The laser systems increases the machine tool performances by the measurement of volumetric accuracy and dynamic coordination.

OPTIMIZE THE PRODUCTIVE PROCESSES WITH FAST AND ACCURATE MEASUREMENTS

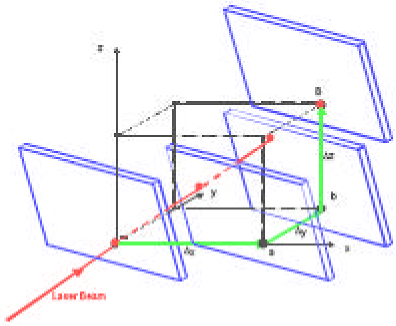
Specialized in the manufacture of laser instruments for machine tool calibration, metrology, OEM and many other industrial applications, OPTODYNE offer a range of product that includes the laser systems for the Volumetric measurement and calibration of squareness, straightness and linear positioning errors and for the non contact measurement of circular and dynamic coordination. Easy to setup and use, this solutions measure errors with accuracy and quickly.

by Mariarosa Colonnetti

With the" VECTOR" laser measurement in few hours can be determinate 3 position error, six for squareness and 3 for squareness.

The competition, in a global market as in the today arena, needs to increase the machine tool performances in order to obtain better productivity together with better cutted parts. With the last generation of CNC controller it is possible to have high accuracy even with less expensive machine. To achieve this result it is important to measure the volumetric errors and compensate it. The vault key is to measure those errors in fast and accurate way. In general it is not enough to only compensate the machine for the linear error on the three axes. There are many other errors as the straightness of the linear guideway, the perpendicularity, the effect of the barycentre of movement and of the counterbalance masses, that cause an error much higher the three linear errors. The larger part of the modern CNC controllers offer the capability for the volumetric compensation that is also called SAG or CROSS compensation. The volumetric error can be used to generate the volumetric compensation table that allow the CNC to compensate the machine errors and to obtain an higher volumetric accuracy.

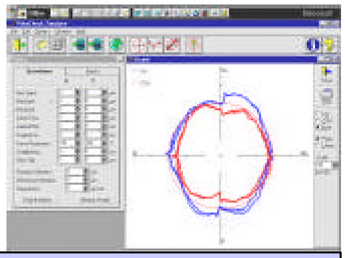
The sequential step or ***"Vector"*** method.



Using the laser "Vector" (patent-pending) method, three errors for positioning, six for straightness and three for squareness can be determinate in few ours instead of some days, as using conventional techniques. The fundamental point for the vector laser measurement technique is that the direction of the laser beam (the measurement direction) is not parallel to the movement direction. The results is that the measured error is the sum of the linear positioning error and the error due to the deviation from the ideal straight line. A method for the application of this technique is to perform the step sequential measurement. The laser beam is directed along the diagonal direction; instead of moving the axes x, y and z continuously into the diagonal direction, the machine is programmed for the the x axis movement, stop and take the data, than move y, stop and take the data and successively move z stop and take the data. The process is repeated till the opposite side of the diagonal is reached; for this reason is called sequential step diagonal measurement method.

Most of the modern CNC have the possibility to perform volumetric compensation (also called SAG or CROSS compensation); the volumetric error can be used for the compensation file generation that allow the CNC to compensate the machine errors obtaining an higher volumetric accuracy.

Dynamic Circular Contouring Measurement



For high quality and productivity machining, high speed machining operations or die and mold manufacturing, to achieve the high precision and super-finishes, static positioning accuracy is not enough. The acceptable contour will depend on the volumetric positioning accuracy and the dynamic contouring accuracy, the machine acceleration and deceleration rate, and the servo algorithm. The standard verification of machine contouring accuracy is the use of circular tests. The circular test provides a rapid and efficient way of measuring a machine tool's contouring accuracy. The circular tests show how the two axes work together to move the machine in a circular path. As the machine is traversing with multiple axes along a circular trajectory, each axis goes through sinusoidal acceleration, velocity and position changes. The measured circular path data will show any deviation the machine makes from a perfect circle. The shapes are diagnosed and correlated to servo mismatch, backlash, reversal spikes, squareness error, cyclic error, stick slip, machine vibrations, etc.

