'Don't Die On Me!': Staying Alive With Predictive Maintenance

In recent years, modern packaging machines have become more intelligent. They are incorporating more decentralized intelligence in order to protect the machine from expensive breakdown situations using error diagnostics and reactions without any detour through the control.

With today's generation of intelligent servo drives, *predictive maintenance* functionality is now built into the electronics. Predictive maintenance monitors machine performance and maintenance thresholds, providing drive-based automated diagnostic and motion control functions that protect the machine throughout its entire life cycle.

Bottle-filling sequences require tight tolerances, which can be monitored, analyzed and flagged by the drive automatically before costly errors occur.

For packaging operations, predictive maintenance can prove highly valuable. The industry demands high levels of machine reliability, availability, throughput, and packaging precision. For example, many packaging operations are typically optimized for 24/7 operation. In this environment, if machines require frequent adjustment and constant repair work, they waste time and money.

Predictive maintenance helps prevent this through an approach built around early detection and repairing of machine problems. If damage is developing inside the machine, drive-based intelligent functions detect the problem early and appropriate remedies are implemented before significant damage occurs, frequently on an automatic, or "self-healing" basis.

Immediate protection for drives and axes

Drive-based predictive maintenance can monitor mechanical characteristics such as backlash, belt stiffness, tension, load variation and other conditions that are critical to the packaging machine's operation. The intelligent drive monitors itself *and* the feedback it gets from the motor it is driving—motor torque, speed, acceleration, and other parameters can be tracked. If these characteristics fall outside of the tolerance bands for that axis, the drive recognizes that something is wrong, and takes the appropriate action.

To keep the data exchange between the drive and its control to a minimum, the performance thresholds are pre-set in the drive and fixed corresponding target values are transmitted to the controller. For example: In a liquid filling machine, 10 containers are being moved down a single conveyor and need to be positioned under 10 nozzles for filling. The machine lowers the nozzles into the containers, fills them, then lifts them out and re-positions the nozzles for the next set of 10. This highly repetitive "walking beam" motion sequence—down to fill, over to the right, up, back to the left, down—has extremely tight tolerances for accuracy and throughput.

With predictive maintenance, the drive detects any variation such as belt slippage that would cause the machine to lose synchronization.

If a belt on the conveyor or a gearbox on the filler axis slips, machine synchronization is lost— which could lead to a crash or improper filling, leading to wasted product. Since this slippage affects motor performance, and the drive detects the variations in the pre-set values, the deviations can then be used for monitoring or analysis of the axis.

Fixing errors before they happen

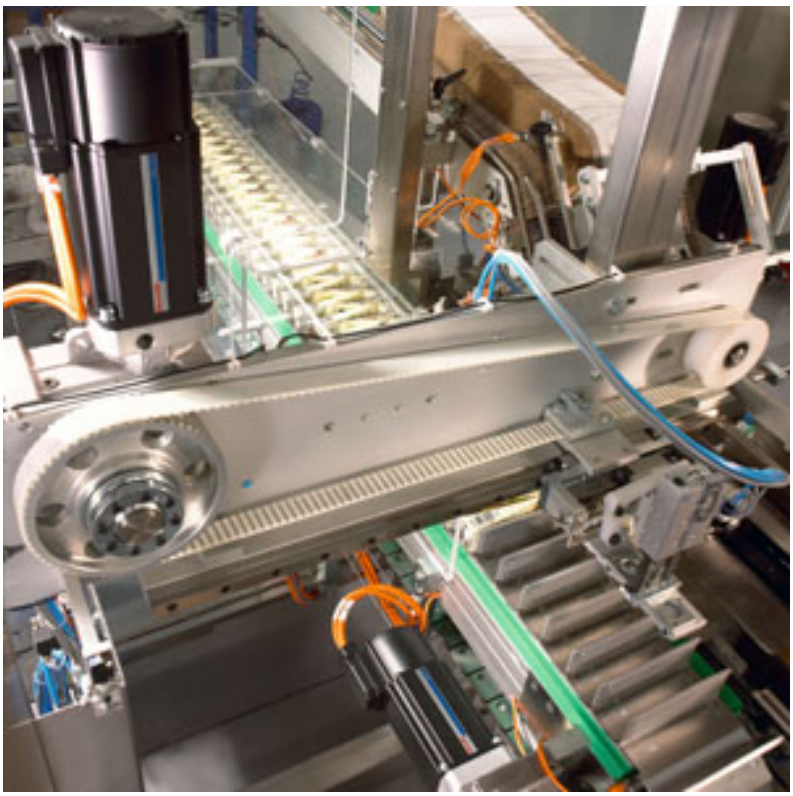
Not all reactions of a machine can be left to the control, however. The detection of a fatal error in the drive must lead to the proper reaction *at the drive*. For the electric drive itself, this is the current state of technology. With predictive maintenance, this protection is extended further to the connected axis mechanics, where additional responses have been included to protect the mechanical system or the entire axis.

Again, consider the filling line. Once the container is filled and capped, a pick and place application inserts the container into a carton, along with any other materials for that product. If there is a jam-up in the carton loading, the container or the carton could be damaged, forcing a shutdown of the cartoner.

