MAGNAFLUX®

A Division of Illinois Tool Works Inc.

QUASAR 4000

Nondestructive Test Systems

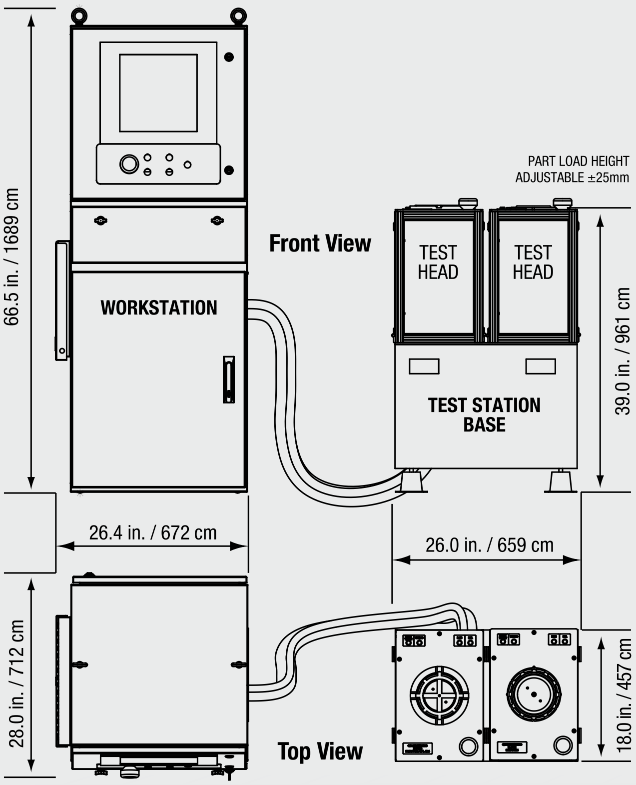
- Finds defects others miss
- Improves shipping quality
- Test fast, changes over fast
- Eliminates operator judgment calls
- Reduces scrap, labor, expendables
- Test for all structural defects at once

THE NEXT STEP IN NDT

MAGNAFLUX QUASAR 4000

Nondestructive Test Systems

Quasar 4000 is a family of Non-destructive Test solutions that use Process Compensated Resonant Test (PCRT) to provide superior NDT at lower cost for metal and ceramic parts.



THE QUASAR 4000 SYSTEM INCLUDES:

Workstation – Houses the Transceiver, the Control Computer, Programmable Logic Controller (PLC), and associated electronics.

Test Head – Contains the tooling that aligns the part under test so that every part is contacted at precisely the same transducer locations. The Test Head tooling is customized for a given part type.

Test Station – Supports the Test Head and isolates it from mechanical noise and vibration.

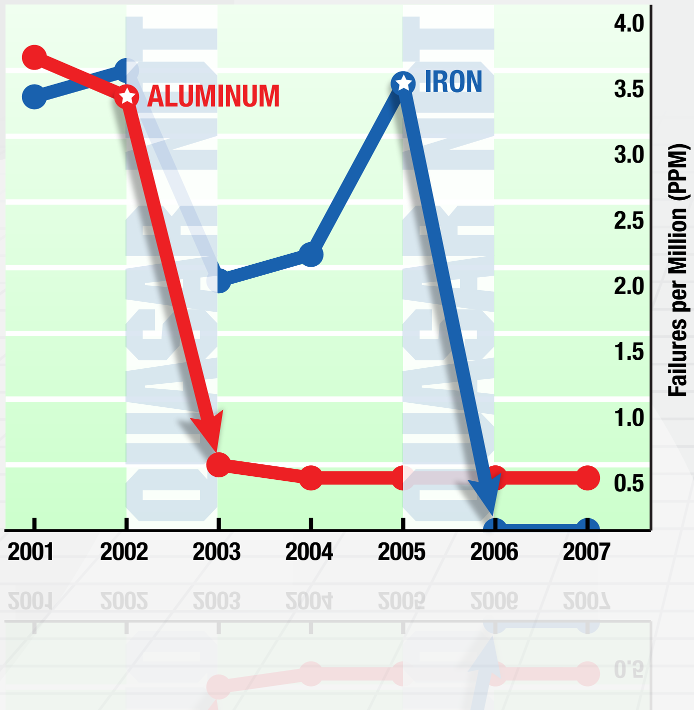
QUASAR PROVIDES BETTER NDT

Quasar provides significant benefits to manufacturers and their customers – shipping quality improves and costs drop. **Figure 1** shows how introducing Quasar improved the failure rate of delivered product for two high volume automotive components: Cast aluminum brake components and cast steel engine components. In both cases, the initial quality was quite good—near six sigma. But, production volumes are tens of millions of parts per year, so nearly 100 dissatisfied customers were being created every year. <u>Adopting Quasar reduced the failure rate by more than an order of magnitude in each case</u>. This level of performance is the reason for Quasar's success—over 100 million parts per year and growing rapidly (**Figure 2**).

