Powertrain Engine and Transmission Leakage Prediction for Advanced Competitive Vehicle Manufacturing

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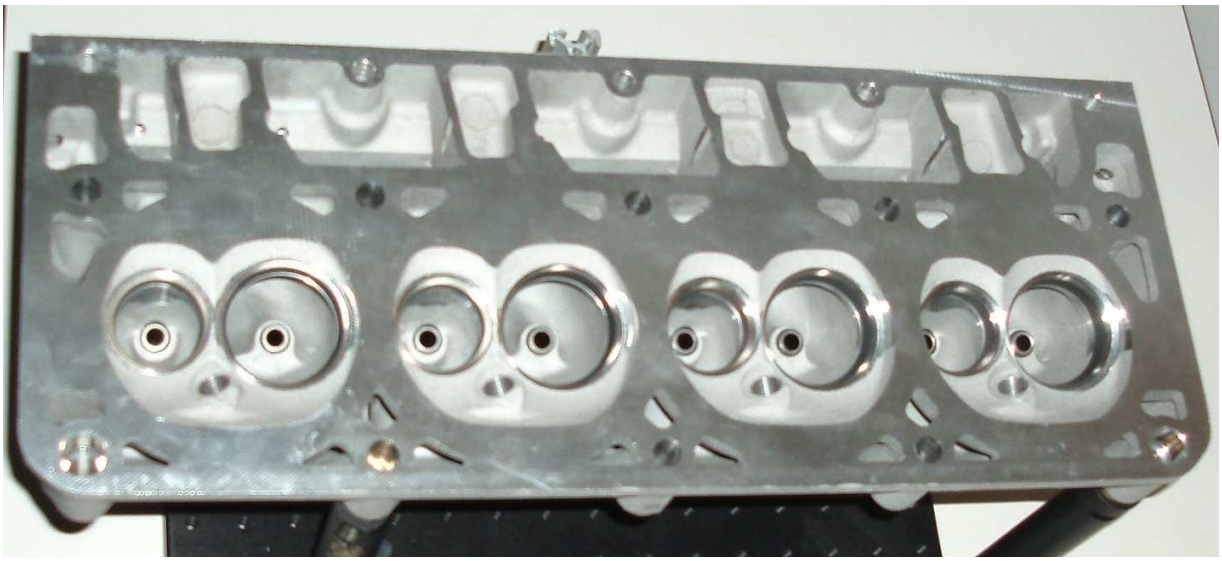
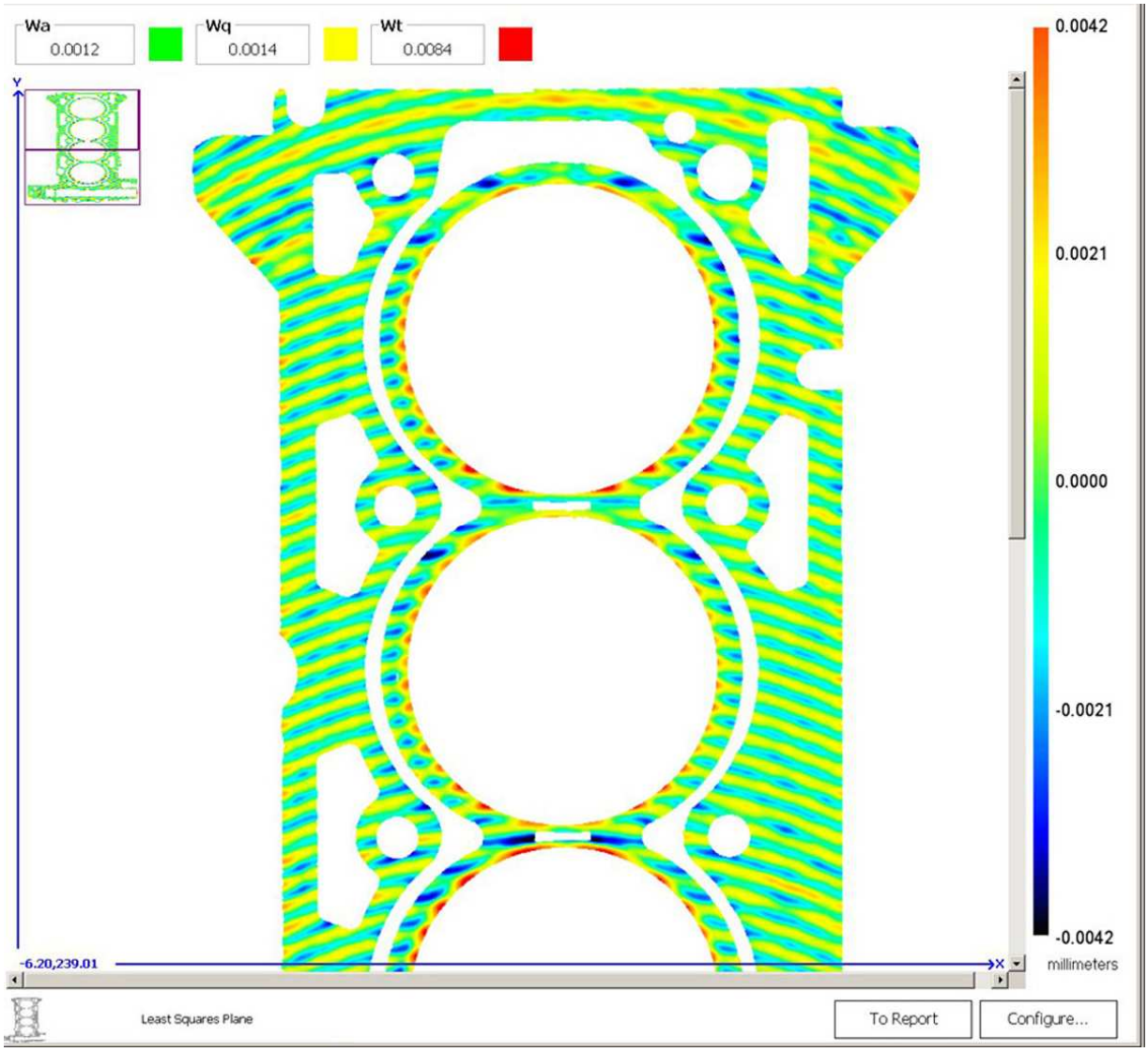
The manufacture of high-performance powertrain systems in the current era imposes significant requirements upon the avoidance of susceptibility to leakage of combustion gases, coolant or lubricant. Advanced powertrains, which must achieve better fuel economy, lower emissions and higher horsepower-to-weight ratios, inherently must be designed with higher internal peak operating pressures. In turn, this imposes the requirement for powertrain parts to be machined with minimal surface waviness and avoidance of the leakage potential that results from excessive surface waviness in critical locations on mating surfaces.

