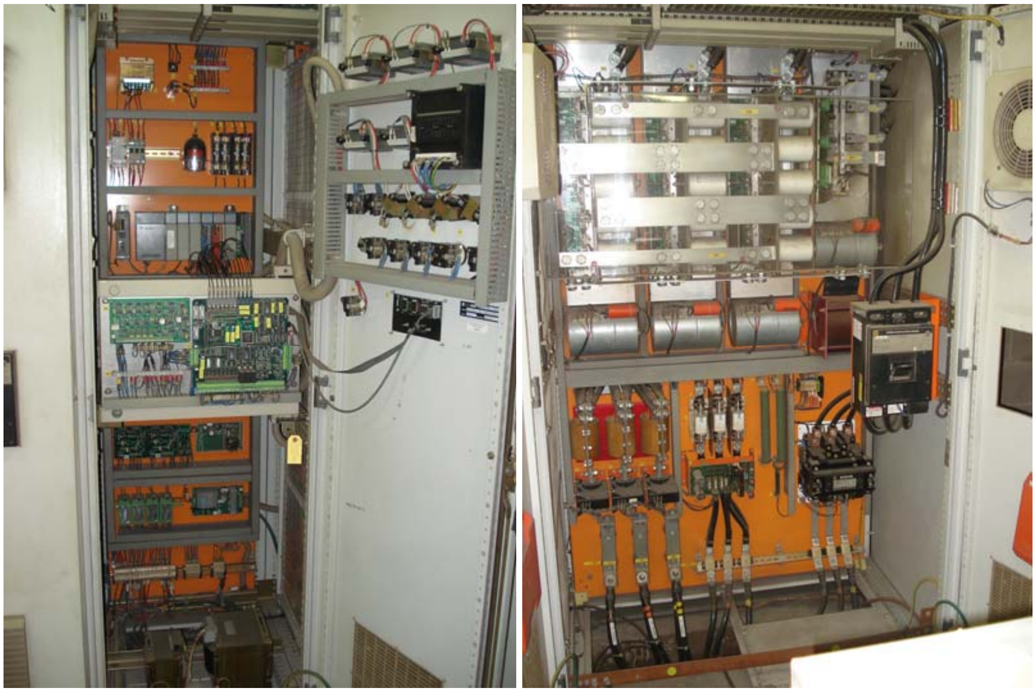

FIGURE 2 – EXISTING EMS POWER SUPPLIES AND CONTROLS

Solution

Through a multi-phased approach, all power converter sections on the machine were replaced. In order to keep costs in line, large or expensive components of the power converter cabinets were retained where possible, without sacrificing the necessary requirements above. A completely new communications architecture on the power converters was installed, allowing for high-speed diagnostics to be run on the system. These combined upgrades allowed for the efficiency of the mill to return to acceptable levels and increase overall output quality, all with reduced maintenance costs associated with the converters.

Power Converter Sections

The basic power converter stages of the systems were replaced with new, modern 3-phase IGBT-based ACCEL 500™ bridges from Avtron. Each of the units is rated at 520A continuous output current. The range of stirring capability for each of the coils ranges from 1-3.5Hz at 350-520A. For simplicity of maintenance and operation, forced air-cooled bridges were supplied. If desired or required, liquid-cooled power bridges could also be provided if heat transfer or physical size were of concern to the installation. To further reduce costs and maintain a tight budget, the mill provided all necessary installation hardware and services, choosing to mount the new converters in different space than the existing line-up. This matched the mill's requirements to perform the work on scheduled outages, further reducing the capital expenditure costs of the upgrade, and also allowing for a backward path in the event problems were encountered during commissioning.

