Honeywell

Agile Machining and Inspection Non-Nuclear Report (NNR) Project

Federal Manufacturing & Technologies

L. J. Lazarus

KCP-613-8552

Published February 2009

Final Report

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Honeywell Federal Manufacturing & Technologies
P.O. Box 419159
Kansas City, Missouri, 64141-6159

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Abstract

This report is a high level summary of the eight major projects funded by the Agile Machining and Inspection Non-Nuclear Readiness (NNR) project (FY06.0422.3.04.R1). The largest project of the group is the Rapid Response project in which the six major sub categories are summarized. This project focused on the operations of the machining departments that will comprise Special Applications Machining (SAM) in the Kansas City Responsive Infrastructure Manufacturing & Sourcing (KCRIMS) project. This project was aimed at upgrading older machine tools, developing new inspection tools, eliminating Classified Removable Electronic Media (CREM) in the handling of classified Numerical Control (NC) programs by installing the CRONOS network, and developing methods to automatically load Coordinated-Measuring Machine (CMM) inspection data into bomb books and product score cards. Finally, the project personnel leaned operations of some of the machine tool cells, and now have the model to continue this activity.

Summary

This report is a high level summary of the eight major projects funded by the Agile Machining and Inspection, NNR project (FY06.0422.3.04.R1). The project was split up into major subprojects that addressed:

- 703024 – Machine Simulation Implementations
- 703025 – Rapid Response
  - Non-Contact Laser Probing
  - Pallet Systems
  - Virtual Optical Comparator
  - MWF Temperature Control
  - NC Process Improvements
  - Work Cell Capabilities
- 703027 – Open Architecture Controls
- 703040 – DNC/CRONOS Implementation
- 703041 – OMGEC for OA American Lathes
- 703042 – 3-D Micro Scale Implementation
- 706685 – CMM Technology
- 706734 – Agile Inspection

The largest project in the group, 703025, was broken up into six major area and summaries are included on these projects.

All address the transition of the machining department to the KCRIMS SAM and how to implement lean practices in daily operations of the machining cells.

Emphasis was placed in implementing and deploying new technologies to reduce cycle time and improve product flow within the department. Individual reports on the major projects outline cost savings achieved and productivity events that were submitted by the project leads. In addition, many older machine tools were upgraded with new Open Architecture (OA) Controls, new resolvers and servo drives that allowed probing to be installed on the Computer Numerical Controlled (CNC) lathes. These older machines are now more reliable, repeatable and accurate.

Discussion

Scope and Purpose

The National Nuclear Security Administration (NNSA) decided that commercial quality would be acceptable for unclassified War Reserve (WR) product. NNSA and Federal Manufacturing & Technologies (FM&T) senior plant management agreed that the Kansas City Plant (KCP) should be downsized and unclassified WR components could be fabricated by outside vendors. Also proposed was a new, smaller facility with a machining area that combined precision machining, the model shop and the tool room into a new department – SAM. This combined department was 40% the size of the original departments with only 40% of the machine tools. These decisions affected the business case for the Agile Machining and Inspection NNR project. The original business case was aimed at replacing older machine tools in the precision machining department with more productive machine tools to meet the work load requirements. No additional machine tools would be purchased with NNR funding and the project had to be redesigned.

The author made a presentation on March 7, 2006 to the Readiness Campaigns, and Subprogram manager for Advanced Design and Production Technologies (ADAPT) and NNR Programs, on the revised Agile Machining & Inspection project and explained how this project was being changed to accommodate this new operating philosophy (the Agile project became agile and retailored itself).

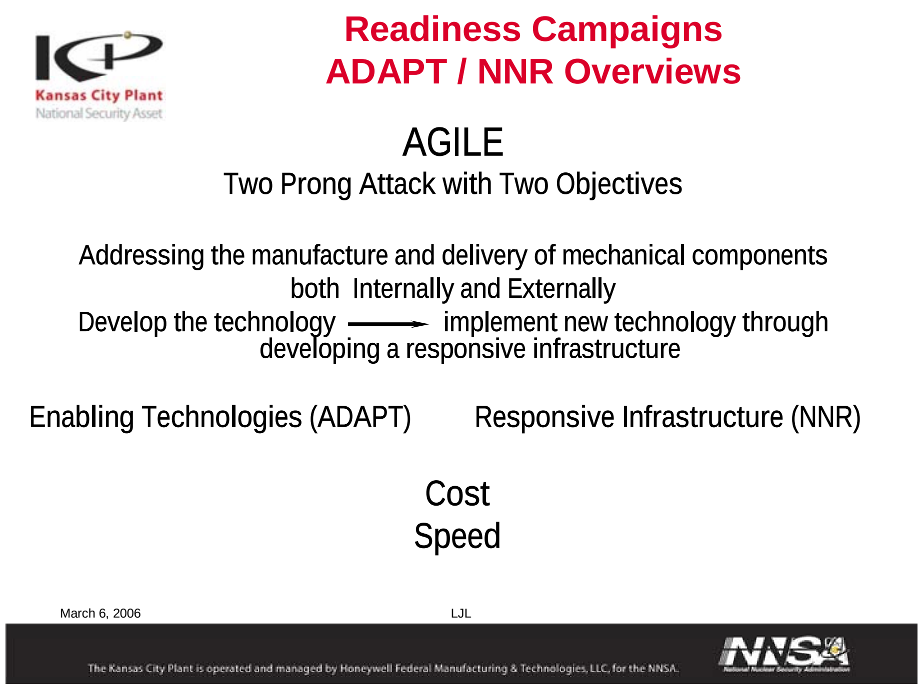


Figure 1. Readiness Campaigns Overview

Emphasis was placed on leaning out processes, rebalancing equipment loading, applying new technologies, and finding ways to operate more responsively and quicker. The new projects and their goals funded by this project were presented. Since 2006, additional changes have been made to meet the goal of making SAM more effective and contributing to the overall efficiency of KCP. All project leads took into consideration KCP's new operating philosophy and future configuration.

The restated scope and purpose of the Agile Machining and Inspection project was to institute lean practices, apply new technologies so that KCP could respond to product change in quicker fashions and remove the road blocks associated with change.

At that presentation the following NNR projects were currently active and in-work (*see* Figure 2).

