Improving Metal Finishing Shop Process Control

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Abstract

The current economy demands that companies of every size improve efficiency and quality, while reducing waste and costs associated with labor and materials, to remain competitive and successful in the marketplace. One area that is key to success in metal finishing operations is process control. It is extremely important that the processes are controlled to insure defect free finishing, minimize raw material usage and minimize generated waste. In addition, it is important to capture metal finishing expertise and economize labor. Software tools are commercially available that are PC-based, Windows™ compatible and designed specifically to assist surface finishers with management of process sampling, analysis and control functions. These programs can automate solution control calculations and provide data analysis and graphing functions. Some are able to use logic statements to "teach" the software to make decisions, thus approaching an expert system. Some programs can also track inventory and initiate purchase orders. Interactive displays can show the readiness of the entire facility. This information can be invaluable when focusing troubleshooting and maintenance activities and can streamline production planning and utilization of the processes. These programs can assist in identifying areas needing improvement and can provide cost reductions that help the facility achieve a quick return on investment (ROI). This paper will look at specific process control software features and how they help achieve process control improvements.

Introduction

The current economy demands that companies of every size improve efficiency and quality while reducing waste and costs associated with labor and materials, to remain competitive and successful in the marketplace (1, 2). One area key to success in a metal finishing operation is process control (3-6). Process control starts with laboratory testing of process solutions and physical properties of coatings, then, data must be organized and interpreted. Process control also includes management functions to control contaminants and metal finishing coating quality. State of the art process control laboratories employ wet chemical methods, instrumental analysis and physical testing to assess various features of the particular metal finishing treatment used (7-10). Collecting, analyzing, storing and evaluating process control data is essential to effective manufacturing. The data collected and statistical methods used to evaluate data assist in ensuring defect-free finishing, while minimizing raw material usage and waste generation. In addition, collecting sufficient data is crucial to minimizing and troubleshooting process problems. Most facilities perform at least some testing, but often facility personnel lack the time, training or expertise to effectively use the data collected to not only verify that things went as expected but to continuously improve the process. What is needed is a tool to allow for easier recording, analysis and interpretation of the data to control and improve processes.

It also extremely important to leverage technical resources so more can be accomplished with less. Tight economies force cutbacks and finding ways to preserve intellectual property and ease technical resource requirements are crucial to continued success and long term profitability. Metal finishing processes require a fair amount art. Nearly every

process will exhibit behavior that is not explained in technical data sheets. It is therefore important to capture metal finishing expertise and document the years of experience built up in the facility to insure continuity when the current "guru" retires or leaves the company. The computing power available in software packages can help in these areas as well. These tools can also be customized to make resource leveraging decisions as well as to provide training for personnel. These capabilities can help record and transfer process knowledge and the experience of long time employees to others ensuring the technical continuity of operations.

Software tools are commercially available that are PC-based, Windows™ compatible and are designed specifically to assist surface finishers with management of process sampling, analysis and control functions. These programs go far beyond simple spreadsheets; as they automate solution control calculations, provide data analysis and graphing functions (6, 11-14). Some are able to use logic rules to teach the software to make decisions and can incorporate training functions that allow the facility to capture process knowledge. Some programs can also automatically track inventory and initiate purchase orders. Interactive displays can show the readiness of the entire facility, and these applications can interact with controllers to directly record process information and can send commands to controllers based on analysis information and exert control. This information is invaluable for focusing troubleshooting and maintenance activities, and can streamline production planning improving utilization of the processes. These tools provide the framework and functionality for surface finishers to improve process control, document results and demonstrate accountability. The software assists with identifying improvements and cost reductions and helps the facility achieve a quick return on investment (ROI). This paper will look at specific process control software features and how they help achieve process control improvements.