QUASAR USES PCRT

The purpose of NDT is to identify and reject defective parts—parts that would fail prematurely. In general, a structural part fails by yielding or breaking, so NDT should measure a property that correlates to the force required to make the part yield or break. Resonance is the ideal NDT measurement because a part's resonant frequencies are determined by its stiffness (material properties) and dimensions, which, in turn, determine its failure level. Deviations in a part's resonant frequencies are caused by changes in either stiffness (such as a crack or an oxide) or dimensions.

Figure 1. Quasar testing reduces failure rate



A resonance deviation then, is a measure of a change in stiffness or dimensions, and the degree of deviation is proportional to the amount of the change. The physical changes that cause frequency deviations can be either acceptable (normal process variations such as variations among dies) or unacceptable (defects). In most cases, the frequency changes caused by process variations are greater than those caused by all except the most severe defects. As a result, these natural process variations *mask* the defects so that simple resonance testing cannot detect the majority of significantly defective parts. That was the essential limitation on resonance testing before Quasar.

Quasar uses resonant pattern recognition to discriminate between the acceptable and unacceptable changes. The interrelationship among the dimensions and stiffness that characterize a particular part type creates a unique resonant pattern for that part type. While the individual resonances deviate as the process varies, the overall resonance pattern remains constant for all Good (acceptable) parts.

In operation the Quasar system measures a set of resonances, applies specialized algorithms, computes the probability that the part is Good or Bad and makes the Accept/Reject decision. The result is a Quasar testing score that has been shown to correlate directly to the level of the part performance expectation.

