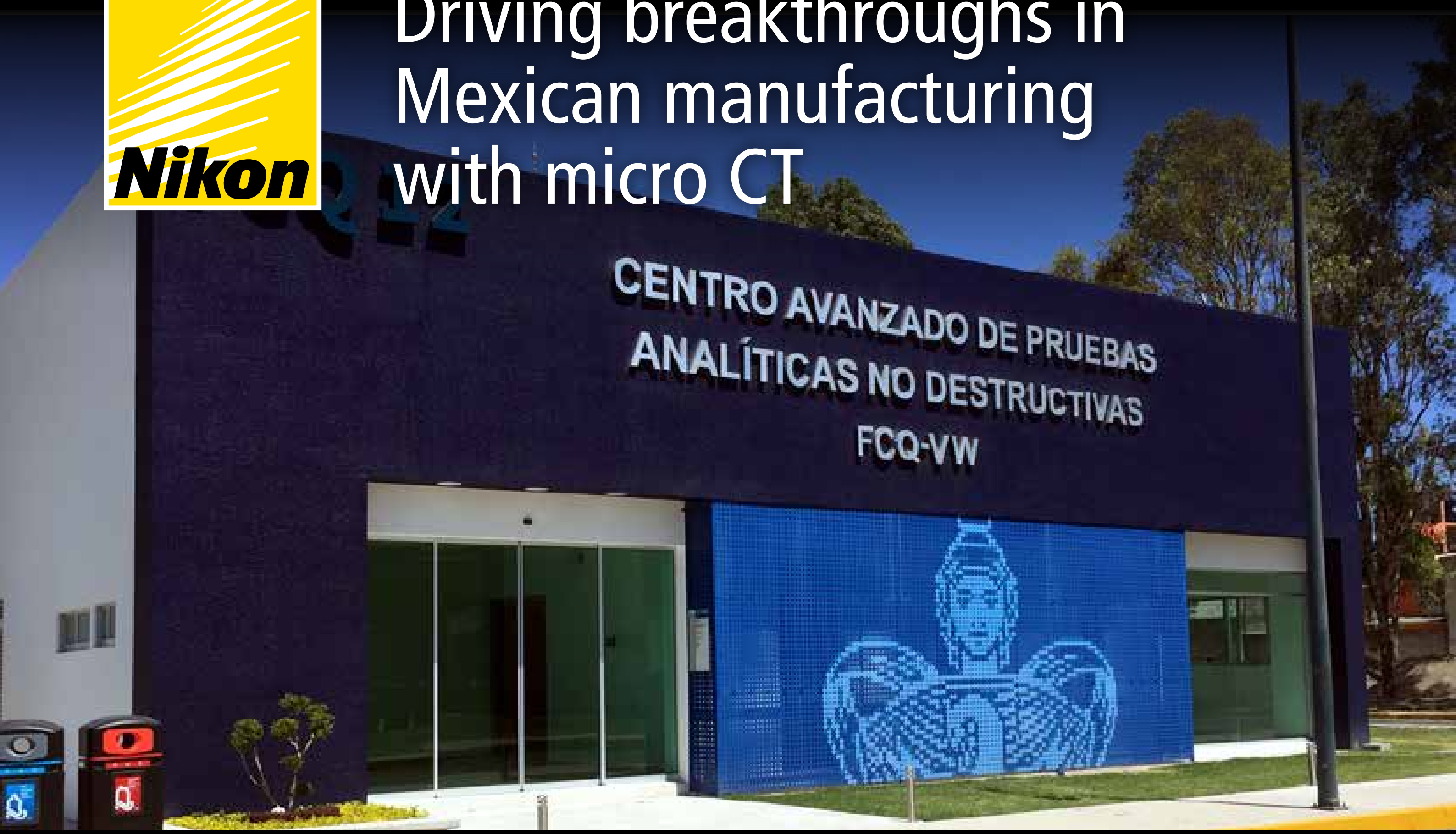
Driving breakthroughs in Mexican manufacturing with micro CT



Founded in 1587, the Benemérita Universidad Autónoma de Puebla (BUAP), located in Puebla, Mexico, is one of the country's oldest and most prestigious public universities. Its mission, in part, is to give its students "the capacity to generate, adapt, recreate, innovate, and apply knowledge with quality and social relevance."

