

## Combined Ultrasonic Testing of Round and Hexagonal Bars

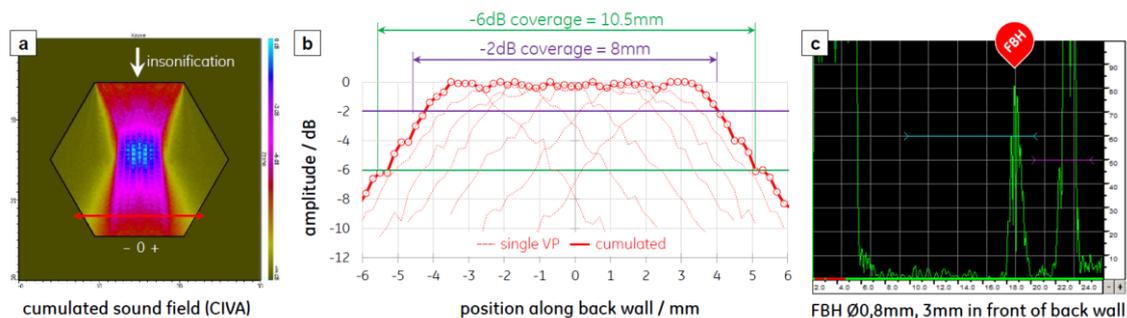
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### Abstract

With increasing requirements on the material characteristics – in particular in aviation and automotive industries – automated testing has to meet increasing standards. In consequence, existing testing machines might reach a premature end of their life-cycle, unless they receive substantial upgrades. Herein we present a new evolution stage for the ultrasonic phased array testing machines of the established the ROWA bar testing platform. This upgrade provides improved testing speeds, extended calibration functionality, and, moreover, the ability for testing of new profiles.

Round and hexagonal bars are the most frequent semi-finished products in steel industry. Since these geometries share common dimension ranges, many plants run production lines for both geometries and, accordingly, aim for a unification of the inspection lines. However, the inspection procedures of round and hexagonal bars are fundamentally different as the edges of the latter are exposed to higher stress in the finished product. Therefore, full-body test needs to be complemented by a surface inspection with a high coverage towards the edges. In a ROWA-B system this requirement is met by separate modes for core flaw detection (CF) and surface flaw detection (SF).

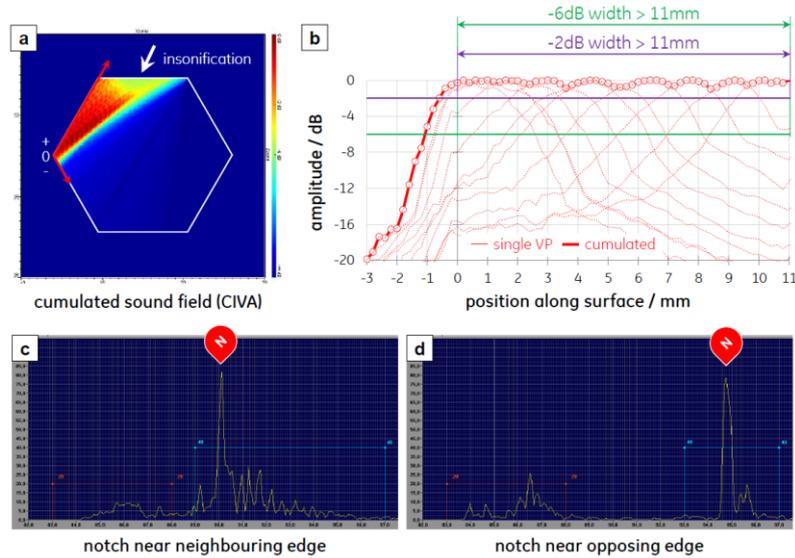
Figure 1 illustrates the CF mode testing carried out on a hexagonal bar with a width across flats of 19mm. Seven virtual probes are defined across the transducer to perform a linear scan across the bar with a pulse distance of 1mm, visualized by simulation data in figure 1a. The calculated coverage (FWHM) of this setup is almost 100% in vicinity to the back wall (see figure 1b). Figure 1c gives an experimental proof of the testing performance, showing the echo of a flat bottom hole, 0.8mm in diameter.



**Figure 1: Core flaw detection in a AF19mm hexagonal bar. (a) cumulated sound field as calculated using CIVA, (b) coverage derived from simulation, (c) experimental detection of FBH 0.8mm located 3mm in front of back wall.**

Testing for surface flaws can in principle be carried out in two ways – inspecting either the neighbouring side surface (SF<sub>n</sub>) or the opposing one (SF<sub>o</sub>). While in both cases the

refraction angle  $\beta$  deviates from  $45^\circ$  typically used for angle mirror refraction on a notch, the SFn mode ( $\beta \sim 50^\circ \dots 70^\circ$ ) is preferred, as only transversal waves are used for testing. An example is given in figure 2, complementing the core flaw detection shown above. In this setup 10 virtual probes are defined to perform a linear scan across the neighbouring side surface. With a pulse distance of 1mm full coverage of the testing surface is achieved, as proven by the experimental data depicted in figures 2c and 2d.



**Figure 2: Surface flaw detection in a AF19mm hexagonal bar, refraction angle  $\beta=68^\circ$ . (a) cumulated sound field as calculated using CIVA, (b) coverage derived from simulation, (c,d) experimental detection of surface notch (0.5mm x 12mm) located 1mm next to the edges of the bar.**

Adapting the testing machine to the new bar geometry requires configuration of the ultrasonic settings only, as well as mounting suitable bar guiding. Hence, it is possible to upgrade existing testing machines to this new inspection functionality.

The ROWA-B platform has furthermore been refined by extended automatization functionalities: The *Reference Standard Manipulator* is designed to perform a validation of the testing machine according to the international standard ISO 18563-3. Moreover, it facilitates handling of calibration bars and allows for an automated adjustment of all ultrasonic channels in less than 15 minutes, therefore preventing operating errors and reducing changeover times significantly.

Existing testing machine may also benefit from the introduction of improved pulsing patterns, which increase the testing speed by about 45% (average value across all ROWA bar type testing machines).