OPTODYNE offers many laser instruments, the spindle eccentricity con be also determinate.

The non-contact laser circular contouring measurement

In today's manufacturing world, high-speed machine tools are frequently required to deliver accuracy in the order of a few micrometers, while moving at relatively high feed rates. It is important to know what is the maximum feed rate while meeting the required accuracy. For example, for most dies and molds the radius of curvatures are less than 50 mm and the feed rates are a few meters per minute, and it is more desirable to perform the contour tests at smaller radius and at high feed rate. Most telescoping ball bar systems normally work with radii of 50 mm to 600 mm, hence the inability to perform circular tests with smaller radii as required in some applications. Also, the errors the telescoping ball bars detect usually are a combination of problems with the machine's geometry and the controller or servo systems. These errors are then larger than those produced by the control loops only. Using laser/ballbar is designed for the non-contact circular contouring measurement (Patent pending). The hardware used for the test are an MCV-500 laser calibration system, an optical adapter, and a flat-mirror target with an adjustable mount, a PC interface card, and a notebook PC with Windows™ software. For a small radius or high feed rate circular test, high data rate is required. With a special PCMCIA interface card, a data rate up to 1000 data/sec can be achieved. The software for the data collection and data processing is a Windows based software. With a few clicks, the data can be collected automatically and processed to generate a polar plot of the circular path.

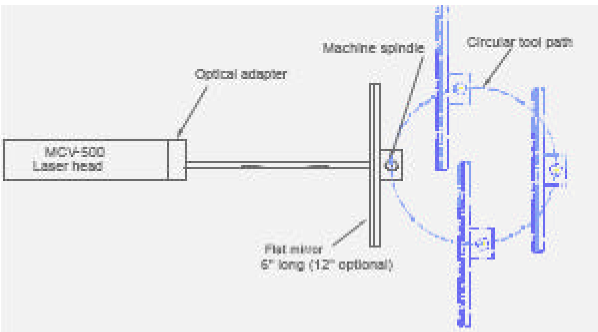


FIG. 8-4 SCHEMATIC OF LASER CIRCULAR TEST

Perform a laser/ballbar measurement

To perform the measurement, the laser is pointing perpendicular to the flat-mirror, which is mounted on the spindle. As the machine spindle moves along a circular path, the flat-mirror remains perpendicular to the laser beam and the displacement along the laser beam direction is measured even with a large lateral movement. Second, repeating the same measurement in the direction 90 degrees from the previous measurement with the same spindle motion, the displacement along the laser beam direction is again measured. Assuming the spindle motion is repeatable, the data on these two measurements can be combined to generate the actual circular path.

With the laser/ballbar can be measured the actual feed rate, velocity and acceleration profile

Comparison with a telescoping ballbar

The laser/ballbar is a 2-dimensional measurement, both the x coordinate, and y-coordinate are measured to generate the circular path. The telescoping ball-bar is a 1-dimensional measurement, only the radius changes along angular positions are measured. Of course, the 2- dimensional laser/ballbar measurement will provide more information, such as feed rate or tangential velocity and acceleration. The laser/ballbar measurement is non-contact. Hence centering is not required and the radius of the circular path can be continuously varied. For a telescopic ballbar, there is a cable between the transducer (inside the telescoping bar) and the electronic processor. This cable is always in the way and makes the circular path with multiple revolutions very difficult if not impossible. Also, because the length of the telescoping bar is fixed, the radius of the circular path are fixed and very difficult to do small radius circles. The laser/ballbar uses a laser Doppler displacement meter for the measurement. Hence the accuracy is very high, typically 1 ppm and traceable to NIST. The telescoping ballbar uses a transducer for the measurement. Hence the accuracy is low, need periodical calibration and it is sensitive to temperature changes. Of course, two sets of measurements with two setups are needed for the laser/ballbar to generate the circular path as compare to telescoping ballbar, only one setup and one set of measurement is needed. Additionally with the laser/ballbar can be measured the actual travel speed, the velocity and acceleration profile curves: these parameters are important for the determination of the dynamic of movement and for the servo system performances.