Implicit in this mission is to work with world-class resources and tools, which the university is doing with its new 225 kV and 450 kV dual-source M1 X-ray computed tomography (micro CT) system from Nikon Metrology (with North American headquarters in Brighton, MI).

"We at BUAP have used other technologies involving X-rays, including dispersion and diffraction, but nothing related to X-ray scanning," says Dr. Jorge R. Cerna, Industrial Liaison for BUAP's Chemical Sciences Faculty. "In addition to academics, we offer specialized services to industries in our region like chemicals, plastics, food and automotive, particularly with Volkswagen, in partnership with the acquisition of the micro-CT system, a triple-helix project. But besides Volkswagen, Audi also has a major plant here. Along with these companies, we also want to develop national testing standards for Mexico. We are confident that relations with companies, research and use of new technology such as micro-CT, will position us as worldwide leaders. "

Dr. Cerna's research and academic background includes a chemistry degree from BUAP, a master's in engineering specializing in quality systems and productivity from ITESM (the Monterrey Institute of Technology and Higher Education) and his Ph.D work at the Center

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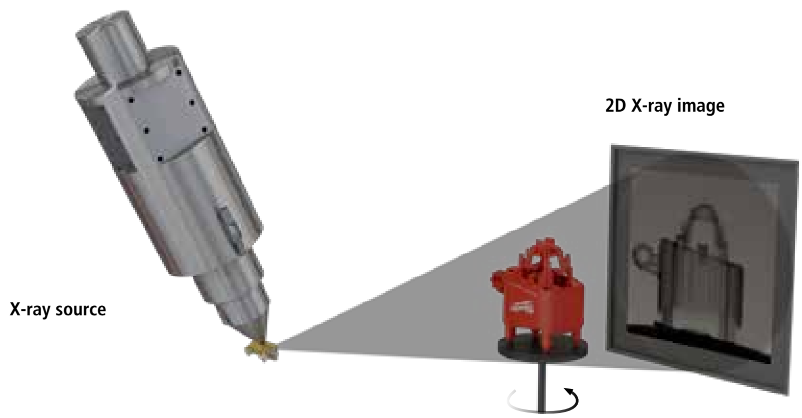
How do we get an X-ray image?



X-ray scans are taken at discrete positions of the rotating stage. Afterwards all slices are reconstructed to a 3D CT volume.

for Research in Applied Chemistry in Saltillo, Coahuila. "Personally, I am working on projects involving polymers, asphalts, and magnetic nanoparticles embedded in polymeric support," he says. "Adding micro CT capacity means we are going to obtain more information about our systems with a technology still unique in Mexico." Nikon Metrology is supporting BUAP's goals with an office and hands-on training facility in Queretaro, Mexico.

The basics of X-ray and CT

X-rays are at the short end of the electromagnetic spectrum with an average wavelength between 10-8 and 10-12 meters, around the size of water molecules, compared to radio waves with wavelengths that could span a soccer field. There are no radioactive sources in X-ray micro CT; rather electrons are produced from a hot filament similar to a light bulb and accelerated at high voltage, creating a beam of electrons reaching speeds up to 80 percent of the speed of light. The electron beam is focused by a magnetic lens onto a metal target, producing a spot typically between 1-5 µm in diameter. The sudden deceleration of the charged electrons when they hit the metal target produces 99.03 percent heat and 0.7 percent X-rays.

These X-rays emanate from the region where the electron beam hits the target. The size of this spot is referred to as the X-ray spot size. In general, the higher the voltage applied, the more power is in the beam, and consequently more power is transferred to the target. The more power on the target, the larger the X-ray spot size, and the more X-ray power produced.

