IN-PROCESS INSPECTION

GPRHI Business Engineering and Consulting gprhi.com

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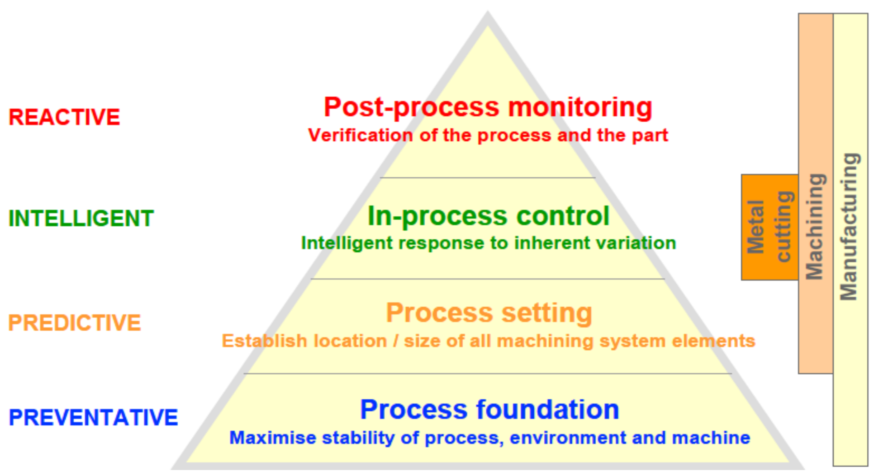
The In-process Inspection Imperative

What are the opportunities for reducing costs without replacing existing machines? This paper explores the ways where savings are found if manufacturers are prepared to change the way they control their machining processes.

Where are the opportunities to reduce costs?

1. Reduce labor costs
2. Reduce unproductive time such as shift change or waiting for people
3. Reduce scrap, rework and Set Up time
4. Reduce inspection costs

Lets begin by focusing on eliminating most manual processes and directly address the root causes of these failures. As much of the nonconformance in many processes arises from human intervention.
But removing manual processes is not enough, we also need to pay close attention to the operating environment, the machine itself, setting processes before we start cutting, and in-process controls once production starts.



The Productive Process Pyramid™ shows how layers of control can be used to systematically remove variation from machining processes.

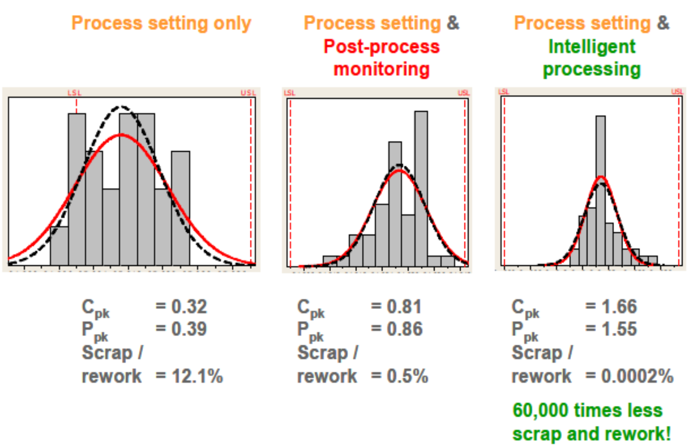
The Productive Process Pyramid™. The Pyramid (above) comprises of 4 layers of process control which build upon one another for successful manufacturing.
Preventive - The PROCESS FOUNDATION layer provides stable conditions in which the machine operates correctly. These are preventative controls that reduce the sources of variation before machining starts.
Predictive – The PROCESS SETTING layer, deals with predictable sources of variation such as the location of the part, the size of the tools and offsets on the machine tool that could otherwise cause the first part to be scrap.
In-Process - The IN-PROCESS control. The sources of variation that are inherent to machining (.i.e tool wear, tempearature growth, coolant degradation)
Post Process Monitoring - The POST-PROCESS MONITORING layer, where the process and ultimately the part are checked against their respective specifications. Most of this can be done on the machine.

