

# SCRATCHING SURFACES IN ROUGHNESS MEASUREMENTS

**S.Z. Zahwi and A. M. Mekawi**

Engineering Dimensional Metrology, National Institute for Standards  
Tersa St., Haram, Giza, 12211 Egypt

*Abstract: The calibration of the stylus type surface texture measuring instruments is usually carried out using a precision reference specimen of regular or random pattern of irregularities. These precision specimens are produced with hardened surfaces in order to minimize the scratching effect of the stylus on their certified values. The continual tracing on these surfaces is expected to deteriorate their quality. An experimental investigation on one of these specimens having a sinusoidal pattern of irregularity has been carried out. The specimen was traced several times on exactly the same position. Up to 350 traces were taken. From each trace a calibration constant for the measuring instrument was computed. Sets of three consecutive traces were taken and the average calibration constants obtained from each set was computed. The behavior of the results was studied, where it has been found that the mean values of the calibration constants continually decrease. After tracing the specimen for about 250 times a loss of more than 6% of its original value was obtained. The plots of the results as well as photographs of the scratches, taken using the Scanning Electron Microscope (SEM), are given.*

*Keywords: Instruments, Measurements, Roughness, Scratching, Stylus*

## 1 INTRODUCTION

With a stylus type surface texture instrument there is always a measuring load on the stylus to keep it in contact with the measured surface. As the dimensions of the stylus are finite, so also the load on it. Although the load is small the area of contact is also small that the local pressure may be sufficiently height to cause significant local elastic downward deformation of the surface being measured. In some cases the local pressure may exceed the flow pressure of the Material and plastic deformation i.e. irreversible damage of the surface may result Quiney [1], Tucker [2] & Guerrero [3] presented a number of scanning electron micro-graphs on stylus damage and concluded that the stylus scratches on steel surface were as much as 0.05  $\mu\text{m}$  deep. It is well known for all who work in the field of roughness measurements, that the stylus generally does make a visible scratch, and the scratch is held to be prima facie evidence of unacceptable damage. With the availability of precision reference specimen that are used for calibrating measuring instrument; and with the possibility that these surfaces are subjected to be traced many times for several months or years; this investigation has been carried out.

## 2 EXPERIMENTAL PROCEDURES

The specimen used in this investigation is a Standard Reference Material produced by NIST (SRM 2073) intended for use as standard for calibration of stylus instruments that are used to measure surface roughness. The SRM is a steel block of nominal Knoop hardness value of 500 and nickel coated by the electroless nickel process. The specimen was fixed rigidly under the stylus of a surface texture measuring instrument having 2.5  $\mu\text{m}$  tip radius and 1 mN (100-mgf) force Zahwi [4]. The specimen was then traced to calibrate the instrument and to obtain a calibration constant Zahwi and Mekawi [5]. The specimen was traced several times on about exactly the same line by traversing the pick up on the same position over the specimen. A calibration constant was computed for each trace. Sets each of three consecutive traces were taken one after the other. The average value for each set was computed, then the deviations or differences; of the constant obtained in each individual trace; from the average of its own set were computed. This procedure was repeated again and again 120 times giving 120 sets representing 360 traces. The behavior of the results was analyzed.

### 3 RESULTS

The calibration constant of each set of results was plotted against its turn Fig. 1. The deviations of the individual reading; from its own average value; within each set of traces was plotted Fig. 2. To normalize the results the average values of these sets were plotted on same line (zero line) in order to easily compare the deviation within each set of traces. The results of all individual readings are shown in Fig. 3.