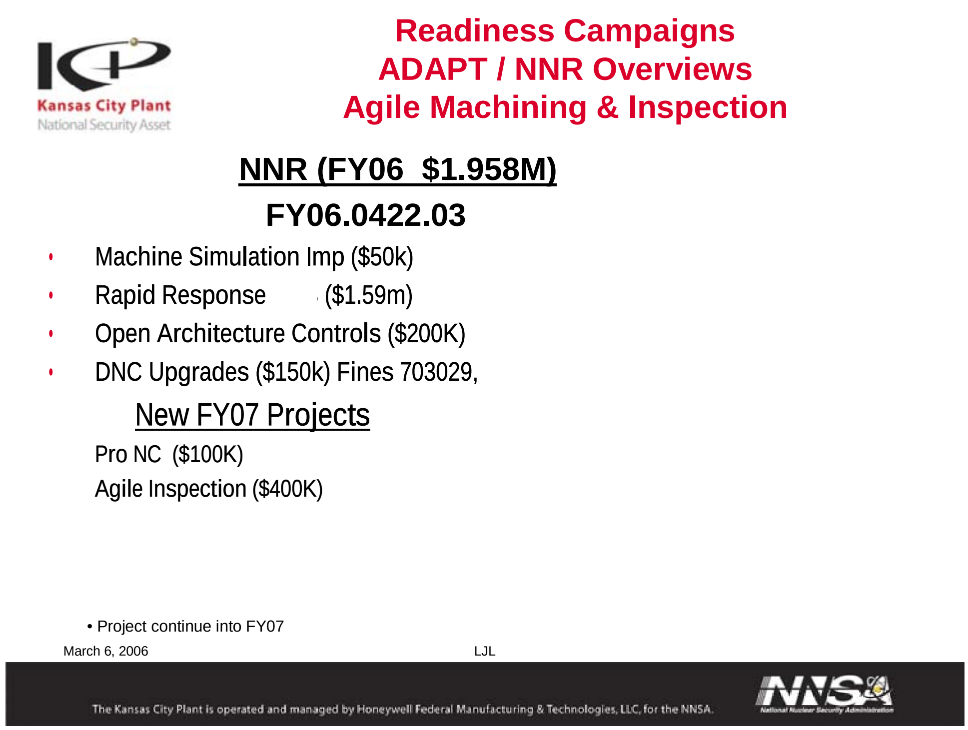


Figure 2. Agile Machining & Inspection Readiness Campaigns Overview

Since that time some of the projects have been completed, others redefined and others have been opened.

Activities

<u>703024 - Machine Simulation Implementation – (L2 Milestone)</u>

The team is responsible for the creation, testing and release for use of machine tool simulation models utilizing VERICUT software. Virtual simulation of machine tool programs saves time and money by detecting program errors and collisions before the program is run on the machine tool. The simulations also have been used to support development of machining processes, especially when determining clearances between cutting tools, part and fixturing.

This is the final year of this project. All machines tools that will be moving to the new facility are now supported. Development for the process of loading, machining and unloading for the component reentry body was simulated. This effort resulted in time savings that allowed the project to be completed early and under budget.

The following machines have been developed and released in FY08:

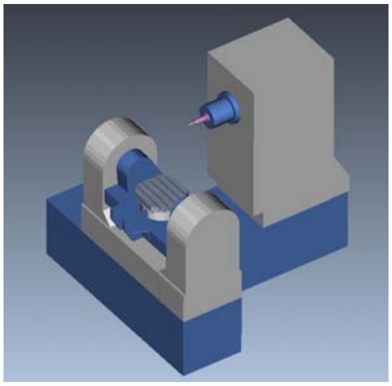
Pnuemo T-bed lathe w/MDSI control
American lathe w/ MDSI control
Monarch VMC 175 w/Fanuc control
Levin lathe w/ MDSI control

Moore T-bed lathe w/MDSI control
Hurco 3 axis vertical mill w/ Hurco control
Hurco 4 axis vertical mill w/ Hurco control
Toyoda 5 axis mill w/ Fanuc control
Mori Seiki 4 axis mill w/ Fanuc control
Mori Seiki mill/turn w/ Mitsubishi control

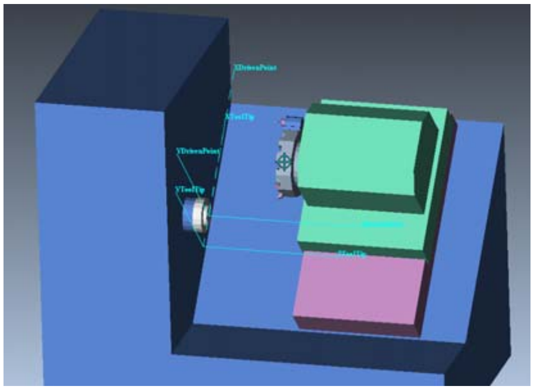
These machine tools were modeled in FY06 and FY07:

FMS K&T Orion/ GL8000; 4 axis horizontal mill
Hardinge Chucker/ MDSI; 2 axis lathe
Monarch VMC75/ Fanuc; 4 axis vertical mill
American Lathe/ MDSI; 2 axis lathe
Mori Seiki/Mori Seiki; 4 axis lathe
Hermle 5 axis Mill/ Heidenhien; 5 axis vertical mill
K&T Moduline/ GL8000; 5 axis horizontal mill
K&T Moduline w/ High Speed Head/ Gemini; 5 axis horizontal mill
Monarch Cortland 3 axis vertical mill
Dixi 5 axis horizontal mill
Mitsui Seiki 5 axis horizontal mill (with probing)
Hermle 5 axis horizontal mill (with probing)
Gildemeister mill/turn machining center
Mori Seiki 3 axis vertical mill (with probing)
Sundstrand OmniMill 5 axis tilt head mill
Hardinge TS51SP Lathe
Hardinge Quest 65SP Lathe

A final report with links to the NC web page is being generated.



Toyoda FA 550 II 5 axis Mill w/ Fanuc 16iM Control



Hardinge T42SP Lathe w/ Fanuc 18T Control

Figure 3. Vericut Models of Machine Tools

<u>703025 - Rapid Response Small Machining</u>

At the inception of the Agile Machining and Inspection Project, this particular project was aimed at obtaining new machine tools to upgrade and round out KCP machining capability.

With NNSA acceptance of commercial quality for nuclear components, outsourcing unclassified machining, downsizing the machining departments and KCRIMS, the scope of this project changed. This project became the vehicle to lean out machining operations, look at implementing proven technologies to improve KCP's process, and make the machining departments more agile.

The sub-activities were broken up into a number of different activities that included:

- Virtual Optical Comparator
- Stereolit Gauging
- Laser Mapping
- Agile Machining Process Standardization
- Small Swiss-Style Mill Turn
- NC Tape Generation Streamlining
- Pallet Study in Preparation for SAM
- First Piece Inspection CMM\Embedded Engineering
- Conversational Programming
- Heat Exchanger Kellenberger Hydraulic System
- Chiller – Metalworking Fluids on Precision Lathes
- Implementing Lean in SAM
- High Speed Machining
- Reprocess the component housing from Department A to Department B

A formal report, KCP-613-8533, "Rapid Response Small Machining" has been completed on this project that details the activities that were funded. Below are the highlights for 2008 on the individual sub-projects.

Non-Contact Laser Probing - Subproject

A method of using non-contact laser probing for part profile measuring has been implemented. The Los Alamos National Laboratory (LANL)/FM&T team has completed a full Engineering Evaluation of the measuring system, and the Design Agency (LANL) has fully approved the system with release of a QER for WR acceptance of the syntactic foam product.

