Controlling Dynamic Spindle Runout

by R. J. Daruch and C. R. Merrett

How do you measure runout when using a drill bit the size of a hair?

Recent developments in controlling dynamic runout have eased the pressure that smaller holes and faster drilling speeds have placed on PCB fabricators. Defined as the orbit of a specific point on the rotating member of a spindle at speed, dynamic runout originates in the spindle, particularly in the collet, and is influenced by the drilling machine as well. Because it is not practical to measure dynamic runout at the tip of a 0.004" (0. I mm) diameter drill bit, measurement is usually taken on a precision gauge pin of the same nominal diameter as the drill shank clamped in the collet, at a point on the pin corresponding to the tip of the bit. New runout measurement equipment, used in conjunction with SPC. has enabled the production of spindles with low dynamic runout characteristics. The same technology can provide drilling machine manufacturers with known, repeatable dynamic runout measurements.

MEASUREMENT TECHNIQUES

While a static runout of less than 0.0002" total indicated runout (TIR) is achievable on all Westwind (Poole, Dorset, U.K.) spindles, this information does not provide proper indication of the more relevant runout measurement at operating speeds. Therefore, as part of a total quality assurance program, measurements are now made on all Westwind air-bearing spindles with the Lion Precision (Minneapolis, MN) Dynamic Runout System prior to shipment. The capacitance based, noncontact Lion system can carry out dynamic measurements of spindles at speeds in excess of I 50,000 rpm. To obtain consistent and repeatable results, rigorous measurement techniques must be maintained. Triple X standard calibrated ground carbide gauge pins are mounted up in the collet to simulate the drill. The pins must be straight to within 1 microinch. For a nominal 'A' collet bore, a 0.1250 ± 0.0001" diameter pin is used; a 3.000 ± 0.025mm diameter pin is used for a 3mm bore. The Lion probe is rigidly mounted on the spindle to view the tip of the carbide pin (Figure 1) at a typical distance of 0.75(19 mm) from the face of the collet. (This arrangement mitigates the effects of external vibration that might affect other systems where the probe is remote from the spindle.) The spindle is then run throughout its speed range. and a graph of the dynamic orbit of the tip of the pin is plotted.

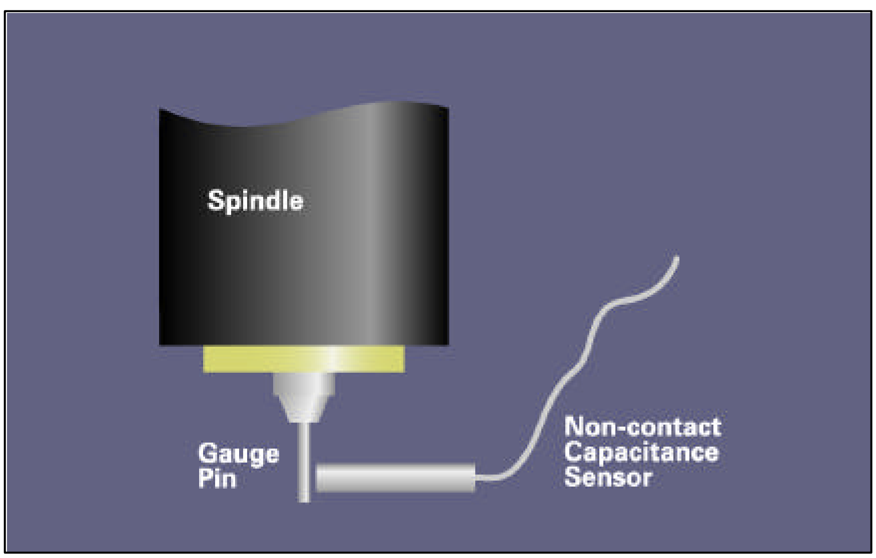

***Figure 1**. Capacitive-based measeurement of dynamic runout.*

An example of such a graph is shown in Figure 2. Shipped to the purchaser with the spindle, the graph indicates how dynamic runout for this particular spindle increases and then drops off before the spindle reaches its maximum operating speed of 100,000 rpm. Note that it is possible to get a variety of tracer curvatures over the speed range, all of which are acceptable. Although the measurements taken are very small, the measuring process is easily controlled in the proper environment. Great care must be taken in a production drilling room to ensure that results are repeatable, and it is of critical importance that clean, calibrated gauge pins are correctly and precisely positioned.

SPC To ensure that new and repaired spindles meet Westwind's dynamic runout standards, statistical process control (SPC) has been applied to this parameter. The dynamic runout figure used for SPC calculations is the maximum value recorded on each trace. Data from each trace is consolidated to produce a set of data for each production batch of every spindle type, and these Figures are plotted over time. This control ensures production consistency by providing an early warning if the graph begins to approach the specified spindle upper control limit. Alternatively, SPC is used to monitor improvements that have been made to a process or a constituent part.

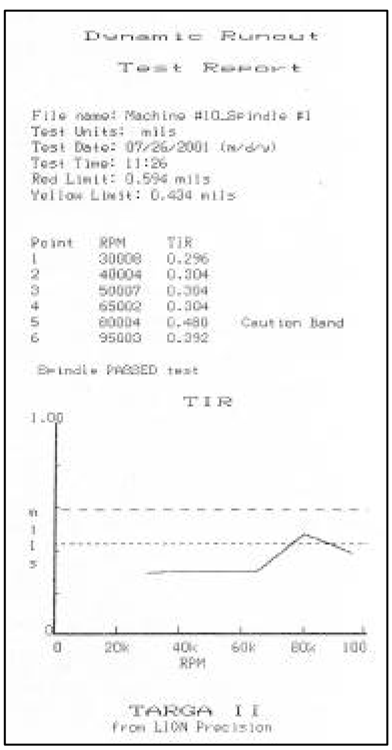

Figure 2. *Dynamic Runout printed report.*

Process control charts, compiled from test data taken at 120,000 rpm, showed that the mean level of dynamic runout for batches of Westwind spindles produced in the first half of 1991 did not exceed 0.00026" TIR. The. lowest mean, level for a spindle batch produced in 1991 was 0.00013" TIR. Dynamic runout levels were similar for two new air-bearing spindle models with different collet designs. The mean level across all batches of standard and new spindle models below 0.0002" dynamic TIR. Results such as these are made possible by putting great emphasis on designing and manufacturing very precise collet configurations.

CONCLUSION

By making full use of state-of-the-art measurement equipment and by applying statistical process control.

Westwind has achieved a 20% reduction. over previous levels of dynamic runout. Further reductions, which have already been achieved on many new spindles, are anticipated, as each of the constituent parts and processes influencing dynamic runout is statistically controlled.

To fully benefit from these improvements in dynamic spindle runout, printed circuit board fabricators must themselves meet two critical requirements. First, careful maintenance of the spindle (in particular, the collet) is essential if the high quality, low runout spindle performance is to be continued in a production environment. Second, in order to consistently monitor dynamic runout over time, it is vital that fabricators adopt the same rigorous disciplines followed by the manufacturer of the spindle.

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