NEWSLETTER SPRING 2020

Dear Readers,

it is a pleasure for me to introduce you a new issue of the newsletter of our Laboratory of X-ray micro and nano computed tomography CEITEC BUT. You can read here about some of our recent analyses, including a unique golf ball analysis, leaks in ŠKODA armrest and papyrus scroll analysis. We will describe computed laminography method and show some details from research of tibia fracture. The last topic is mold correction which is a big trend in industry.

Enjoy the reading!

Tomáš Zikmund
Head of the laboratory

CTLAB
X-ray Computed Tomography

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BRNO | CZECH REPUBLIC

UNIQUE GOLF BALL ANALYSIS

The CT lab had an opportunity to try a new fun form of golf which was invented by an American company named Topgolf. Unlike classic golf, this game is fully tied to modern technologies to meet today's trends. The player sees his ball trajectory on the digital screen. Points are awarded to the player automatically after the ball is hit. The longer the ball is flying and the closer the ball is to one of the targets, the higher the score is.

We wondered what technology is hidden inside the golf ball, so we decided to do an X-Ray analysis. The aim of our analysis was to understand the internal structure that would help us to discover the principle of the Topgolf game. For this purpose the ball was measured using micro CT and the obtained data were analysed. It was found that in the middle of the ball a microchip with an antenna was embedded, which was detected despite its small size. The microchip and antenna were segmented for better visualization.

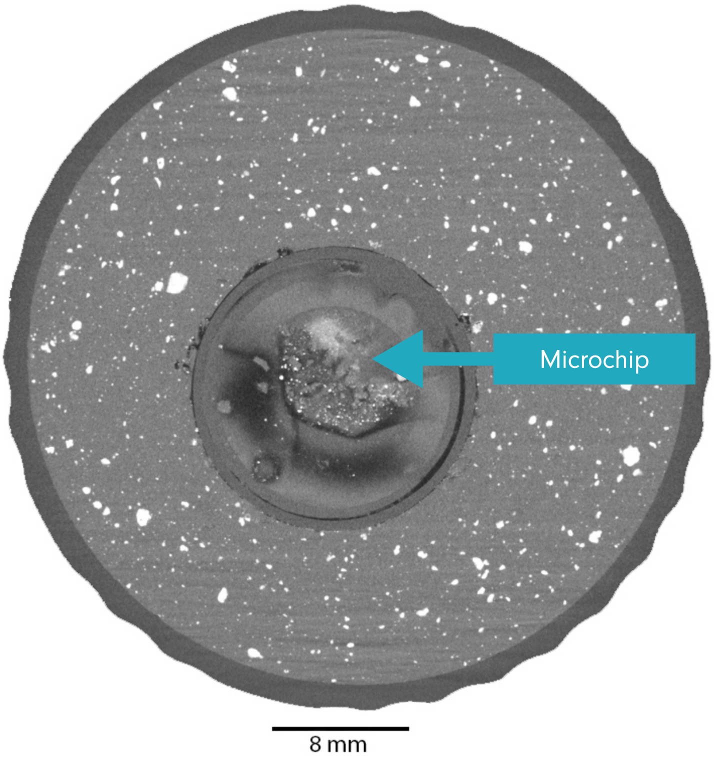

Figure 1: Cross section of a unique golf ball.

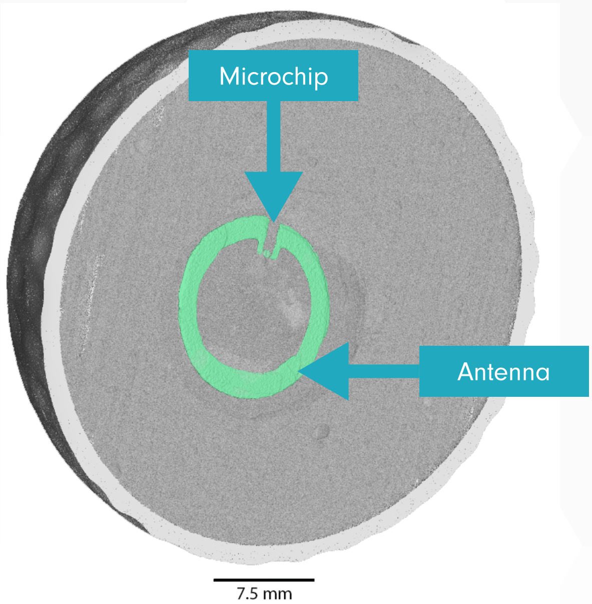

Figure 2: 3D view of golf ball with segmented RFID tag.