The system utilizes standard technologies with novel methods that map a comparative measuring standard to the gage (laser measuring system). The gage provides a near zero measuring impedance to the part to avoid damage, and automates the process in a way that eliminates operator variability and reduced inspection time. The gage will replace a certified CMM acceptance method for profile check, and was expanded to measure other part geometries to eliminate some hard gages. The CMM and gage acceptance methods will provide a backup role. The gage can be used by production personnel for first piece and in process gauging with a quick turn around.

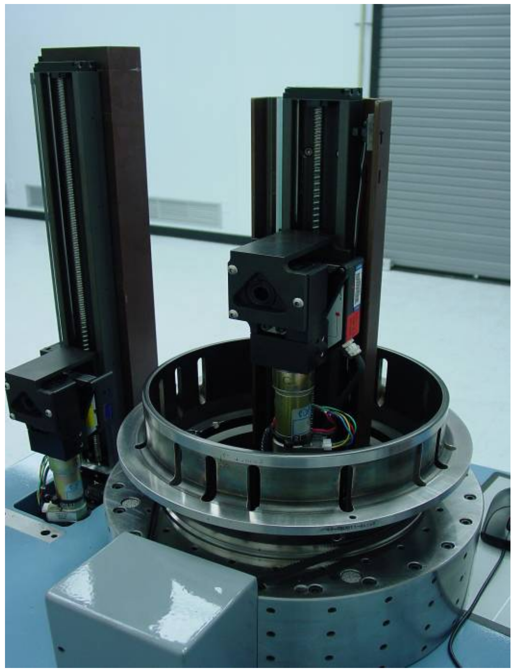


Figure 4. Laser Probing Fixture for WR Part

A formal report, KCP-613-8525, "Non-Contact Gauging with a Laser Probe" has been submitted that outlines the acceptance of this technique by the design agencies to inspect WR components.

Pallet Systems –Subproject – (L2 Milestone)

Mounting fixtures on the pallet system will allow quick switch out of machining setups in multi-shift operations and allow multiple job classes to use the same machine tool. In the SAM department, both production jobs are run multiple times per year, where work piece material is mounted on production fixtures and development jobs which are small quantities run once in open set-ups.

A study was conducted on System 3R's Delphin Pallet System to test load repeatability for the pallets. A critical question for the use of pallet systems is how well the pallet repeats its position from load to load. The operator and the engineer must be confident in the loading repeatability of the pallet for the system to function as intended.

The test was run on Department B's Hermle, by using the probe to touch specified positions between loads and comparing how close the pallet came to locating in the same position as the previous load. These tests proved the repeatability of the system in the new condition without high side loads.

A production fixture was mounted on a pallet system mounted in a production Cortland VMC-75B Machining Center. Approximately 90 parts were run during the major roughing operation. After every fourth part the pallet system was released and reset. KCP found the system repeated within 0.0003 during the whole run. This was equivalent to normal variation encountered when the fixture was bolted to the table. The setup is shown in Figure 5.

Pallet System Installed on Monarch VMC-75B

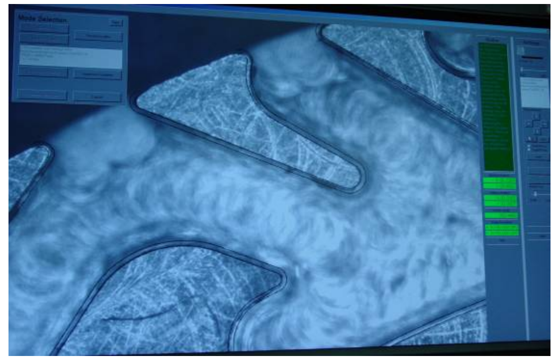
Pneumatic Clamping Control System

Figure 5. Pallet System Installed on a Monarch VMC 75B Machining Center

After these tests, eleven base plates were ordered with multiple top plates and hardware. The four section base allows two, two-section top plates to be mounted on the same machine tool. The platen systems will be installed on six Cortland Machining Centers, a Jones & Shipley Grinder, and four Hermles, (2 in Department G and 2 in Department B). One unit is currently installed on a VMV-75B in Department B.

Virtual Optical Comparator – Subproject

The Virtual Optical Comparator, (VOC), was conceived as a result of the limitations of conventional optical comparators and vision systems. It was funded by NNR Project 703025, Rapid Response Small Machining. Piece part designs for mechanisms have started to include precision features on the face of parts that must be viewed using a reflected image rather than a profile shadow. The VOC concept uses a computer-generated overlay and a digital camera to measure features on a video screen. The advantage of this system is superior edge detection compared to traditional systems. No vinyl charts are procured or inspected. The part size and expensive fixtures are no longer a concern because of the range of the X-Y table. Product redesigns require only changes to the CAD image; new vinyl charts are not required. The inspection process is more ergonomic by allowing the operator to view the part sitting at a desk rather than standing over a 30 inch screen. The procurement cost for the VOC will be less than a traditional comparator with a much smaller footprint and less maintenance and energy requirements.



VOC With Part Being Inspected on White Paper **Video Image of Part With Overlaid Tolerance Bands**

Figure 6. Virtual Optical Comparator for Small Part Inspection

A formal report has been generated, KCP-613-8517, “Virtual Optical Comparator,” which details the activities and accomplishments of this project.

Metal Working Fluid (MWF) Temperature Control - Subproject

The MWF absorbs the heat generated in the machining process. During the normal shift it is not unusual to have the MWF increase in temperature by 25°F. When one is trying to maintain tolerances within 0.0002 on a contour, this becomes a factor in maintaining final machined tolerances. The first attempt to control MWF was to install a fluid to air heat exchanger in the return line to the fluid sump on the Kellenberger cylindrical grinders. This lowers the temperature change during the shift to less than 10° F. The second approach used a chiller to control the MWF sump temperature. This increased the cost for maintaining the temperature significantly, but it performed at a much higher level. For three T-Bed lathes (precision turning machines), chillers have been purchased and installed. In addition, chillers have been added to one of the American lathes. KCP can now maintain the MWF temperature within 3° F easily, and better than 2° F when making light cuts using a 50-50 mix of oil-based MWFs.

Figure 7. Typical Installation of a Chiller on a Lathe

NC Process Improvements – Subproject

The intent of this subproject is to analyze the business practices of the NC programming department, identify, and implement opportunities for improvement. Some businesses practices are inefficient and can cause lengthy turnaround times for program requests as well as being costly on machine prove in time. There are seven NC analysts who maintain approximately 51 different post processors, and that support approximately 70 machine tools.

