Phased array technology applied to centrifugally cast stainless steel with columnar structure with consideration of anisotropy

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Cast stainless steel (CSS) is widely used in nuclear power plants, particularly in PWR primary coolant systems. The JSME Fitness-for-Service Code requires periodic in-service inspection of welds in such systems by ultrasonic testing (UT), but anisotropy and heterogeneity of CSS make flaw detection and sizing difficult. Phased array ultrasonic technology (PAUT) is considered the most promising candidate to solve such difficulties. In this study, we focused on centrifugally cast stainless steel (CCSS) with columnar crystal grains and assumed that such a CCSS is transversely isotropic, namely, it has five independent stiffness constants. We made an attempt to acquired element-wise signals in a linear array probe when a longitudinal normal-angle beam probe wase located at the bottom surface of a CCSS specimen. By means of time reversal method, we attained focal laws corresponding to different refraction angles. Then we tried to determine those stiffness constants having impact on flaw laws obtained so that the squared error between the acquired focal laws and those focal laws calculated based on stiffness constants determined. In order to verify the correctness, we observed wavefields generated by a 2-MHz linear array probe which was triggered by the focal laws based on the determined stiffness constants. Observed wavefields showed that longitudinal waves travelled along the designated direction and focused on the location expected. Finally, we detected artificial flaws introduced in a CCSS specimen with the focal laws mentioned above. Experimental results showed that an improvement of performance of PAUT applied to CCSS with columnar structure.