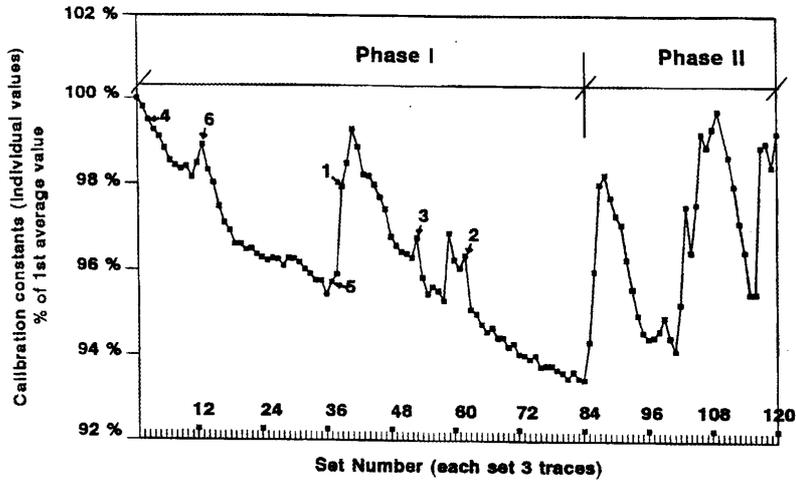


Figure 1. Behaviour of average results after a certain number of repeated traces

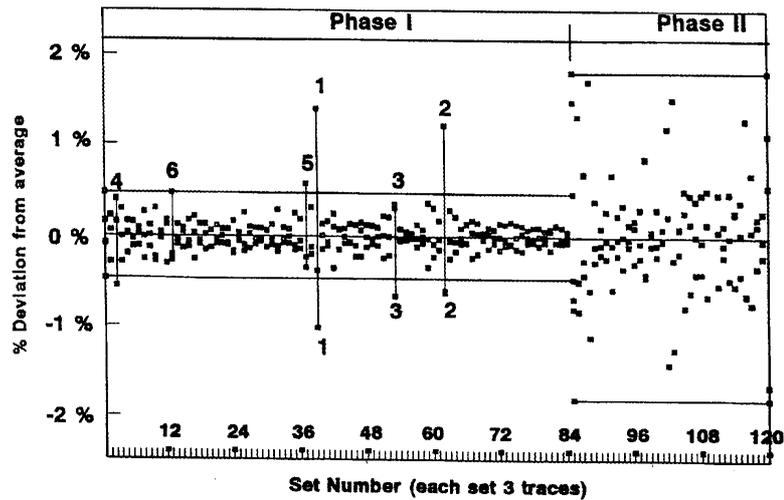


Figure 2. Scatter of individual calibration results around their averages

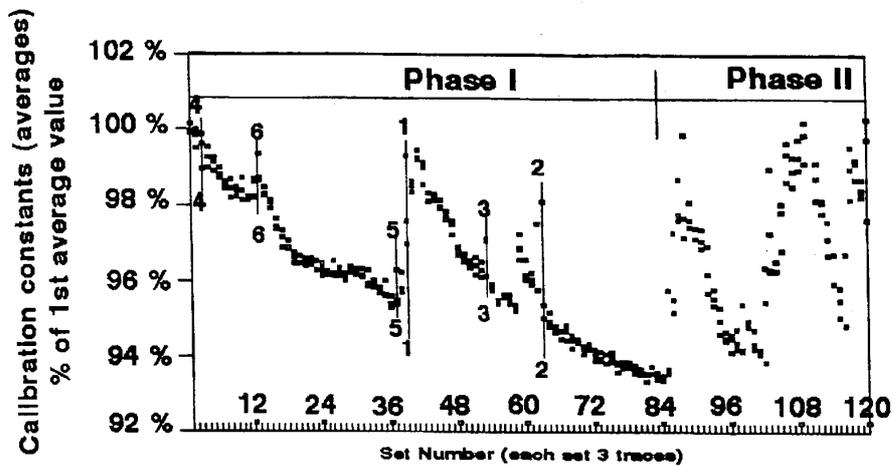
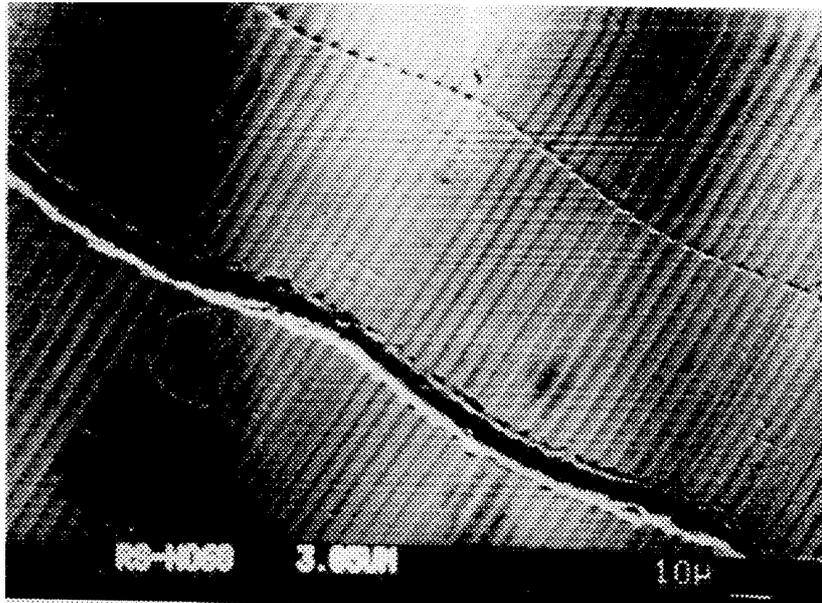


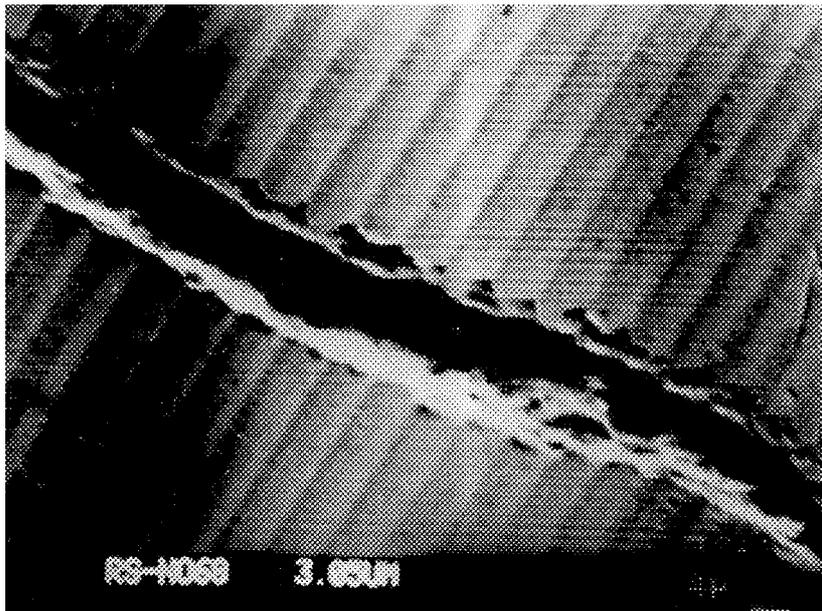
Figure 3. Behaviour of individual results after a certain number of repeated traces

#### 4 DISCUSSION

The behavior of the results could be divided into two phases. The first phase; phase I; is up to 252 traces (i.e. up to 84 sets) and the second phase, phase II for the traces taken after that. During phase I the scatter or deviations within each set is relatively small except few points as indicated by the arrows Fig. 1 and 2. In phase II it could be noticed that the deviations increased considerably. When carefully examining the measured surface of the reference specimen at the measured position at the end of the experiments, it was noticed that the surface had been widely scratched due to the repetitive traces that had been taken over the same position (360 traces had been traced over the same position). The scratch was examined under the Scanning Electron Microscope. The scratch photograph is shown in Fig. 4. To see how much the specimen surface is affected by the number of traces taken on it. Two more positions on the reference specimen were subjected to a different number of repeated traces. The effect when the position was traced 360 times, traced 30 times and 10 times are shown in Fig. 5. Taken with an optical microscope.

