White Paper

Automation of Inspection Equipment

Jim Stertz
Director of Quality/Technology
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[This white paper is an introduction to the subject of robotic automation of inspection equipment. It is meant as a brief summary of the topic. Further research on the practicality and usefulness is highly recommended.

LOWELL

Lowell, Inc.
9425 83rd Ave N
Minneapolis, MN 55445

P: 763.425.3355
F: 763.425.8510
lowellinc.com

Robotic Automation of Inspection Equipment

Like many domestic manufacturers Lowell faces intense competition for business against domestic and increasingly off shore sources. In addition, we are constantly seeking ways to add value to the work environment of the associates employed here. Many of Lowell's associates are highly trained and experienced machinists - - the average employee has been here over 20 years. Lowell is faced with a dual challenge – how to reduce costs and how to retain experienced employees. Lowell is achieving both those goals through automation.

In 2008, Lowell invested in a sophisticated sub-micron accuracy PMM from Leitz of Switzerland Germany (This same equipment is used to calibrate gages at NIST.) to add inspection capacity to our existing Brown & Sharpe CMM. To operate at peak accuracy we built a 450 square foot, climate control space that maintains a temperature variation of <.9° +/- 1° F to house the high end equipment. However, we soon found inspectors couldn't keep up with demand in spite of doubling our capacity. These two highly sophisticated and very expensive pieces of equipment sat idle while a Lowell associate loaded and unloaded parts into the machines by hand. This down time meant that fewer parts were inspected as both customers and machinists waited for their parts. Clearly this was not fault of the operator, a human can only work so fast before they tire or worse, start to make mistakes – but what about a robot??

This question lead us on an 18-month long journey to automate our two key pieces of inspection equipment. Now instead of an associate laboriously tending the two machines, a Motoman HP20 robot does the work. We did the entire project ourselves including selecting the robot, programming it's operation and interface with the inspection software down to the racking, palletizing and barrier systems that allow the robot to work safely. The robot runs virtually 24/7 freeing our operator to perform higher level tasks such as creating test programs and data analysis. In addition, throughput increased dramatically. Our investment in our Motoman robot is part of our automation strategy - not to reduce the number of employees, but to allow our associates to perform higher level tasks and increase productivity. The robot has done all that and more.

Previous methodology – how was it done?

Metrology is known as the science of measurement. Like many of the sciences, Metrology has benefited from technology. Digital micrometers have replaced analog, optical scanners have replaced simple backlight comparators all in the pursuit of greater certainty. The first coordinate measurement machines (CMMs) were developed in the 1950's to measure increasingly complex military and aerospace components. These were crude 2 axes devices that were controlled by hand. Today's 3 axes CMMs are actually robots themselves performing hundreds of measurements via direct computer control. (DCC) Unfortunately, many of these new methods, including CMMs added significantly to the amount of time required to check, inspect and verify features. In addition, partly because of an ability to measure them, features on many components have become smaller and more complex. It is not unusual at Lowell to see tolerances of ±.00001 or 10 millionths.

Without automation a CMM operator must load components into a holding fixture and then start the CMM on its testing routine. Depending on the complexity of the part, the CMM's touch probe might take dozens or hundreds of data points during scanning. The operator unloads the part, then provides the test data directly on the machinists or inspector's workstation or via a print out. The testing itself is not the issue. At Lowell, the CMMs are used to test features during set up, in-process and final inspection. The issue was how to use the CMM's more productively.

Generation of the idea

Back in 2008, a team from Lowell visited Applied Engineering in Yankton, SD. Applied Engineering is well known for precision machining of aluminum for Defense, Aerospace, Medical and Industrial applications. They are also an industry leader in the use of robots in machining. Dave Brinkman of Applied gave the team from Lowell a tour of their facility and showed how they developed robotics systems to automate production equipment for nearly continuous operation. Our team returned to Minneapolis with an idea. How could we apply what they learned at Applied Engineering to automate our CMMs?

We saw that it could be done but how could we make it work in an area other than manufacturing. Lowell started with a system we learned during our lean manufacturing journey – process mapping. A team broke down each step in the flow of parts from engineers to the programmers, machinists and inspectors. A process flow was developed and the team identified a glaring weakness in the system. Both machinists and inspectors were waiting - in some cases hours - for parts to reach the front of the testing queue. The CMM was already automated itself. This was valuable time lost in a man-made problem. Through no fault of his own, CMM operator could not keep up with demand. It was then that the team came up with the system Lowell has today.

Execution – who did what?

Lowell had already spent months automating the software routines for PMM/CMMs. Our existing system took information from the part itself and loaded pc-dmis metrology software for the collection and analysis of the CMM/PMM data points. This was an important first step. Now all the team had to do was to insert a robot into the picture. Applied Engineering used Motoman robots and a system of pallets to move parts from place to place. Lowell refined the pallet system for their use.

