Autocollimators

Squareness and parallelism measurement on machine tools

Introduction

Squareness and parallelism are key features to ensure precision during assembly and calibration of machine tools. Critical features include squareness of the main slideway to a column or to a second horizontal slideway and parallelism of guideways. These can all be measured to high accuracy using an autocollimator together with an optical square and mirror (The optical square 142-77 will always bend the light through 90 degrees within 1 second: using our latest software we can error correct the 1 second error for improved accuracy).

Squareness measurement

The simpler application is squareness of the main slideway to the machine tool column (figure 1).

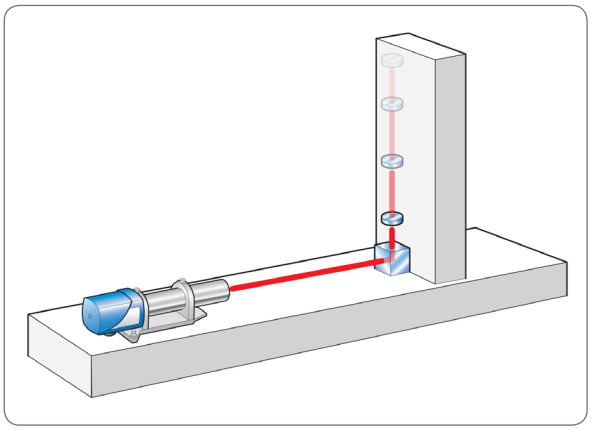
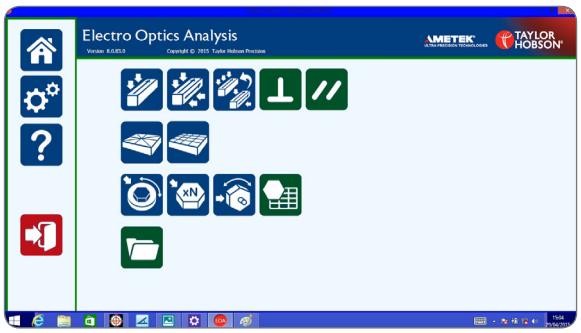
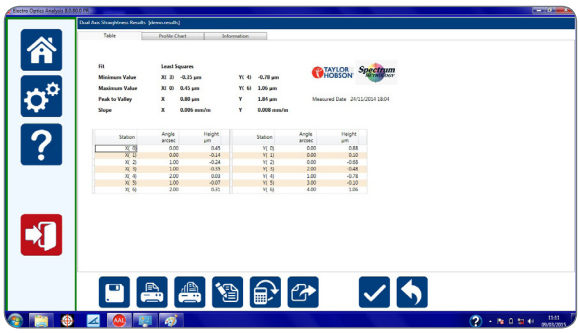


Figure 1

The autocollimator can be mounted directly on the machine or adjacent to the machines, on trivets, tripods or heavy duty stands. The reflector is mounted on a base and moved along the first rail - in this case the horizontal rail. A straightness measurement value and slope value is calculated at equal points along the rail. Leaving the autocollimator in the same position, the optical square is set up to bend the autocollimator light along the second (vertical) rail and the reflector, on its base, is moved up this rail (vertically). Straightness/slope measurement is also taken on this second rail. The out of squareness is the difference between the slope value for each rail.

Communication between the autocollimator and the operator on the tablet PC is icon driven and each stage of the measurement to be carried out is prompted by the PC display, which also indicates when any error in operation has occurred. The results are displayed in tabulated and graphical form. Along with the straightness calculation there is a value for slope. This slope value is important when measuring parallelism and squareness between slideways as it is the difference in slope value that determines the out of squareness.

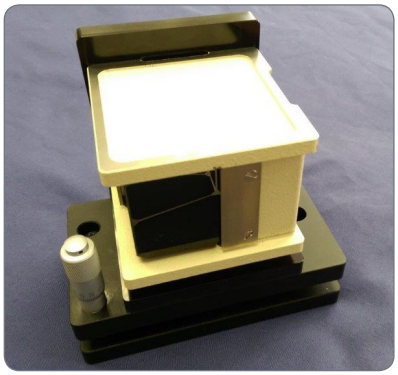




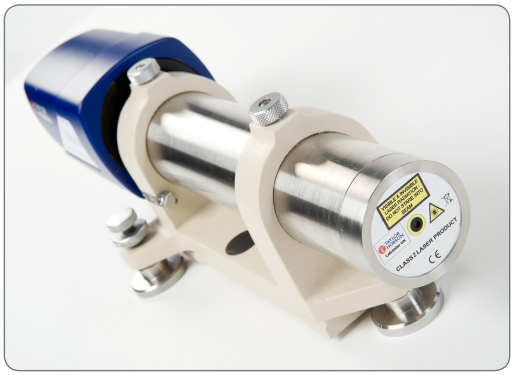
Using the Optical Square

It is imperative that the autocollimator is not moved between measurements when measuring squareness and parallelism; it is also important to align the front face of the optical square with the autocollimator. This can be done manually by using shims of some kind or using the 112-5439 adjustable table for optical square.