A short search found that the Topgolf company uses technology called RFID, which consists of three parts – an RFID reader, antenna and tag. The tag placed in the ball consists of a microchip and an antenna. RFID readers are placed on the playing field and send a signal to the antennas. This signal continues in the form of a radio frequency wave. As soon as the golf ball is in the read zone, the antenna captures the energy of the transmitted wave, which powers the embedded chip. The chip sends its own signal back to the antenna, which then interprets the ball's flight information. Subsequently, the obtained data is sent to the computer and the determined score is automatically credited to the player on his digital screen.

LEAKS IN ŠKODA ARMRESTS

We recently addressed the problem of leakage through decorative stitching in the armrests for one type of Škoda car. The rubber imitation of leather armrests is stitched at the factory and the sewing is covered with a liner tape on the inside. The work piece is then placed on a plastic base, and the gap between is filled with foam. This foam seeps through some parts through the sewing and leaves visible shiny marks on the product surface.

Problem sections were excised and analysed using Phoenix v|tome|x L240 with a resolution of 20 μm/voxel, according to the size of the cut-out. Resulting CT data revealed two possible causes of leakage. The first one is the unwanted perforation of the tape, the second one is the deformed contact of the tape with the rubber, caused by the foaming process where the foam flows under the tape. The causal link is hidden in another monitored parameter, which is the thickness of the rubber material and subsequent tape repression, its damage and leakage.

Figure 3: Leak in the armrest.

Tomographic analysis helped us not only to identify the possible root cause of the defects but also to visualize the situation in order to prove the failure of the supplier to meet the prescribed thickness of the input material. This issue is being further monitored.