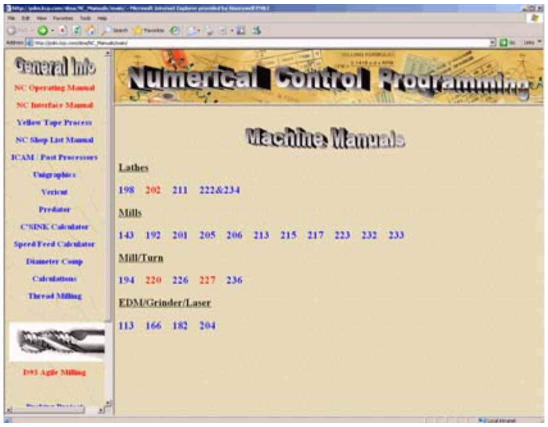


Figure 8. Screen Shot of NC Website

With the wide variety of tools and applications used plant-wide, it is difficult for individual analysts to be proficient in all applications of every process. NC analysts specialized in a certain area which limits flexibility. A major goal of this subproject was to identify methods of capturing and retaining machine or process specific knowledge so that it could be easily communicated to all analysts. This led to the creation of the NC Online Manuals website. This project allowed KCP to build up and expand this website. This easily accessible database of knowledge is also available to process engineers, machinist and model makers.

Unigraphics is the Computer-Aided Manufacturing (CAM) software used at KCP. Since all programmers are familiar with differing functions of the software, KCP has implemented a Unigraphics users group which meets regularly and allows personnel to present and share challenges encountered and solutions to issues department wide. This gives an open forum to proactively gain knowledge and be aware of potential pitfalls instead of trying to reactivity find solutions during a crisis.

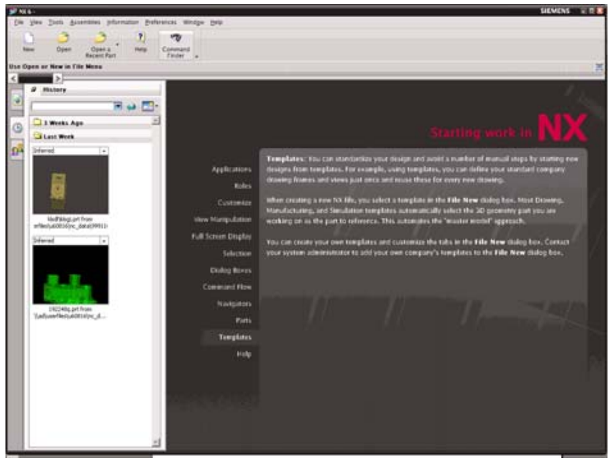


Figure 9. Unigraphics NX6 Front Page

Minor procedural changes have increased efficiency but they are difficult to quantify. Increased collaboration with the process engineering departments and shop floor personnel are vital to the success of the NC program. A direct communication step with customers was added to internal procedures. This step can eliminate hours of unnecessary programming time by verifying the intent of the programming, and eliminating or controlling any manufacturing variables.

Custom part templates have also greatly increased efficiency. By using templates, it increases the uniformity of the group's programming methods. This makes it exponentially easier for analysts to go from one program to another and be able to readily trouble shoot an issue, regardless of whom the original author was.

The NC software is upgraded regularly. All changes must be carefully scrutinized to ensure that they meet the mission requirements and will generate reliable output from work done in prior editions of the software. This is done to ensure KCP's ability to regenerate and produce parts that were made long ago, which KCP must maintain production capability for the life of the system. New revisions of software also lead to improvements in usability and function that simplify the work and dramatically reduce turnaround time. As a result of this subproject, KCP will soon be completely upgraded to Unigraphics NX6.

Work Cell Capabilities – Subproject

A number of small projects have been undertaken to improve the capabilities of the work cells as they will be setup in the new facility. The projects listed give an idea of the scope of activities. They include standard setup carts for each work cell. This makes sure the right items necessary to setup a job within the cell are within the reach of the machinist or tool maker setting up the job. This concept was proven out as part of the Hermle Milling Cell. KCP has increased the compliment of live tooling for the Mori Seiki Mill Turn cell. The tool makers are using more live tooling in producing parts and avoiding making extra set-ups. Small center sets have been obtained for the Gildemeister Mill Turn Cell and the Star Cell so that machined component concentricity between different diameters can be easily checked. Since these machines have multiple spindles and the fabricated part get passed from one spindle to another so that both ends of the part can be machined. This concentricity check must be made to assure compliance to drawing requirements before a lot of parts are sent to inspection. This improves cell performance and reduces scrap. A Machinist can easily tell if a tool is forming a small burr that is effecting the clamping in the tail stock spindle. A small project was completed to redesign the harperizing and vibratory deburr area for better work flow. This requires the purchase of a combination storage unit to replace three different units. A standard part was developed to check the relationships of the Gildemeister spindles. This part also can be used for qualification of the machine tool after the machine tool is moved as part of KCRIMS. In addition, cross training has started of the machinists in Department B and tool makers in the model shop and tool room on the common equipment that includes the White Sundstrand, Hermles, and Charmiles EDM's.

703027 – Open Architecture Controls and Machine Tool Upgrades & Machine Tool Modernization – 01902701

This project was undertaken to upgrade older machine tools that used mini-computers and proprietary computer controls from General Automation, Allen Bradley (various models), G&L (Model 8000), Bendix (System 5, 5C, 5CM), Fanuc T-3 and Bostomatic. These older computer systems, some proprietary, were past their expected lives and not supported by their original manufacturer. They used servo drives from a number of vendors including GE and proprietary ones made for the different vendors. Both the controls and servo drives had old electrolytic capacitors that were over fifteen years old. Even though these capacitors were hermetically sealed, they were starting to dry out and break down. Other electrical problems encountered with these older machine tools were the wiring harnesses that were fatigued and breaking. The wires were in the flexible conduit that allows the different axis's to move and were prone to fatigue failures that resulted in open circuits.

On the mechanical side, seals were dried out and leaked, way covers had leaked or were damaged, bearings and some lead screws were worn. Basically, KCP was running machine tools that could still make products but were unreliable and prone to breakdown. In a number of cases they were not supported by their original manufacturers who had been bought out or had ceased operation. The main components of the machine tools were still good but the electronics and mechanical wear items were near the end of their lives.

Previously, KCP had hired the original vendor to come in and evaluate their machine and quote on an overhaul. After agreeing on a cost, they would come in and upgrade their machine. They would install their proprietary control and servo drives, resulting in a machine tool that performed to the original specification.

In 2003, the American Hustler Lathe in the Process and Machining Evaluation Laboratory had the first OA Control installed. MTC was hired to upgrade this machine tool. Main components included an off-the-shelf Pentium PC, NT operating system, touch screen monitor, relay tree, new off-the-shelf servo drives, resolvers, solenoid switches and new wiring harness. MDSI's Open CNC control software was installed to act as the machine tool interface and command structure. This revitalized the machine tool. KCP discovered during the setup that the Z axis lead screw had been stretched and had a 0.002 error over the length of it travel. By using maintenance's laser interferometer system, KCP was able to reduce the error to under 0.0003 over the same travel.

Before this project, a second contract was issued with another outside vendor and both American Lathes were upgraded in the Model Shop. Maintenance engineering was unhappy with both previous vendors because they failed to provide adequate documentation. It was decided that KCP would work with the next vendor so that KCP could learn to upgrade the machine tools themselves.