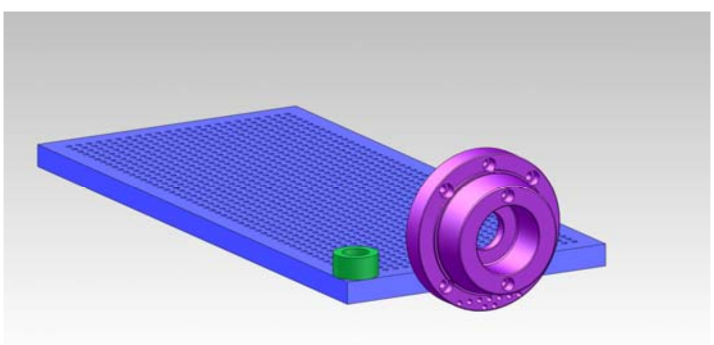

Figure 1. An early CAD model of the pallet system.

Each standard 6.5" x 13.5" pallet (Figure 1.) is fitted with a unique holding fixture and testing routine is designed for each component. The pallet is identified by the robot through a binary count proximity sensor. Then the CMM/PMM touch probe will verify the pallet through a unique donut identification device on the pallet. At that time the pc-dmis software is loaded and the testing protocol begins.

The pallets are staged on two racks. The first is the 24 pallet In/Out bay. (Figure 2.) Parts are staged here with three priorities – low, high and next. A manual switch on the robot control panel manages these priorities. This step was extremely important for Lowell since the CMM/PMM are so widely used for in-process testing. Machinists needed immediate access to the test equipment to verify features prior to further processing. The second storage rack is used to stage 120 pallets for processing in the low and high priority steps. The robot picks pallets from high to low priority using a first in first out (FIFO) system.

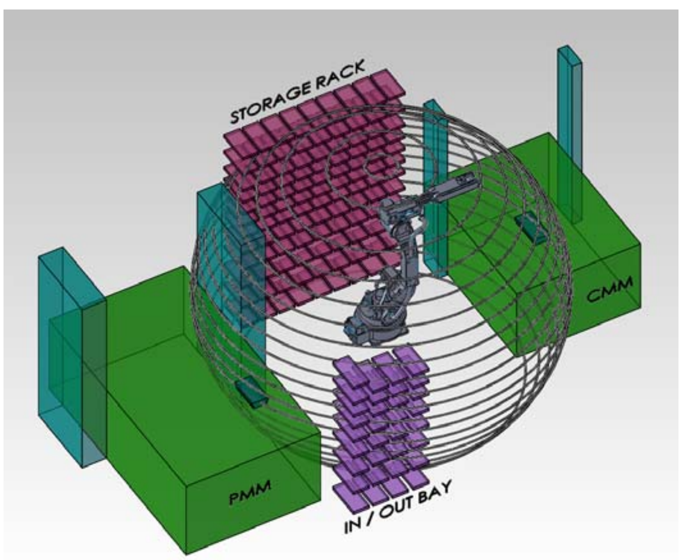

Figure 2. The rotational axis of the Motoman robot in relation to the PMM, CMM and rack system.

Today – what does it do, savings, time, money?

Today the CMM/PMM room and the Motoman robot are under the watch of Brad Traczyk. Brad has witnessed firsthand the success of our automated inspection system. "The robot has turned me from a part loader into an upper level programmer." He spends most of his time today writing the exacting test protocols in pc•dmis, designing test fixtures and interfacing with the machinists and inspectors to keep the system is running smoothly. It has truly changed the way he works. Lowell has seen a significant gain in efficiency too. Prior to the robot, we were limited to roughly two-shifts of inspection time. Now the robot and CMM/PMM run about 120 hours a week, an increase of nearly 60%, with a target of 165 hours a week. This would leave only 3 hours a week for equipment and server maintenance.

Future – what other projects are coming?

Lowell continues to look at the efficacy of automation. Our current projects include the laser etching department, cleaning and polishing operations and machine tending. With the combined pressure of off shore competition and increasing costs of everything from energy to raw materials, Lowell is searching for ways to become more efficient. As a company we spend nearly $1.3 million a year on new equipment to stay ahead of the technology curve. Robotic inspection is just the beginning. We've come a long way from the first visit to Applied Engineering 4 years ago.

Equipment List

Motoman HP20 Robot (6 axes)
Motoman Controller
Omron Safety Curtains
Banner Proximity Sensors
Kurt Vises
Leitz PMM-C 700 12-10-7
Brown & Sharpe CMM EXCEL 7-10-7
450 SF Controlled Environment
SmartProfile Software
pc•dmis Software

Jim Stertz is the Director of Quality/Technology for Lowell, Inc. in Minneapolis, MN. Jim has lead the Quality efforts at Lowell for 30 years including the implementation of their ISO 9001:2008 and 13485:2003 Quality Management System. He is a senior member of ASQ and serves on the Automation and IT teams at Lowell. Jim also rides a vintage BMW motorcycle that he will replace with a Harley Davidson on his 100th birthday.
You can contact Jim at jim.stertz@lowellinc.com