A STUDY OF GAGE BLOCK WRINGING

Rajesh K.Vegesna, Dr Robert J. Hocken
Center for Precision Metrology
University of North Carolina at Charlotte, Charlotte, NC 28223-0001

Abstract

The wringing of gage blocks has been studied for many years. Although surface tension is believed to be partially responsible for the adherence, surface finish of the blocks plays an important role. The surfaces of the wringable, non-wringable and stoned gage blocks have been studied using a white light interferometer and surface finish parameters computed. Also different filtering techniques were used on the data. In order to understand how the magnitude of the wringing force varies with distance, a method has been devised to study the force vs. displacement relationship between wrung gage blocks as they are separated.

Key words: gage blocks, wringing, stoning

Introduction

Gage blocks are still the primary artifacts for disseminating the unit of length through out the world. They are used for calibrating measuring instruments like calipers, micrometers etc. Gage blocks of different lengths are combined together by wringing in order to obtain a specific length. Wringing of these gage blocks plays a very important role in generating these lengths, as the blocks that do not wring well are not reliable and contribute more uncertainty to the measurements.

This phenomenon of wringing has not been completely understood. In the past a significant amount of research has been done on the wringing film to see how it accounts for the observed magnitude of wringing force [1, 2]. Earlier experiments also confirm a metal to metal contact by electrical measurements [3].

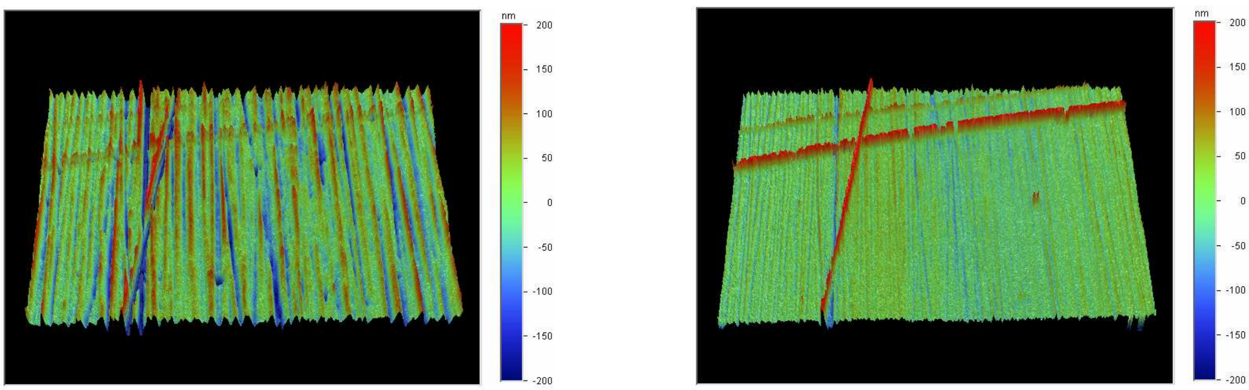
We are interested in seeing how the surface finish of the metals in contact effect the wringing force. The work aims at seeing if there is any correlation between surface parameters and wringing and characterizing the differences between wringable, non-wringable and stoned gage blocks.

The surfaces of the gage blocks have been measured using a Scanning White Light Interferometer, a Flatness Interferometer and an Atomic Force Microscope. Initially the non-wringable gage blocks were measured and remeasured after stoning to see how stoning affects the surface. A method to measure the wringing force has also been devised to study the force vs. displacement relationship as the gage blocks of different materials are being pulled apart. The current practices involved in gage block wringing and stoning have been surveyed.

Several surface finish parameters were investigated. Filtering techniques such as wavelet analysis were used to study the difference in surfaces of different gage blocks. In future the experimental results of the force and displacement measurement will be compared with a theoretical model [4] to test its applicability.

