RECLAIMING CONTROL

A rail-to-ship iron ore transfer terminal in the US sought a replacement for its 40 year old bucket wheel reclaimers, which often caused conveyor stoppages and resulted in high shiploading times. **James Cone Jr (CN Two Harbors, USA) and Michael Gawinski (Rulmeca Corporation, USA),** detail the terminal's solution.

Built in the late 1970s, the Two Harbors iron ore terminal (Figure 1) serves as an essential interface between iron ore trains, which bring taconite pellets from the Minnesota Iron Range, and self-unloading lake vessels, which take the ore to steel mills on the Great Lakes. Complete with a rail loop and pier, the terminal consists of a train dumping system, a shiploading system and a material storage (stockpile) area.

The stockpiles serve as a buffer between frequent deliveries from inbound trains and periodic transloading to ore carriers. Additionally, the stockpiles allow trains to continue delivering pellets when Lake Superior is frozen and unnavigable. Stockpile equipment consists of a stacker, a yard conveyor, and two crawler-mounted bucket wheel reclaimers. Each bucket wheel machine was originally designed to reclaim iron ore pellets at 4000 tph to minimise shiploading time. It is impractical to attempt to load ships directly from trains due to the natural limitation of the train unloading rate.

Figure 1. Overview of CN Two Harbors's iron ore transloading terminal on Lake Superior, linking Minnesota iron mines with Great Lakes steel mills.

Figure 2. By 2015, reclaim rate on 40 year old crawler-mounted MX bucket wheel reclaimer had dropped to 1500 tph, increasing the time required to transfer taconite pellets from storage piles to yard conveyor.

Bucket wheel reclaimer rate problem

By August 2015, the reclaiming rate of each 40 year old bucket wheel reclaimer (Figure 2) had decreased to 1500 tph. This drop in reclaim rate directly increased vessel load times. In addition, unscheduled stoppages of the reclaimers' conveyors caused significant delays in ship turnaround time.

Despite the bucket wheel operators' attempts to manually maintain the reclaim rate at or above 1500 tph, the external temperature of the existing 200 hp drives would occasionally exceed 300˚F, even in winter weather. Subsequent motor burnouts caused conveyor stoppages and the need for frequent drive changeouts and rebuilds.

Motorised pulley upgrade

By 2015, Rulmeca motorised pulleys had already been used successfully at the following shiploading terminals:

- More than 10 years on several MX reclaimers in Allouez, Wisconsin.[1]
- More than 30 years on a Demag reclaimer at the CN Terminal in Escanaba, Michigan.
- More than four years on the reversing dock conveyor at CN Duluth Dock.[2]

Therefore, Two Harbors' management decided to replace existing drives with six model 800H Rulmeca motorised pulleys (RMPs).

Engineers from Rulmeca and Jasper Engineering worked with Two Harbors' operations personnel and Rick Embry of Embry Automation & Control to identify the problems with the existing drives, verify conveyor belt power requirements, and make a load sharing plan for the discharge conveyor dual drive system.

Rulmeca and Jasper recommended the installation of three model 800H at 180 hp/drive to replace the three existing 200 hp drives on each of the two reclaimers. The Rulmeca drives were built and expedited to Two Harbors so that the upgrade could occur during the scheduled 'winter shutdown'.

Installation and commissioning

Rulmeca motorised pulleys were delivered to the terminal in December 2015. Terminal personnel removed the existing drive pulleys, mounted the Rulmeca drives (Figure 3), and connected them to the onboard generator using the existing variable frequency drives. The Rulmeca motorised pulleys immediately enabled the machine to achieve a reclaim rate exceeding 4000 tph. The maximum rate was limited by the width and speed of the belts and not the drive power.

From day one, CN Two Harbors could tell the increased reclaim rate would immediately decrease ore carrier loading time. The company also expected the elimination of reclaimer conveyor drive breakdowns to improve the reliability of its shiploading system. That has proven to be the case.

Power calculations and motorised pulley cooling

Working with CN Two Harbors operations personnel, Rulmeca and Jasper engineers performed conveyor belt power calculations to verify that the RMPs would provide enough power to move 4000 tph of iron ore pellets at an appropriate conveyor belt speed. They confirmed that 180 hp would be more than adequate to drive the boom conveyor and 360 hp (2 x 180 hp) would provide more than enough power to drive the articulating discharge conveyor. Additionally, Rulmeca personnel verified that the standard 'partially lagged' model 800H motorised pulley design would be able to dissipate internal heat adequately.

Although the thermodynamic characteristics of motorised pulleys are complicated to calculate and test, they are relatively easy to understand. The internal motor creates heat which must be continuously dissipated. The higher the power, the more heat there is to dissipate.

