Detectability of Residual Stress Anomalies in Various Types of Railway Wheels Subjected to Thermal Overload Based on Back Gauge Change

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Temperature increases of railway wheels due to frictional braking on the wheel tread can lead to maintenance challenges such as tread wear and thermal cracking. While heating within the anticipated design range should not adversely affect the structural safety of the wheels, excessive temperature rises resulting from brake system failures can induce tensile residual stresses in the rim, potentially leading to wheel fracture. Detecting wheels with abnormal residual stresses is therefore crucial for railway safety, and monitoring residual displacements in the rim due to changes in circumferential residual stresses is an implementable approach. However, the shape of the wheel web varies, and the displacement response to thermal input differs depending on the wheel geometries. This study aims to explore general deformation behaviours related to wheel shape and elucidate the relationship between shape and heat resistance. The elastic-plastic finite element analysis employing simplified intense thermal input revealed that residual deformation after excessive thermal loading consistently results in back gauge expansion, although the deformation and stress responses differ based on the web geometry. Differences in heat resistance are indicated by the variation in the temperature at which compressive yielding due to thermal stress occurs, depending on the web shape. The residual stress detectability of each wheel is determined based on the principle that greater residual displacement at lower stress indicates higher anomaly detectability.