Part Quality Inspection Application: Resonant Acoustic Method NDT

NDT-RAM™

In the world of manufacturing today, the liability of shipping a defective part can be catastrophic for you, your customer, and the consumer. Resonant Acoustic Method NDT (RAM NDT) is designed to help you deliver fully inspected parts, economically and on time, giving you and your customer confidence in the quality of your parts.

The principle of resonant inspection is simple: every part has a unique resonant signature or pattern that reflects its structural integrity. A deviation from the expected signature or pattern can indicate the presence of a flaw. For example, a bell with a crack no longer has a clear ring or the ability to hold its tone.

The resonances of a structure are defined by its mass, stiffness and damping. These resonant frequencies can be measured in most rigid materials including most metals, ceramics, and composites. NDT-RAM systems detect frequency shifts which can be caused by imperfections such as cracks, porosity and voids, as well as variances in nodularity, dimension, geometry, weight, density and manufacturing processes.

TYPICAL USES:

- Production - In-Line Inspection
- Field Service - Troubleshooting
- Quality Control - Spot Checking
- Engineering - Development

SUCCESSFUL APPLICATIONS:

- Powder Metal
- Iron Castings
- Forgings
- Metal Stampings
- Aluminum Foundry
- Ductile Metals
- Ceramics
- Composites

BENEFITS:

- 100% inspection - ensures the confidence that every part is objectively tested
- No part preparation required for inspection
- High throughput - as fast as a part per second
- Simple to learn and use application software
- Reduces scrap costs associated with false rejects
- Greatly lowers operating expenses by eliminating consumables
- Industrial package - NEMA4 enclosure allows factory floor operation.
- Versatility - same system can test many different parts
- Eliminates quality recall/containment costs
- Financially justified - ROI analysis available

CALL FOR FREE PARTS EVALUATION AND TEST REPORT

"Simplifying with Smart Sensing Solutions"

THE MODAL SHOP INC.

A PCB GROUP CO.

Helping you test, model, and modify the behavior of structures and processes.

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Who needs NDT Resonant Inspection?

Manufacturers or users of metal parts that...

- have substantial inspection cost.
- require 100% parts inspection.
- desire to improve part quality.
- produce and/or use safety-critical parts.
- have customers demanding higher quality.
- have substantial scrap costs due to false rejects.

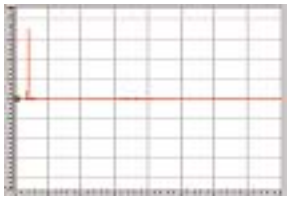
What does NDT Resonant Inspection detect?

- Cracks, chips, holes, and voids
- Porosity & Nodularity
- Out-of-tolerance dimensions
- Variations in hardness
- Residual stress
- Bonding, welding, or brazing failures
- Machining or heat-treating processes

RAM NDT provides confidence and peace of mind. It is simple, reliable and affordable.

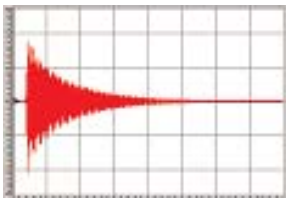
Here's how it works...

IMPACT THE PART



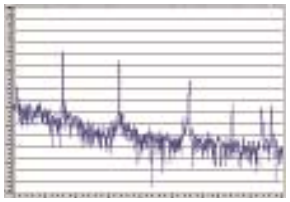
An industrial instrumented impact hammer taps each part with a measured and repeatable force.

MEASURE THE RESPONSE



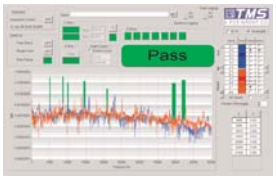
The impact causes the part to "ring" - audible and inaudible sound is measured by the microphone.

PROCESS THE DATA



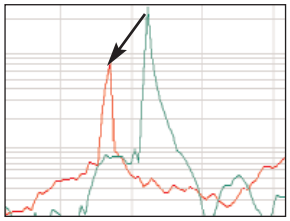
The Smart Digital Controller performs a Fast Fourier Transform (FFT) on the measured data.

QUANTIFY THE RESULTS

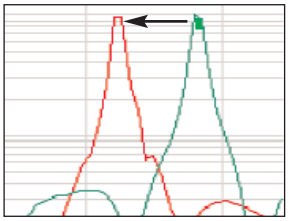


NDT-RAM software compares the results to acceptable limits and accepts or rejects the part accordingly.

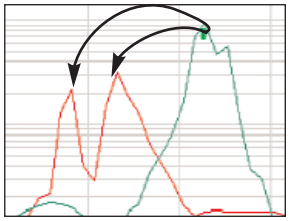
Changes in mass, stiffness & damping due to certain defects can cause...