Drive-based predictive maintenance can prevent these slips from growing into significant problems. It does this by monitoring the backlash between the servomotor and the axis mechanics the motor moves. The performance of the motor is directly related to the performance of the mechanics the motor moves. The drive monitors how the motor responds to the amount of play in the gears or the belt; if it falls outside the tolerances you set for that axis, the drive intelligence can do one of several things:

- Generate a warning message to the controller or operator
- Modify the drive current to compensate for the change in the mechanics
- Initiate a safe shutdown, to prevent machine and product damage *before* the situation gets critical.

A servomotor will not turn or fulfill its intended function if drives did not have something like reflexes. Intelligent drives, such as the Rexroth IndraDrive can stabilize the disturbance [noise] of all types using the control loops found in the drive. Quick and direct real-time access to all drive parameters is what makes faster reflexes possible.



The intelligent drive monitors itself as well as the feedback from the motor it drives – including torque, speed, acceleration and other parameters.

Sometimes, a reaction in the drive can be triggered by multiple or risky conditions. These can include an extreme condition signal, like setting an input or initiating a command—a reverse movement after a collision, for example—or the targeted initialization of an analysis function in the drive to detect the detailed axis status.

Complex information is prepared in the drive and translated into a simple diagnostic for the controller; this replaces sending all the complex information to the controller, and taxing cycle times to have the PLC do the diagnosis. It’s a more efficient controls architecture, since the communication required between the control and the axes is automatically reduced.

Prediction depends on extended diagnostics

When machines are not functioning properly, they diminish their productivity until reaching a complete breakdown. Proper care, on a regular basis, is the best solution for long-term machine health and productivity.

Wear-related machine breakdowns make themselves known ahead of time, and extended diagnostics makes preventive measures possible. With its IndraDrive, Rexroth has structured preventive maintenance into three key diagnostic functions:

- Maintenance Planner: Tracks time-specific maintenance intervals defined in

the drive, to issue a warning, remind about upcoming maintenance activities, or execute a self-analysis.
- Monitoring Function: Provides expanded diagnostics, runs during operation, and enables constant monitoring of the total axis status, including the attached mechanics. It can also indicate a subsequent system analysis that needs to be performed.
- Analysis Function: Expanded mechanical analysis and comparison with “zero-hour-record”—the performance tolerances set in the machine at start-up. In a separate test run, while using expanded analysis methods, a correlation between the error location and cause can often be determined.

In our cartoning example, a motor is hooked up to a belt, which drives a pusher loading the container and materials into the package. The belt is a toothed belt, run on a toothed gear driven by a servomotor. If excess wear and tear, or high accelerations, or poor lubrication causes a tooth to jump on the belt, the container and material won’t be fully inserted in the package— setting up a potential jam situation.

On this machine, using extended diagnostics:

- The Maintenance Planner has a pre-set schedule calling for maintenance of belt tension every 100 hours.
- The Monitor Function will be set to monitor belt stiffness, based on motor feedback, to detect if a belt is getting loose.
- And the Analysis Function compares that axis’ performance to the zero-hour record in the drive; if it falls outside the tolerance band for that motor, the situation calls for maintenance intervention to protect the machine and production.

Diagnostic messages can be displayed on the drive display, PC, or handheld units. To keep the communication requirement as low as possible while continuing to transmit the established standard communication mechanisms, the information related to signal processing is taken care of in the drive and therefore highly compressed.

With today's generation of intelligent servo drives, predictive maintenance capabilities are built directly into the electronics. (Rexroth IndraDrive)

"Zero-hour" baseline crucial to predictive maintenance

Drive-based predictive maintenance must be built on capturing and loading into the drives the optimal performance of each axis at it's healthiest: "zero-hour" when the machine has completed commissioning, but before it's released for production.

Some tool builders and manufacturers hesitate to invest the time and effort to accomplish this— but it is investment that will protect machine performance and practically guarantees to extend the machine's operating life.

This investment is especially valuable for synchronized multi-axis lines. For example: In a robotic pick and place application, 12 robots could operate over a single conveyor (a row of six robots on both sides of a conveyor). Each robot is assigned an operating zone; if one robot slips a gear tooth, an out of position situation could develop.

Unless the drive has the "zero-hour" tolerance band for that axis, it can't recognize that the one little gear tooth slip could jeopardize the entire line. If the drive is monitoring the backlash, it recognizes when the tight coupling between the motor shaft and the gearbox shaft is malfunctioning. The drive's "reflex" is whatever you

define: initiate an error message to the machine controller, or perform a safe shutdown, to prevent damage to product, or other parts of the machine.

Predictive maintenance lets you monitor everything—motor speed, position, acceleration, torque, temperature, current, volt, frequency— that governs the healthy operation of every axis. Based on the parameters you set, intelligence in the drive keeps you fully aware of the diagnostics of each axis, predicts if there is a problem, and lets you apply the right solution before the damage grows severe.

Bosche Roxroth is a manufacturer of automated drive and control systems. Visit Rexroth online at www.boschrexroth.com *[1].*

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