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Gage Block Flatness and Parallelism Measurement

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GAGE BLOCK FLATNESS AND PARALLELISM MEASUREMENT

Introduction

The conventional methods described here for measuring flatness and parallelism can be useful in evaluating gage block geometry. It is important to realize, however, that limitations are imposed by the relatively small amount of data taken to describe a frequently complex geometric shape. Further limitations are imposed by the quality and precision of the measuring devices and the observer's carefulness. Photographing fringe patterns in the interferometric methods is a useful technique where more complete and objective measurements are needed or where permanent records are desired. Results from these methods should be judged in the light of the user's measurement problem.

Flatness Measurement

Various forms of an interferometer are applicable to measuring gage block flatness. All produce interference fringe patterns formed with monochromatic light by the gage block face and a reference optical flat of known planarity. Flatness is measured by evaluating these patterns.

The reference flat must be sufficiently plane in an area at least the size of the gage block surface so that fringe curvature can be attributed to lack of planarity in the gaging face. Typical commercially available reference flats, plane to within 1 or 2 microinches over a 2.5 inch diameter, are usually adequate.

Gage blocks 0.1 inch and greater can be measured in a free state, that is, unwrung, while gage blocks less than 0.1 inch nominal size should be wrung to an optical flat. Blocks less than 0.1 inch are generally flexible and have warped surfaces and there is no meaningful way of evaluating the flatness except by "wringing" the block to a fused silica flat. The flat should be of the same quality as the reference flat described above. The gage block is wrung to the flat using a wringing agent, that is, an oil film, and the wrung surface may be viewed through the back surface of the flat. The interface between block and flat should be a uniform grey color. Any light or colored areas indicate poor wringing contact which can cause erroneous flatness measurement. After satisfactory wringing is achieved, the upper (unwrung) face is measured for flatness. This process is then repeated for the remaining surface of the block.

Figures 1 and 2 illustrate typical fringe patterns. The angle between reference flat and gage block is adjusted to orient the fringes across the width of the face as in figure 1 or along the length of the face as in figure 2 and also to control the number of fringes, preferably 4 or 5 across and 2 or 3 along. Four fringes in each direction are satisfactory for square blocks.

Fringe patterns under these circumstances can be interpreted as contour maps. Points along a fringe are points of equal elevation and the amount of fringe curvature is thus a measure of planarity. Curvature can be measured as shown in the figures.

$$\text{Curvature} = \frac{a}{b} \qquad \text{in fringes}$$

For example, a/b is about .4 fringe in figure 1 and .9 fringe in figure 2. Conversion to length units is accomplished by multiplying the measured fringe fraction by the half wavelength of the interferometer light source. Light in the green range is approximately 10 microinches per fringe (½ wavelength), therefore the two illustrations indicate flatness deviations of 4 and 9 microinches respectively for green light.

Another common fringe configuration is shown in figure 3. This indicates a twisted gaging face. It can be evaluated by orienting the uppermost fringe parallel to the upper gage block edge and then measuring "a" and "b" in the two bottom fringes. The magnitude of the twist is a/b.

In manufacturing gage blocks, the gaging face edges are slightly bevelled or rounded to eliminate damaging burrs and sharpness. Allowance should be made for this in flatness measurements by excluding the fringe tips where they drop off sharply at the edge. Allowances vary but .02 inch is a reasonable bevel width to allow.

PARALLELISM MEASUREMENT

Parallelism between the faces of a gage block can be measured in two ways; with interferometry or with an electro-mechanical gage block comparator.

Interferometric Technique

In this procedure, blocks are wrung to an optical flat and an evaluation is made of the fringe pattern formed with monochromatic light by the gage block's upper face, the optical flat and the interferometer's reference flat.

Figures 4 and 5 illustrate typical fringe patterns. The angle between reference flat and gage block is adjusted to orient the fringes across the width of the face as in figure 4 or along the length of the face as in figure 5 and also to control the number of fringes, preferably 4 or 5 across and 2 or 3 along. Four fringes in each direction are satisfactory for square blocks.

