Using Infrared Thermography with Ultrasound to predict mechanical failures

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As the largest package sorting facility in the world, United Parcel Service's (UPS's) Chicago Area Consolidation Hub (CACH) currently processes up to 1.7 million packages per day. These packages are sorted using an automated conveyor system that consists of 9,226 individual conveyors. At CACH, we operate our conveyors twenty hours a day, five days a week. This only leaves weekends for major repairs. The Plant Engineering Department has traditionally serviced these conveyors through Preventive Maintenance Inspections (PMI's). The PMI has been an effective method of maintaining conveyors at UPS. However, as newer, more specialized equipment has been installed, situations arose where traditional PMI's became less effective. Because of this, UPS's Plant Engineering department developed a predictive maintenance program. The program at CACH consists of thermography, vibration analysis, ultrasound and motor circuit analysis. One challenge that we face is how to properly integrate these technologies to optimize system performance and increase reliability.

One instance where we have integrated predictive technologies is on our "power curve" conveyors (**Figure 1**). All of our package sorting lines incorporate one or more of the Transnorm 1500 series belt curve conveyors. These power curves consist of various shapes and sizes. Currently there are 452 power curves installed at CACH, most in critical sorting areas. Failure of the conveyor in any way could result in several hours of downtime leading to loss of production and increased maintenance costs. Prior to utilizing predictive maintenance technologies there was not an effective method of diagnosing power curve problems while they were operating.

Figure 1

To fully explain what problems we encounter, one must understand the nature of a power curve conveyor. The conveyor belt is driven by an AC motor that is connected to the pulley by a sheave and polychain. These conveyors have a conical belt that is folded flat and tightened around 2 tapered end pulleys. As rotation starts, the conical belt tracks inward. Transverse forces occur and have to be diverted. The belt is provided with a highly elastic edging strip (bead), flanged top and bottom (**Figure 2**) with a durometer of 75. The flanges of the edging strip are centered between two rows of ball bearing guide rollers set at an angle. One row is on top and one row is on bottom for the return.   The guide rollers prevent the belt from tracking off line.

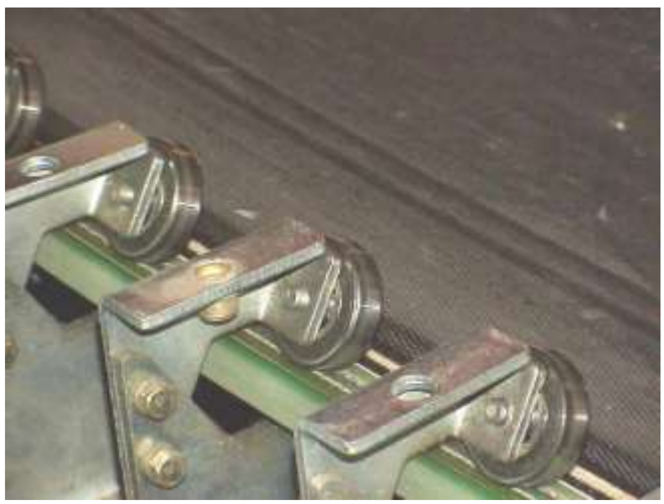

Figure 2

Once the decision was made to implement predictive technologies, thermography was brought in. Using thermography we are able to diagnose common problems with motors including clogged or broken fans, winding degradation and excessive drag (**Figure 3 & 4**). This drag could be from a bad pulley bearing, a misaligned sheave or debris stuck in the pulley. Once properly diagnosed using thermography, these problems could easily be fixed during scheduled downtime.

