BOTTLENECKS OR STANDARDS?

The measuring room can turn into a bottleneck within a manufacturing organisation; for example, products cannot be delivered because the measurement report is missing. This may be due to the lack of a sound measurement strategy. The Meten 2018 seminar, held in early February in Veldhoven, the Netherlands, and organised by Mikrocentrum, was devoted to the optimisation of industrial measuring processes. It covered trends in metrology practice, the operation of a measuring room, the management of measuring equipment, and calibration standards. The following is a brief report.

AUTHOR'S NOTE

Frans Zuurveen, former editor of Philips Technical Review, is a freelance writer who lives in Vlissingen, the Netherlands.

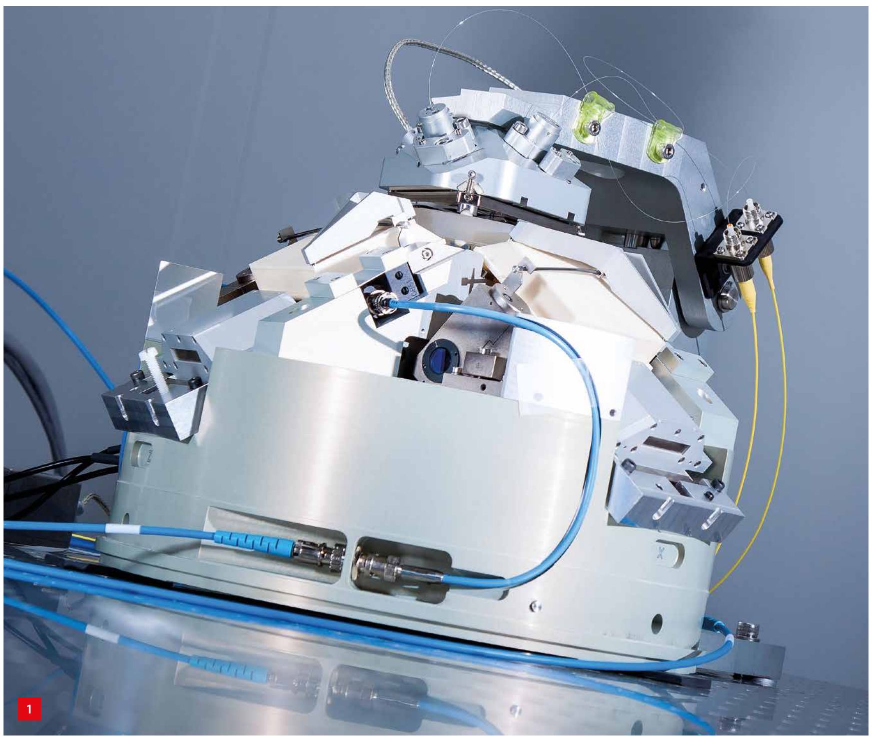
FRANS ZUURVEEN

The national metrology institute VSL is commissioned to manage the measurement standards in the Netherlands, not only for length, but also for mass, temperature and electrical and other quantities. In his introductory lecture to the Meten 2018 seminar, chairman of the day Jacob Jan de Boer, a consultant at VSL, explained that several trends may be observed in today's metrology practice, when differentiating between the old and new technological economy.

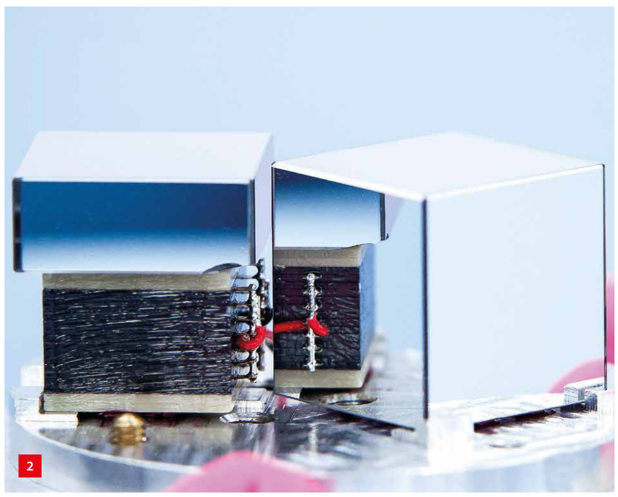
The old economy is based on mass production in large series, with Taylor-derived management of workforces. In the new technological economy, goods production is flexible, with lower serial quantities based on local demands, bringing a better and more human-friendly working climate. The ultimate goal is the "factory of the future", which is continuous in operation and where people are only necessary for supervision and flexible-production programming.