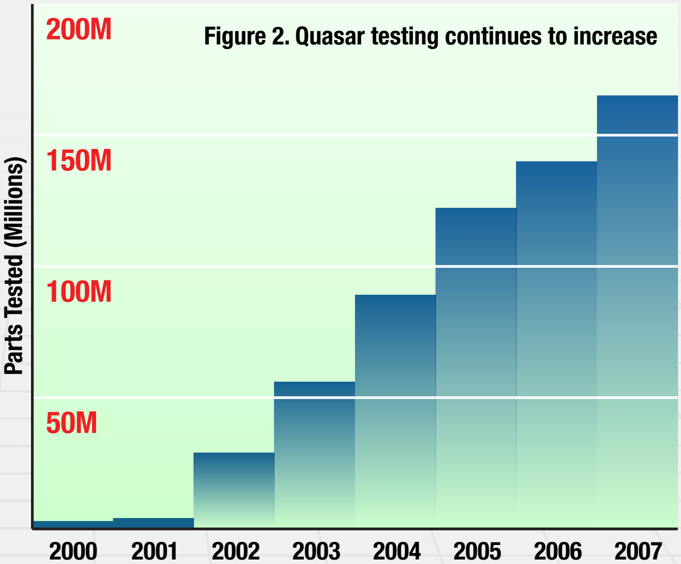


Figure 2. Quasar testing continues to increase

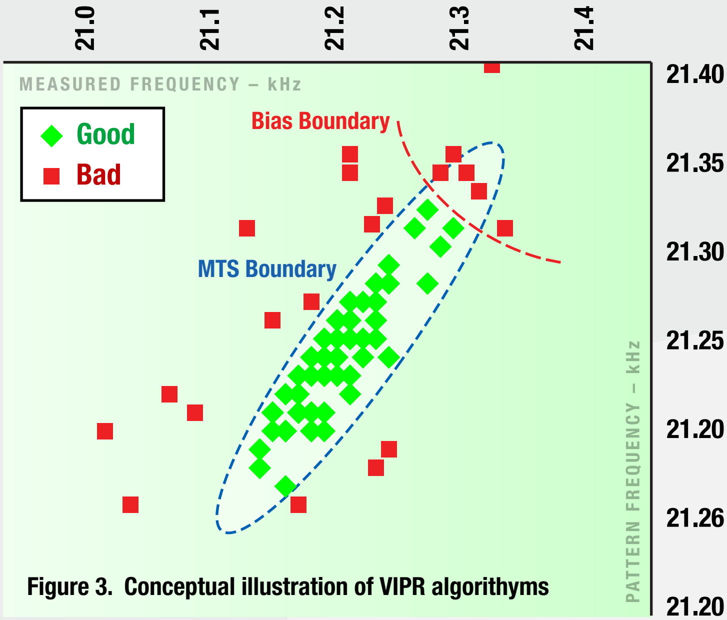


Figure 3. Conceptual illustration of VIPR algorithyms

To develop the algorithms, resonances are measured for a Training set of known Good and Bad parts. VIPR (Quasar's pattern recognition program) analyzes the resonance data to identify the algorithms that best discriminate between the known Good and Bad parts. This Good/Bad sorting is conceptually illustrated in **Figure 3** which plots the computed pattern frequency vs. measured frequency for a Training Set of parts, with Good parts in green and Bad parts in red. One algorithm is represented by the ellipse (only parts inside the ellipse are accepted) and the other algorithm is represented by the curved line (parts to the right of the boundary line are rejected). Good parts pass both tests, while some bad parts fail one algorithm and some fail both. Together these methods detect all significant structural defects, despite normal process variations.

APPLICATIONS

Quasar is primarily used to test metal or ceramic parts and is particularly appropriate for higher production volumes (>100,000 per year). **Figure 4** lists examples of the type of parts that are currently being tested with Quasar. **Figure 5** lists the type of defects being detected in these applications, including both common and process-specific defects.

Figure 4.

EXAMPLES OF QUASAR APPLICATIONS

ABS Rings	Bearing Caps
Brake Anchors	Bearing Hubs & Races
Brake Calipers	Cam Caps
Cam Shafts	Clutch & Pressure Plates
Connecting Rods	Control Arms
Cylinder Heads	Engine Blocks
Engine Mounts	Flywheels
Gears	Knuckles
King Pins	Links
Master Cylinders	Pump Housings
Rocker Arms	Steering Racks
Sprockets	Transmission Shafts
Wheels	Yokes

OPERATION

In production, the operator (or robot) simply places the part on the Test Head. The transducers lift the part from the tooling, vibrate it across a predetermined frequency range and measure its resonances. The Quasar software compares the pattern of the measured resonances to the stored pattern for good and bad parts and makes the accept/reject decision. A typical measurement takes 4 to 6 seconds (depending on the part size) and the decision is made in milliseconds. The Accept/Reject decision is communicated to the operator for part disposition.

SOFTWARE

An integrated suite of software tools guide the process of developing and implementing a Quasar test. These programs manage the Quasar process, from taking data on the Training parts, through creation and optimization of the Sorting Module, control of the testing, and reporting of the test results.

HARDWARE COMPONENTS

Precision defect detection requires precision measurement despite the operating environment. The Quasar 4000 is designed and built to detect resonant vibrations in the micron range even when operated near large presses or grinders. The rugged design tolerates factory shock, heat and electrical interference. Every day Quasar systems demonstrate their ability to operate in foundries, forges or sintering lines.

Figure 5.

DEFECTS DETECTED BY QUASAR

Common Defects All Processes	Cracks	✔
	Inclusions	✔
	Chemistry	✔
	Missing Features	✔
	Non-fill	✔
	Dimensions	✔
Aluminum Cast	Oxides	✔
	Shrink Porosity	✔
	Cold Shuts	✔
	Blow Holes	✔
	Elongation	✔
Iron Cast	Oxides	✔
	Shrink Porosity	✔
	Cold Laps	✔
	Nodularity	✔
	Carbides	✔
Forge	Bar Ends	✔
	Double Strikes	✔
	Laps (folds)	✔
	Quench	✔
	Material	✔
PM	Oxides	✔
	Chipped Teeth	✔
	Porosity	✔
	Coining	✔
	Sintering	✔

FEATURES

The Quasar 4000 is a fourth generation PCRT system. It includes a range of features developed in response to factory use and customer feedback over the past decade. These features include:

- **Standalone testing or integrated into production line**
- **Testing throughput matched to production, up to 1000 pph for dual system**
- **Test hardware customized to part configuration**
- **Automatic test head recognition**
- **Integrated Quasar software suite simplifies sort development and production testing**
- **Integrated fault detection and troubleshooting programs**
- **Automatic Temperature Compensation**
- **Test results available for permanent storage and reporting**
- **Quantitative data for process feedback and SPC**
- **Internet-based remote support and diagnostics**
- **Rugged NEMA electronics enclosure**
- **Standardized interface to material handling systems**

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The RI 1000, RI 2000, Quasar 3000, Quasar 4000 and RU Spec systems employ nondestructive inspection methods covered by U.S. Patents including numbers 5,408,880; 5,495,763; 5,425,272; 5,631,423; 5, 641,905; 5,837,896; 5,886,263; 5,952,976; 5,965,817; and 5,992,234 assigned to Illinois Tool Works, Inc., and also by other U.S. and European patents pending and allowed.