The full load amperage (FLA) of each CN Two Harbors 180 hp motorised pulley is 218 A on a 460 V/3 phase/60 Hz power supply. Since the motorised pulley is hermetically sealed (with no vents to the atmosphere), internal motor heat must be continuously removed from the pulley face by surface contact with the moving conveyor belt. In steady-state, the conveyor belt temperature increases by 1 - 3˚F as it wraps around the pulley shell. This heat is radiated from the belt into the atmosphere within a few seconds.

Circulating oil and 'partial lagging' are essential to limit the internal motor temperature to 250˚F and the external surface temperature to 170˚F in the 180 hp RMPs. Synthetic oil not only lubricates moving parts, it also cools the motor. 'Drip lips' continuously pour oil on the motor, drawing heat from the motor winding to the inner surface of the pulley shell. As shown in Figure 4, 'partial lagging' enhances heat dissipation from the pulley shell and into the conveyor belt.

Full load testing at Rulmeca Germany and field testing at a wide variety of locations have proven that 'partial' rather than 'full' lagging is essential to dissipate internal motor heat into the moving conveyor belt under certain circumstances, such as the 180 hp RMPs at CN Two Harbors.

The thermal conductivity of each material must be considered in motorised pulley design. A watt per metre per K (W x m^{-1} x K^{-1}) is a derived SI unit of thermal conductivity. This unit of measure shows that in a material 1 J of energy per 1 sec. (that is 1 W) moves through the distance of one metre due to a temperature difference of one kelvin. Since the thermal conductivity of carbon steel is approximately 40 Wm^{-1} K^{-1} while the thermal conductivity of rubber is approximately 0.2 Wm^{-1} K^{-1}, it is obvious that rubber lagging is an insulator while steel is a conductor of heat.

An efficient heat flow path through the insulating rubber lagging must be provided in higher FLA conditions. The central 'unlagged' section of the Rulmeca pulley shell provides a direct path for heat to flow from the inner side of the steel shell directly to the belt on the outside of the steel shell. Under most operating conditions, partial rubber lagging provides adequate traction to drive the conveyor.

Cold weather conditions

After five months of experience with the new drives, CN Two Harbors hired Embry Automation & Controls to fine tune the VFDs to improve drive load sharing in the nested dual drive arrangement beneath the discharge conveyor.

Rick Embry said: "The existing analogue control signals at the VFD were replaced with digital ethernet communications, allowing for a faster response and more accurate control of the speed and torque. By making this change, we were able to more completely utilise the existing VFD's and fine tune the system to operate the pulleys at their peak levels."

In spite of electronic load sharing, occasional sub-zero temperatures presented slipping challenges to the upper (booster) drive pulley in the nest. This, in turn, reduced the actual reclaim rate below 4000 tph. Therefore, CN Two Harbors equested that Rulmeca and Jasper (Rulmeca's motorised pulley distributor), upgrade the partial smooth rubber lagging.

Jasper's Ben Delich said: "Once we got the six motorised pulleys into our custom rubber shop in Hibbing, Minnesota, we were able to quickly remove the smooth rubber lagging and cold-vulcanise ceramic embedded rubber lagging onto the shells. The $^3/_4$ in. x $^3/_4$ in. ceramic plates enabled us to increase traction on the belts and eliminate cold weather slipping."

Figure 3. Three 180 hp Rulmeca motorised pulleys were installed on the bucket wheel reclaimer in December 2015 (two in nested dual arrangement on discharge conveyor and one on boom conveyor).

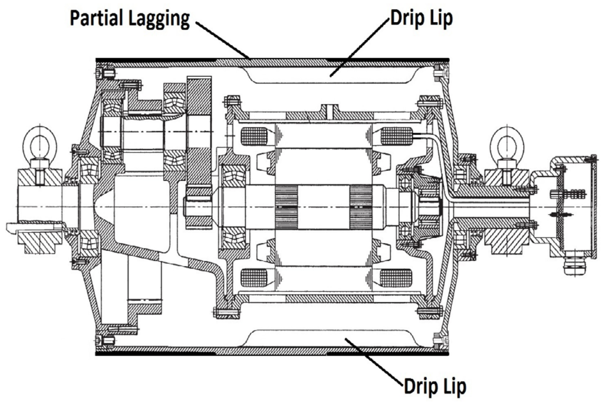

Figure 4. Cross section of 180 hp motorised pulley (oil not shown). Circulating oil and partial lagging are essential to limiting internal motor temperature to 250˚F. Note that the centre section of the pulley is 'unlagged', allowing heat to flow efficiently through the carbon steel pulley shell and into the conveyor belt.

Conclusion

The experience of CN at Two Harbors is consistent with that of other Rulmeca motorised pulley users, not only at shipping terminals on the Great Lakes, but at terminals, mines, steel mills and bulk plants throughout the world. GMR

References

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