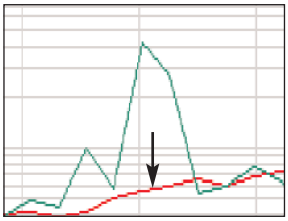
...resonant frequency peaks to shift in both frequency and amplitude.



...resonant frequency peaks to shift frequency but maintain amplitude.



...peak shifts with more pronounced splits in resonant frequency.

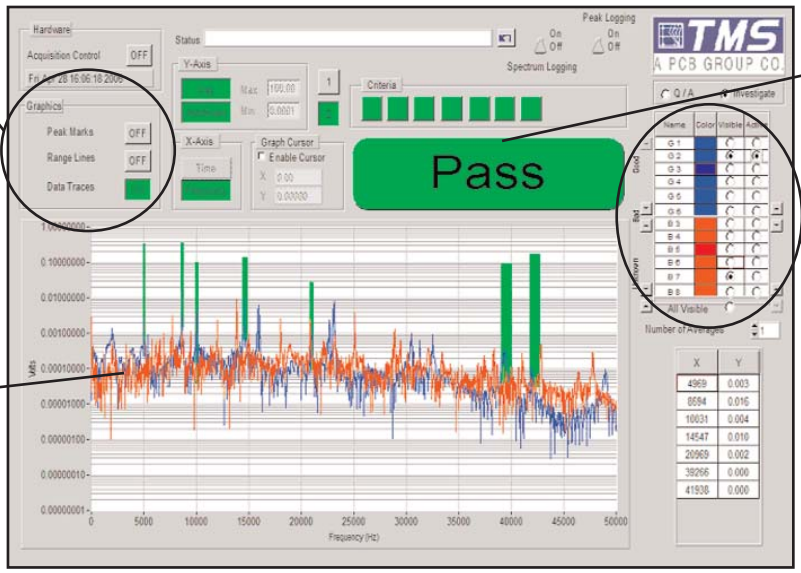


...resonant frequency peak energy to disappear completely.

NDT-RAM's Graphical User Interface

Screen shot from NDT-RAM software showing resonant frequencies and sort result

Improved graphical features ease visual data evaluation



Clear indication of pass/fail by criteria range

Overlay of data shows color coded spectra for "good" and "bad" parts against acceptable criteria ranges

Improved investigate mode supports up to 1500 part spectra, labeled good, bad or unknown

NDT-RAM's Report Generation

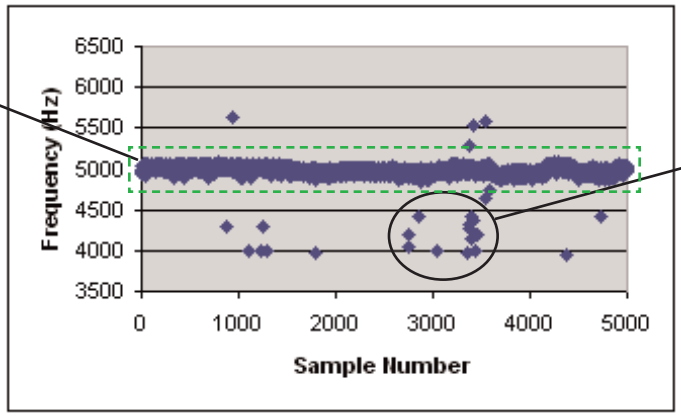
Allows you to fine tune criteria by using standard spreadsheets to evaluate statistical data taken for each part tested. Data from NDT-RAM can be exported to EXCEL® for statistical analysis. A typical scatter plot of resonant frequencies in a given criteria range for a lot of 5000 parts is shown below.

Report Dates: 26-Sep-04 12:09:15 - 26-Sep-04 12:10:13
Setup Name: "C:\NDT\Test.stp"