KCP worked closely with Agile when they upgraded the Hardinge CHNC and CNNC4 lathes during their upgrades and with MDSI when the White Sundstrand was upgraded (5 Axis Machining Center). KCP started to do their own upgrades and have trained their electricians and machine repairmen to do the upgrade installations. They have upgraded the operating system from NT to Windows 2000 Professional to be compatible with KCP's networks. KCP has upgraded the versions of Open CNC to newer versions of MDSI software as they have become available, so that all the machine tools are using the same versions of software. They have acquired more accurate resolvers and newer solid state servo drives. The maintenance department has only one CNC control to learn for the upgraded machine tools. KCP has added mist collectors, probes capability, auxiliary spindles and been able to control their operation with these controls. These old machine tools are now more accurate, reliable and easier to repair than the original machine tool when they were new. KCP can now obtain generic off-the-shelf components for repair. They have expanded the machine tools capabilities and increased their accuracy

In 2006, the author presented to the Subprogram Manager for NNR & ADAPT the following slides that show the progress made on the installation of OA Controls & Machine Tool Upgrades project, which is part of the Agile Machining & Inspection NNR project. In 2007, FM&T completed the last machine tool which was the K&T Moduline 5 Axis Machining Center.

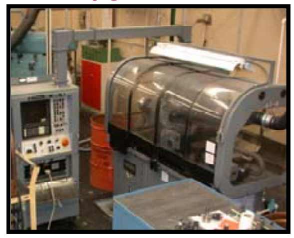
Kansas City Plant
National Security Asset

Readiness Campaigns
ADAPT / NNR Overviews
Open Architecture Controls & Machine Tool Upgrades 703027

KEY CUSTOMER SATISFIERS

- *Common Interface Look & Feel*
- *Data Output On Common Platform*
- *Ergonomics, Better Operator Interface, Swivels & Tilts*
- *Deliver Tighter Tolerances for Better Product Performance*
- *Capacity, Accuracy & Flexibility All Enhanced While Maintaining Unique Capabilities & Lower Costs*

- *PC Based*
- *Commercial Off-the-Shelf*
- *One Size Fits All, Common Controller Replaces Mulitple OEMs*
- *Integrates with Plant IT Systems*
- *National Security Compliant*
- *Improve Accuracy*
- *Eliminate Need for Costly Equipment Replacement*



1984 Hardinge CNC Lathe Before Modification

OA control w/new servo drives

March 6, 2006 LJL

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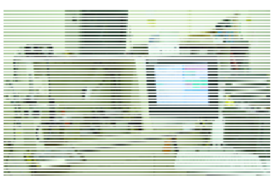
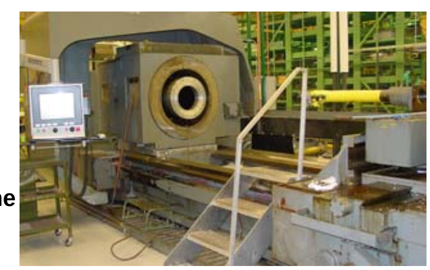
Kansas City Plant
National Security Asset

Readiness Campaigns
ADAPT / NNR Overviews
Open Architecture Controls & Machine Tool Upgrades 703027

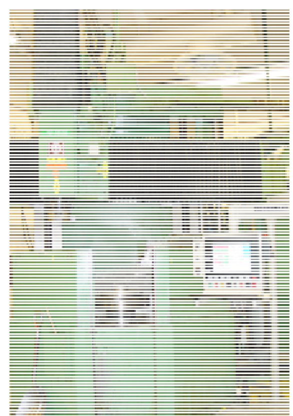


Miniature Levin Lathe w/60,000 rpm spindle made from 1986 NC Levin Lathe

K&T 5 Axis Horizontal Machining Center 1977



Hollow Spindle Lathe 1988



G & L Vertical Turret Lathe (w/ 2 Turrets) – 1982/ 84

March 6, 2006 LJL

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Kansas City Plant
National Security Asset

Readiness Campaigns
ADAPT / NNR Overviews
Agile Machining & Inspection

- Install OA Controls on all Bostomatic Machining Centers
- OA Controls have proven extremely successful
  - Machine tools can be adapted with new technologies at minimum costs
    - High Velocity Spindle in
    - On Machine Probing in
    - Installation of Mist Collector in
    - Easy of electrical installation & maintenance
    - Reduced number of machine tool controls
    - Increased accuracy of machine movement with tighter compensation intervals
  - Requested to modify machine tool at LANL
- Support of both Senior Leadership & KC Area Office

Figure 10. Readiness Campaigns Slide Presentation

The following machine tools have been modernized:

American Hustler Lathe – Department D PMEL
Large American Lathes (2) – Department C
Hardinge CHNC (5) – Department B, Department E
Hardinge CHNC4 (2) – Department B, Department D
Bostomatic Machining Center – Department C
White-Sundstrand 5 Axis Machining Center – Department B
American Lathes (3) – Department B, Department F (1)
Bullard Lathe – Department F now in Department C
Hollow Spindle – Department B
Levin CNC Miniature Lathe – Department C
T- Bed Lathes (3) – Department C Model Shop & Tool Room
Moduline 5 Axis Machining Center Department B

Twenty-three machine tools have been modernized. Six were modernized previous to this project. Seventeen have been completed under this project. A number of these machine tools were selected for the transformation as part of KCRIMS. At present, 16 have been designated to make the move and are in the floor plan. Two of the machine tools not going are part of the heavy machining capability that is not being transitioned to the new facility and four because of excess capacity and down sizing.

Recently in “Connections,” a publication of FM&T Communications, the following article on the modification of 45 Reentry Vehicles for the Department of Defense was published. The machine tool in the background is the modernized 5 Axis Moduline Machining Center. During this program, no machine problems were encountered because of the upgrades. All these machine tools have contributed to the mission of FM&T. They have taken old, unreliable machine tools and made them consistent machines with the same basis PC control with high reliability, better accuracy and more easily repaired by maintenance staff with off-the-shelf generic components. In addition, in the future, as new more accurate resolvers, lower power servo drives become available KCP will be able to upgrade these machine tools themselves.

Reentry bodies glow white-hot when returning through the atmosphere, making a dramatic picture in the night sky.

FM&T completed Vehicle work for the Department of Defense on time and under budget.

FM&T recently completed and delivered 45 Vehicles that were modified for the

The Department of Defense had initially sought contractors to make modifications to the Reentry Vehicles. But DoD personnel were discouraged when initial bids came in unacceptably high.

FM&T, which did not originally bid on the work, was recommended for the job because of our well known reputation for high quality machining. In a rebid for the work, FM&T won the contract.

began processing the first parts in January and continued to produce about eight units a month until the job was done.

The units required careful handling because the epoxy heat shield (the black material on the outside) cannot be touched by bare skin. Special fixturing was required to hold the units, and orange neoprene covers were used to protect the finish during much of the work.

