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INTEGRATED TEST PLATFORMS: TAKING ADVANTAGE OF ADVANCES IN COMPUTER HARDWARE AND SOFTWARE

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ABSTRACT

Ongoing hardware, software and networking advances in low-cost, general-purpose computing platforms have opened the door for powerful, highly usable, integrated test platforms for demanding industrial application. With a focus on the automotive industry, this paper reviews the pros and cons of integrated test platforms versus single-purpose and stand-alone testers. Potential improvements in in-process testing are discussed along with techniques for effectively using such testing to improve daily production quality, to maintain high production rates, to avoid unplanned downtime, and to facilitate process and product improvement and refinements through the use of monitoring, data collection, and analysis tools.

INTRODUCTION

Manufacturing test platforms come in many shapes and sizes, as does the concept of integration. Integration can be in the form of combining different test technologies onto a single platform in order to improve production rates, or it can be in the form of sharing or multi-tasking advanced test controllers in order to minimize capital investment. Alternatively, effective integration can exist only at the conceptual level by integrating only the test data, resulting in a greater understanding of the total picture. This paper touches on each of these in turn.

IN-PROCESS TESTING

In-process testing is key to product quality and consistency. The standard focus of in-process testing is accuracy and repeatability, which is key to maximizing product quality while minimizing costs. Often overlooked though, is the opportunity for an organization to extract the maximum value from its test data for the benefit of both the manufacturing process and the product design. Cost effective improvements that result in more accurate test data, more efficient collection of test data, or better use of test data can be leveraged to create a competitive advantage and to improve profits. Several enabling technologies now exist to do just that.

Enabling Technologies for improved Testing

Technological advances in personal and office computing continue to create new opportunities for extending he capability and value of in-process testing. These advances include:

* Low cost, high speed computing platforms
* Low cost, high speed data networks
* Low cost, ultra high capacity storage devices
* Advanced, easy to use operating systems
* Software advances that facilitate the rapid creation of solid products that simplify even the most complex of tests.

The resulting improvement opportunities exist at four levels:

1. Individual tests
2. Individual test stations
3. The complete production line
4. Multiple production lines; remote or local

Figure 1: Classical Leak Detection vs. Advanced Leak Detection

Part	Component	Leak Test Method	Trials	% Time Reduction	% Tests Within		
					± 2.5%	± 5%	± 10%
Engine Model 1	Cylinder Head	Classical	400	Baseline	N.A.	N.A.	89
		ALD	400	3%	N.A.	N.A.	99
Engine Model 2	Oil Cavity	Classical	100	Baseline	50	52	99
		ALD	100	40%	90	99	100
Non-engine	N.A.	Classical	60	Baseline	N.A.	N.A.	N.A.
		ALD	60	27%	60	90	100

Test Level Improvement Opportunities

Individual tests can be improved by improving the test method, the test implementation, or by some combination of these. Improved test methods sometimes result from revolutionary scientific advances, but, more often than not, improvements are evolutionary in nature. Advanced leak testing1 is one example of the later. By using high-resolution sensors, increased data collection, and incrementally smarter algorithms, test time can be reduced while simultaneously increasing test accuracy. For some applications, reduced test time can mean the elimination of an entire test station, for example, two stations to perform a given test instead of three stations. Figure 1 summarizes test accuracy and test duration improvements achieved for several applications when advanced leak testing technology has been applied.

Implementation improvements facilitated by the aforementioned enabling technologies include:

* Clear, intuitive user interfaces to minimize training costs and reduce operator error
* Test-to-test consistency using presentation standards, again to minimize training costs and reduce operator error
* Built-in diagnostics and troubleshooting tools for rapid detection and resolution of problems
* Advanced logging and data export options that enable process and product improvements through both real-time and after-the-fact data analysis.

Station Level Improvement Opportunities

Very significant, on-going savings can be achieved by doing more at a particular test station. Such station-level integration, where multiple tests are performed either concurrently or nearly concurrently y overlapping portions of different tests, have the potential for higher production rates through reduced overall test time and educed inter-station transfer time. Direct savings also result from fewer test stations and reduced real estate requirements.

Disadvantages of station-level integration include increased test station complexity, which is primarily a development concern, and increased dependency upon a single station, which can be addressed by an adequate spares policy.