The degree of parallelism can be measured as shown in the figures.

$$\text{slope} = \frac{a-a'}{b} \quad \text{in fringes}$$

For example, a-a'/b in both figure 4 and 5 is about .3 fringe. Conversion to length units is the same as described under flatness.

Points along a fringe are points of equal elevation and the slope of the block fringes relative to the platen fringes is thus a measure of the parallelism of the two gaging faces.

This method depends on the wringing characteristics of the block. If the wringing is such that the platen indeed represents an extension of the block's lower gaging face, then the procedure is reliable. If, however, a burr on the block or the platen or even a particle of dust between the surfaces permits only imperfect wringing, then the method is not reliable. Eliminating burrs and dust during wringing is essential.

Imperfect wringing is often difficult to detect by "feel", but wringing can be qualitatively judged if a fused silica optical flat is used as the platen. Once the block is wrung to the fused silica flat, the interface between block and platen can be seen through the back of the platen. The interface should appear uniformly grey when it reflects a plain light colored wall or ceiling. Any light areas or color in the interface indicates poor wringing.

Gage Block Comparator Technique

Electro-mechanical gage block comparators with opposing measuring styli can be used to measure parallelism. A gage block is inserted in the comparator as shown in figure 6 after sufficient temperature stabilization has occurred to insure that the block is not distorted by internal temperature gradients. Variations in the block's thickness from edge to edge in both directions (across the width and along the length of the gaging face) are measured. Tongs are recommended for handling the blocks to minimize temperature effects during the measuring procedure.

Figures 7 and 8 show locations of points to be measured with the comparator on the two principle styles of gage blocks. The points designated a, b, c, and d are midway along the edges and in from the edge about .02 inch to allow for normal rounding.

A consistent procedure is recommended for making the measurements:

(1) Face the side of the block associated with point "a" toward the comparator measuring tips, push the block in until upper tip contacts point "a", record meter reading and withdraw the block.

(2) Rotate block 180° so side associated with point "b" faces the measuring tips, push block in until upper tip contacts point "b", record meter reading and withdraw the block.

(3) Rotate block 90° so side associated with point "c" faces the tips and proceed as in previous steps.

(4) Finally rotate block 180° and follow the procedure to measure at point "d".

The estimates of parallelism are then computed from the readings as follows:

Parallelism across width of block = a-b

Parallelism along length of block = c-d

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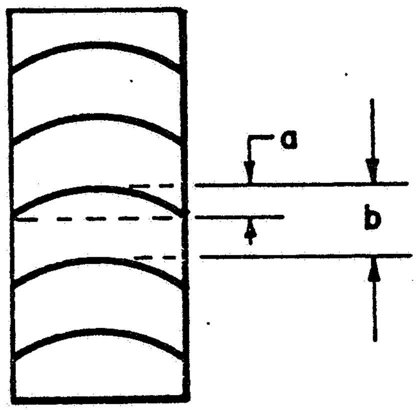