Performance	Laser/ballbar	Telescoping ballbar
Measurement sensor	Laser Doppler Displacement sensor	Transducer
Measurement method	Measures x-coordinate and y-coordinate to generate the circular path. Basically a 2-dimensional measurement	Measures the radius changes along angular positions on a circular path. Angular positions are not measured. Basically a 1-dimensional measurement.
Sensor Calibration	Linear accuracy is traceable to NIST	Transducer needs periodical calibration
Sensor range	Up to a few meters	Up to a few mm
Non-contact measurement	Yes	No
Radius of circular path	Continuously variable from 1 mm to 150 mm	Fixed radius with increment of 50 mm
Measures feed rate	Yes	No
Sampling rate	1000 data/sec	250 data/sec
Maximum feed rate	Up to 240m/min	Up to a few m/min

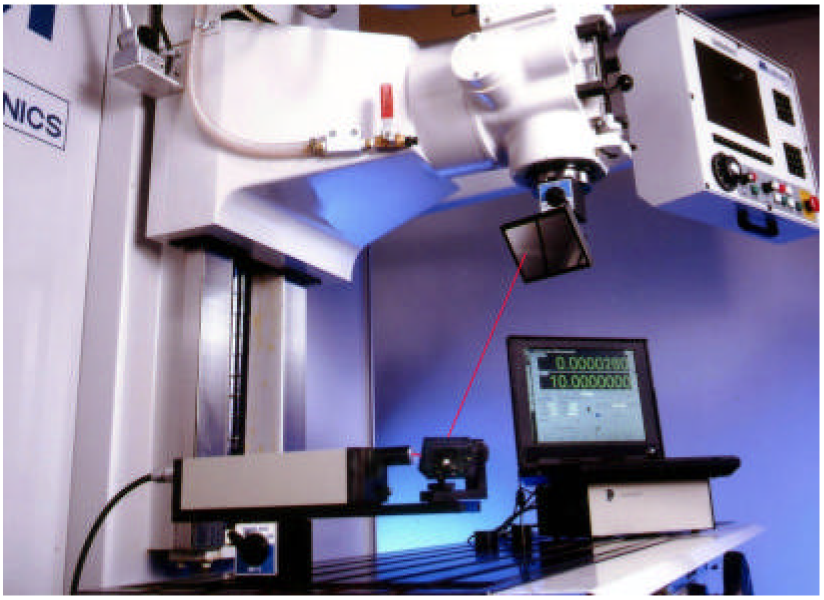
Comparison between laser/ballbar and telescopic ballbar

Systems based on the single coaxial beam laser

Manufacturing process control has long been recognized as an important and necessary milestone on the road to reduce cost, improve throughput and superior quality product. For the improvement of this process the laser systems are diffusing in this field. Optodyne design, manufacture and distribute precision laser instruments for the calibration and compensation of machine tools, metrology, OEM and a wide variety of industrial applications. This systems can be used for the incoming inspection , periodic calibration, scheduled calibration, ISO 9000 documentation, quick checks and diagnosis of problems. Volumetric calibration and compensation in 4 easy setups by your regular machine operator in as little as 2 to 4 hours for a working volume smaller than 1 cubic meter. The conventional approach takes about 5 times longer and requires a highly trained specialist. The measured volumetric positioning errors can be used to generate the 3 dimensional error lookup table for the on-machine probing. At high feed rates, to ensure high part accuracy die or mold manufacturing, the measured radius shrinkage and feed rate change can be used to check the dynamic compensation algorithms of the control and replace the expensive and time consuming cutting tests.