Process Control Software Overview

Whatever software solution is chosen to help provide facility process control, there are a number of features that should be considered in building a system that meets the facility's needs. These features should include:

- Intuitive user interfaces for easy and effective use with minimal training
- The ability to easily schedule testing and enter analysis data
- Powerful features that allow the facility to organize, track and display laboratory data
- Graphing and statistical process control (SPC) calculation functions
- The ability to automatically track chemical usage
- The ability for the software to take over some decision making
- The ability to communicate results, problems, and recommendations
- The ability to link to automated analytical equipment and process sensors

User Interface Data Collection

The majority of metal finishing facilities manually collect samples and take them to process control laboratories for analysis. The data collected is either entered into a spreadsheet or a log book. Neither the log book nor a standard computer spreadsheet provides the ability to insure that the data is entered correctly. It is of primary importance to process control that the data is reliable. Some programs have the ability, either through logic rules or input ranges, to provide "mistake proofing". The data range puts limits on the input values allowed. In this way values that are

expected are allowed to be entered. However, controlling data inputs through the use of input ranges assumes that all data outside the range is in error. Process upsets can result in real data that is outside the normal range. This data could not be entered if the data range is used. Using a logic rule that compares the current value to the previous value and looks for a large change can be used to more effectively mistake proof data entry. Values that are more than maximum allowed are questioned so the data entry person has a chance to catch entry errors. The importance of mistake proofing cannot be overestimated. Once data is in the software it is considered good. The logic, or "Rules", feature is especially valuable when the software is calculating adjustments. Allowing values outside of the expected ranges allows the program to calculate how to rebuild a solution that is far outside the limits either by calculating a decant or a large addition.

Other important attributes include the ease of navigating the data interface. Some programs use a tree structure similar to Windows™ to facilitate navigating the screen or "hot" buttons for commonly used functions. Most facility personnel are familiar with standard Windows™ application format so a program structured in this way is intuitively easier to navigate. Figure 1 shows the opening screen of a laboratory process control software package. Each of the process tanks are shown in a tree structure similar to Windows™ file format structure. Two levels are possible; the process level expands by double clicking to the individual tanks in the process. In addition the top tool bar provides a number of hot buttons that assist the user in navigating to particular features.

Automated Data Collection

Many software systems have the ability to retrieve data from instrument controllers. However, programmable logic controllers (PLC) are often used to interpret the data and cause some action. An additional step is required to take this data and send it to the process control software to record the data in a database for use in process analysis. Interfacing to computers is easy enough now that the PLC can be omitted and inputs can be retrieved from automated test equipment directly to the computer software, i.e. from spectrometers, UV/vis, AA or ICP, auto-titrators, etc. Typical process control software packages support controller outputs, exporting to Excel™, direct emailing of active screen, and signals to equipment controllers and other software to initiate specific actions. These connectivity options provide lean, integrated information and control systems. These systems are also much less expensive than PLC driven systems and can be applied facility-wide or to particular tanks at a fraction of the cost of fully automated data collection PLC systems.

