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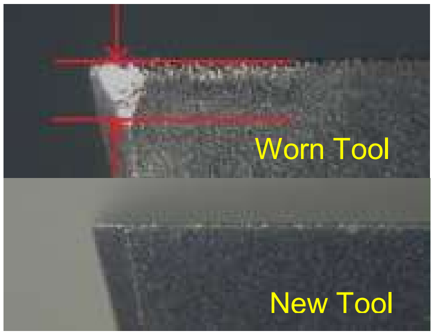
*High-Definition Metrology and Vision Application Note #09-12*

# Machining Center Tool Change Optimization

## The Powertrain Challenge



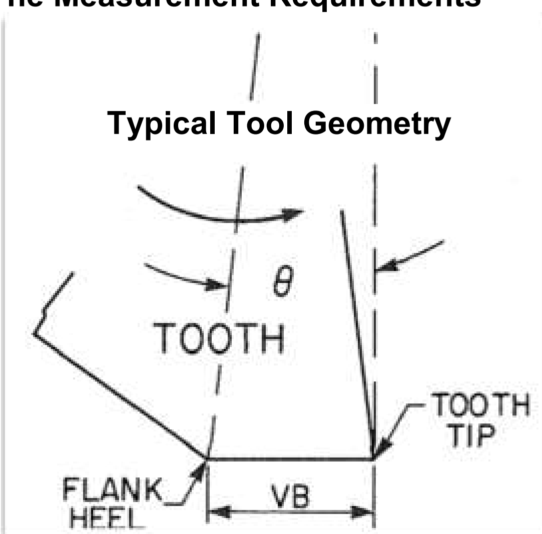

Cutting tools are a significant cost item in automotive powertrain machining and similar high volume applications. Tool replacement strategies have a significant impact on tooling cost. In current practice, tools are typically changed after a specified number of parts are machined, regardless of part and tool condition. This strategy originated when powertrain components were machined on large serial transfer systems; for these systems, tools were typically changed between shifts to eliminate unscheduled downtime. Currently, however, major powertrain components are often made on parallel CNC systems. In these systems, redundant tools can be loaded into the tool magazine, so that tools can be changed on an as-needed basis if their condition is reliably sensed. This can significantly reduced tooling costs (on the order of ten or twenty percent) without compromising part quality.

## The Metrology Need

Powertrain mating surface machining – of transmission valve bodies, cylinder heads and engine blocks - are all critical manufacturing processes. Product quality is affected by the machined surface flatness and surface waviness that result from multiple machines, with multiple tools, mounted on multiple machining heads, removing material from multiple surfaces of those precision parts. Measurement is needed that will ensure that all of the CNC machines' tools are always in satisfactory wear condition. Such measurements will enable optimization of changes of individual tools before the surface quality of the produced parts degrades and before tool breakage occurs, but without premature changes that simply increase consumable tool costs.

For efficient in-line production operations, the specific metrology need is for a means to determine when this optimum tool change point is about to be reached, and then when it has been reached, so that the most efficient operation of the machining line or cell can be consistently maintained.

## The Measurement Requirements




The measurement requirements include the ability to evaluate and track the condition a tool as it breaks in after its initial installation, follow it through its primary life, detect when the tool wear has reached a point where surface quality is starting to degrade, and reliably determine when the point has been reached that tool change is warranted so that minimal machine shutdown is required. In addition, when tool change has just occurred, measurement is required to detect if some mis-adjustment of the new tool has, or has not, occurred that would create an unacceptable machining quality or other undesirable condition. The ultimate measure of these factors lies on the surface of the machined parts themselves.