The job of lining up the reflector is made very easy by using the laser sighting aid which is supplied as standard with the Ultra Autocollimator.



112-5439 - Adjustable table



Autocollimator with laser sighting aid

The optical square will always bend the light through 90 degrees as long as the front face is square to the autocollimator in the one axis as shown below. If the optical square is not set correctly in this plane an error can occur.

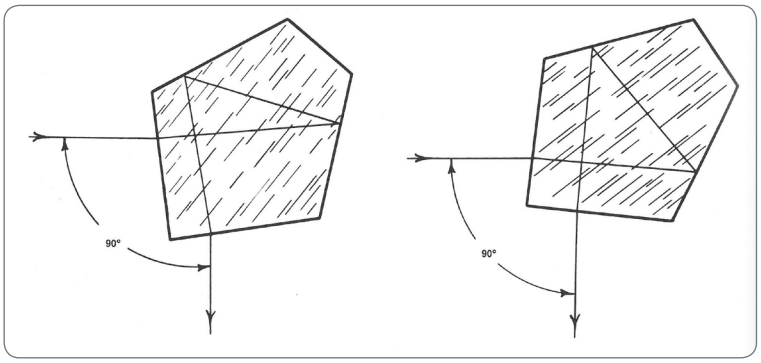


Figure A

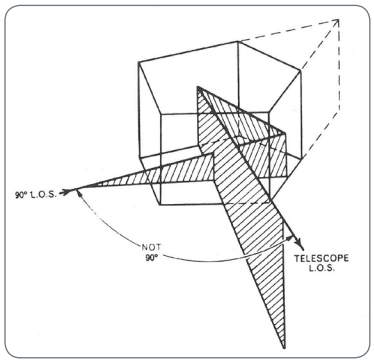
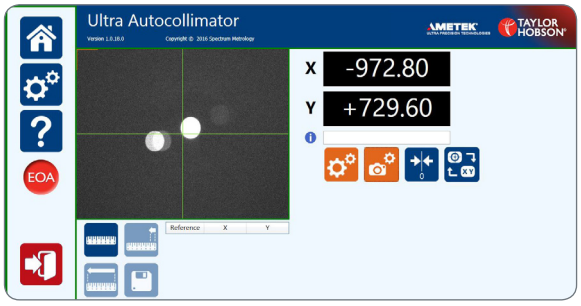
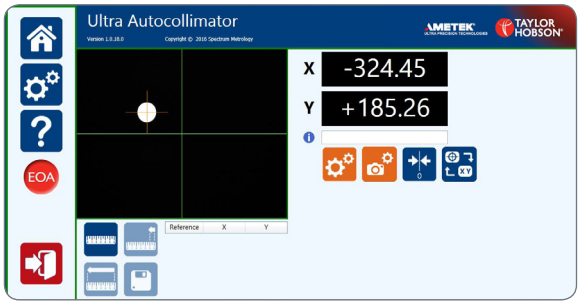


Figure B

The optical square always bends the light through 90 degrees to within 1 second (figure a) unless the front face of the optical square is not square to the autocollimator (figure b).

During set up of the optical square it is important that any ghost images (from the various reflective faces of the optical square) are removed from the autocollimators view by rotating the optical square:





Now the operator must make sure the mirror being used on the second axis (in this case the vertical axis) remains in range of the autocollimator over the entire rail. Again this is made easy by using the ultra autocollimator laser sighting aid.

Straightness readings for the vertical rail are then taken using the software – again there will be a slope value included in the results.

The out of squareness of the machine tool column to the main slideway is the difference between the two slope values . If the rails are square the slope values are the same. So for example if one rail had a slope value of 0.010 mm/m and the second rail a slope value of 0.015 mm/m the out of squareness would be the difference which is 0.005 mm/m, ie 5 µm/m which is approximately 1 second.

Note - make sure you get the signs correct when you are calculating the straightness. When using the software squareness icon you will simply be asked to input the two straightness results you wish to make a squareness calculation of.

Parallelism of Rails

The second common application which can be measured simply and accurately using the Ultra Autocollimator and optical square is the parallelism of 2 rails. To measure the horizontal squareness and hence out of parallelism, a similar procedure is followed as with the machine bed/column squareness checks.