Example: Station-level integration

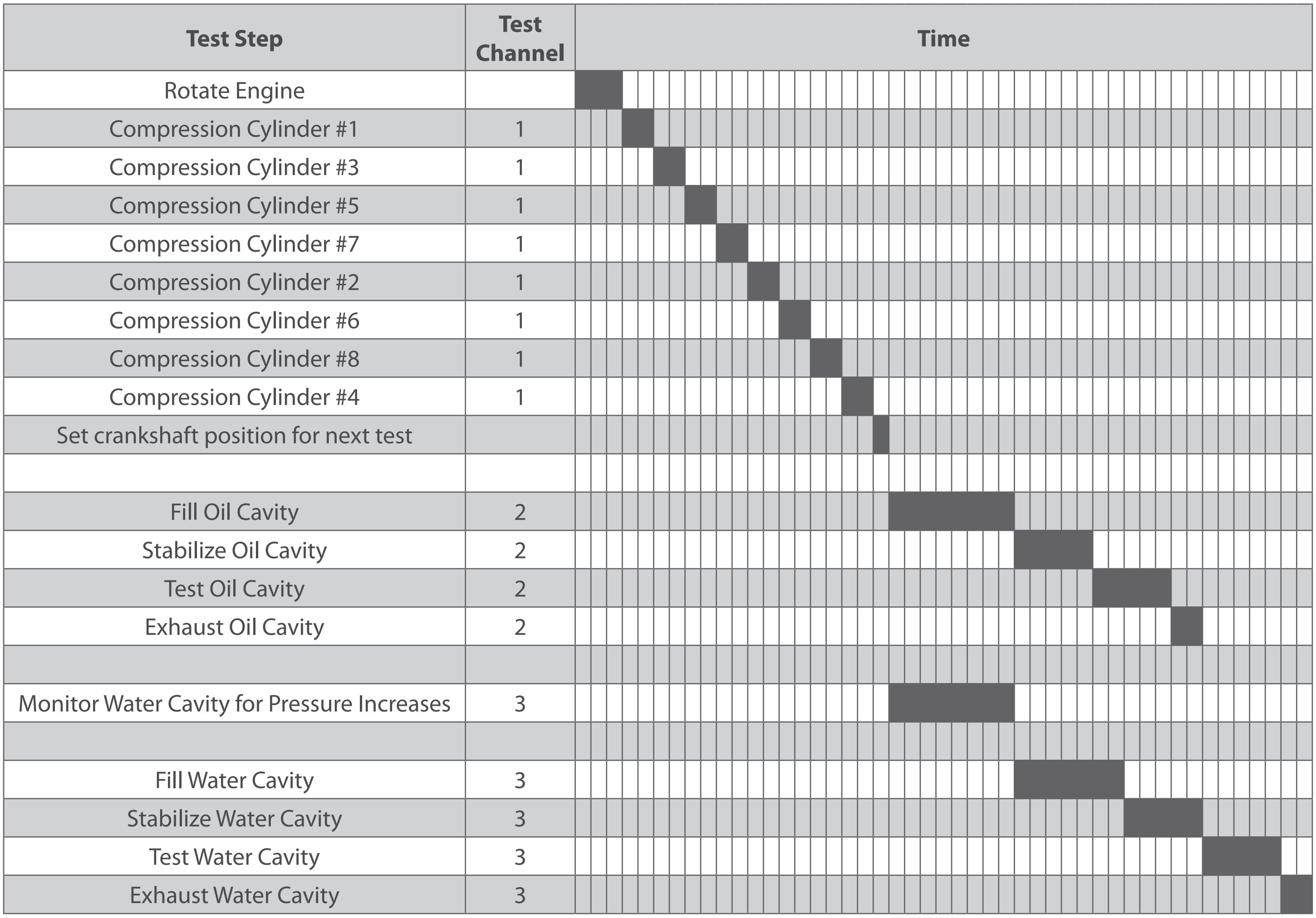
One example of station-level integration is to combine leak testing of the water jacket and oil cavity with green-engine compression testing.

During the machining of the engine components, cylinder block, and cylinder heads, they are leak tested to assure there are no leaks in the water cavities or in the oil cavities.

As the engine is assembled, the engine must be tested to verify the assembly of the seals, gaskets, and plugs.

The main areas to be tested are the water cavity, the oil cavity, and the compression of the power stroke of the engine. These tests can all be performed in one test station using state-of-the-art multi-channel testers, such as the Uson Vector.

Figure 2: Integrated Test Station: Engine Compression Test, Water Cavity and Oil Cavity Leak Tests



The test process first rotates the engine to establish the initial conditions for the compression test. Transducers at each spark plug opening measure the pressure rise due to the compression of the cylinder while torque and position sensors monitor the crankshaft. Pre-programmed limits for each cylinder as well as a detailed master "signature" of all sensor signals are compared against results for the part under test as each cylinder experiences its compression cycle, yielding quick test results. A failed compression test can abort the test sequence or continue with the leak tests in order to gather more information about the nature of the defect.

The compression test is exited with the crankshaft properly positioned for the subsequent leak tests of the water cavity and the oil cavity. Portions of these tests can be overlapped to minimize test time.