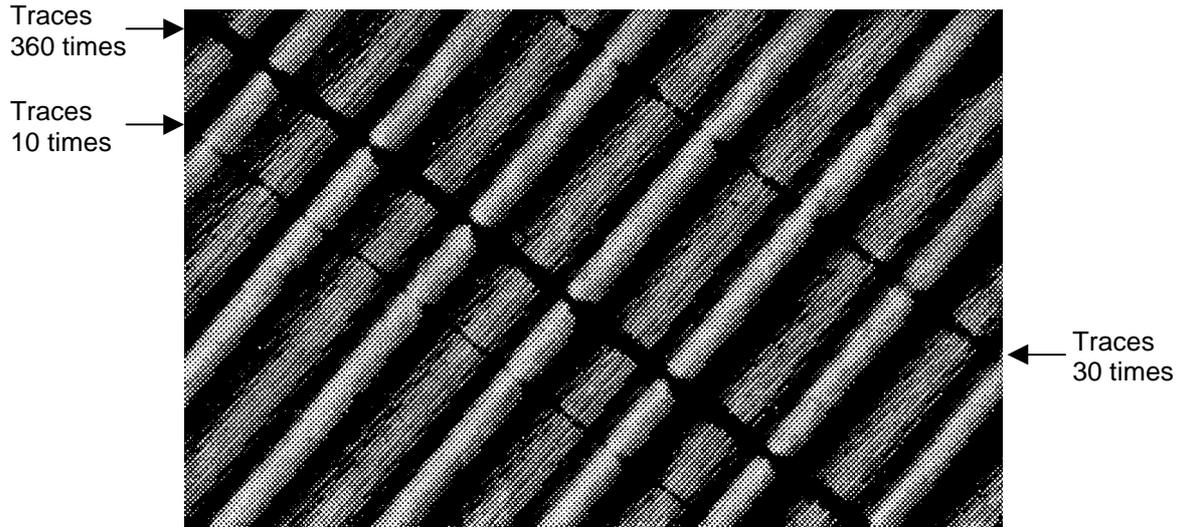


a)

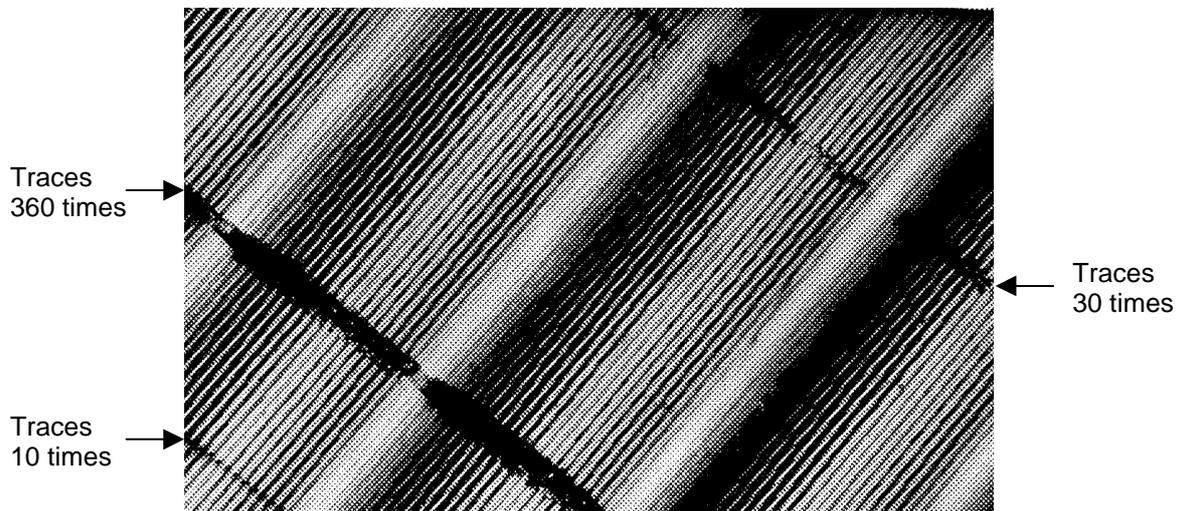


b)

