AuToMaTic Machining

DECEMBER 2002

PRECISE PROCESS CONTROL

...removes obstacles to six sigma

By: Kelly Weener, President, Topcraft Metal Products, Inc.

Topcraft Metal Products, Inc. is a manufacturing facility located in rural Hudsonville, (SW) Michigan. For over 30 years, it has built a solid reputation by maintaining a strong relationship with our customers and employees. The culture is unique as indicated in its purpose statement: to be a company, led by God, to provide a superior product that will allow opportunities to enrich the lives of our members and our business partners.

Topcraft specializes in the precision machining of carbon, stainless steel, brass and other alloys and utilizes our innovation to develop work cell and flow manufacturing, as well as other value added processes. Its vision, Turning Manufacturing Requirements & Challenges into World Class Routines, includes need to give all employees (even those who are new to our company or industry) the ability to make successful decisions at the most basic level, something we were challenged with in our SPC System.

When our Management and Engineering Team pursued an aggressive plan to achieve sustained top-quality product and reduce manufacturing and quality costs, we began searching for ways to use SPC, not just for formal documentation required by some customers, but for real process control. It was evident we needed a system that could help us focus on improving our processes and decrease the frustration of poor quality performance.

For the past seven years, Topcraft has invested hours in the training and development of our manual SPC system. Employees were trained in theory, mathematics and application of Statistical Process Control. The company and employees struggled with the interpretation of control limits and their connection to the purpose of controlling our machines and tooling. We had a difficult time analyzing the real-time process data plotted on X-bar and R charts and also realized that SPC assumptions are inherently flawed when applied to our machining processes.

Control limits were created at the start of a production run and then re-calculated only when the average of the data set was charted Out Of Control. All decisions leading up to this point were the responsibility of the operator. Each person involved had different interpretations of the data.

- Some would keep running without plotting the readings that appeared out of the control limits, assuming that the process was in perfect machining control.
- Some would recalculate new Control Limits in order to make a chart look good.
- Some would adjust the tooling.
- Some would sharpen the tooling, yielding to SPC rules.

Each scenario had its own negative effect on quality and efficiency. The best decisions for quality (though very rarely seen) were tool adjustments or sharpening based on initial control limits. The operator was aware of over-adjustment but parts were not sorted. When control limits were recalculated or the process sampling was not accurate, employees would decide whether it was necessary to sort parts. Quality Assurance would put the product On-Hold and direct the operators to sort all their parts. All these inputs lead to high Cost Of Quality and limited product flow to the customer (not to mention finger pointing and stress felt at all levels of the organization).

Jesse Weener and Paul Cooper, are just two of Topcraft's many employees that benefit from the new process control system.

Right Tool Makes It Simple

Topcraft's Management and Engineering Team began researching process control software, with the anticipation of finding one that would fit our machining environment. We knew that even the best-computerized SPC system would not be effective for the type of machining that we run on our shop floor. We found that several local companies use the expert system Micronite developed by High Tech Research, Inc., Deerfield, IL. The unanimous feedback from these companies was that after implementing Micronite they would never go back to an SPC system.

Introduction to the system was through an interactive Internet workshop conducted by Dr. Stephen Birman who surprised us with his knowledge of problems we face every day and the description of our processes through adaptive modeling techniques. It took an hour and a half to fully grasp the extent of power the intelligent Process Adaptive Control Technology (iPACT) is capable of.

Gene Weener and Adam Davis, the managers in charge of training and system utilization.

The pace of implementation reminds us of a high-speed train. At 8:00 a.m. HTR's technician began installing the network. At 10:00 a.m. operators started data collection. Training the operators to interact with our new system was simple. By using the easy-to-understand, color-coded machining control system, operators were aware of tool wear which can lead to defects. No control limits need to be installed or recalculated. The system tells the operator to stop running the process, make adjustments, or sharpen a tool. The operator's responsibility is running the machine, entering data in accordance with Micronite's prompts, and following real-time instruction given through the custom-designed screens.

Operators know when they are running good parts. They also know when to start watching the process with more frequency and when to stop the machine and ask for support before bad parts are made. Floor personnel have caught on very quickly.

Two days of training were devoted to: (1) the preparation of our machining database, (2) the logic of grouping blueprint characteristics and tool details entry, (3) job-specific sampling designs, (4) procedures for real-time production control, (5) means of communication, and (6) total data control for product certification. Setup people and engineering learned to recognize stable, weak or failing processes. They understood the system's intelligence would help shift the burden off the operator's ability to make the correct decision when a process becomes uncontrollable and instead rely on the process redesign, machine maintenance or correction of gauging. Within two days of training all three shifts were using Micronite, not just for data collection, but also for meaningful process control.