Company Name: Test
Part Name: Parts 123
Production Run: 2004

Date	Time	STATUS	CRITERIA #1			CRITERIA #2			CRITERIA #3			CRITERIA #4	
26-Sep-04	12:09:32	PASSED	P	10102	1.8071	P	20883	0.3775	P	29133	0.0332	P	36750	0.0328
26-Sep-04	12:09:34	PASSED	P	10102	3.0346	P	20883	0.8493	P	29133	0.0871	P	36750	0.0386
26-Sep-04	12:09:37	PASSED	P	10102	1.0709	P	20883	0.4106	P	29133	0.0443	P	36750	0.0140
26-Sep-04	12:09:38	PASSED	P	10102	2.8046	P	20883	0.1199	P	29133	0.0286	P	36750	0.0487
26-Sep-04	12:09:40	PASSED	P	10102	0.4268	P	20883	0.2684	P	29133	0.0276	P	36750	0.0081
26-Sep-04	12:09:56	FAILED	P	10125	0.3425	F	20977	0.9665	F	29273	0.0750	F	36914	0.0139
26-Sep-04	12:10:03	FAILED	F	9891	1.0599	F	20484	0.2765	F	28969	0.0847	F	36445	0.0935
26-Sep-04	12:10:07	FAILED	F	9891	1.2375	F	20742	0.9112	F	29016	0.0313	P	36703	0.0104
26-Sep-04	12:10:11	FAILED	F	9891	2.7080	F	20484	0.1852	F	28992	0.0562	F	36445	0.0182
26-Sep-04	12:10:13	FAILED	F	9867	1.2891	F	20484	1.2729	F	28969	0.0332	F	36445	0.0544
Total Passed:	5		6			5			5			6		
Average Passed:	50.00%			10105.5	1.6418		20882.8	0.46		29136.2	0.0379		36740	0.0249
Std Dev Passed:				12.2	1.0262		0	0.335		0	0.0299		17.1	0.0143
Total Failed:	5		4			5			5			4		
Average Failed:	50.00%			9884.9	1.6857		20634.4	0.7225		29043.8	0.0561		36595.3	0.0363
Std Dev Failed:				11	0.7289		198.1	0.4209		116.2	0.0215		193	0.0336
Total:	10		10			10			10			10		

Structurally similar parts exhibit consistent resonant frequencies



Statistical outliers indicate presence of a structural defect

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	ET	MT/PT	UT	RT	RAM
Defect Type					
Cracks/chips/porosity/voids	Yes	Yes	Yes	Yes/No	**Yes**
Missed processes/operations	Yes/No	No	Yes/No	Yes/No	**Yes**
Material property	Yes/No	No	No	No	**Yes**
Structurally significant	Yes	Yes	Yes	Yes	**Yes**
Product lot variations	Yes/No	Yes	Yes	Yes	**Yes/No**
Defect Location					
Surface (external)	Yes	Yes	Yes	No	**Yes**
Internal	No	No	Yes	Yes	**Yes**
Brazing/bonding/welding	No	No	Yes/No	Yes/No	**Yes**
Speed/Training/Cost					
Part throughput	Medium	Low	High	Low	**High**
Training requirements	High	High	Medium	High	**Low**
Overall inspection costs	Medium	Medium	High	High	**Low**
Automation Capacity					
Quantitative results	Yes/No	No	Yes/No	No	**Yes**
Automation requirements	Medium	N/A	Complex	Complex	**Easy**
Automation cost	Medium	N/A	High	High	**Low/Medium**

Traditional NDT technique comparison

Traditional NDT techniques focus on detecting *and* diagnosing defects. They use visual techniques or imaging to scan for any indication of defects. These scanning methods include magnetic particle testing (MT), ultrasonic testing (UT), eddy current/electromagnetic testing (ET), dye penetrant testing (PT), and X-ray/radiographic testing (RT), and are often manual and require subjective interpretation by an operator. As a result, the operator requires a certain level of technical training and/or certification to properly diagnose such indications of defect and infer the effects on the functionality of a part. Additionally, whenever such a technique requires the judgment of an operator, overall reliability suffers. Some studies suggest a reduction in reliability of up to 20% for subjective human interpretation and operation.

While diagnosing specific defects is applicable when evaluating an individual part or system, it is not appropriate for high volume 100% manufactured part inspection. For these cases, it is of primary importance to detect *if* a part is non-conforming rather than *why*. Identifying the type of defect itself is secondary to identifying the non-conforming parts. Therefore, an end-of-line "go/no go" objective inspection, such as by RAM NDT, is preferred here to a slower subjective diagnosis.

Resonant inspection (RI), specifically RAM NDT, measures the structural response of a part and evaluates it against the statistical variation from a control set of good parts to screen defects. Its volumetric approach tests the whole part, both for external and internal structural flaws or deviations, providing objective and quantitative results. This structural response is a unique and measurable signature, defined by a component's mechanical resonances. These resonances are a function of part geometry and material properties which are the basis for RI techniques. By measuring the resonances of a part, one determines the structural characteristics of that part in a single test. The simple, single screen graphical user interface shows these resonant frequencies and, more importantly, provides clear indication of the resulting "go/no go" inspection.

After defective parts have been sorted with RAM NDT, complementary NDT techniques provide a means for subjective diagnosis on the smaller subset of parts. This is useful for determining a defect's root cause and ultimately improving the production process.

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