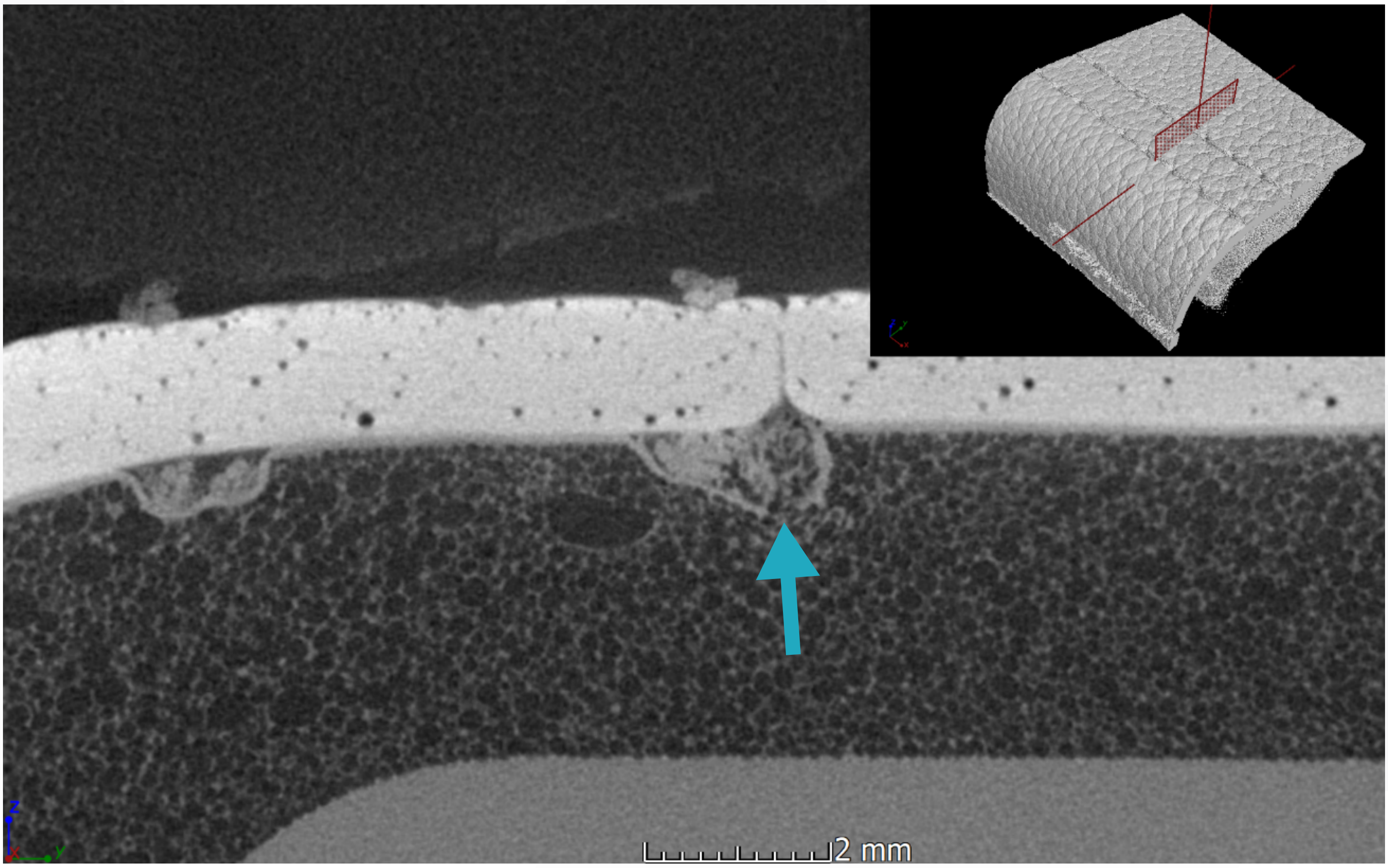

Figure 4: Tomographic cross section showing the site of damage to the inking tape where the foam leaked.

PAPYRUS SCROLL ANALYSIS

During a student exchange with the University of Calabria, Italy, we had the opportunity to use our micro CT device to analyse a unique papyrus scroll (Fig. 1). This scroll is not a historically rare artefact, but was actually created as a reference sample for testing the existing possibilities of non-destructive techniques.

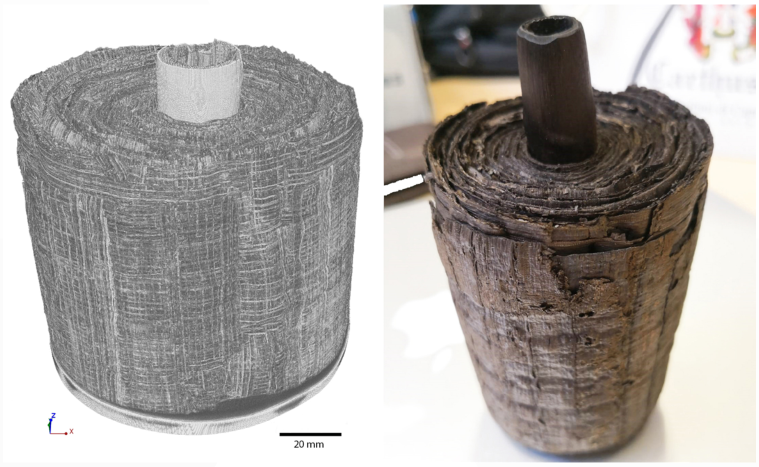

Figure 5: 3D model of papyrus and the real picture of papyrus.

The sample was created by rolling up a sheet of papyrus, which was covered by carbon ink containing lead acetate at various concentrations. The presence of lead was supposed to simulate water pollution conditions in the days of ancient Rome. In addition, the coil was subjected to a heat treatment whose purpose was to simulate the eruption conditions of the Vesuvius volcano in 79 AD.

The aim of the tomographic analysis was not only to verify the presence of lead inside the scroll but also to visualize it in 3D and to accurately identify the ink deciphering ink trace.

Tomographic data (Fig. 6) clearly show the complex structure of papyrus, which also makes it difficult to detect lead particles. These were finally found by virtue of the virtual roll unwinding (Fig. 6) in which the surface of individual sheets of papyrus can be better read. The light dots represent lead particles which at this low concentration do not allow the ink text to be deciphered. However, these initial experiments confirmed that authentic samples of invaluable value could be studied in the future.