A typical internal combustion engine presents many opportunities for leakage to occur between combustion chambers coolant flow channels, fastener holes, and the exterior of the cylinder head and engine block. Increasingly sophisticated but expensive gasket technology gasket, together with improved machining process control, are employed to minimize and ideally eliminate leakage of all gases and fluids that would compromise critical engine characteristics. Process control to ensure this strategy succeeds requires accurate and complete surface waviness measurement.



The same challenges exist in the parts forming the fluid logic of automatic transmission systems whose internal operating pressures are also required to be much higher than in past decades.

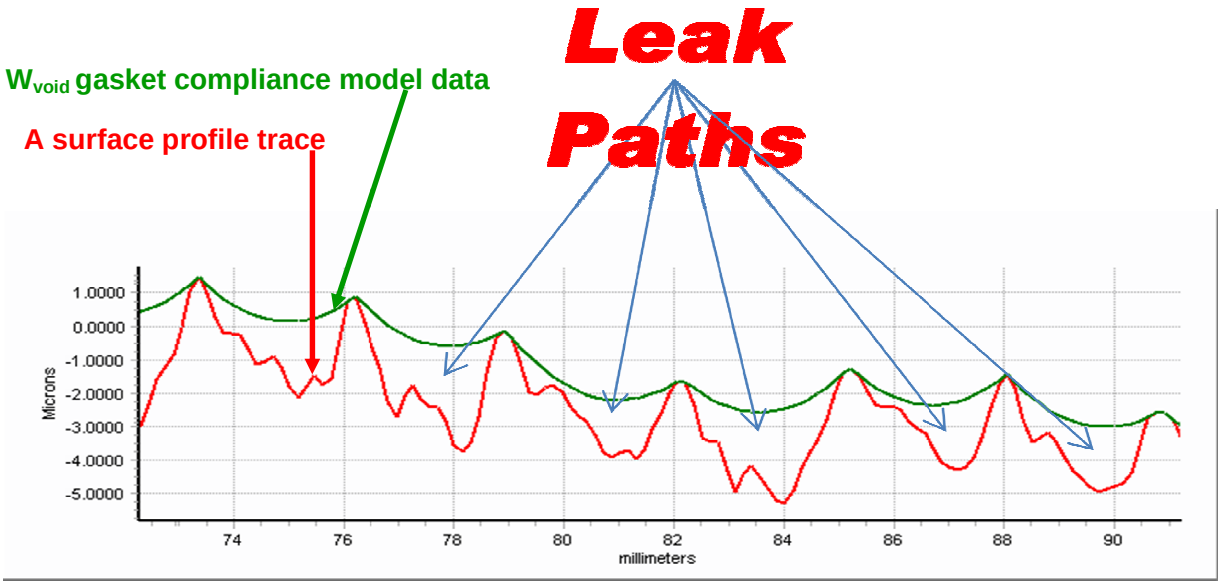
Accurate powertrain leakage potential requires measurement over the entire length of all of the critical potential leakage paths on the part surface. Legacy mechanical waviness measurement devices cannot provide sufficient measurements within the time period required to effect adequate control of the machines employed in the manufacturing process.