These trends also influence geometrical measuring practice. Smart sensors monitor production progress, and measuring and inspection take place during machining, avoiding the possibility that products are rejected at the end of an expensive production process. More advanced precision-measuring technologies are going to be introduced into work-shop practice, even atomic-force and interferometric measurements, resulting in nanometer accuracies.

Figure 1 shows the Atomic Force Microscope (AFM) developed by VSL. In such a measuring instrument, a tiny mechanical probe made from tungsten scans the contours of



1 *The AFM developed and assembled by VSL, the Dutch metrology institute, used as a reference tool for nanoscale measurements. (Photo: VSL)*



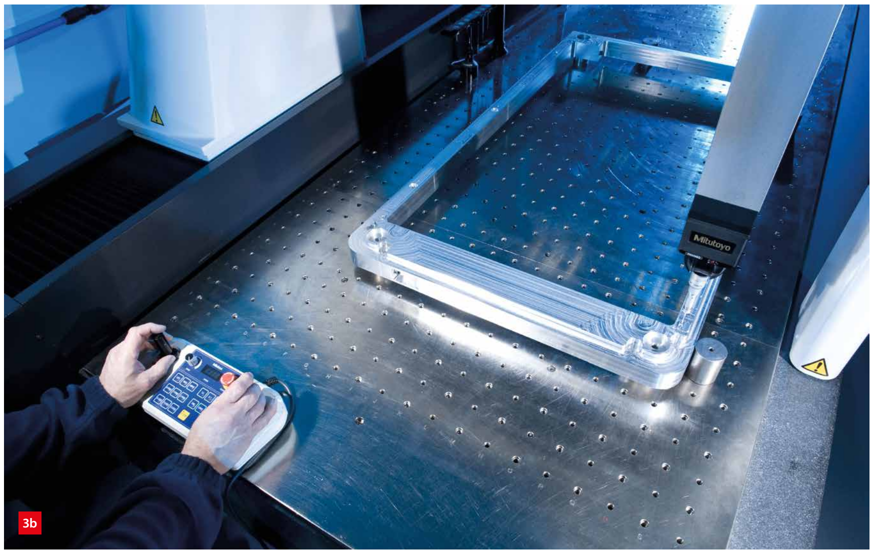
2 *Virtual standards with a tuneable pitch, developed by VSL for the calibration of AFMs [1]. They consist of highly linear, shear piezoelectric cubes, with a dimension of about 1 cm^3. (Photo: VSL)*

a surface line-by-line, capturing the shape of the surface with potentially sub-nanometer accuracy. Figure 2 depicts the virtual standards developed by VSL for the calibration of AFMs. These standards have a tuneable pitch, specifically designed for the calibration of small scanning ranges. VSL has thus created a virtual pitch by periodically shifting the lateral position of an arbitrary surface over a well-known distance in the 10 nm range [1].

Measuring room a bottleneck?

Peter van Lierop is a team leader in the measuring room of the KMWE Group, which specialises in high-precision mechanical cutting. In his lecture, Van Lierop discussed the problem of how to transform a measuring room from a bottleneck into a success factor (see Figure 3).