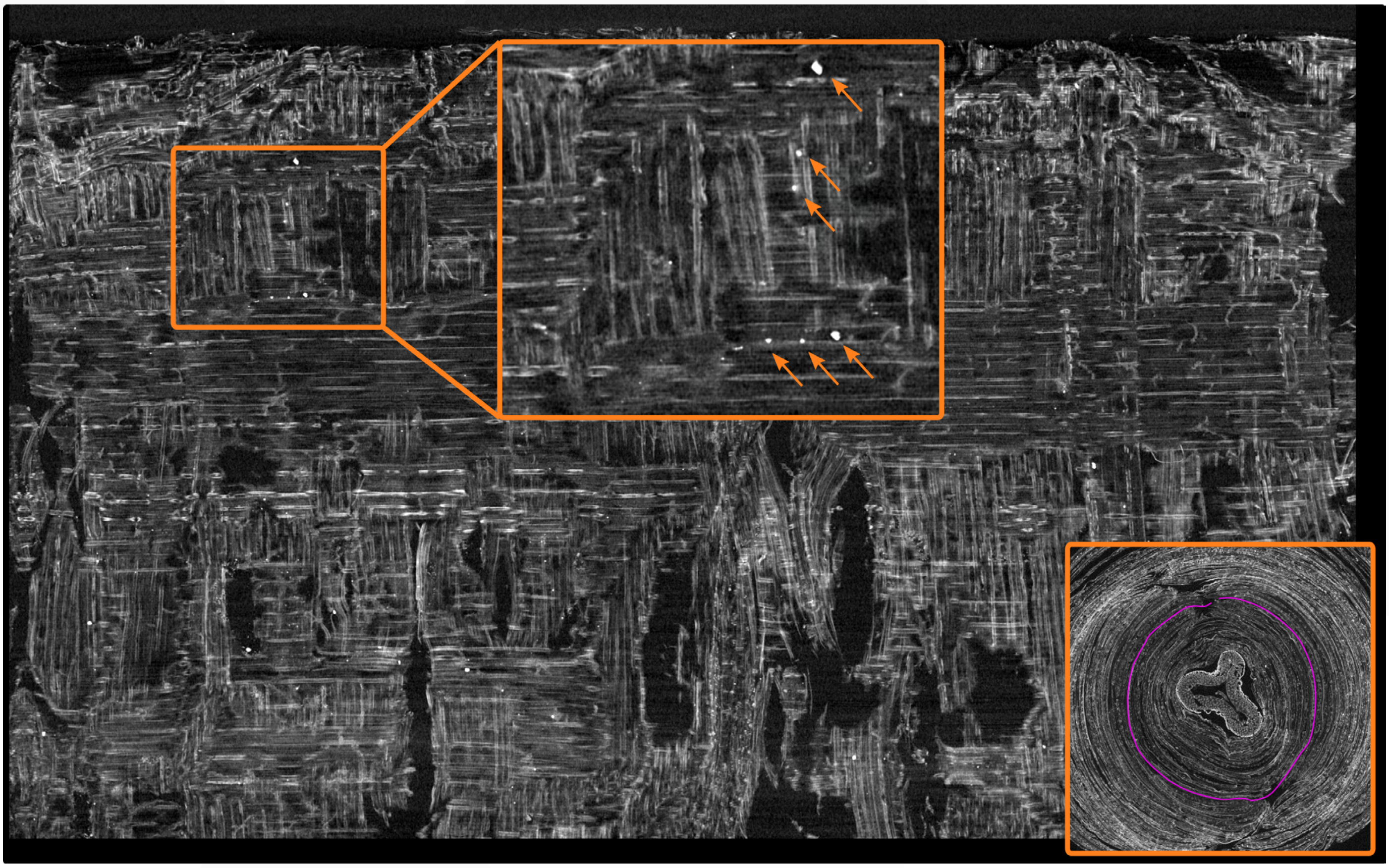

Figure 6: Virtually unfolded scroll depicting lead particles. Purple mark shown the unroll area in cross section.