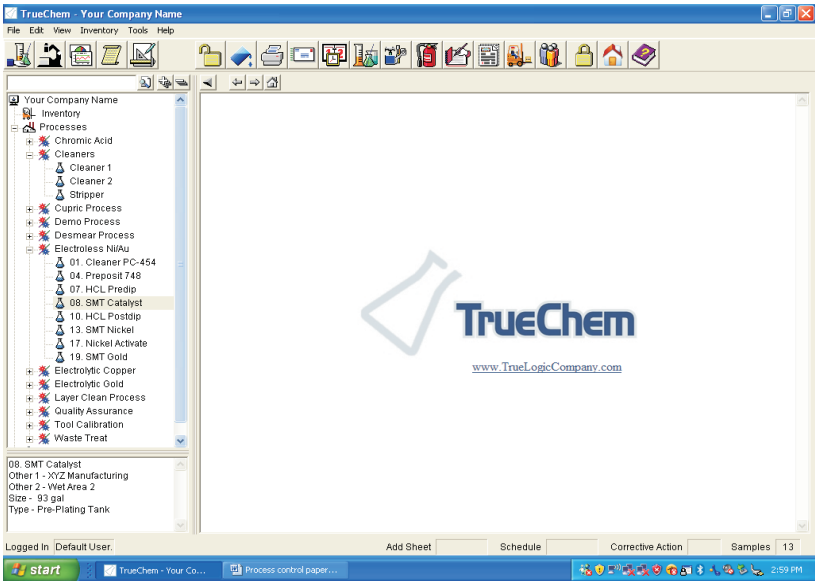

Figure 1: Laboratory Process Control Software User Interface

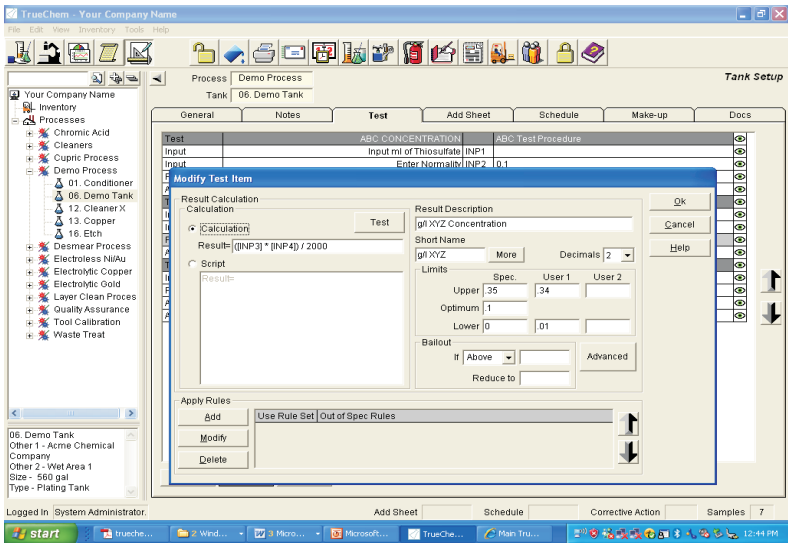

Figure 2: Establishing Process Operating Limits

Control Limits

Process control software packages simplify controlling processes to operating limits. As shown in Figure 2, the user is able to establish both specification limits and adjustment targets as well as shop limits (called User 1 limits in Figure 2). These limits can be set based on requirements or process knowledge and then adjusted as the process control data indicates.

Data Analysis

Spreadsheets can calculate the results of a solution test. What is more important, and is very useful in terms of assessing the overall condition of a process, is how the data is presented. Most are familiar with run charts, but software solutions provide much more in-depth information to maintain and improve the process. Typical charts that are of value include: X-Bar, Range Charts, Run Charts, Moving Range Charts and Histograms. These charts are very important in determining if the process is in control, in identifying variables in need of control to establish proper SPC control of the process, and in assessing sampling rates. Figure 3 provides an example of a data presentation screen. This is an overview screen, but the user can customize the view. In addition, it should be noted that capability indices (Cp, Cpk, Pp and Ppk) are calculated and displayed automatically.

Communication

Perhaps the greatest benefit of process control software packages, in addition to their ability to accurately collect and display data, is their ability to communicate. Logic rules can be used to generate pop up messages, send emails, etc. The notifications are only limited by the collective imaginations of personnel. The messages can inform the user of suspected data input errors, notify supervisors that tank operations (tests, additions, filter changes etc) are late or that out of specification conditions have occurred. They can notify purchasing that chemicals need to be ordered, maintenance that filters need changing, or the operations manager that a particular line is down.

