To what Extent may we Accept Manufacturing-related Microscopic Defects in Cast Steel?

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The occurrence of process-related discontinuities and minor flaws in the interior of cast steel cannot be fully avoided during the manufacturing process. Obviously, these microscopic defects affect the material properties of the casting near locations where they occur. However, their very occurrence does not necessarily deteriorate the stability of the entire casting element. Unfortunately, current testing approaches do not integrate a reliable and customized case-by-case quality assessment. Consequently, manufacturers usually apply a general, rather expensive and resource-intensive finishing of cast steel components. Our research is aimed at making best use of the available material and avoiding such potentially unnecessary finishing steps. For this purpose, non-destructive testing (NDT) is combined with fracture mechanical assessments allowing us to assess the quality of cast steel in a reliable way.

As a first step of our proposed approach, a reliable process needs to be developed to determine realistic standard defect sizes and material parameters as basis for subsequent fracture mechanical assessments of cast steel. To this end, we determined quantitatively the 3D distribution of microscopic defects and material parameters in representative cast steel samples using innovative, volume-oriented NDT methods (e.g., ultrasonic testing using the phased-array technique and high-energy x-ray tomography). In this paper we compare and discuss the results obtained with the aforementioned methods to verify the validity of the proposed NDT approach. Furthermore, our work provides the basis for an improved correlation between existing quality classes and the real defect pattern in cast steel and, thereby, contributes fundamentally to an optimal use of the resource steel.