**Figure 4.** View of the stylus scratch by Scanning Electron Microscope at different magnifications



a) Magnification:  $X50 \times 3 = X150$



b) Magnification:  $X100 \times 3 = X300$

**Figure 5.** View of scratches due to different number of repeated traced (by optical microscope)

It seems that the coating was scratched and partially removed by the stylus during the first 250 traces phase I and large deviations between results seems to have occurred from the particles removed from the scratch during phase II. In an explanation for the results obtained it is expected that the surface of the specimen is degraded due to the several traces taken on the same position and that the stylus after few traces penetrates beyond the coating or the surface layer on the specimen where the values of calibration constants are shown to be lowered; approximately after 10 sets i.e. 30 traces. Then and due to the particles separated from the surface, the stylus is pushed and climbs on the very near edge of the scratch which explains the relatively increase in scatter between results at that point i.e. point #6. The stylus then adjusts itself in a very near position (order of few microns near) and again a high value of calibration constant is obtained and approximately the same effect of deterioration or degradation occurs lowering the results values even more, then the stylus is pushed sideways to one of the edges where the scatter between individual results increase again e.g. point #1. This happens several times until the scratch becomes wide enough and holds the stylus within its edges and results of type shown in phase II are obtained where incoherent calibration values are obtained.

## 5 CONCLUSION

- 1- The calibration results of the stylus type surface texture measuring instruments taken using precision reference specimen made out of steel are affected by the scratching effect of the stylus on its surface, specially when the surface is traced many times on the same spot.
- 2- According to the experimental results obtained in this investigation more than 6% loss in the value of the calibration constant of the instruments could be obtained if the specimen is traced for about 250 times.
- 3- The scatter between repetitive results is noticeably increased after tracing the specimen for more than 250 times.

## REFERENCES

- [1] R. Quiney, F. Austin, and L. Sargent , Jr., "The measurement of surface roughness and profiles on metals", *ASLE Trans*, 10 (1967) 193 - 202.
- [2] R. Tuckr, Jr. and R. Meyerhoff, "An SEM study of surface roughness measurements ", *Proc. 2<sup>nd</sup> Annual Scanning Electron Microscope Symposium*, (IIT Research Institute, Chicago), 1969, p. 389 - 396.
- [3] J. Guerrero, and J. Black, "Stylus tracer resolution and surface damage as determined by scanning electron microscopy". *Trans. ASME J. Eng., Ind.*, (1994) 1087 - 1072.
- [4] Zahwi, S.Z. "NISURF measuring facility" National Institute for Standards Internal Reports, 1991.
- [5] Zahwi, S.Z. and Mekawi, A.M., "A software used in calibrating computerized roughness instruments", *J. Egyptian Soc. Of Engrs.*, **34**, (2) (1995) 42 - 46.

**AUTHORS:** Prof. Dr. Sarwat Z. ZAHWI and Eng. Alia M. MEKAWI, Engineering Dimensional Metrology, National Institute for Standards, Tersa St., Haram, Giza, P.O.Box -.I36 Giza, Code No. 12211, Egypt, Fax: 020 3867451, E-mail: [zahwi@sit.nis.sci.eg](mailto:zahwi@sit.nis.sci.eg) and [amekawi@sit.nis.sci.eg](mailto:amekawi@sit.nis.sci.eg)