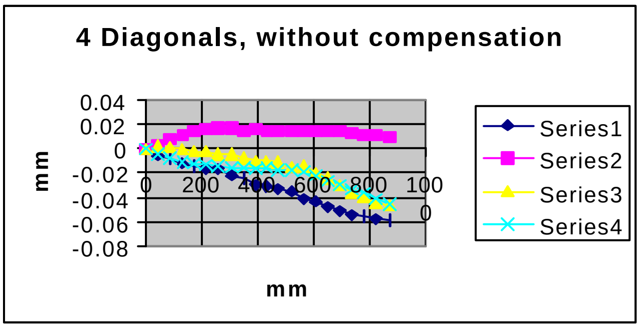
Laser Doppler Displacement Meter

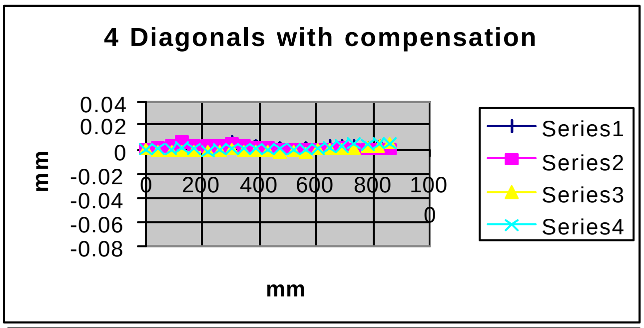
The Optodyne products are based on the patented technology (Optodyne proprietary) called LDDM Laser Doppler Displacement Meter that allow to produce high accuracy cost effect instruments precision measurement equipments for machine tool calibration and compensation, metrology, OEM, and a wide variety of other industrial applications. Optodyne offers many instruments and laser systems for volumetric measurement, measurement of linear positioning error, straightness, perpendicularity spindle eccentricity of rotation, dynamic measurement and vibration measurement, parallelism and alignment of guideway, measure of pitch and yaw angles, axis and rotary tables.



Laser calibration system

The large instrument selection of Optodyne includes MCV-500 a compact laser system for the calibration and compensation of CNC machine tools, coordinate measuring machines (CMMs),and other precision measuring machines and stages. This compact laser system is designed for easy setup and operation. The basic system, including Windows software, automatic temperature and pressure compensation, and accessories are packaged at an extremely affordable price. The system is very compact and fits in one small carrying case. The Windows software, running on any notebook computer, is user friendly and is designed to collect data automatically and to analyze data in accordance with a variety of industry standards, such as NMTBA, VDI, ISO and ASME B5.54. The laser system is calibrated and traceable to NIST. Compact and light-weight, rugged and long life, it is easy to setup and operate. No tripod and no interferometer are needed, it includes automatic data collection, automatic comp file generation and automatic environmental compensation for air temperature and pressure and for material temperature.





Comparison between the results of sequential diagonal test before and after compensation.

Volumetric Calibration and Compensation

SD-500 is an add-on package to the MCV-500 laser calibration system for the measurement of volumetric error components, including 3 displacement errors, 6 straightness errors and 3 squareness errors. The combined system provides a rapid and efficient way of measuring a machine's volumetric accuracy over the working volume. The software also generates axis specific files, 6 bi-directional displacement errors and 12 bi-directional straightness errors, that can be used to generate volumetric compensation tables. The available compensation file format is usable on controllers such as Giddings and Lewis, Milltronics, Siemens 840, Fanuc15, 16/18, and many others.

Non-contact circular contouring tests

LB-500 Laser/ballbar is an add-on package to the MCV-500 laser calibration system. The combined system is designed to perform circular contouring measurement of CNN machine tools, CMMs, and other precision measuring machine, for servo tuning and dynamic testing. The laser/ballbar provides a rapid and efficient way of measuring a machine's contouring accuracy along a circular path. The circular test shows how the axes work together to move the machine in a circular path The deviation from a perfect circle are caused by errors such as backlash, servo mismatch, scale mismatch, machine geometry, periodic errors, stick-slip, etc. A polar plot is then generated to show the machines true contouring capabilities, and a Polarcheck program is provided for the diagnosis of problems. Because of the unique capabilities, high data rates, high resolution and small radius, dynamic errors at high machine feed rates can be determined. The measurement is 2-dimensional, hence the true radius, velocity and acceleration can be determined.

Squareness and straightness measurement

SQ-500 is an add-on package to the MCV-500 laser calibration system for the measurement of squareness and straightness. The package includes a quad-detector and an optical square. The quad-detector is a precision position sensor, and the optical square is a precision pent-prism to bend the laser beam 90 degree. A laser produces an intense beam of red light which is a straight line of the greatest accuracy in a vacuum. In atmosphere, the straightness of a laser beam may be changed by temperature gradients or air currents. For a typical indoor condition, the stability of the laser beam is in the order of 0.0001"/ ft or a few µm/m. Longer average time may reduce the effect of turbulence or air current. SQ-500 is easy to align and setup, compact and light-weight Measures both squareness and parallelism.

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