Experimental work

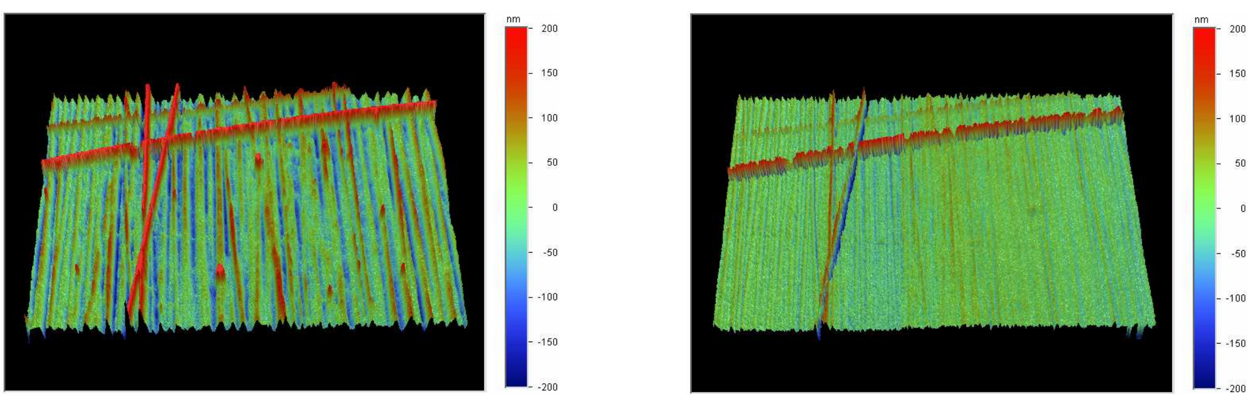
Surfaces of the non-wringable blocks were measured using a scanning white light interferometer with the 50X objective. Most of the measurements were performed on SWLI taking into account the measurement time. After being stoned and tested for wringability by a skilled worker the blocks were remeasured at the same location to observe the changes introduced by stoning. Fig 1 shows one of the images of a gage block surface before and after stoning. The measurements correspond to an area of 144µm X 108µm. Clearly the change in roughness indicates a very fine amount of material loss from the surface after stoning. There was no significant change in flatness.



(a) RMS-0.075 (b) RMS-0.037

Fig 1: Images of surface a) before stoning b) after stoning (µm)

In Fig2 it can be seen that the stoning also affected the area below the mean line. Scratches and pits on the surface disappear after stoning. Low and high pass filtering revealed that the high frequency components of the surface are not affected as much as the low frequency components.



(a) RMS-0.075 (b) RMS-0.037

Fig 2: Inverted images of surface a) before stoning b) after stoning (µm)

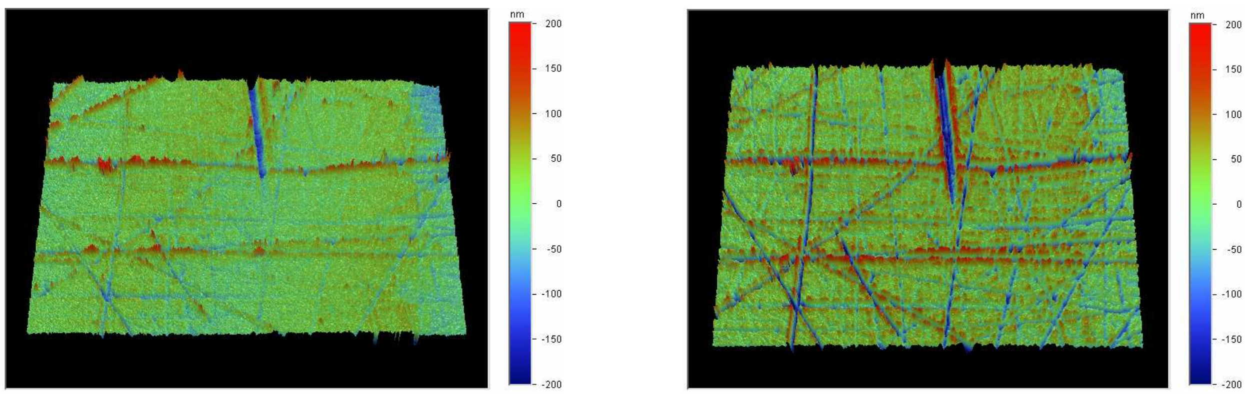
Table 1 shows the root mean squared values of wavelet amplitudes applied to a profile obtained from the surface of a gage block before and after stoning. It tells us that the higher wavelength components are affected more as the RMS dropped down significantly.

Wavelength	RMS (before stoning)	RMS (after stoning)
≤ 1.28	0.0086	0.0091

1.28-2.56	0.013	0.0128
2.56-5.12	0.0384	0.0231
5.12-10.24	0.0436	0.0156
10.24-20.48	0.0402	0.015

Table 1: Wavelet analysis of a profile before and after stoning, units: µm

Fig 3 shows another image which comes as a contradiction to our own measurements. After stoning, changing the block from non-wringable to wringable, the surfaces showed an increase in roughness. It's evident that the wringing force decreases with the increase of surface finish and the adhesion force varies greatly in magnitude for slight increase or decrease in roughness at nanometer scale [5]. There are no independent tests to check the wringability other than trying to separate them with hand. So it's difficult to get a good estimate of the wring quality.