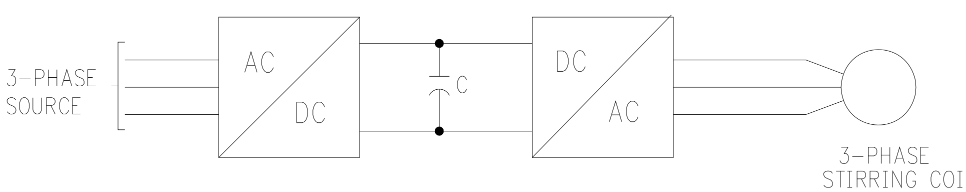

FIGURE 3 – TYPCIAL ONE-LINE OF AN EMS POWER SUPPLY

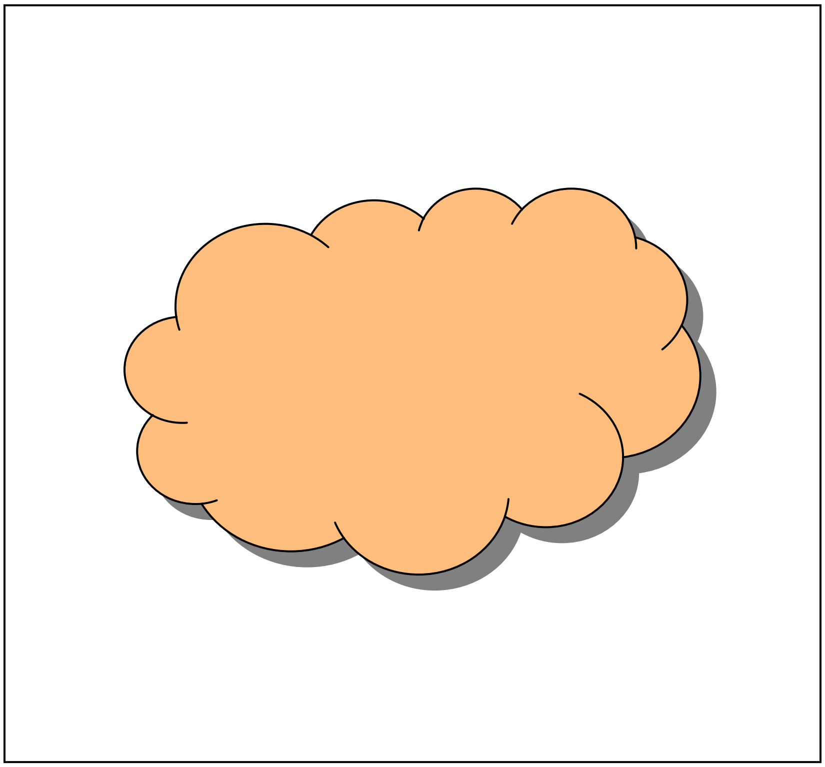

FIGURE 4 – NEW POWER SUPPLY SECTIONS

Application Code

Each of the power supply units is individually programmed and controlled by means of a built-in keypad and microprocessor unit. Block-configurable application code in each of the units is specially tailored for EMS work, being able to alter both voltage and current through the full range of their unit ratings, and being able to “reverse” the stirring direction. This application code is the same for each unit, with minor user-configurable parameters different between each. The built-in keypads offer the convenience of being able to store the unit-specific data in them, and since they are removable and portable, can be used during service of the units to quickly and easily load the replacement units with the proper operating data. Each unit also has a built-in serial communication link for interrogation and downloading by a PC, as well an Ethernet link. The Ethernet connection gives the option to perform the following in the future:

- Network all the units to an upper-level supervisory system, providing a high-speed diagnostic and control link for better predictive and preventative maintenance functions
- Provide a means to supply remote diagnostics and maintenance to the mill for faster and even more cost effective service options

Automation Code

In an effort to keep costs in line, the basic control and automation of the converters was completed by the mill technical staff. A supervisory PLC was in place on the mill already, so it was retained and re-used during the upgrade. All control signals to/from the power converters are hardwired +24VDC I/O. Functionally, the control of the new power converters remained basically the same as the existing, so the mill technical staff provided the programming changes required for the new system.   Avtron engineers worked in conjunction with the mill to provide the proper configuration points for the power supply to match the mill’s automation scheme requirements.

RESULTS AND SUMMARY

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

- New state-of-the-art digital power supply components for the coils
- Reduced the high cost of service of existing power converter components.
- Provided availability of local (US-based) support from Avtron
- Provided increased diagnostics for future troubleshooting and improvements.
- Brought productivity and efficiency ratings as well maintenance costs back to acceptable levels.

Republic is pleased with the success of the project that 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 Republic and Avtron before, during, and the project.

Republic acknowledges the benefits of having a responsive 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 a simple pre-outage factory test of the hardware, 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. This upgrade not only achieved the desired results, but also provides a path for growth and future upgrades to the power supplies that were not in the original scope of work.

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