SDI Heartland Temper Mill Stand Motor and Drive Replacement

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ABSTRACT

Steel Dynamics Inc. - Flat Roll Group Heartland Division had a problem on its temper mill. The stand bottom motor was on the verge of failure. Did it make sense to replace the DC motor with another DC motor when the drive was obsolete? Did it make sense to replace with an AC motor and drive for a mill that was all DC? What happens if a new AC motor and drive are ordered and the DC motor fails in the interim? These are the questions that were faced. The paper will address the alternatives in detail, the challenges that were encountered, and how it worked out.

Keywords: Temper Mill, DC Drive Replacement, Modernization, DC Motor Replacement

DISCUSSION

SDI Heartland Division Temper Mill

SDI Heartland Division is located in Terre Haute, Indiana. Steel Dynamics Inc (SDI) purchased the Heartland Division operations from CSN, LLC in 2018. The Temper Mill Bottom Stand Replacement project was initiated while it was still CSN LLC, but the engineering and commissioning was done by SDI Heartland Division.

The Heartland Division Temper Mill is a single stand mill. The mill was built in the late 1990's and the automation system was replaced in 2016. The motors and drives were as originally supplied, although master control functionality originally done in T300 technology modules had been moved to the master control programmable logic controller (PLC) as part of the automation replacement in 20161.

Stand Bottom Motor Problem

The Temper Mill has separate motors for the stand top and stand bottom work rolls. The original motors for stand top and stand bottom were 1500 hp DC motors. The stand bottom motor (See Figure 1) experienced a near insulation failure and was sent out to a motor shop for repair. A temporary repair was made to allow the motor to be placed back in service, but this was only a short-term solution. The Heartland operations were still recovering from losing customers during the previous automation failure on the Temper Mill which precipitated the automation replacement. It was important to avoid a long temper mill outage.

Figure 1. Existing 1,500 hp Stand Bottom DC Motor

Options Developed

Once the short-term repair was accomplished, options were developed for how to deal with this situation long term.

Find a Used DC Motor

A search was conducted for a suitable used DC Motor. Used equipment dealers and online searches were initiated. A suitable long-term solution was never found for a similar enough motor in power, size, and speed range. A couple were found that could be used on an emergency basis, but not as a long-term answer.

Replace DC Motor With New DC Motor

A new replacement DC motor was another option. New DC motors are very expensive but would definitely be suitable. Unfortunately, the DC drive was obsolete and would have to be replaced in the not-too-distant future.

Replace With New AC Motor and AC Drive

Replacing both the DC motor and DC drive with an all-new AC motor and drive was also an option. This would be a larger scope, but it did offer the benefits of improved power factor and to serve as a beginning to an all-AC system. This option would free up an entire drive's worth of spares for similar obsolete drives where spares are no longer available.

Bids Solicited

Bids were solicited for a new replacement DC Motor and also for a new AC Motor and Drive replacement. A suitable used long term replacement DC motor was not found, but a couple that could be made to work on an emergency basis were identified. Since the new equipment required substantial lead times, an option was placed on one of the used DC motors as an insurance policy in case the repaired motor failed.

Decision Factors
The following factored into the decision of how to proceed:

- Replacement all new DC motor was very expensive.
- Replacement AC Motor would fit in existing location without civil work.
- Replacement AC drive would fit in footprint of existing DC drive.
- The existing DC drive was obsolete. Replacing this drive would free up additional spares to support the other obsolete drives.
- The desire to eventually convert the entire mill to all AC.

The decision was made to purchase a new AC motor and drive.

New 1500hp AC Motor
The new 1500hp 690V Stand Bottom induction motor was specified to fit on the existing motor foundation. The existing DC motor was blower ventilated, but the new motor was totally enclosed with top mounted air to water heat exchanger (TEWAC). A motor factory design engineer traveled to site for a detailed survey to confirm the available space and the existing foundations. The new motor was planned for dual windings to accommodate the dual inverter bridges of the new drive.