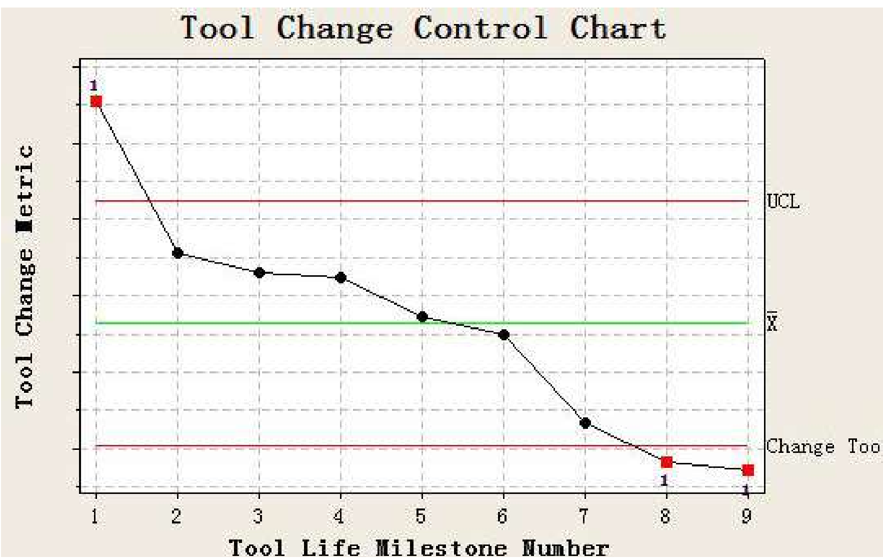
## The Coherix Solution

***ShaPix*** employs its full-surface-coverage, high-definition, holographic 3-D measurement of surface height across the entire machined surface of a part to provide robust information about surface quality relevant to tool wear. By applying its proprietary surface analysis algorithms, this measurement information is converted to an accurate evaluation of the wear state (condition) that is valid for the particular type of tool being used (diamond or carbide), the machining operation being employed (face or side milling) and material being machined (aluminum or cast iron). It has been shown that surface variations in the waviness band-pass spectrum, and NOT in the shorter-wavelength surface roughness spectrum, are an accurate measure of the actual condition of a machining center cutting tool. ***ShaPix*** provides the unique ability to evaluate the effects of tool wear throughout the entire surface. In about 1 minute it evaluates the surface quality across all of the tool mark arcs carved on the most recently processed part.

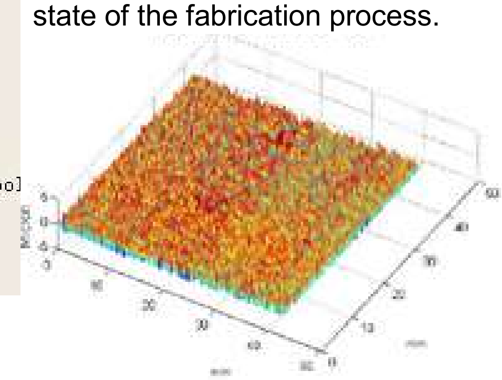
## The *Coherix* Results

As in all efficient manufacturing automation, what is needed is actionable information to the operators and supervisors that is instantly understandable, clear, and consistently accurate.

Control limits can be set by the set-up operator to define any tool change policy that is appropriate for the manufacturing process.



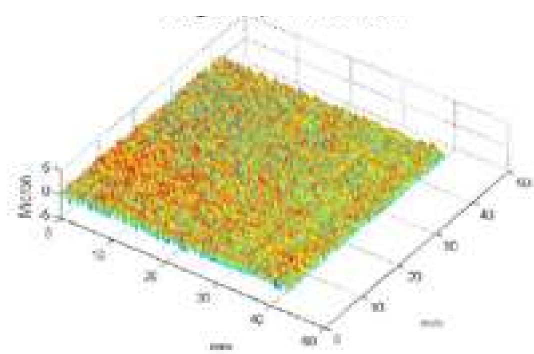

The ***ShaPix*** system samples the milled part mating surfaces at a density of 44 sample points per square millimeter. It measures every one of those sample points to +/- 1 micron repeatability and accuracy. It produces a surface hologram that defines a 3-dimensional high-definition "point cloud" for the surface. That "point cloud" can be analyzed to evaluate dimensional surface characteristics of the milled surface that relate to the part's functional performance and the state of the fabrication process.



**New Tool *ShaPix* surface hologram**

## The Powertrain Value Delivered

The typical achievable savings of cutting tool costs on a powertrain engine or transmission line is in the range of $400,000 savings per single-shift year, by eliminating the typical 20% wasted cost of premature tool changes. In addition to this saving and its other delivered high-definition measurement values, ***ShaPix*** can simultaneously reduce down time and preventing excessively worn tools from producing parts that leak or fail to deliver required horsepower and fuel economy. This continuously-delivered actionable information adds value to the benefits realized from ***Shapix*** in product engineering, through process launch, during problem diagnosis, and for ongoing process control.



**End-of-tool life *ShaPix* surface hologram**