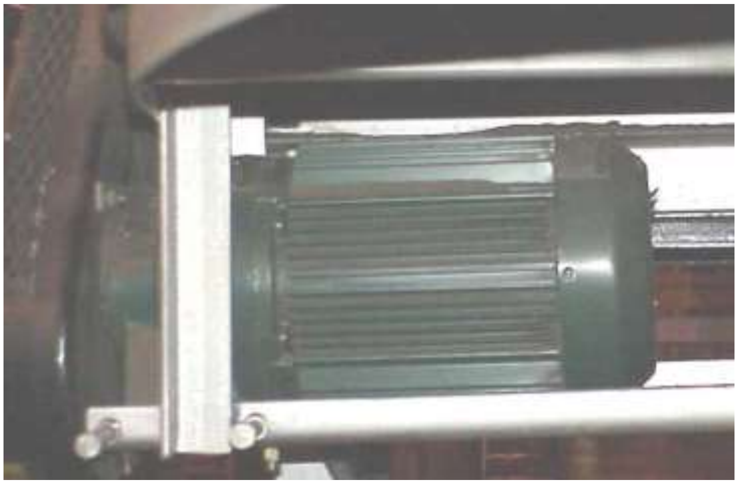

Figure 3

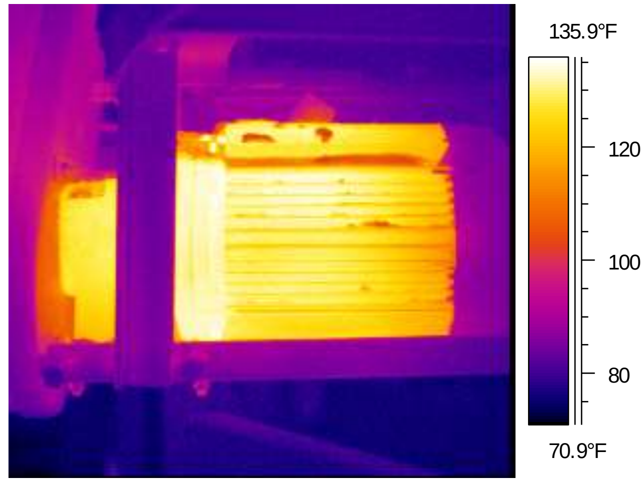

Figure 4

The next power curve problem that thermography was used for was bead failure. There are several possible causes of bead failure including belt misalignment, guide roller misalignment or failing guide rollers. A mechanic conducting a normal PMI inspection could not adequately inspect for these conditions due to the high belt speeds and the conveyor guarding that restricts the view of the bead (**Figure 5**). Using thermography we are able to detect these problems before damage is done to the bead (**Figure 6**). Minor adjustments could be made to the belt tracking to correct the problem thus preventing conveyor breakdowns.

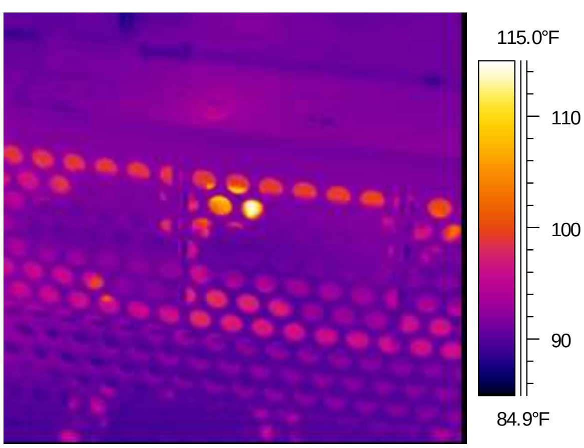

Figure 5

Figure 6

Recently we have begun to see increased failures of the powerturn guide rollers. These rollers are 1 ½" diameter, sealed, grease filled, ball bearing rollers (**Figure 7**). CACH has been open since 1995 and the majority of these guide rollers are original to the building. Some run at speeds over 1,100 rpm's for a period of time of up to twenty hours a day. We are concerned that we are approaching the end of the life of these guide rollers. Infrared Thermography has proven helpful in detecting guide roller failure, but in many cases it does not detect it early enough to prevent breakdowns due to bead failure.

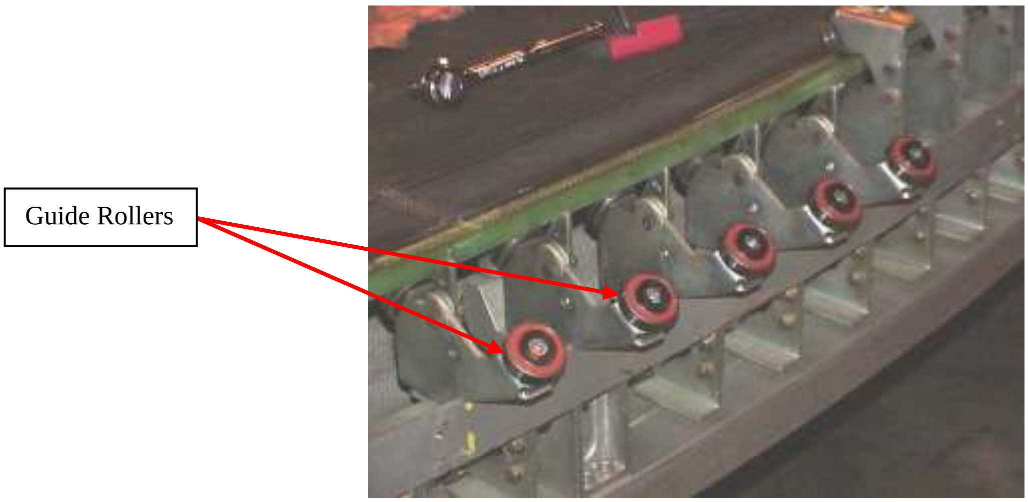

Figure 7

During the scheduled PMI shutdown of the power curves, we began to experiment using Ultrasound on the guide rollers. Guide rollers showing no significant rise in temperature and giving off no audible sound are easily identified as nearing failure using the Ultrasound device. Distinct grinding sounds can be detected and isolated to a particular guide roller. This allows us to selectively change out guide rollers during our scheduled downtime.