An HTML-based visual display (dashboard) of select status information is another tool that can be

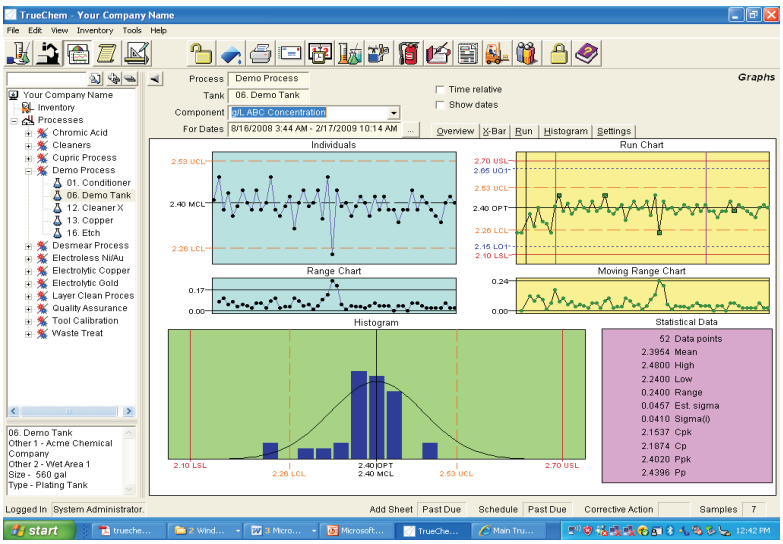

Figure 3: Process Control Software Data Presentation Screen

Figure 4: Process Control Dashboard

utilized. Shown in Figure 4, the dashboard presents a view of the overall status form a top down view (process line, tank, and analysis levels). Color-coded displays (e.g. green yellow and red) indicate the process readiness with respect to operating limits and timed countdowns display when to next action is due.

The dashboard can be taken a step further. An electronic tank placard can be tied to database to reflect process readiness at the tank as information is gathered. The electronic placard creates the ability to place a process tank online or offline as a result of process laboratory testing and immediately communicates that information to the process line operators.

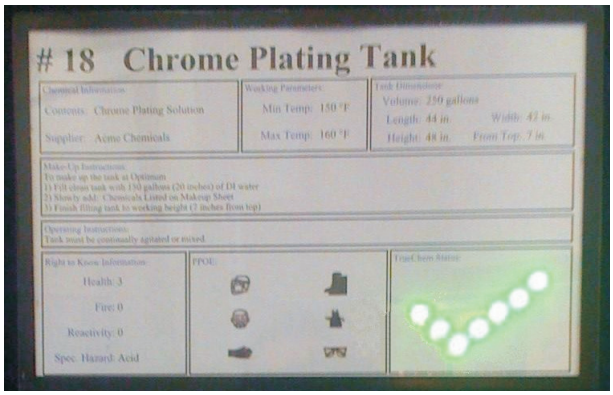

Figure 5: Electronic Tank Placard

Summary

Improving process control is attainable for every facility. Commercially available off-the-shelf process control software packages provide a wealth of capability at a fraction of the cost of developing a tool of equal capabilities. These packages are easily installed and provide users with fast startup; requiring a relatively small amount of training after setup. Some packages are customizable. As the data is collected and analyzed, new controls can be added to accommodate the change. However, regardless of the capability, these programs must provide solid return on investment (ROI). Improving process control impacts the bottom line significantly and these programs can pay for themselves relatively quickly.

Table 1 summarizes typical gains in chemical usage, while Table 2 summarizes gains possible through scrap reduction. These savings can be quantified by

Level of Process Control	Description	Typical Savings
Poor Control	Current process is erratic with large adjustments; frequently out of spec	>50%
OK Control	Regular large adjustments are made; sometimes out of spec	30-50%
Good Control	Less variability frequent moderate adjustments; rarely out of spec	20-30%
Well Controlled	Small frequent adjustments; out spec 1-2 times/yr	10-20%
Very Well Controlled	Small frequent additions; has not been out spec for >1 yr	<10%

Table 1: Chemical Savings from Improved Process Control

looking at current chemical costs and scrap rates, then determining cost reductions from process improvements. Table 1 cites typical savings in chemical cost from improvements in process control. Savings are recognized by taking the process from a startup level to a very well controlled process. Facilities typically waste chemicals by using too much to account for process variability, or from prematurely dumping baths because of solution contamination. It should be noted that improving process control also has the effect of reducing waste treatment costs. The savings noted in Table 1 are typical, and actual savings will vary by process, facility and substrate. To more accurately calculate savings, the facility should also take into account changes in the production levels.