COMPUTED LAMINOGRAPHY METHOD

The **computed laminography** method (CL), also called planar CT, is an imaging technique especially suitable for large flat specimens. In classical **computed tomography** (CT) flat specimens either do not achieve complete rotation (360°), due to the impact of the specimen in the X-ray tube, or X-rays are completely attenuated by large amounts of material when the specimen reaches parallel to the beams.

Computed laminography is a specific case of computed tomography that uses an axis of rotation tilted less than 90 degrees to the incident beam. In laboratory systems, this movement is achieved either by tilting the detector or the axis of rotation. For larger parts, the source and detector are attached to two independent robotic arms that perform synchronized movement around the part.

This method has a wide range of applications, especially in electronics where it is used for the checking of printed circuit boards with double-sided mounting where inspection by classical 2D X-ray is not possible. Other applications in industry have been shown to inspect glued joints of large parts or large-dimensional carbon composites.

Figure 7: Measured chip.

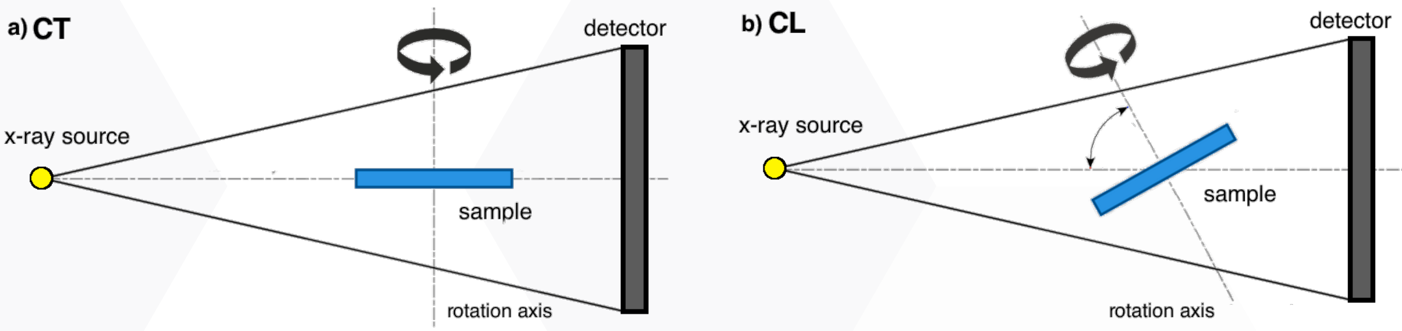

Figure 8: The difference in the spatial arrangement of components in (a) Tomography (b) Laminography.

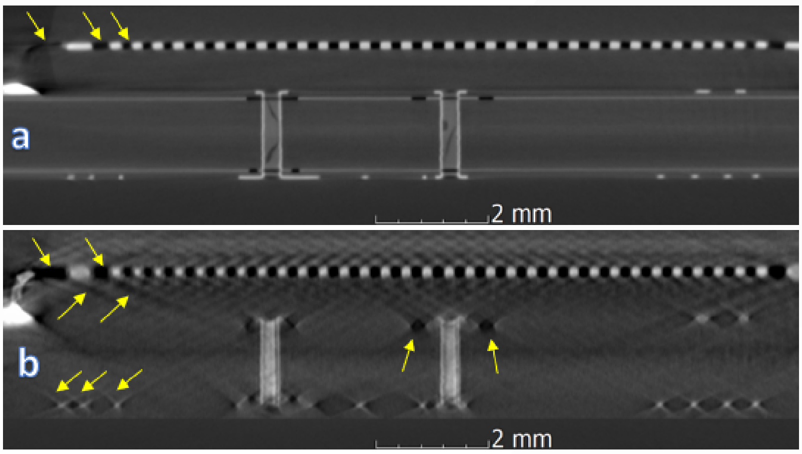

Figure 9: Computer chip cross section obtained by using (a) micro CT, (b) laminography. Yellow arrows indicate artifacts.