Figure 8 shows a small section of a power curve conveyor. Only one guide roller on this conveyor has an abnormal temperature reading (bottom center). After using ultrasound it was determined that 36 of the 250 guide rollers needed replacement. The guide rollers were replaced and the conveyor was returned to service.

The old guide rollers were saved for evaluation. Upon inspection of the guide rollers, excessive amounts of dust, grit and a lack of lubricant were observed (**Figure 9**). This analysis was accomplished by removing the bearing seal to expose the inner housing.

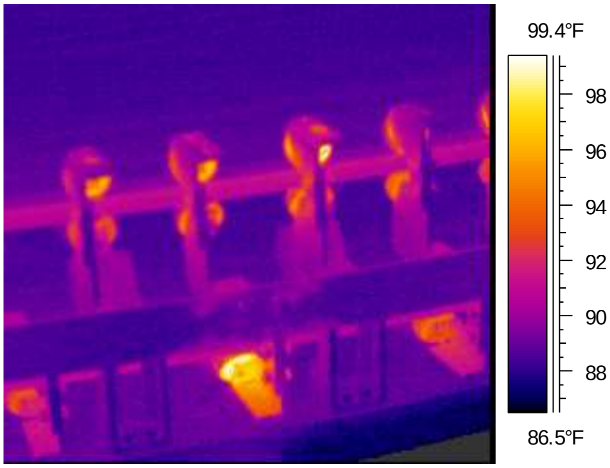

Figure 8

Figure 9

After reviewing our findings with our guide roller supplier, we switched to a guide roller with a tighter seal fit. The new guide roller has zero clearance between the seal and the inner race where the old one had a .003” clearance.

Financial Analysis

Operational Costs				
Component	Reactive			Prevented Operation Penalty
	Flow/hr	Loss of Avail.	Cost/piece	
Powerturn Belts	3000	4	$ 0.55	$ 6,600
Powerturn Motors	3000	2	$ 0.55	$ 3,300

Table 1

By preventing power curve breakdowns we are able to significantly impact the operations at CACH. Each time a power curve belt breakdown is prevented it saves the operation $6,600 in lost production and excess labor charges. Failed motors cost the operation $3,300 per occurrence (**Table 1**).

Maintenance Savings								
Component	PdM	Action	# Mechs	Paid Hours	Hourly Wage	Labor Cost	Material Cost	Predictive Savings
Powerturn Belts	Reactive	R&R Belt & Bead	2	3.5	$ 36	$ 252	$ 3,768	**$ 3,993**
	Predictive	Check & Track	1	0.75	$ 36	$ 27		
Powerturn Motors	Reactive	R&R	2	1.5	$ 36	$ 108	$ 725	**$ 806**
	Predictive	Repair	1	0.75	$ 36	$ 27		

Table 2

The Plant Engineering Department measures deferred cost savings by comparing predictive measures versus reactive (**Table 2**). When a power curve belt problem is detected with thermography and repaired before bead damage has been done there is a cost deferred savings of $3,993. Similarly, there is an $806 cost deferral for power curve motors.

Guide Roller Replacement Cost			
Guide Roller Cost	Time to replace	Labor cost	Total Cost (each)
$6.77	0.16	$36	$12.53

Table 3

In the case study previously discussed, 36 of the 250 guide rollers were replaced for a total cost of $451. Before predictive maintenance was utilized, complete retrofits were being performed on all of the guide rollers at a cost of $3,133. In this case a $2,682 cost savings was realized.

Conclusion

At CACH, thermography has been an effective tool for diagnosing equipment problems and preventing breakdowns. However, it does not always tell the entire story. By searching for opportunities to integrate thermography with other predictive technologies such as ultrasound, vibration analysis and motor circuit analysis, we are able to get a complete picture of our conveyor systems.

We have shown one example of how thermography and ultrasound are being used together to solve a challenging problem on our power curves. There are countless other opportunities that exist to integrate predictive technologies at CACH. To keep our predictive maintenance program moving forward, we need to find these opportunities and act upon them. By doing this we will be able to have a greater impact on the reliability of the building and ultimately, our customers.