Improved process control also reduces scrap. Table 2 shows typical scrap reductions from improved process control. A well controlled process produces more uniform effects on the parts processed, which reduces over and under-processing parts that can directly result in scrap. Many defects occur because the processing times must be varied to get the same results with poorly controlled solutions. Excellent process control maintains consistent processing times which helps optimize the production rate and serves to reduce defects. Process problems that cause scrap can arise in other parts of the plant. The good news is that the steps taken to improve process control create a methodology that can be captured in a software package and can be successful at identifying and eliminating process problems in other areas of the facility.

Scrap Rate	Typical Scrap Reduction
>5%	50%-90%
3-5%	30-50%
2-3%	20-30%
1-2%	10-20%
<1%	<10%

Table 2: Scrap Reduction from Improved Process Control

Improving process control also saves labor. Better controlled processes need fewer analyses and result in less labor to maintain. As the process is optimized so is the labor needed to keep it running well. There are fewer retests, less process down time and less engineer/manager attention required. Facilities using one of the software packages available gain added savings by transferring regular work performed by a technician, engineer or manager to the computer. Transferring these items to the computer frees the technician to perform additional tests that there was no time for previously, allows the engineer to focus on the data and process improvement rather than troubleshooting, and allows management to focus on optimizing production rather than finding ways to get product out the door with erratic or inefficient processes.

The commercial software packages available require varying levels of capital investment. Typically, in addition to the software cost, there is customized set up required to match the facility to the software. Installation and user training must also be considered when calculating payback. Typical paybacks vary depending on the size of the facility, level of current process control, chemical budget and the quantity and value of the scrap produced. However, for most facilities, payback from a few months to two years can be expected. After that time period the process control software packages continue to make money for the facility by reducing defects and operating costs. In addition the laboratory and facility process control then become showcases of the facility capability rather than a source of managerial frustration.

Bibliography

1. **Innovative Pollution Prevention Course, Module 1**, ASEF, Orlando FL 1996

2. B. Brigham, "Demystifying Six Sigma", **Circuits Assembly**, p 44, Feb 2005.

3. T.Pyzdek, **The Six Sigma Handbook**, McGraw-Hill, New York, NY 2001.

4. H. Fischer, "A Yardstick for Measuring Uniform coating Thickness", Internet article, 2008.

5. S. Crest, "Programmed for Success-End of SPC", **Metal Finishing**, p 57, April,1998

6. S. Crest, "Programmed for Success", **Metal Finishing**, p 81, Fb1998

7. J. Lord, "Evaluating Process Control Test Methods in Establishing Process Limits" **Proc SURFIN Conference**; AESF; June, 2004

8. J. Lord, "Integrated Process Control for the Modern Surface Finishing Facility", **Proc SURFIN Conference**; St. Louis, MO; June, 2005

9. M. Anderson and P. Whitcomb, "Reducing Variability With DOE", Internet article. 2008.

10. L. Hao, L. Zhang, and S. Westre, "Evaluating Anodizing Process Capability", Metalast, Minden NV, 2001

11. L. Flott, What is SPC, **Metal Finishing**, pp 112-114, Feb 2002

12. **ASTM E-1578: Guide For Laboratory Information Management Systems (LIMS)**

13. **ASTM E-622: Guide for Developing Computerized Systems**

14. TrueLogic website http://www.truechem.com/

TrueChem™ software is designed and manufactured by TrueLogic Company LLC of Plano, Texas. The Black Company Environmental is a group of metal finishing process consultants that also install TrueChem and train user.s