(a) RMS-0.04 (b) RMS-0.07

Fig 3: Images of surface a) before stoning b) after stoning (µm)

The first method devised to measure the wringing force is shown in Fig 4. After wringing the two gage blocks, one of which is fixed and the other rests on the movable carriage of an air bearing, as they are separated a load cell and a capacitance gage are used to measure the force and displacement respectively. Due to the clamping problems the design has been revised and a new design is being currently tested.

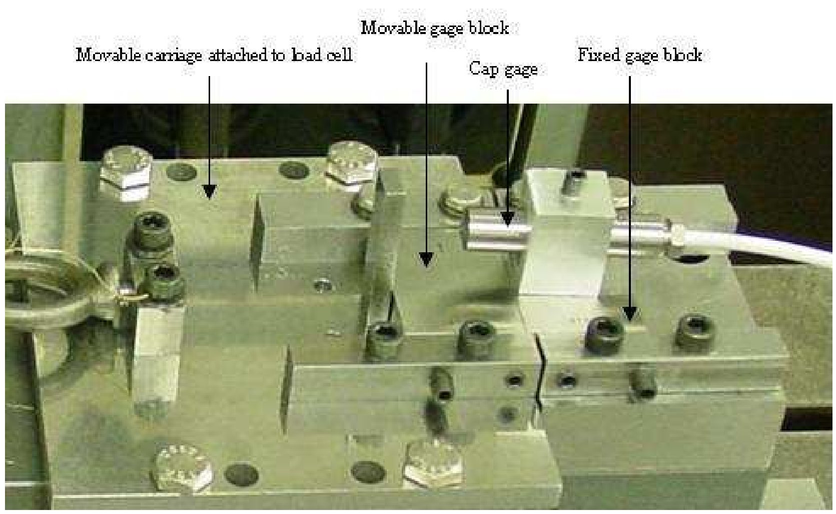
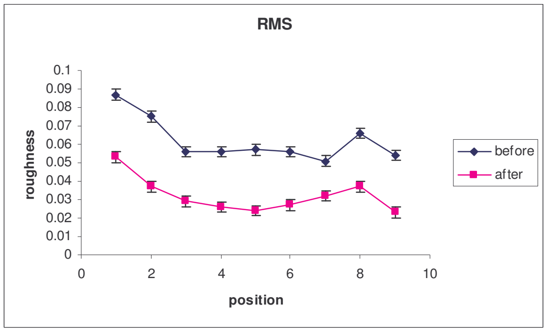


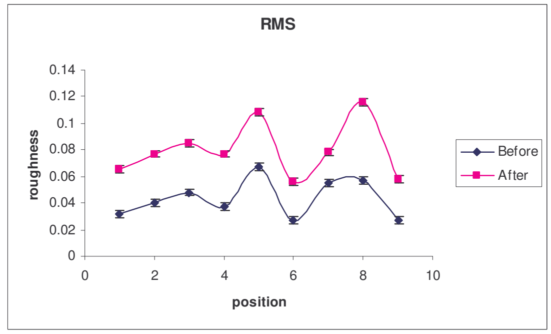
Fig 4: Measurement of wringing force

Results and Discussion

Gage blocks were measured at several positions on the surface. Fig 5(a) shows the roughness of surface of block measured at all the different positions. The roughness has decreased at all the positions after stoning. Fig 5(b) shows the results of the surface of block for which the roughness has increased at all positions



(a)



(b)

Fig 5: RMS roughness of before and after stoned surface at all positions, µm

Nicks, burrs, scratches and surface finish are mainly responsible for the lack of adherence between the gage blocks. A block with scratches and higher roughness might exhibit poor wringing. But a smooth block with even just a nick or burr will not permit wringing. Stoning the smooth block with a nick on it might have caused the roughness to increase by eliminating the nick, which could be the possible source of variation of measurement in the second case. The increase or decrease in roughness could be due to the variability of stoning pressures as not all blocks are stoned the same way and it depends on amount of reconditioning needed.

Conclusions

The changes in surfaces of gage blocks have been studied for the first time. Variations in measurements have to be better understood. In order to understand the wring quality the force vs. displacement measurements from the devised method might be useful, which is currently being tested. These measurements could also be used to verify the theoretical studies [4].

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