In order to demonstrate the possibilities of this method, and at the same time the difference between classical CT, we carried out the analysis using the procedure of the desktop computer motherboard. Measurements were performed on the GE mixrome|x and the micro tomography station GE v|tome|x L240. Although laminography was performed with a better voxel resolution of 11 μm/voxel over micro CT 15 μm/voxel, the comparison clearly shows that micro CT achieves significantly better results due to multi-angle projections. Laminography can thus be used on samples such as large printed circuit boards, where the micro CT would be limited by the resolution and often also by energy needed to penetrate the board in the transverse direction.

RESEARCH OF TIBIA FRACTURE

Intra-articular fractures of the proximal tibial epiphysis, also known as „plateau fractures“, are very complicated and require extensive experience to fix them. The treatment of these fractures is based on classification according to the extent of bone damage (AO classification) or related soft tissues (Moore classification). Despite advanced methods of diagnosis and appropriate treatment, the results of healing are not satisfactory.

It is not yet known how the pressure acting on the proximal pineal gland of the tibia is transmitted and how the bone beams are arranged. Dr. Ritesh Rathi of James Paget University Hospital in Norfolk, England is a specialist in the treatment of „tibial plate fractures“. He cooperates with the head of the Institute of Anatomy, Dr. Marek Joukal (Faculty of Medicine, Masaryk University). They work on creating a new classification taking into account the microstructure of the proximal tibial pineal gland, which can be used to individualize the treatment of these fractures. For better examination conditions, measurements were performed using micro CT, thanks to which a team of doctors obtained a complete 3D model, including the internal structures of the tibia. By looking into any part of the bone through a 3D model, the research area will be better understood and will facilitate the work of scientists.

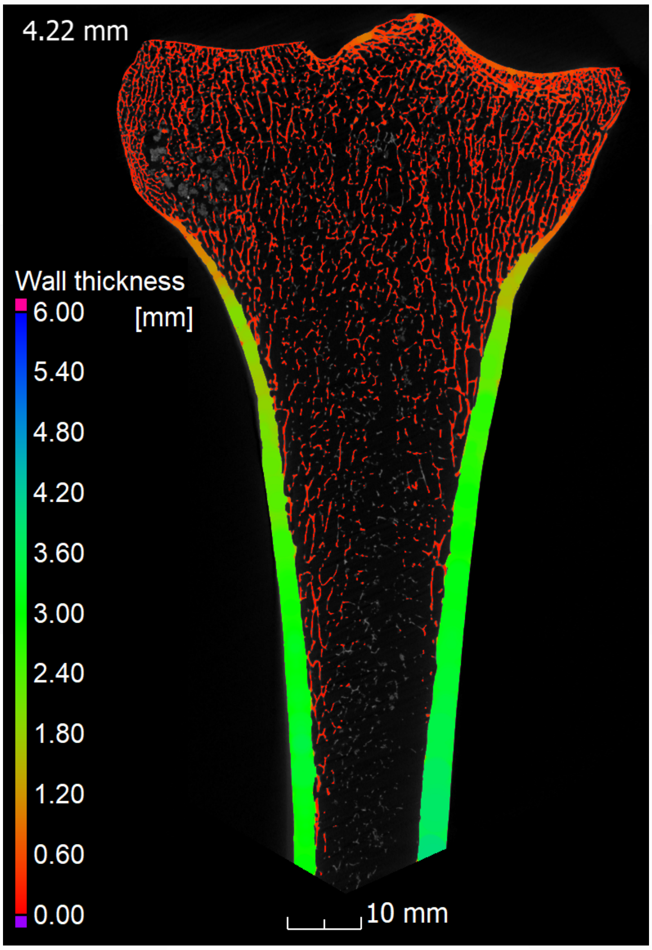

Figure 10: Cross section of the tibia.

Figure 11: Picture of real tibia.

MOLD CORRECTION

Currently, 3D software and manufacturing process simulations are used in the design and manufacture of injection molds. In these simulations, however, exact conformance to boundary conditions cannot be achieved. These geometrical deviations are often not within the tolerance of the component and the injection mold must therefore be corrected to eliminate these deviations. Moreover, in many cases this is not a single correction, but the form undergoes a multi-cycle process.