New AC Drive
The new 690V drive consisted of a TMdrive 10e-2 dual bridge converter and a TMdrive 10e-2 dual bridge inverter. The existing drive had the drive transformer, drive incoming breaker, and reactor all mounted in the ground floor electrical room (e-room) of the electrical house (e-house). The existing drives were mounted in the 2nd floor control room of the e-house. (Prior to the shutdown, SDI added a wall between the drives and the automation equipment on the 2nd floor to improve the ambience in the area near the automation equipment where the workstations are located). SDI wished to retain the same split and to retain the existing 690V drive transformer and breaker. The existing reactor was not suitable, however a new reactor was selected to fit in the same location.

Interface to the Automation
The existing drive utilized a Profibus interface to the drives. The T300 technology module in the existing drive had been removed during the recent automation replacement. This greatly simplified the replacement of the drive, since the functionality in the T300 had already been moved to the main automation system which minimized automation changes. There was some I/O in the existing drive that was replaced by adding additional I/O to the automation system.

Planning for Future Drive Replacement
During this project for the Stand Bottom Motor and Drive consideration was given in the design to future replacement of the Stand Top, Bridles, and Reel motors and drives. The control power transformer was sized with all of the future drives in mind. Also, the auxiliary control panel for brake/blower/heater control was sized to support the future Top Stand, Bridles, and Reel motors and we provided holes with blank fillers for disconnects for the other motors.

Installation Engineering Planning
Planning for the installation included:

- Planning for removal of the existing drive lineup and placement of the new drive lineup in the elevated control room.
- Planning for removal of the existing reactor and replacement with the new reactor.
- Selection and planning for new Variable Frequency Drive (VFD) cable from the new reactor to the new converters.
- Selection and planning for new VFD cable from the new inverters to the new motor.
- Plan for plant cooling water for the new TEWAC cooling unit on the new motor.

Arrival of the New Motor and Drive
The concern about the weakened condition of the existing DC motor resulted in every effort being made to treat it with care so that it would remain operational until the new motor arrived. That strategy proved successful and the old motor lasted until the new motor arrived. Shortly after the new motor arrived, the mill shut down for the motor and drive replacement.

Pre-Shutdown Activities
Since most of the new equipment directly replaced existing equipment, there wasn’t much that could be done in advance other than planning. The new piping for plant cooling water was run from the existing building column pipe and stubbed off near the motor base.

Shutdown

Removal of Motor and Drive

The existing DC motor was disconnected and removed from the existing foundation. The existing DC drives were disconnected and removed from the 2nd story of the E-House. The existing reactor was disconnected and removed from the ground floor e-room.

New Motor Placement

The new AC induction motor was set on the existing foundation (See Figure 2). Per SDI's request the new motor was engineered to be 2mm below the existing shaft height to allow for shimming during alignment. This ensured that there would be no need to remove material from the foundation during the alignment process. The new motor base supplied with the motor was engineered to match the foundation bolt pattern of the existing motor. Once the motor was placed and aligned, the connection of the new TEWAC water connection was completed.

Figure 2. New 1500 hp AC Induction Motor being placed on the existing foundation.

New Drive Placement

The new AC drive lineup was slightly larger than the existing DC drive lineup. For this reason, the location of the new drives was shifted slightly to allow room for a future identical drive to replace the Stand Top drive. Once the old drive was removed, the new drive was placed in position in the 2nd floor control room. (See Figure 3)

Figure 3. New Bottom Stand Drive in foreground with Old Top Stand Drive in Background

New VFD Cable

New VFD Cable was run between the reactor in the ground floor E-room and the drive converters in the 2nd floor control room. Four 3-conductor continuously corrugated welded (CCW) armored cables with 3 symmetrical grounding wire were utilized – two cables for each converter. (See Figure 4)

The same VFD cable was run from the 2nd floor inverters out to the new dual winding motor. Two VFD cables for each winding were utilized.

