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Heat-Induced Uncertainty of Industrial Computed Tomography Measuring a Stainless Steel Cylinder

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Abstract : Uncertainty analysis in industrial computed tomography is commonly related to metrological trace tools, which offer precision measurements of external part features. Unfortunately, there is no such reference tool for internal measurements to profit from the unique imaging potential of X-rays. Uncertainty approximations for computed tomography are still based on general aspects of the industrial machine and do not adapt to acquisition parameters or part characteristics. The present study investigates the impact of the acquisition time on the dimensional uncertainty measuring a stainless steel cylinder with a circular tomography scan. The authors develop the figure difference method for X-ray radiography to evaluate the volumetric differences introduced within the projected absorption maps of the metal workpiece. The dimensional uncertainty is dominantly influenced by photon energy dissipated as heat causing the thermal expansion of the metal, as monitored by an infrared camera within the industrial tomograph. With the proposed methodology, we are able to show evolving temperature differences throughout the tomography acquisition. This is an early study showing that the number of projections in computer tomography induces dimensional error due to energy absorption. The error magnitude would depend on the thermal properties of the sample and the acquisition parameters by placing apparent non-uniform unwanted volumetric expansion. We introduce infrared imaging for the experimental display of metrological uncertainty in a particular metal part of symmetric geometry. We assess that the current results are of fundamental value to reach the balance between the number of projections and uncertainty tolerance when performing analysis with X-ray dimensional exploration in precision measurements with industrial tomography.

Keywords : computed tomography, digital metrology, infrared imaging, thermal expansion
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