The black epoxy heat shield covering the body cannot be touched by bare skin, requiring the work to be done with extra care.

lead engineer on the project, was extremely happy with the support the project got from precision machining. "This was one of the biggest parts we've worked on in in a long time," said . He praised the skill and conscientious work of general machinist and production fabricator , who performed most of the work.

There had initially been a concern that because we hadn't done this type of job before, unexpected issues might require additional funding. Instead, the Kansas City Plant completed the work on schedule, and returned to the customer not only the contingency funding, but an additional amount as well, since the work was completed almost 4 percent under budget.

duction fabricator Body Sections for body is seated on a special blue fixture borrowed from Pantex. The orange neoprene covers on the body protect the surface.

Figure 11. Article from "Connections" – K&T Machining Center w/OA Control in Background

<u>703040 – DNC/CRONOS Deployment – L2 Milestone</u>

All machine tools listed in Table 1 are connected to the CRONOS network where classified NC programs can be pushed from classified work stations connected to CRONOS to machine tool's CNC control for part fabrication. This eliminates the need to generate CREM to move the classified program from the classified work station to the classified machine tool controller.

In FY08, the fiber network was installed in the Model Shop and Tool Room (Department G) previously Department B, Department F and Department E machine tools listed in Table 1 were connected to the network. Interface equipment was installed within the machine tool control cabinet and connected to the new CRONOS network. All the machine tools listed in Table 1 will either be moved to the new facility, be used for dual build capability while moving in the present facility, or to meet the NNSA goal of removing CREM from the current facility.

Under the KCRIMS plan the equipment from Department C, 17 (unclassified machinist training area) and Department B (both the classified and unclassified room) will be combined into one department, SAM. Department E portions of Department H (Welding) and Department I will be combined together as the Gas Transfer Systems (GTS). Both GTS and SAM will be within the secure portion of the new facility where all the machine tools will be capable of running classified product and where the CRONOS network will be available. Therefore, there will be no need for CREM to transfer classified programs from the servers to the machine tool controllers.

Cronos DNC Machine Tools

Mach CE #	Comp CSI#	Machine	Dept	Control
22324	30254	Ex-Cell-O Lathe	C/MS	OA
35368	18061	American Lathe	C/MS	OA
53482	8901	Pnuemo Lathe	C/CR	OA
55934	18062	American Lathe	C/MS	OA
56009	24438	Okuma Lathe	C/MS	Prep
60543	19886	Bullard Lathe	C/MS	OA
66374	24373	Hurco 50 Mill	C/TR	Prep
74580	24369	Hurco 20 Mill	C/TR	Prep
80512	20051	Levin Lathe	C/MS	OA
81386		Stereo Lith	C/MS	OA
83837	24428	Hurco 20 Mill	C/MS	Prep
83839	24427	Hurco 20 Mill	C/MS	Prep
83861	24380	Hurco 20 Mill	C/TR	Prep
84653	24430	Charmiles EDM	C/MS	Prep
113289	30205	Moore Lathe	C/CR	OA
113833	24437	Hardinge Lathe	C/TR	Prep
210030	24374	Monarch Mill	C/CR	Prep
210505	32305	Bostomatic Mill	C/MS	OA
210973	24436	Toyoda Mill	C/MS	Prep
211804	24435	Mori Seiki Mill	C/MS	Prep
212260	24372	Charmiles EDM	C/CR	Prep
212583	24368	Hauser Grinder	C/CR	Prep
213384	16548	Mori-Seiki Lathe	C/MS	OA
81232	24533	Mori Seiki Lathe	E	Prep
81233	24531	Mori Seiki Lathe	E	Prep
84148	24525	Index Lathe	E	Prep
84697	24529	Index Lathe	E	Prep
113708	24520	Hardinge Lathe	E	Prep
113709	24518	Hardinge Lathe	E	Prep
113710	24522	Hardinge Lathe	E	Prep
113711	24526	Hardinge Lathe	E	Prep
113712	24524	Hardinge Lathe	E	Prep
113713	24527	Hardinge Lathe	E	Prep
210158	24530	Hardinge Lathe	E	Prep
210278	24523	Mitsui Seiki Mill	E	Prep
210279	24519	Mitsui Seiki Mill	E	Prep
210284	24521	Monarch VMC	E	Prep

210525	24528	Hardinge Lathe	E	Prep
210909	24534	Mori Seiki Mill	E	Prep
212002	19981	Hardinge Quest	E	OA
212660	24516	DIXI 5X Mill	E	Prep
213446	24532	Mori Seiki Lathe	E	Prep
56734	19492	American	F	OA
66415	24367	Monarch/Alpha	F	Prep
210400	24366	Lumonics Laser	F	Prep
210910	24365	Monarch Mill	F	Prep
212009	24382	Mori Seiki Lathe	F	Prep
212010	24383	Mori Seiki Lathe	F	Prep
212661	32775	Hermle Mill	F	OA
214347		Hermle Mill	F	OA
35393	19803	G&L 5X Mill	B	OA
50744	19686	American Lathe	B	OA
51427	15159	American Lathe	B	OA
53480	31936	American Lathe	B	OA
55674	19493	G&L VTL Lathe	B	OA
63977	24375	K&T High Speed	B	Prep
84774	24377	Monarch Mill	B	Prep
113622	24378	Monarch Mill	B	Prep
113623	24379	Monarch Mill	B	Prep
113801	24370	Bostomatic Mill	B	Prep
210185	24376	Monarch Mill	B	Prep
210186	24381	Monarch Mill	B	Prep
210693	24535	Mori Seiki Lathe	B	Prep
212179	32774	Hermle Mill	B	OA
212180	32776	Hermle Mill	B	OA
212655	24364	Star Screw	B	Prep
213844	24371	Star Screw	B	Prep
131313	22705	T&C Test	J	Prep
Desk_Test	41238	Black Box	J	Prep
54522	19680	Hardinge	K	OA
213281	22692	Hermle Mill	K	Prep
213288	22839	Gildemeister	K	Prep
67260	22648	Klingenberg	L	Prep
67969	22649	OGP	L	Prep
212968	23797	ESI Laser	L	OA
54096	18797	Hardinge	B	OA
54097	18522	Hardinge	B	OA
54117	18799	Hardinge	B	OA
54943	19889	Hardinge	B	OA
55323	18798	Hardinge	B	OA
56983	22703	Star	B	Prep
58944	22701	Star	B	Prep
58998	22696	Wasino Grinder	B	Prep
61394	22702	Superslant	B	Prep
71907	22686	Traub	B	Prep

113798	22698	Boston Mill	B	Prep
113799	22708	Boston Mill	B	Prep
212649	22840	Gildemeister	B	Prep
1313	39004	Test PC	J	OA

K - Moved to new building
K-T Move to new T00 Facility
D - Dual Build
N-R - Being replaced in FY08 currently hooked to CRONOS

Table 1, CRONOS Connections

A formal report KCP-613-8516, "DNC/CRONOS Deployment," outlining the work on this project has been submitted and includes the details of the project implementation.

