An automatic interferometer capable to measure the gauge blocks up to 1,000 mm

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Abstract

An new system for absolute measurement of gauge block length by interferometry is described. The system is based on a Michelson interferometer which can measure the short gauge block and the long gauge block together. 3 frequency stabilized lasers are used as the light source of the interferometer for determining the length of the gauge block by the exact fraction method. The gauge blocks can be automatically measured after initial setting of the gauge blocks.

1 Introduction

The absolute length of the gauge block is usually determined by interferometric method. The gauge block interferometer is divided into two types: short gauge block interferometer and long gauge block interferometers. In general, the short gauge block interferometer can measure up to 250 mm in vertical setting and the long gauge block interferometer can measure from 250 mm to 1,000 mm in horizontal setting. Most of gauge block interferometers determine the length of the gauge block by evaluating the interference fringe. This interferometer requires multiple frequency stabilized laser sources. For higher accuracy, gauge block temperature measurement system, air refractive index measurement system and the temperature control system of gauge block are required. These systems are very expensive and very complicate to maintain. Many national metrology laboratories maintain the short gauge block interferometer and the long gauge block interferometer individually so that more investment and more space are required.

In this paper, we propose the new design idea of the gauge block measuring system that can measure the short gauge block and the long gauge block together. The gauge blocks can be fully automatically measured after initial setting of the gauge blocks on this system.

2 Measurement System

The interferometer is set on the cast iron block of which the cross-section dimension is 670 mm x 360 mm and the length is 1,270 mm. The temperature of the interferometer is controlled by the thermal chamber of which temperature is stabilized by an external thermo-circulator. The size of the chamber is 780 mm x 860 mm x 1,460 mm. Fig. 1 shows the schematic of absolute measurement system of the gauge block length. Three laser are used: a 633 nm commercial Zeeman stabilized He-Ne laser, a 543 nm two mode stabilized He-Ne laser and 772 nm frequency doubled acetylene diode laser, One light of lasers, which is selected by the shutter 1, passes the dichromatic mirrors and is focussed on the multimode fiber with 100 ㎛ core diameter. The light is incident on the interferometer after the speckles are moved by the fiber vibrator using speaker. The collimated light is divided into two beams at beam splitter BS and directed to reference arm and measurement arm. The optical wedge, which is set on the translator with a very accurate linear encoder in reference arm, is used to measure the excess fraction of a gauge block. The measurement beam is reflected at the mirror 3 and directed to the long gauge block LGB and the base plate. The long gauge block for measurement is selected by the translator with a linear encoder. For measurement of the short gauge block, the mirror 3 is removed and the measurement beam is vertically directed to the short gauge block by mirror 2. The short gauge block for measurement is selected by the rotation stage with a rotary encoder. 10 gauge blocks up to 250 mm and 3 long gauge blocks up to 1,000 mm can be loaded vertically and horizontally respectively. The reflected beam at the gauge bock and base plate is combined with reference beam at the beam splitter BS. The interference fringe is captured at the CCD camera CAM and analyzed to obtain the excess fraction. The lights from reference arm and measurement arm are focussed on the Position Sensitive Detector (PSD) and their XY positions are measured to get the information on gauge block alignment.

The temperature is measured by the precision thermisters: 6 sensors for gauge block temperature and 2 sensors for air temperature. One thermister is selected by the switch box and its temperature is measured by DC bridge. The computer automatically records the environmental parameters for air temperature, pressure, humidity. The concentration of CO_2 is manually input by key board.

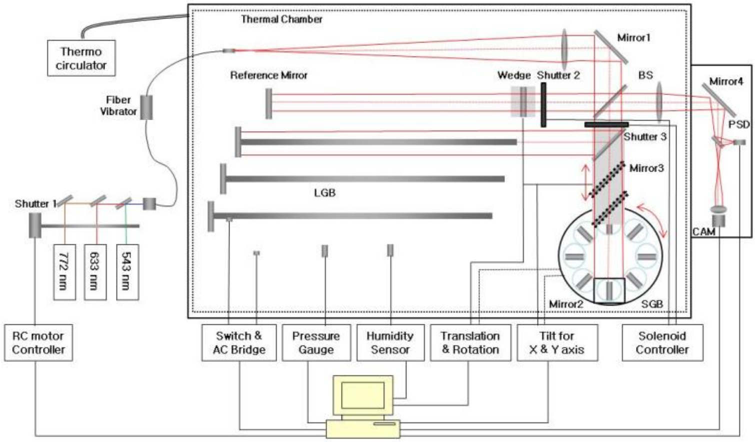

Figure 1: Schematic of hardware for absolute measurement of the gauge block

3 Measurement

After the gauge block is set on the system, it is positioned in order to be within the measuring window and precisely aligned to get the good interference fringe manually. The fringe interval and angle can be adjusted by two axis tilting system with 2 Pico motors. The XY position of the light from measurement arm (shutter 2 close, shutter 3 open) is measured by PSD. At the same time, the information on gauge block such as their nominal size, position number (encoder value of the translator or rotation stage), thermister number and PSD outputs is recorded. Above process is repeated for all gauge blocks for measurement. After thermal equilibrium, the automatic measurement starts. The gauge block is automatically selected and aligned so that the PSD value is same as the recorded value. The computer captures the interference and read the environmental parameters for three wavelengths and calculates the exact length of the gauge block. The above process is then repeated for all gauge blocks.

The traceability of the gauge block measurement ensured through the calibrations of the laser vacuum wavelength and the instruments for measuring the environmental parameters. The vacuum wavelength of the frequency doubled acetylene stabilized laser at 772 nm is defined at CCL and its value is confirmed by the optical comb. The frequency of the Zeeman stabilized He-Ne laser at 633 nm is measured through comparison with an iodine stabilized He-Ne laser. The wavelength of the 543 nm He-Ne laser is measured by the wavemeter. This laser is usually used for finding the fractional fringe order because its frequency accuracy is not so good. The thermisters are calibrated comparing with PT-25 SPRT and AC bridge used as a reference thermometer which is calibrated at the triple point of water and Ga melting point at temperature center of KRISS.

4 Conclusion

The designed interferometer can measure the short gauge block and the long gauge block together. 10 Short gauge blocks up to 250 mm and 3 long gauge blocks up to 1,000 mm can be loaded vertically and horizontally respectively. 3 Frequency stabilized lasers as the light source of the interferometer are used for determining the length of the gauge block. The measurement can be performed automatically after setting the gauge blocks and initial alignment. The temperature of the gauge block and the refractive index of air are measured. After the fractional interference order by the method of exaction fractions is calculated at a specified wavelength, other wavelength is selected and the fractional interference is determined. Then finally the length of the gauge block is calculated. The system is automatically operated so that the personal labour is reduced, and as both the long and short gauge blocks are measured on one system, (using common frequency stabilized lasers, environmental measuring system, optical equipment and thermal chamber) so further cost and space are saved.

References:

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