Process foundation
Controls in the base layer of the Pyramid are targeted at maximising the stability of the environment in which the process is to be performed. These preventative controls stop special causes of variation having an impact on the machining process.

Process setting
The second Pyramid layer contains the “ getting ready to machine” mode. These controls tackle sources of error in the Set-up of the machine, Part, Tool and Probe and which must be dealt with if the first component is to be machined correctly. Building on the stability introduced by the process foundation layer, process setting controls help to eliminate human error by automating manual processes.

In-process control
This layer is least understood. Tackling the inherent sources of variation in the machining processes (i.e tool wear, temperature and heat growth). On-machine probing is the only cost-effective way to monitor the in-process state and gives the machine the intelligence it needs to make its own decisions, constantly centering the process and eliminating the adverse affects of process drift.

Post-process monitoring
The top layer of the Pyramid provides the final assessment of process outcomes. Verification can be performed on the machine tool itself using a probe, at the machine using hand gauges or offline on a CMM. These are reactive controls, as the measurements are too late to influence the component being measured unless a rework process is called up.

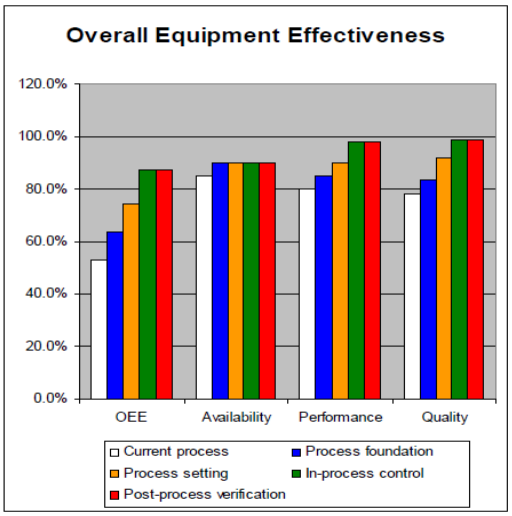


Results of a capability study conducted at Renishaw on the same parts using different process control techniques. With just process setting, scrap levels are unacceptable and process centring is poor.

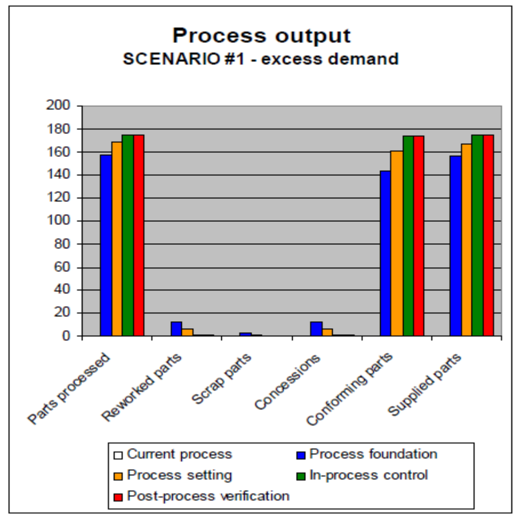
Post-process monitoring gives improved centring and reduced part-to-part variation, but results in capabilities that are below acceptable levels for most firms.

Only intelligent in-process control yields the level of capability that Renishaw finds acceptable and which permits extensive periods of unmanned operation.