<u>703041 - OMGEC for OA/American Lathes</u>

On Machine Gauging and Error Compensation (OMGEC) 0 has been used at KCP for several years on the Hardinge Quest machine located in Department E. The advantage of OMGEC over commercial probing software, such as Renishaw, is a contoured surface can be measured, where commercial software can only measure in "X" & "Z" direction.

A retired engineer from Los Alamos, NM had written OMGEC while employed at LANL, then after retirement he started MecSoft, LLC. A purchase order was placed with MecSoft, LLC to develop, install and train using the OMGEC probing software on the American Lathes that had been upgraded with OA Controls. This software needed to be adapted to MDSI control software in order to use the same PC being used to operate the machine tool. This was different than previous OMGEC that required a second PC to communicate with the Fanuc control.

Software, probes and connecting hardware were installed on both American Lathes in Department C, three American Lathes in Department B and the American Lathe in Department F. All of these lathes are slated to make the transformation to the new facility under KCRIMS. The engineer wrote the computer code to interface OMGEC with the modernized American Lathes and installed the first system and verified its operation.

<u>703042 - 3D-Micro Scale Implementation</u>

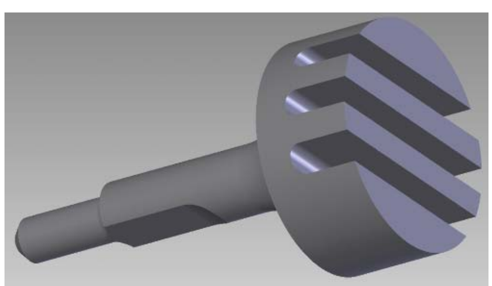


Figure 12. Sample Micro Part

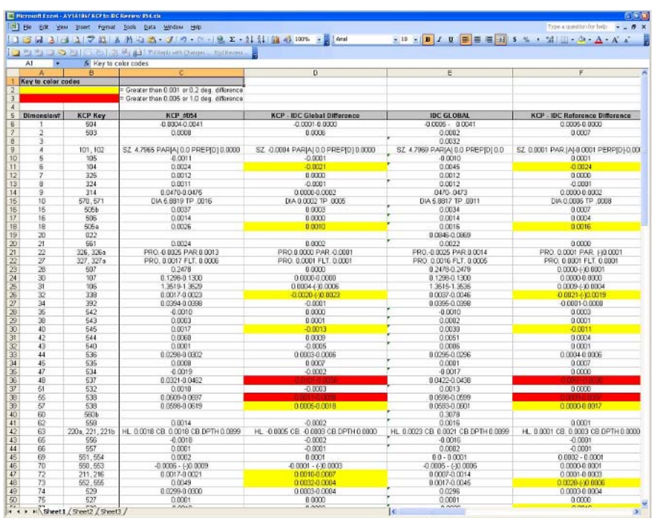
KCP supported micro-machined features to prepare for future work by machining 3D features on a very small scale using existing equipment. The machines evaluated were the Charmiles Wire EDM and the Levin Lathe. Features turned on the Levin Lathe were in the 0.005" Diameter range and the Wire EDM features were 0.0025"-0.0150" size range.

Based upon inspection data for the parts, the team learned about feature tolerancing, fixturing, and material selection for the miniature scale. This work supports development and production of future designs by providing manufacturability experience of miniature features. Additionally, several attempts were made to purchase parts from vendors throughout the country. However, as the micromachining field is still in its infancy, the technology was not found to be readily available from suppliers.

A formal report, KCP 613-8521, "3D Micro-Scale Machining Implementation," has been submitted that details the activities of this project.

<u>706685 - CMM Technology</u>

A comprehensive review and comparison was performed on CMM measurement results for the component that were inspected at IDC, a KCP supplier, and at KCP. There were two serial numbers inspected at each site, and 121 discrete measurements were performed for each serial number. FM&T product and quality engineers, a design agency engineer, and inspection personnel from IDC subsequently met to discuss the results. Significant differences were highlighted to aid FM&T's engineers in evaluating the measurements. The vendor initiated actions on ten different items to improve the inspection and quality of the housings.



Key to color codes
(yellow) = Greater than 0.001 or 0.2 deg. difference
(red) = Greater than 0.005 or 1.0 deg. difference

Dimension#	KCP Key	KCP_#054	KCP - IDC Global Difference	IDC GLOBAL	KCP - IDC Reference Difference
1	504	-0.0004-0.0041	-0.0001-0.0000	-0.0005 - 0.0041	0.0005-0.0000
2	503	0.0008	0.0006	0.0002	0.0007
3				0.0032	
4	101, 102	SZ. 4.7965 PAR|A| 0.0 PREP|D| 0.0000	SZ. -0.0004 PAR|A| 0.0 PREP|D| 0.0000	SZ. 4.7969 PAR|A| 0.0 PREP|D| 0.0	SZ. 0.0001 PAR.|A|-0.0001 PERP|D|-0.00
5	105	-0.0011	-0.0001	-0.0010	0.0001
6	104	0.0024	-0.0021	0.0045	-0.0024
7	325	0.0012	0.0000	0.0012	0.0000
8	324	0.0011	-0.0001	0.0012	-0.0001
9	314	0.0470-0.0476	0.0000-0.0002	.0470-.0473	0.0000-0.0002
10	570, 571	DIA 6.8819 TP .0016	DIA 0.0002 TP .0005	DIA 6.8817 TP .0011	DIA 0.0006 TP .0008
15	505b	0.0037	0.0003	0.0034	0.0007
16	506	0.0014	0.0000	0.0014	0.0004
18	505a	0.0026	0.0010	0.0016	0.0016
20	022			0.0846-0.0869	
21	561	0.0024	0.0002	0.0022	0.0000
22	326, 326a	PRO.-0.0025 PAR.0.0013	PRO.0.0000 PAR.-0.0001	PRO.-0.0025 PAR.0.0014	PRO. 0.0001 PAR. (-)0.0001
27	327, 327a	PRO. 0.0017 FLT. 0.0006	PRO. 0.0001 FLT. 0.0001	PRO. 0.0016 FLT. 0.0005	PRO. 0.0001 FLT. 0.0001
28	507	0.2478	0.0000	0.2478-0.2479	0.0000-(-)0.0001
30	107	0.1298-0.1300	0.0000-0.0000	0.1298-0.1300	0.0000-0.0000
31	106	1.3519-1.3529	0.0004-(-)0.0006	1.3515-1.3535	0.0009-(-)0.0004
32	338	0.0017-0.0023	-0.0020-(-)0.0023	0.0037-0.0046	-0.0021-(-)0.0019
34	392	0.0394-0.0398	-0.0001	0.0395-0.0398	-0.0001-0.0000
36	542	-0.0010	0.0000	-0.0010	0.0003
38	543	0.0003	0.0001	0.0002	0.0001
40	545	0.0017	-0.0013	0.0030	-0.0011
42	544	0.0060	0.0009	0.0051	0.0004
43	540	0.0001	-0.0005	0.0006	0.0001
44	536	0.0298-0.0302	0.0003-0.0006	0.0295-0.0296	0.0004-0.0006
45	535	0.0008	0.0007	0.0001	0.0007
47	534	-0.0019	-0.0002	-0.0017	0.0000
48	537	0.0321-0.0462	[illegible]	0.0422-0.0438	[illegible]
51	532	0.0010	-0.0003	0.0013	0.0000
55	538	0.0609-0.0697	[illegible]	0.0598-0.0599	[illegible]
57	538	0.0598-0.0619	0.0005-0.0018	0.0593-0.0601	0.0000-0.0017
60	560b			0.3078	
62	558	0.0014	-0.0002	0.0016	0.0001
63	220a, 221, 221b	HL. 0.0018 CB. 0.0018 CB.DPTH 0.0899	HL. -0.0005 CB. -0.0003 CB.DPTH 0.0000	HL. 0.0023 CB. 0.0021 CB.DPTH 0.0899	HL. 0.0001 CB. 0.0003 CB.DPTH 0.0000
65	556	-0.0018	-0.0002	-0.0016	-0.0001
66	557	0.0001	-0.0001	0.0002	-0.0001
69	551, 554	0.0002	0.0001	0.0 - 0.0001	0.0002 - 0.0001
70	550, 553	-0.0006 - (-)0.0009	-0.0001 - (-)0.0003	-0.0005 - (-)0.0006	0.0000-0.0001
72	211, 216	0.0017-0.0021	0.0010-0.0007	0.0007-0.0014	0.0001-0.0003
73	552, 555	0.0049	0.0032-0.0004	0.0017-0.0045	0.0028-(-)0.0006
74	529	0.0299-0.0300	0.0003-0.0004	0.0296	0.0003-0.0004
75	527	0.0001	0.0000	0.0001	0.0000

