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Analysis of wheel flats and spalling defects of carbon and microalloyed railway wheel steels

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When a railway wheel unintentionally slides on the rail, often due to brake malfunction, a defect known as wheel flat may form. This defect is associated with plastic deformation, metallurgical transformations, and localized wear. Spalling, another defect, occurs when martensitic regions present in the wheel flat result in material loss from the surface. This study analyzed failures in three pearlitic steel wheels (cast and forged carbon steel, and one cast microalloyed steel) from a Brazilian railway. Large defects suggested high friction energy dissipation at flats (? 100 J). White etching layers (WEL), up to 1 mm thick, hard (up to 950 HV0.05), and brittle, containing martensite and precipitates, were identified. These layers were prone to crack nucleation and propagation. Brown etching layers (BEL), more ductile, containing tempered martensite and pearlite, also formed after successive sliding events on WELs. Preventing flats and spalling requires proper maintenance and material selection of brakes, and control of wheel-rail friction. To prevent martensite formation, alloying elements can be introduced in steels to reduce austenitization due to friction heating, but this requires careful balance during material selection because it can increase steel's hardenability. Also, harder, more thermally conductive steels may reduce plastic deformation and contact temperatures.