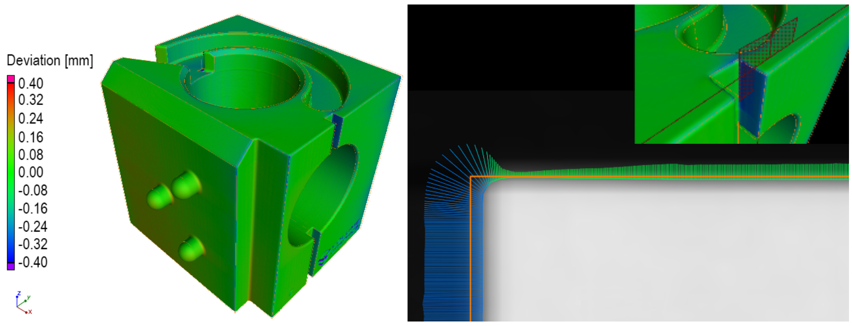

Figure 12: Colour map of surface deviations from nominal CAD model. The CAD model is shown as with an orange contour.

With the help of computer tomography, this cycle can be made more efficient and the possible costs of mold correction can be saved. Using the software tools, the scanned part is compared with the nominal CAD model of the part and the manufacturing deviations of the shape are detected (Fig. 1). Manually selected surfaces with intolerable deviations are subsequently used to design a new modified mold. Although this is not an entirely automatic process, this approach is currently a big trend in industry. Our laboratory is now testing a software tool designed specifically for this application.

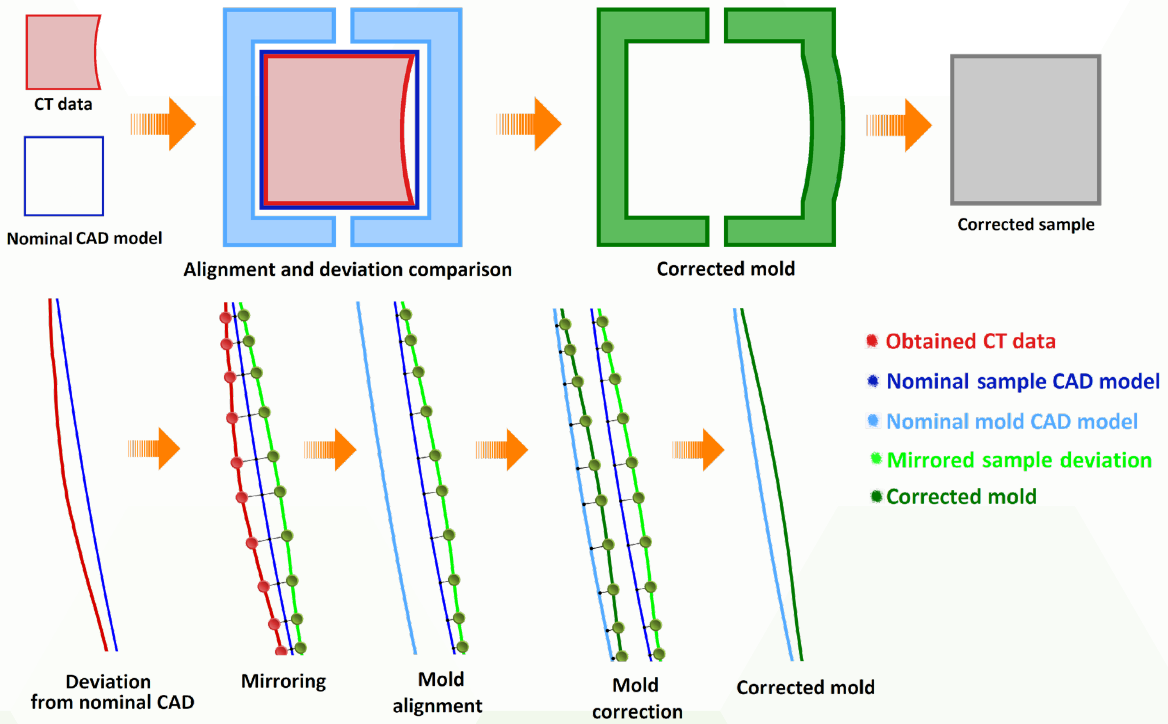

Figure 13: Illustration of the procedure.

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