Start Walking

The first part operators setup on the system was one that we had trouble with in the past. As soon as the operator began running the part, the program halted the job with a call for corrective action. The system's built-in Gauging and Primary Variation studies showed a gage repeatability that used 40% of dimensional tolerance; the gage didn't have a high degree of resolution. Using a higher resolution gauge, operators were able to get a more accurate picture of the process capability. This study was done at a machine in a couple of minutes, using a technique which is much more accurate and versatile than the Gage R&R we used before.

The Micronite system associates dimensional data to tools and their wear characteristics. One of the parts we started running had three O.D.'s with different length characteristics. In the past, operators were frequently resharpening a tool to hold lengths. Feature Group Track allowed our Engineers to make changes in the process design, which shifted the resharpening decision and achieved a substantial increase of machine uptime with reduction in tooling adjustments.

One of the most powerful features in Micronite is Process Adaptive Control. In the past, the setup people and veteran operators used their years of expertise to check dimensions at a frequency based on experience. The company required checking parts every hour but more experienced operators would check some dimensions with less frequency. Our industry seems to equate this to the skill level developed through years of experience and understanding.

Micronite has programmed much more than this experience into the system. The tool wear models look at trends for each dimension using the data being input by the operator. A group control model analyzes tool-related dimensions. It increases the frequency if the system detects an increase of tool wear or abnormal process variation. Conversely, if the system sees very little tool wear and variation, it decreases the frequency. This is a benefit the operators like because the system actually exercises intelligence based on the stability of the process. The system now pinpoints the time to sample pieces based on actual machine uptime and allows us to maintain very accurate sampling intervals.

The Process Adaptive Control quickly communicates areas of the process that have more stability than others. It is fun to watch a dimension move from a one-hour frequency to two, three or even four-hour, based on tool wear rate and process stability. The natural reaction of operators and engineering is, How do we get all dimensions in this operation stable enough so we only have to check parts every four hours? The Process Adaptive Control gives newest operators a skill that used to be developed with years of experience. The atmosphere surrounding this kind of focus is energizing at every level of our organization.

Before Micronite, tool life was an educated guess for all new processes. Tools were visually inspected for wear after so many stockups or hours of production. At this point we would establish the Predictive Tool Life. Our new program analyzes multiple tool-bonded processes (HTR's definition of machining modeling) and recommends tool replacement in real time to eliminate a previously unpredictable effect of variables introduced through a new lot of material or changes in the temperature of the coolant.

Critical Investment

The Micronite system allows operators a quick and easy way to log any changes made to the machine, whether they adjust a tool, sharpen or change it. Typically, if an adjustment to the process or a tool change is made and the operator fails to log this adjustment, the system will see the change and stop the operator from continuing until the change is explained. This feature gives engineering better tool feedback and creates better insight into the history of the process.

Micronite helps measure performance, enabling correct actions to be taken. If performance does not meet expectation, the process is examined, not the operator. The natural reaction is to question actions taken by the person who ran the bad parts. Micronite provides a consistent interpretation of process data for the operator, setup person and engineering department. With the new system we realized that process control in machining is not just charting of critical characteristics and calculation of a Cpk value. The system provides total data control including; overall part quality, real-time process capability, risk of defects, tool life, tool wear and failure description, shift production, problem alerts and many others.

It identifies weaknesses in the tooling plan, machine and gauging or process capability, forcing Management and Engineering to focus on process optimization rather than the ability of the operator to run good parts. This has been a welcome change from the past. If a machine is continually stopped and cannot produce zero-defect product due to unstable processes, the engineers take that opportunity to identify and prevent it from happening again. The system provides highly useful troubleshooting tools. The engineering group is able to dissect data per operator, machine, spindle, shift and so on. We are now able to see results of the system's analysis to all of the above.

One difficult and time-consuming area was the segregation and analysis of data per spindle, inter-spindle capability. In the past, with manual SPC, operators examined a dimension on each part per spindle and then manually charted the data. If a problem was detected, the setup person would perform a spindle study by collecting, measuring and charting the dimension for each spindle. This took a lot of time and the accuracy of an analysis was questionable. Micronite collects data per spindle by default, and allows troubleshooting to occur quickly. Engineers have already diagnosed bad spindle bearings, collets, pushers, etc., based on data recorded and analyzed by the system. Micronite is saving us time and solving chronic problems.

