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Research on the impact of the warm-up of multisensor measuring machine on measurement accuracy

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Abstract

It will not be an exaggeration to state that nowadays the quality control department is one of the most important sections in modern production facilities. An effective control department can prevent huge financial losses associated with the waste of means of production as well as those resulting from breaching contracts. That explains the high demand for methods and measuring techniques which are characterized by both reliability and accuracy. In terms of geometric quantities measurements the solution which meet those requirements is the Coordinate Measuring Technique (CMT) which over last several decades became one of the most often utilized methods in industrial practice. The main tool of CMT is Coordinate Measuring Machine (CMM). Such machines have been developed and modernized for many years, so the problems of classic CMMs are quite well known and successfully corrected. One of the most significant factors affecting CMM accuracy is temperature. Measuring instruments and especially CMMs are often made of many materials characterized by different coefficients of thermal expansions, which means that appropriate constructions and connections of such elements should be used to avoid excessive stresses and torsions of the machine which cause deterioration of accuracy. The main kinematic elements of devices intended for work in production halls are made of materials such as granite or ceramics which are characterized by a low coefficient of thermal expansion. Such solution allows machines to work in a wide temperature range (15-35 °C) without significant reduction of the quality of measurements. Additionally, temperature compensation is usually used to ensure stable measurement results. In that case correction can be performed for individual kinematic axes and with the use of an additional temperature sensor for the measured part, so the measurement results are referred to standard conditions of 20 °C. Modern market requirements force producers to constantly strive to reduce the costs associated with the production of the product. Such reduction can be implemented in many ways, one of them is minimization of machine downtime and optimization of its worktime. Of course, complete elimination of downtime is impossible even because each measuring machine requires periodic inspections by the service and confirmation of its accuracy, which is usually carried out by external laboratories. During services, the machine is turned off and, as a result, its operating temperature drops, which is why many manufacturers use special programs to warm up the machine before servicing starts. A similar situation related to a decrease in the operating temperature of the machine occurs when system of one or two shifts is used in the plant, when the machine is turned off or not used until the next shift. Researchers from Laboratory of Coordinate Metrology decided to examine whether the problem of using not warm-up machine may cause instability of measurements and whether warming-up measurements should be used before the machine would be used for its primary purposes. Additionally, obtained results allows estimation of the uncertainty of the temperature sensor applied to the machine parts. Experiments were carried out on a Zeiss O'Inspect 442 multisensor measuring machine which is located in a temperature stabilized room T = 20.3 °C ± 0.2 °C. Research started with recording the temperature of the measured part on a stopped machine. The machine was then programmed and stayed turned on for 46 hours of continuous part measurement. The experiments allowed to identify the time needed for the machine to obtain a stable operating temperature as well as its value - Figure 1.

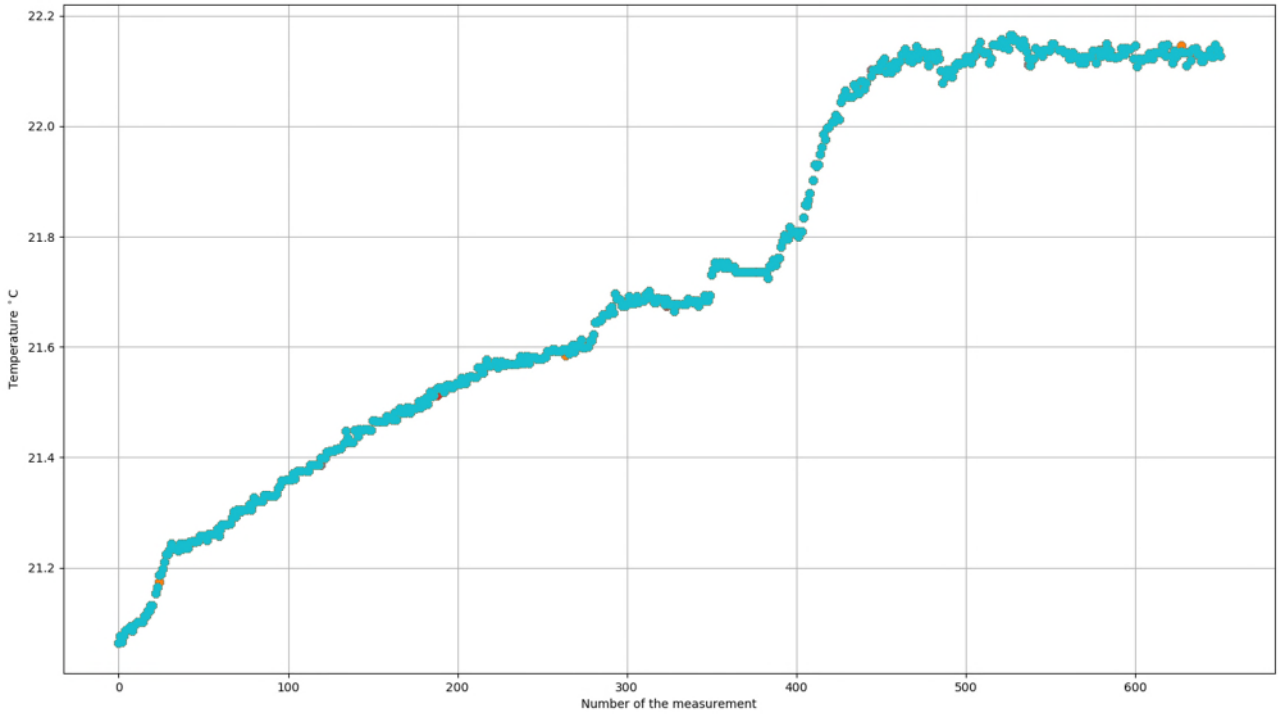

Figure 1. Part temperature changes during 46 hours of measurement.

Additionally, it was checked whether the results collected during temperature stabilization were acceptable and whether they were subjected to additional measurement uncertainty.
The obtained results turned out to be very interesting. The results were divided into two groups: related to machine warming-up process and obtained when the machine had achieved temperature stability. The results show that in the first group where it was expected to observe the non-stability of the measurements, the results in fact do not show an effect associated with the lack of warming-up of the machine, as the first and second group of measurements give comparable results. However, it should be noted that the tests were carried out on a relatively small measuring machine and possible measurement instability associated with measuring the element immediately after turning the machine on is very small and should not affect the results. In the future, the authors plan to repeat the experiment on a machine with a much larger working range.

Metrology, Optical, Temperature, Visual Inspection