Firstly, Van Lierop explained that abandoning measuring operations guarantees saving money in a production chain. In most cases, however, inspection and measuring are unavoidable steps in the production of high-precision components. When the capacity of a measuring room has not grown in parallel with the expansion of production facilities, the measuring room indeed becomes a bottleneck. A one-hour waiting time to fulfil the measuring specification demands of a finished workpiece very often means a standstill of one hour in the complete production process.



3 *In the KMWE measuring room. (Photos: KMWE)*
(a) A Mitutoyo co-ordinate measuring machine, type Crysta-Apex, with a Y-axis range of 3,000 mm.
(b) Measuring an aluminium frame for ASML.

The solution to the described problems is to improve the organisation of factory routing and planning. A helpful work tool is ERP: Enterprise Resource Planning. This system helps to streamline processes and information exchange across the entire factory. The software also helps to synchronise reporting by production-chain staff. For example, sales orders automatically flow into the financial system, whereby measuring becomes a seamless finishing element in the production process. Finally, statistical values such as *Cp* and *Cpk* can help to monitor the efficiency of the organisational changes being introduced. These quantities explain how the three-sigma values of the statistical spreading curves are situated in relation to the specified tolerance fields.

Measuring aeroplane parts

Roy Helmos' responsibility is the management of measurement equipment and processes at Fokker Aerostructures in Papendrecht, the Netherlands. This company is part of Fokker Aerospace, recently taken over by GKN Aerospace. The most interesting fact here is that Fokker Papendrecht makes lightweight components for aeroplanes from different materials, among them Glare.

4 *Aircraft manufacturing is a complex, high-precision business.*
(a) Making a lightweight horizontal stabiliser for the Gulfstream G650 business jet. The photo shows the final drilling of holes by a robotic arm in the Fokker Aerostructures factory. (Photo: Fokker Aerospace)
(b) The giant Gulfstream assembly factory. (Photo: Gulfstream Aerospace)

5 *Overview of calibration activities at MetricControl. (Photos: MetricControl)*

This is a glass fibre-aluminium laminate that integrates light weight, high stiffness and high strength.

Aluminium and thermoplastic composites, however, are also included in the materials used in the modern aircraft components being made in Papendrecht, for example for the giant Airbus 380, the Dassault F7X and F5X, and the Gulfstream G650 (see Figure 4). The very stiff and strong torsion box of the horizontal stabiliser in Figure 4a is the result of co-operation between several companies, among them Airbus and Fokker, in the TAPAS project: Thermoplastic Affordable Primary Aircraft Structures.

Helmos explained that measuring huge parts is not at all easy. That's why this remnant of the famous Fokker history tries to avoid measuring workpieces by instead only measuring the tool, thus ensuring that its accuracy is carefully reproduced in the component. But when parts inspection is unavoidable, Fokker Aerostructures uses an AT901 laser-tracker system from Leica Geosystems, which was shown by Hexagon Manufacturing Intelligence during the seminar.

The Leica AT901 works according to an absolute interferometric principle, with two lasers in which the radiation intensity is doubled or extinguished, depending on the phase relation of the two interfering beams. Thus the system features multiples of laser-beam wavelengths. At short distances, accuracies of 10 μm are attainable, but for the long-range versions with measuring distances up to 30 m, an uncertainty factor taking the measuring distance into account has to be calculated.

Calibration

Gert de Bruin represents MetricControl in Hengelo (Ov), the Netherlands. This calibration institute has its origins in 1922 with the start of Hollandse Signaalapparaten (HSA), later becoming part of Philips Electronics. In 1990, HSA was taken over by the Thales Group. After some renaming and reorganising, MetricControl has become an independent institute with a workforce of 38 people working with elaborate equipment, not only for geometric calibrations, but also for the calibration of mass, electrical quantities, force, pressure, temperature and more (see Figure 5). MetricControl has been acknowledged by the Dutch Raad voor Accreditatie (Board of Accreditation), according to standard ISO/IEC 17025.