Because the oil cavity is the larger of the two cavities, the tester fills the oil cavity first. During this step the tester monitors the water cavity for a pressure increase in order to detect cross-wall leakage between the two cavities. Following this step, normal leak tests are performed concurrently on each cavity. Figure 1 illustrates the time line for the test steps.

Line Level Improvement Opportunities

Test controllers, running gigahertz-class processors, are capable of supporting multiple test stations concurrently. This approach diverges significantly from the current business model used by large manufacturers, but deserves consideration, as the potential exists for reducing initial deployment costs by tens of thousands of dollars. For example, a ten-channel test platform could support ten distinct tests. These tests could be distributed between one to ten different test stations.

The economic benefit of replacing ten $20,000 testers with a single $150,000 tester is obvious.

The introduction of a single point of failure for the affected test stations merits concern, but an adequate spares policy can mitigate this risk. Because of the fewer number of components, the actual mean time between failures for the system as a whole is reduced.

A second form of integration at the production line level is data integration: the creation of an integrated, global view of the test results and associated test data. From such a perspective, subtle trends can be detected that would otherwise go unnoticed, enabling emerging problems to be preemptively identified and corrected.

Data integration has only modest costs associated with it, yet I can result in tremendous savings both short term and long term by minimizing down time and facilitating product changes for improved manufacturability.

RESULTS MONITORING AND ANALYSIS

Regardless of the level of integration, monitoring and analyzing test results can yield significant gains. Benefits arise from monitoring test results real time as well as from after-the-fact analysis of data collected over weeks, months, or even years.

Real-Time Monitoring

A well-implemented and utilized information system can help improve production quality by enabling the timely detection of process level problems, and having a clear indication of the source of process problems can minimize the time needed to correct a problem. By pro actively monitoring quality-impacting trends as they happen, higher production rates can be achieved by correcting emerging problems before they result in product rejects.

Example: Early Detection Of Trends

Assume that for a particular test, a part is completely acceptable if its test results are below 100. However, by design, and confirmed by historically collected data, good parts, on average, pass the test with a value of 80. Furthermore, the tests are repeatable to within +/- 10% of the average value. By continuously monitoring this average over a period of hours, days or weeks, a monitoring system can detect emerging problems, such as excessive machine wear. When the running average reaches a configured threshold, say 90 for this example, the monitoring system automatically notifies a supervisor or maintenance personnel via e-mail or other mechanism, supplying sufficient details to enable investigation of the situation. With such early detection, corrective action can be taken before any parts are rejected. All of the parts may still be passing the test, but by a much smaller margin. Because of the normal variability in the results, casual observation of the data by an operator would likely not detect the worsening condition.

Historical Data Analysis

An important trait of a test results monitoring and analysis system is the ability to archive detailed test data and interim test results. By collecting and analyzing interim test results, as well as final test results, valuable insight can be gained into the types of problems that occur and the relative frequency at which they occur. Armed with this information, product improvements aimed specifically at reducing or eliminating those problems can be implemented resulting in increased manufacturability and fewer product rejects.

The accumulation of historical data also creates a detailed audit trail that can be beneficial for in-depth studies of process or product defects. The data archive can also be used for management reports and for tracking various improvement initiatives. Zoom-like capability in the analysis tool can facilitate rapid identification of problems, such as a misaligned pallet, by highlighting deviations at a high level, and then allowing an increasingly granular view of the test results. For example, if a weekly report summarizing the percent rejects by day shows an anomaly on Friday, then a "drill-down" feature would allow Friday's test results to be readily viewed by operator, by batch, or by pallet, allowing the underlying cause to surface.

Perhaps one of the greatest yet under appreciated values to accumulating a large body of test results is that the statistical distribution of those results can be ore fully understood. Understanding the true distribution of test results is key to optimally setting pas/fail criteria. Which in turn affect the number of good parts falsely rejected and the number of defective parts erroneously accepted.

Example: Needless Part Reworking

To minimize falsely accepted parts, reject limits are typically set lower than the true design requirements dictate. If this limit is not set optimally, an excessive number of false rejects can occur causing needless rework and retesting. By reviewing historical data to fully understand the distribution of test results, an optimal reject limit can be determined to minimize wasted effort.

CONCLUSION

The right combination of test equipment and tools can provide insight into process problems and potential product improvements that would otherwise be unavailable. Having insight into such subtle trends gives you the ability to preemptively solve problems for greater profitability. While low cost and stand-alone testers have their place, combining powerful and flexible test equipment with integrated information management will be the distinguishing hallmark of companies that survive today's competitive climate.

REFERENCES

1. *System and Method for Leak Rate Testing During Adiabatic Cooling*, U.S. patent 6,741,955 B2 dated May 25, 2004

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