A full-surface high-definition surface waviness measurement report for a portion of an engine deck face, produced by a Coherix ShaPix system and displaying traditional waviness metrics

Surface waviness generally refers to surface variations from a perfect plane that include spatial frequencies up to 1.2 cycles per millimeter and down through much longer spatial-wavelength (low spatial frequency) surface variations. Surface waviness measurement has been performed very slowly, tediously and incompletely for decades using antiquated mechanical probe systems to produce a number of long-used waviness metrics - which were the only metrics feasible for such mechanical devices to measure on a practical basis.

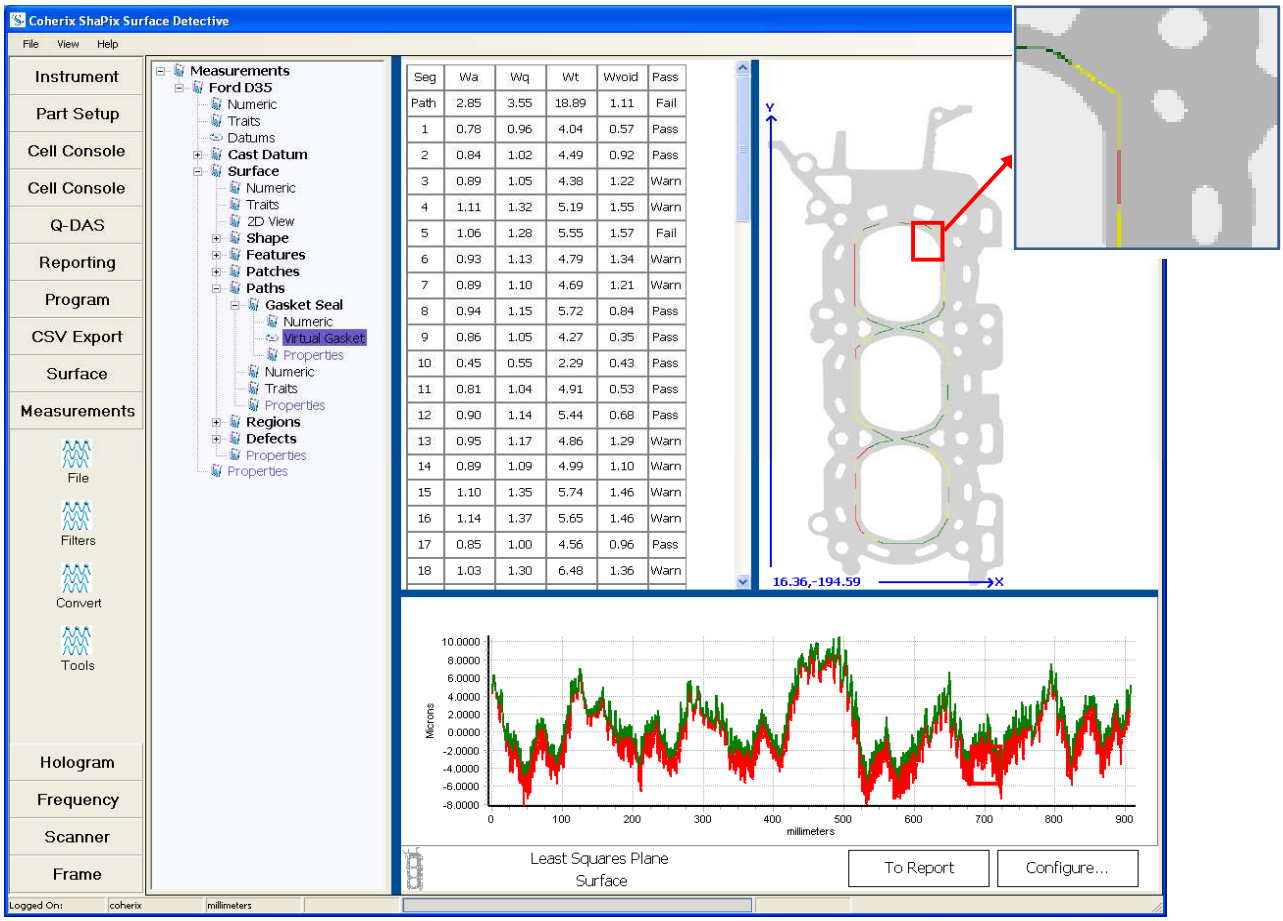
But surface leakage potential is accurately predicted only by use of the recently defined W_{void} metric formulated by Dr. Mark Malburg. This waviness metric models the compliance characteristics of gaskets used in powertrain systems and more accurately predicts the degree to which a cylinder head-gasket-engine system or a gasketed transmission system will likely leak under specified operating conditions.