Figure 4. New VFD cable utilized for the motor and drive power circuits

New Reactor Cable

New VFD Cable was run between the reactor in the ground floor E-room and the drive converters in the 2nd floor control room.

Figure 5. New Reactors mounted in ground floor E-Room

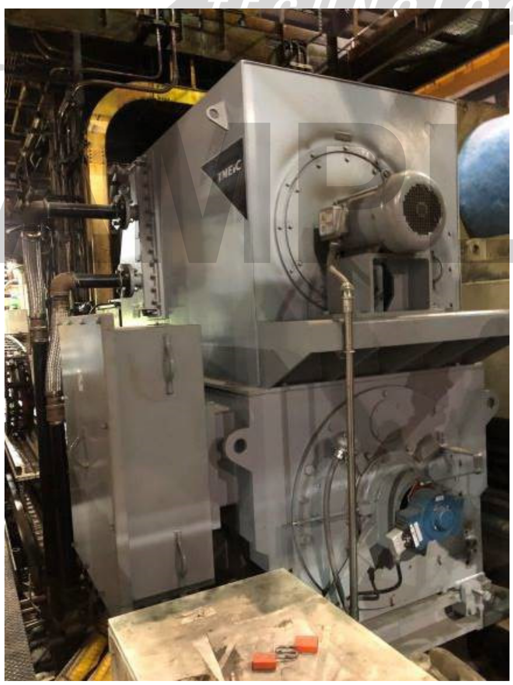

Figure 6. New 1500 AC Induction Motor with top mounted TEWAC cooling unit

Interface to the Automation System

I/O for the new motor and drive were connected to the existing automation system. Once power was applied, each point was verified to the software.

Drive Commissioning

Initial drive commissioning checks were done with control power only. Initial drive commissioning with the motor were done uncoupled. Final tuning was done with the Stand Bottom work roll connected. The dynamic response of the AC drive is typically faster than that of a DC drive. In a coordinated drive system, the responses need to be matched for smooth operation and to share load properly. In this application, the control philosophy was maintained that the Bottom Stand followed the Stand Top. The new Bottom Stand response had no trouble following the slower Top Stand dynamic response.

Startup

The startup with the new Stand Bottom motor and drive was very smooth. The new Bottom Stand AC motor and drive and the 20+ year old Top Stand DC motor and drive shared load and operated together flawlessly.

Results

This was a very successful project. The photo below shows the new Bottom Stand Motor with the top mounted TEWAC cooler. Table 1 summarizes the project goals vs the results.

Table 1: Results vs Goals

Goal	Result	Remark
Baby existing motor until new motor and drive could be arranged.	√	Successfully utilized existing motor up until the shutdown.
Replace DC motor and drive with all new AC motor and drive	√	—
Fit new AC motor and drive within the footprint of the existing DC motor and drive	√	The new motor utilized the existing foundation. The new AC drive converter and inverter fit in same location as the DC drive.
Re-utilize transformer and incoming AC breaker	√	Both the transformer and AC breaker were reutilized.
Integrate/interface the new AC motor and drive to the existing automation system.	√	—
Smoothly match response and share load between existing stand top DC motor and stand bottom AC motor.	√	New stand bottom AC motor and drive follow the response of the existing DC stand top motor
Improve efficiency	√	New drive operates at 1.0 PF versus 0.7 or worse for old DC drive.
Create additional spares	√	Replacement of DC Drive created additional spares.

CONCLUSIONS

Near failure of an existing 1500hp DC motor provided an opportunity to begin transition of SDI's Heartland Division Temper Mill from DC to AC. The Temper Mill team evaluated the available options and began the transition to AC while covering the short-term risk by careful operation of the motor and putting an option on an emergency motor during the manufacturing cycle for the new equipment. The motor and drive are working flawlessly with the old drive equipment and a path is available to convert to all AC in the future.

REFERENCES

1. T. Richards, N. Carpenter, and G. Sinders, "CSN LLC Temper Mill Modernization," *AISTech 2017 — Proceedings of the Iron & Steel Technology Conference,* 2017.