FIGURE 1

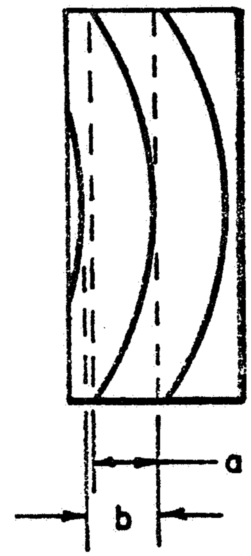


FIGURE 2

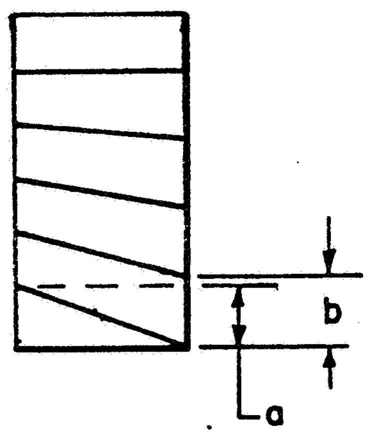


FIGURE 3

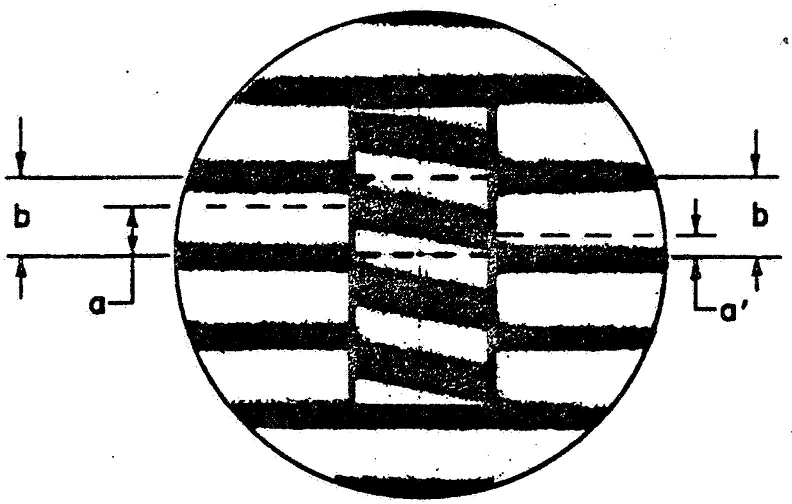


FIGURE 4

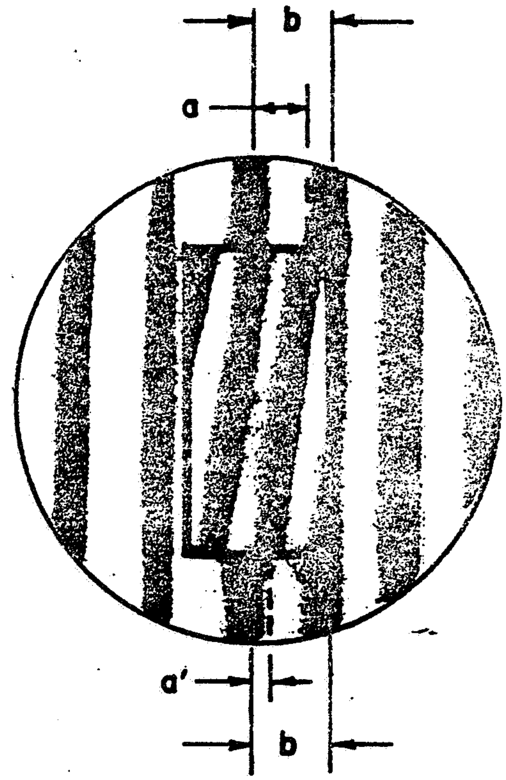


FIGURE 5

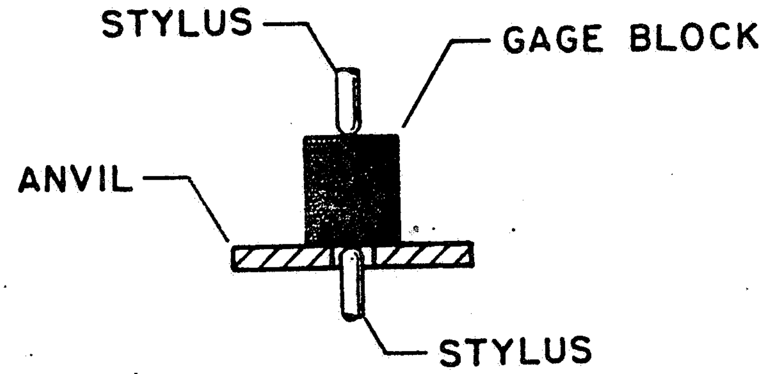
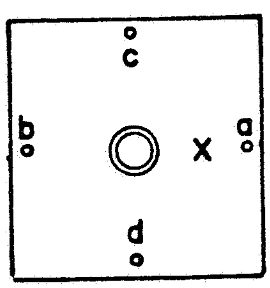
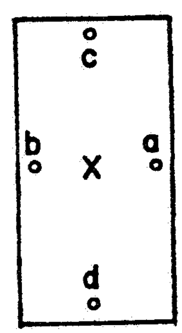


FIGURE 6

X=DEFINED GAGE POINT



UPPER GAGING FACE
FIGURE 7



UPPER GAGING FACE
FIGURE 8