W_{void} Metric produced from Coherix ShaPix Surface Waviness Measurement

The only measurement system capable of producing the W_{void} leakage susceptibility metric for any of, and the entire set of, powertrain mating surfaces is the Coherix® ShaPix® Surface Detective™. Waviness measurement is performed by ShaPix Systems for an entire powertrain part surface in seconds and leakage susceptibility maps are produced to enable any of a number of analytical and process control procedures. Leakage may be predicted along the entire length of a gasket bead, or may be predicted for any particular chosen region on the surface that is of interest to a powertrain product engineer, manufacturing engineer or machine operator. Waviness and powertrain leakage potential can be measured in any direction relative to the

machine surface tool marks or in all directions if desired. If the CNC machine cutting process produces tool marks whose directionality varies across the surface, the leakage susceptibility measurement can be specified to change direction dynamically across the surface so as to be perpendicular everywhere to the local tool mark direction.



Coherix ShaPix Powertrain Part Leakage Susceptibility Report for a Complete Gasket Bead Path
Color-Coded Bead Path Segments Show Pass/Fail Leakage Potential

Powertrain potential surface leakage as modeled with W_{void} is a measure of the total leakage cross-section for the area or gasket bead path that has been specified for measurement. Using this unprecedented quality of information, gasket, engine and transmission designers can determine what specific gasket characteristics, as well as what powertrain machining performance characteristics are required to ensure that high-performance and reliable powertrain systems will be manufactured and delivered for the advance vehicles required to meet CAFE standards and the consumers' needs for economical total costs of transportation.

The Coherix ShaPix Surface Detective produces both a 3-D color coded image map of the surface waviness measurement for each measured powertrain part, but also the numeric quantitative leakage cross-section data for the part and a specific indication of where potential leakage paths exist. This information provides the product engineers and manufacturing personnel with the information required to optimize both the product design and the machining process steps to eliminate potential leakage and ensure satisfactory powertrain machined surfaces.

The “bottom-line” difference is very significant in manufacturing success, between reliance on slow, inaccurate and incomplete mechanical surface waviness measurement devices and full-surface high-definition 3-D measurement of the W_{void} surface leakage susceptibility metric using a Coherix ShaPix system. It is the difference between:

- Discovering leaky powertrain systems only after expensive down-stream assembly and pressure testing (or after a dissatisfied customer returns a vehicle for service) and
- Detecting leakage within a few minutes or sooner after a part has been finish-machined so that no further leakage-prone parts are produced.

Coherix’s ShaPix systems surface waviness measurement results make this difference.