Many typical high-power X-rays sources are minifocus, in the range of 1 mm across. This limits the resolution of images to that of the detector: a very fine detector is needed to get high resolution and no magnification is possible. Microfocus, as with BUAP's machine, means the size of the X-ray source is only a few microns across (1 micron or 1µm is 1/1000th of one millimeter).

Biodegradable polymers

One area BUAP and Dr. Cerna intend to explore is applied nanoparticles in polymers resulting in biodegradable automotive components. "Micro CT will let us inspect and see how fibers are arranged and can be modified for these applications," he says. Other areas of industrial interest in our region may include plastics, ceramics, metals, and electronics, he adds.

"In Mexico, micro CT equipment is very new, and we are working to develop standards for VW Mexico and also to develop the Mexican official standard in this area. Furthermore, we want to do research in additional areas as biochemistry, biology, materials, archaeology, forensics, and many more. Our community has expertise in many areas which will surely allow us to offer innovative solutions to our society and to solve problems in the industry."

Volkswagen de México's Corporate Social Responsibility policy, defines sustainable development as an opportunity to focus their innovation capabilities to ensure business continuity in the long term. Social responsibility, the company says, involves taking an active part in the development of communities, as part of this strategy since 2009, Volkswagen of Mexico has established a strategic relationship with major universities in Puebla. At the heart of this strategy is the exchange of knowledge, the promotion of innovation and technological development

The Volkswagen plant complex in Puebla, one of the company's largest.

BUAP describes itself in its mission as "a community of knowledge and as such is pivotal in the development of art, culture, and the proposal of solutions to economic, environmental, social and political problems of the region and of the country... contributing to the creation and development of a proactive, productive, just and safe society." Being at the forefront of advanced technology is a concrete step in realizing this vision.

Better understanding the rules of micro CT

High-accuracy X-ray micro CT technology has continued to evolve over the past 10 years. Applications are diverse and growing across the automotive, aerospace, energy, medical, and consumer sectors, dealing with metals and exotic alloys as well as plastics and other workpiece materials. Accompanying software tools enable the analysis of part volume against the CAD model, either via direct volume-to-CAD comparisons, or through geometric dimensioning and tolerance measurements. And with price points low enough to make it competitive with other techniques, X-ray micro CT is ready for the metrology mainstream.

Better understanding the rules of X-ray micro CT not only opens the door to production cost savings and productivity improvement, knowing when to break them can provide even further process flexibility.

The rules

The rules for good X-ray micro CT are as follows:

1. Penetrate the sample from all angles.
2. Minimize noise in each projection image.
3. Use filters to reduce beam hardening.
4. Always use 360 degrees rotation.
5. Use the detector's full dynamic range.
6. Keep the object in the field of view.

Amorphous silicon flat-panel detectors have a fluorescent screen which converts the X-ray energy into light to form an image on an array of light-sensitive diodes. Electronics allow this image to be read by a computer.

Combine the penetrating power of X-rays and the ever-increasing data-processing power of the computer and computed tomography is the result. The fundamental setup includes X-ray source, object being measured, and a detector. A rotating platform for the object being imaged helps comply with Rules 1 ("Penetrate the sample from all angles"), 4 ("Always use 360 degrees rotation"), and 6 ("Keep the object in the field of view").
Thousands of digital images can be produced from a single sample, and each two-dimensional pixel in each image contributes to a three-dimensional voxel as computer algorithms reconstruct 3D volumes. For example, with 3000 images, each voxel in the resulting billion or so is processed 3000 times. The result is a 3-D volumetric map of the object, where each voxel is a 3-D cube with a discrete location (x,y,z) and a density (ρ). Not only is the external surface information known, such as with a 3-D point cloud from laser scanning, but internal surfaces and additional information about what is in between the surfaces from the fourth dimension (density) is provided. Furthermore, "slices" produced by the process and accompanying software can yield much information without destroying the part.