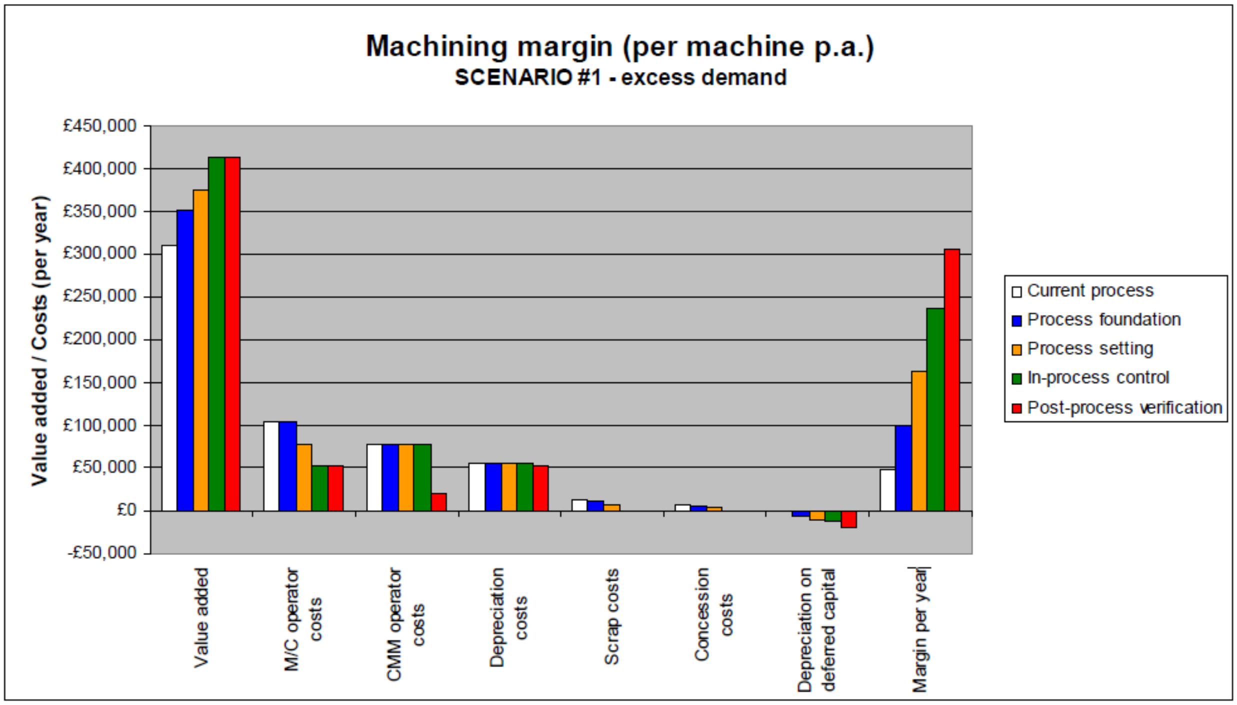
This chart shows the trends in the elements of OEE that result from applying the four levels of controls:



The following chart shows the number of parts processed, as well as levels of rework, scrap and concessions:



This chart summarises the value added, costs and margin that the machine generates in a year under different levels of process control. The incremental improvement from full implementation of all four Pyramid layers is around £250k p.a. – equivalent to half the capital cost of the machine tool each year!



Summary and recommendations
The Productive Process Pyramid™ provides a systematic approach to eliminating variation in machining. Making fundamental changes to the overall process can yield substantial recurring cost savings through automation and lowering quality costs. The level of investment to implement these controls is relatively low, with payback felt immediatly. Eliminating variation from your processes will increase the returns on any future capital investments that you will make.
The Pyramid controls should be implemented from bottom up, as each layer builds on the one below to progressively reduce variation. Implementing the process foundation layer is the first step, followed by implementing probing to automate setting processes. In-process control is more process-specific, and makes sense where there are many similar machines and processes to share the improvements.

Replacing post-process measurement on your CMMs, with on machine measurement, is the best strategy. The machine's primary purpose is to make good parts, and so any verification that is done on the machine should be focussed on the process just completed rather than checking every feature on the part.
On-machine verification makes most sense where parts are very large and complex or where the lead time and cost of moving parts is high.

Attention must be paid to the accuracy of on-machine measurement, particularly the effects of temperature. In most circumstances, a CMM that employs high speed scanning technology is generally the most cost effective may to verify component geometry and surface conformance.

With new On-Machine Scanning Probes and software, this process can be verified on the machine tool.

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