Summary

The whole system makes our processes more stable and helps us perform at a higher quality level. Topcraft's operators are now proactively sharpening or changing tools based on directions from the software. This saves the company money in purchasing new tooling and also saves in downtime for unnecessary process changes. The management and engineering team is continuously using Micronite to uncover problems and quickly solve them with the confidence that many of them (problems) will not return.

Before implementation of this system, the company averaged 3.5 percent of sales per month on scrap and sorting. After three months, Topcraft watched the cost of quality dropped to 1.7 percent, approximately 50 percent savings in scrap and sorting cost. The software offers a tool to make successful, real-time, accurate decisions while alleviating the stress that comes with scrap and reduced productivity. Our feelings after only three months of working with it are that we would never go back to the old system. We believe High Tech Research and its leader, Dr. Stephen Birman, deserve credit from the machining community for their development of this new control tool.

For more data on the software program described here circle the number below on a Reader Service card from this issue.

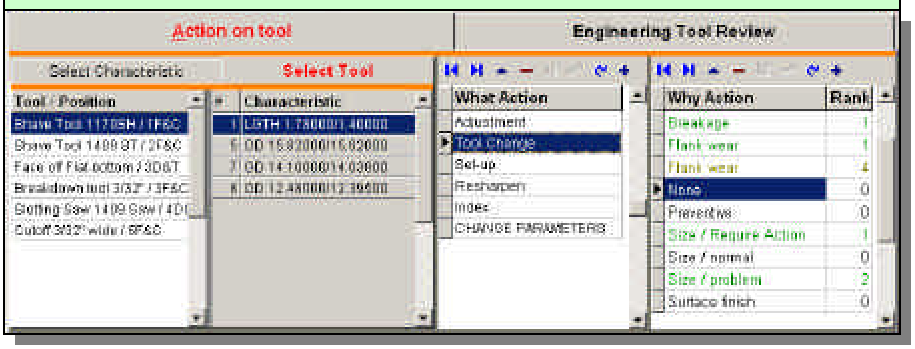
For data circle 132 on a Reader Service Card.

Adaptive Job Control Planning (AJCP) with the expert system MICRONITE

(Machine-specific, Process Adaptive planning is a practical alternative to APQP)

- Define critical and major drawing dimensions, tolerances, go-no/go and attributes (visuals)
- Select machine type, define tool layout with tool positions and link finishing tools to related dimensions
- Select the "Comp and change" model for decision to "how much to compensate" change or re-sharpen tool, etc.
- Assign Special Groups of dimensions and tolerances for process monitoring
- Select the process control model for individual characteristics, choose sample size and sampling frequency (fixed or adaptive)
- Select sampling design and acceptability criteria for GMPa (Gaging, Machine set-up and Process acceptance)
- Assign "Off-line" acceptance sampling for inspection by variables

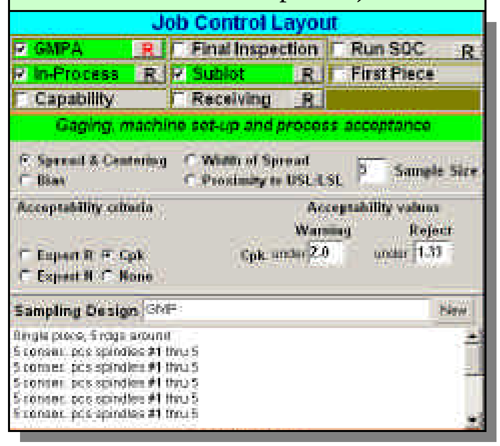
Drawing dimensions are linked to finishing tools.



Length and 3 OD's are assigned to the shave tool

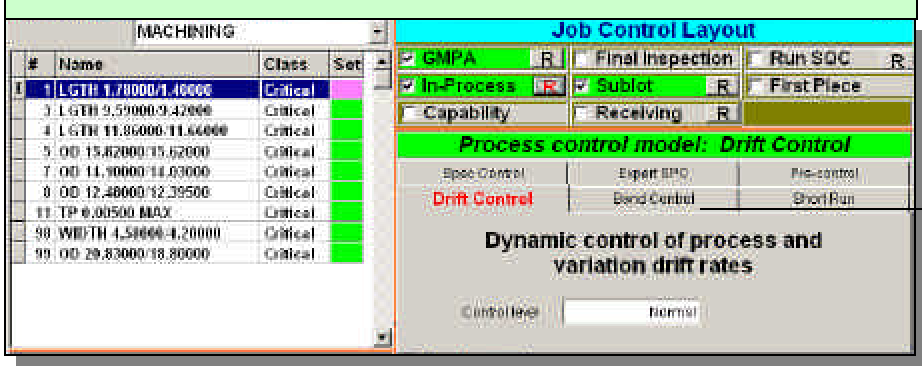
When process change (re-sharpening) is recorded, the system will require measurement of all tool bonded dimensions