Figure 13. OSV Comparison Study

FM&T personnel successfully ran a CMM inspection program created by FM&T's FBMeas software and edited by personnel in the U.K.'s Atomic Weapons Establishment (AWE) to run on one of their CMMs. The CMM was running PC-DMIS, CMM inspection software used by AWE and by KCP. The program was run at KCP using an off-line version of PC-DMIS. Results of the inspection run were furnished in .pdf, .rtf, and Microsoft Excel formats, enabling AWE and KCP to investigate different output formats. FM&T personnel also reviewed and improved tolerancing schemes on two different AWE stronglink parts to assist in knowledge sharing between the two industrial partners.

Below are just two of the examples of reports that were created from CMM data tables automatically. These reports can be used by engineering, quality, purchased product engineering in final form to be included in product files. Product scorecards and CMM inspection summaries were provided for 1662 different part number runs so far this fiscal year. Approximately $156.7K was saved this fiscal year by automatically generating these reports.

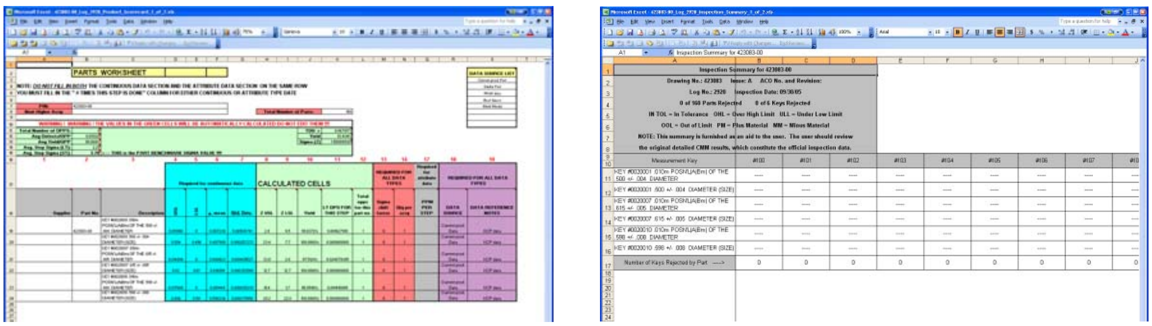


Figure14. Automatically Generated Product Score Card and Inspection Summaries

The PC-DMIS standard report template was revised to include classification markings at the top and bottom of each page of printed measurement results. This improvement will eliminate the need for engineering, production and inspection personnel to hand-stamp these results.

Figure 15. Classification Markings Added to Headers and Footers

A formal report KCP-613-8518, "CMM Technology," has been submitted that outlines all the activities that have been accomplished on this project.

706734 - Agile Inspection

Logbooks were established in the inspection department to track orders. A logbook is filled out when the order is received, when the order leaves the department, and when the order is placed on the NCR shelf. This allows the Quality Team Manager (QTM) to be able to track an order and to know easily where the order is and which inspector is working on it. A new contour reader was obtained and a program was written to help usability of the contour reader. Cross training of the majority of the inspectors in the department was completed to allow flexibility and increase efficiency. Inspector needs were reviewed and a basic set of tools needed were identified. This “Tool Kit” will be given to each inspector to increase efficiency in the department. As part of this review, a list of equipment needed in the department (not necessarily with each inspector) was also identified and is being purchased.

A formal report has been generated that outlines the activities on this project.

Conclusions

This project has been agile in meeting the objectives of its business plan while everything it was based on was being changed. KCP is better prepared for the consolidation of the machining departments in KCRIMS and now have new operating methods.

It has upgraded the machining departments by converting older machine tools with aging computer systems into modern reliable machine tools with better accuracy and dependability. Since the maintenance department was trained and made the conversions they are better prepared to trouble shoot and repair these machine tools when necessary. KCP has expanded the capabilities of these machine tools by adding probing. KCP has saved millions of dollars in replacement costs and now have lathes and machining centers using the same computer numerical control that can be upgraded by staff as new versions of operating systems PC Operating Systems, MSDI Open CNC become available. KCP now has a choice and can purchase generic replacement hardware for the computers, relay trees, resolvers and servo drives and not pay the premium from the machine tool manufacturers for their proprietary components.

KCP has implemented new inspection methods and had them approved by the design laboratories to accept WR product. KCP has set up new operating procedures in inspection areas. In the case of the VOC, KCP has applied for a patent.

KCP has improved the plant security with the elimination of CREM. KCP now transfers classified NC programs from the computer work stations to the CNC controls by using the CRONOS network in four machining departments (Department C, E, F and B) and not using CREM.

KCP now automatically load CMM data from equipment to bomb books and product scorecards instead of doing it manually. KCP is expanding this program to the OSV CMM data.

Finally, KCP has reviewed how they operate in specific machine tool cells and implemented new methods for operation. The Hermle milling sell was the focus of a black belt project and the Mill Turn cell was the focus of a lean project. These examples will be expanded as KCP consolidates the machining departments.

Through the years a number of cost savings and productivity events have been submitted related to these projects. KCP will continue to implement these new procedures in the future to reduce operating costs and reduce cycle times.