De Bruin explained that calibration implies the comparison of measurement results, from an instrument to be calibrated and from some kind of standard. The outcome is 'satisfactory' or 'not satisfactory'. The last verdict doesn't always mean the rejection of the instrument, because comparison with specifications may result in the instrument complying with less severe demands, while necessary modification of an instrument often brings about a second calibration.

MetricControl helps to install calibration management systems, determining regular calibration moments and respective registrations after agreed time intervals. Problems may arise when no norms are available for quantities to be calibrated. Norms for geometrical quantities are, however, in general excellently defined, as referred to when discussing Jan Hendrik van Swinden's activities (regarding the definition of the meter; see the next page).

To conclude

Many items discussed during the seminar seemed to be rather obvious, but nevertheless were worthy of reconsideration. Moreover, exhibitors like Mitutoyo, Faro, Bemet, GOM, Hexagon and MetricControl showed how their companies can help to solve difficult measuring problems. In any event, the interchange of ideas between measuring specialists was exceptionally useful.

REFERENCE

[1] R. Koops, M. van Veghel and A. van de Nes, "Virtual standards, real advantages", *Mikroniek*, vol. 57 (4), pp. 32-38, 2017.

INFORMATION

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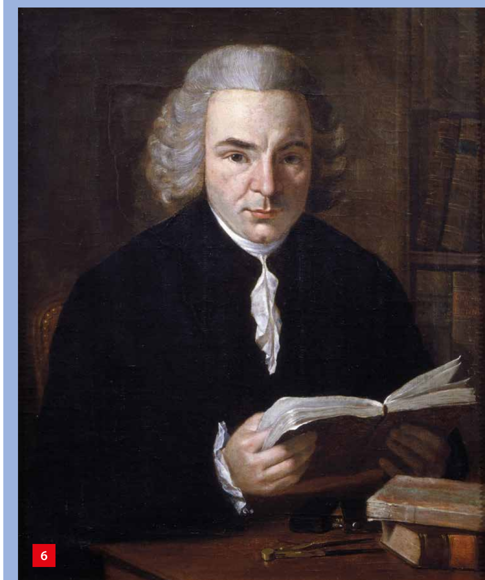
In Van Swinden's footsteps

Jacob Jan de Boer was the chairman of the Meten 2018 seminar in Veldhoven, held on 6 February. He is a consultant at VSL, the Dutch metrology institute, situated in Delft. The initials VSL stand for Van Swinden Laboratory, after mathematician and physicist Jan Hendrik van Swinden (1746-1823), who is historically important for the unification of length units and the development of geometrical measuring in the Netherlands.



6 *Mathematician and physicist Jan Hendrik van Swinden (1746-1823, artist unknown).*

On behalf of the Netherlands, Van Swinden (Figure 6) participated in the Conférence Générale des Poids et Mesures held in Paris from November 1798 to July 1799. This event resulted in the definition of the meter as the distance between two marks on a square-sectioned bar of platinum, of which Van Swinden could take home a copy with an accuracy of about 0.05 mm. This meter definition was based on measurements taken by Delambre and Méchain of the length of one earth quadrant, because the world unit standards should be based on constants in nature, thus defining one meter as 10^{-7} part of the quadrant length of 10,000 km.

After the signing of the Treaty of the Meter by seventeen countries on 20 May, 1875 in Paris, the meter was redefined as two marks on an X-formed bar of 90% platinum and 10% iridium, kept in Sèvre, a suburb of Paris. All contributing countries received a copy of this standard. This means that such a copy should still be somewhere in the basement of the VSL.

In 1802, Van Swinden published the article "Verhandeling over volmaakte maaten en gewigten" (Treatise on perfect measures and weights). He could not have imagined that about two centuries later 'his' definition of a meter would be replaced by a definition made in relation to the wavelength of the orange-red line in the spectrum of the krypton-86 isotope. Today, the meter definition is related to the speed of light, standardising the time necessary to propagate light across a distance of one meter exactly. According to Wikipedia, the accuracy of this last definition amounts to 0.1 nm.