GMPa (Gaging, Machine set-up, and Process acceptance)

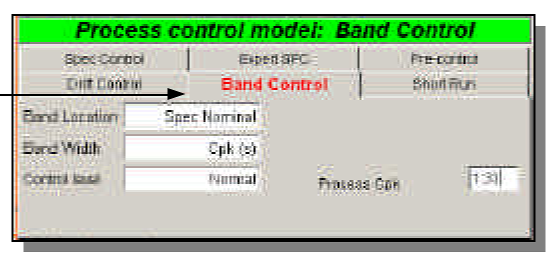


Sampling design and acceptability criteria are selected for close-tolerance critical characteristics

The process control model is selected from the template containing 6 types of models.



DriftControl is applied to processes with unstable tool wear rates.



BandControl is used for compliance with customer-requested Cpk value

(Typically, it takes 5 to 10 min to complete AJCP)

Multi-spindle set-up acceptance

Results of set-up measurements, conclusions derived from them and following corrective actions determine to a large extent whether easy or difficult-to-control processes lie ahead. If basic sample variation which includes gaging variation, within-part variation and within and between-spindle variation doesn't exceed 15-20% and centering of tool-bonded dimensions is accepted by the system, control of tool wear becomes the only potential problem. The usefulness of statistical set-up acceptance is not arguable but flexible and precise tools were not available before the expert system MICRONITE was developed.

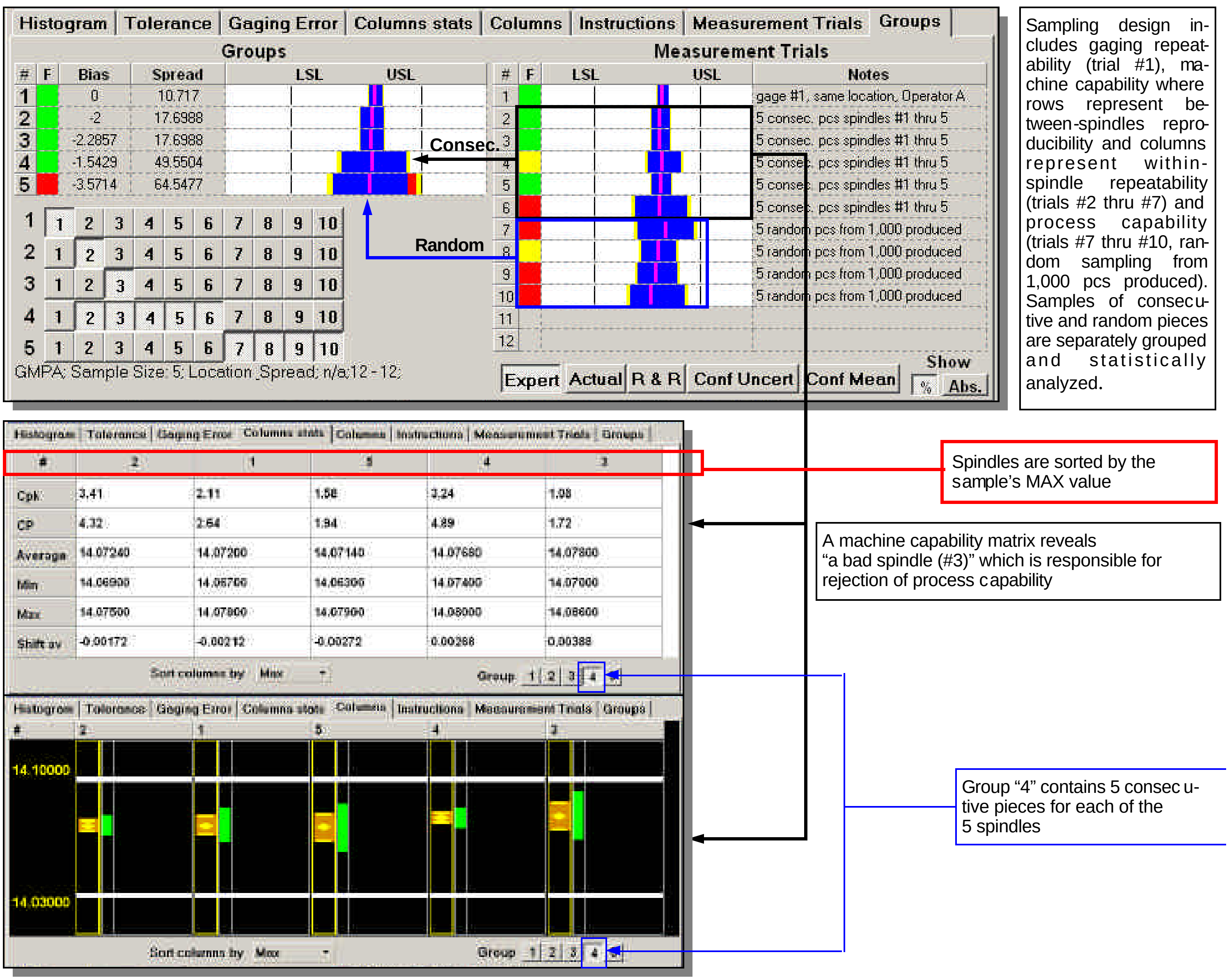
Multi-spindle set-up acceptance includes three major elements:

1. GMPa (Gaging, Machine set-up and Process acceptance)
2. Group capability acceptance
3. Variation controlled PPAP

All three elements are necessary to use for new jobs or repetitive jobs with chronic problems. A well-designed set-up acceptance assures that the critical characteristics will be thoroughly measured and unnecessary process adjustments during a production run will be avoided.

GMPa (Gaging, Machine set-up and Process acceptance) for critical characteristics

The purpose of GMPa is to estimate causes of sample variation and accept machine and process capability prior to a production run. At least one close-tolerance dimension should be fully examined after set-up, others can be put on reduced inspection or "skip PPAP"



"One of the Most Powerful Features in Micronite is Process Adaptive Control."

Date Time	LSL USL	Decision	Action	Reason for change	Operator	Pcs. Prod	P Cpk	Range, %
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12/3/2002 8:21:05 PM		ALERT			358	1334	1.48	11.76%
12/3/2002 8:42:48 PM		ALERT			444	217	1.68	17.65%
12/3/2002 9:35:23 PM		CONTINUE			444	525	1.61	17.65%
12/4/2002 12:20:10 AM		WARNING			444	1647	1.24	17.65%
12/4/2002 1:16:30 AM		CONTINUE			444	563	1.35	5.88%
12/4/2002 5:39:55 AM		ALERT			444	2327	1.36	23.53%
12/4/2002 6:21:00 AM		WARNING			409	410	1.34	23.53%
12/4/2002 4:25:43 PM		ALERT			409	1328	1.38	17.65%
12/4/2002 8:51:02 PM		ALERT			409	276	1.33	23.53%
12/4/2002 10:25:14 PM		WARNING			444	941	1.32	29.41%
12/4/2002 11:34:43 PM		ALERT						
12/5/2002 12:57:45 AM		ALERT						
12/5/2002 5:49:55 AM		STOP						
12/5/2002 6:39:34 AM		ALERT						
12/5/2002 6:06:34 PM		ALERT						
12/5/2002 11:00:02 PM		ALERT						
12/6/2002 12:44:17 AM		CONTINUE						
12/6/2002 2:33:59 AM		CONTINUE						
12/9/2002 6:25:04 AM		CONTINUE						
12/9/2002 7:02:43 AM		CONTINUE						
12/9/2002 8:17:09 AM		CONTINUE						
12/9/2002 9:30:49 AM		CONTINUE						
12/9/2002 10:48:45 AM		CONTINUE						
12/9/2002 11:53:24 AM		CONTINUE						
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12/19/2002 3:55:10 AM		CONTINUE			444	774	1.58	17.65%

Three operators were involved in a two-week zero defect streak. Process changes were made strictly under guidance of MICRONITE. Prior to MICRONITE, adjustments, re-sharpening and tool changes were made 2-4 times more frequently. Both critical tools (shave and breakdown) are running close to Six Sigma as oppose to three sigma before MICRONITE.

Dr. Birman defines machining models as uni-directional, non-linear, non-repetitive, asymmetrical relatively to spec nominal and unstable in sample variation. The combination of these components and their contribution into a tool wear curve is unique for every tool run. These charts illustrate the multitude of machining models for a single tool. MICRONITE's artificial intelligence allows to recognize tool wear patterns and stop processes before excessive tool wear starts.

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#3 LTH 9.59000/ 9.42000 -- Breakdown tool

Resharpening Adjustment Tool change

MICRONITE is a Master of Group Modeling

Theoretical machining models and common knowledge are not necessarily helpful in zero-defect control of a cutting tool. In this example: MICRONITE recognized different tool wear patterns and determined the risk of defects for related dimensions machined by the same shave tool. Decisions to re-sharpen a tool are made for one or another dimension regardless whether it's larger or "most close tolerance" dimension.