Firstly, the autocollimator is positioned and set up with the optical square to measure the first rail. The autocollimator can be mounted on trivets, tripods or heavy duty stands and the reflector is moved on a base along the first rail. The Taylor Hobson Optical Analysis software will display the straightness measurements and also calculate the slope value. Leaving the autocollimator in the same position, the optical square and reflector are then moved to the second rail and the measurements repeated.

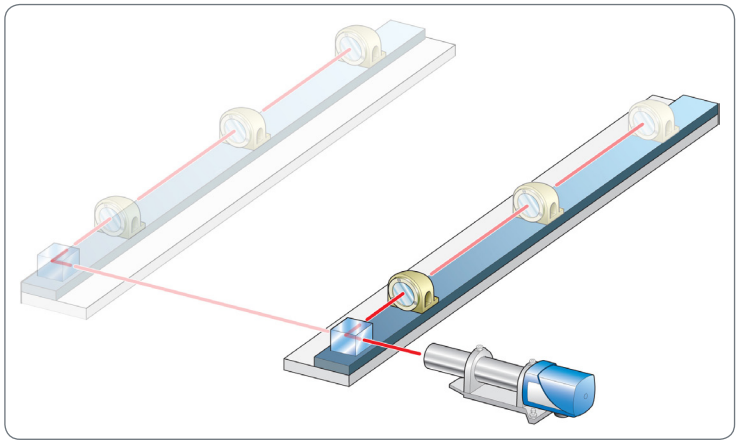
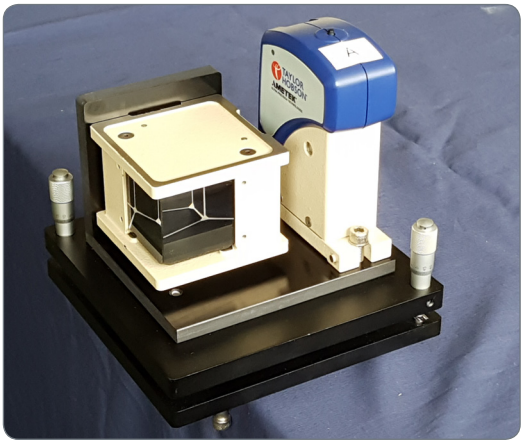


Figure 2



Adjustable table for Talyvel and Optical Square

Note - it is imperative that the autocollimator is not moved from the first rail position as this is the reference line. The out of squareness (parallelism) between the two rails is the difference in the individual slope values.

If it is important to put the two rails parallel and also in the same vertical plane, a Talyvel electronic level can be used to set the optical square in the plane of the two rails or a 'bridge' can be created across the two rails and the 'twist' option used.

There is also the option to set the optical square level at both rail ends. The mirror location pins/feet on the base must be parallel to each other if the mirror and base are to be used on both sides of the rails.

Demonstration

For a full demonstration video, please see - http://www.spectrum-metrology.co.uk/news/twin-rails.php.

Our electro-optical metrology product range comprises:

Micro-Alignment Telescope

Used for checking and setting for example:

- Alignment: (series of bores or bearings)
- Squareness: (column to a base)
- Parallelism: (series of rollers)
- Level/flatness: (machine bed foundation)
- Straightness: (rails or guideways)

...with its optical and mechanical axes aligned to within 3 seconds, a typical accuracy of 50–70 um at 30 m is achievable.

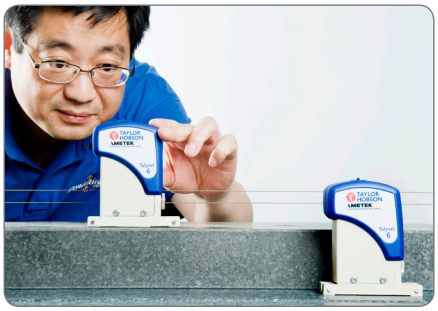
Autocollimators

Used for measuring for example:

- Angle: (indexing head accuracy)
- Straightness: (machine tool slides in two axes)
- Squareness: (spindles to slideways)
- Parallelism: (slideways)

...from inexpensive visual to dual axis digital systems capable of measuring 0.01 second, equivalent to 50 nm per m.

Electronic Levels & Clinometers



Used for angle and level measurements:

- Level/flatness: (granite tables)
- Straightness & twist: (machine slides)
- Squareness: (of machine columns)
- Angle: (remote monitoring of movement of structures)

...from full 360 degree measurement to level measurements to 0.1 second.

This application note demonstrates just one of the applications for the Taylor Hobson electro-optical metrology range.

Contact Spectrum Metrology to discuss your own measurement requirements.

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