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Mechanics of the reciprocal effects of bending and torsion during 3D bending of profiles

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ABSTRACT

Profiles with circular cross-sections can be geometrically described by the shape of the bending line. To achieve 3D bending lines with kinematic bending processes, a continuous change of the bending plane is needed, resulting in bending force vectors that change direction accordingly. These force vectors generate a bending moment in the forming zone and, hence, longitudinal tensile and compressive stresses. For profiles with non-circular cross-sections the orientation of the cross-section along the bending line needs to be controlled additionally. This can be achieved by applying a specific torque to the bending process and, thus, introducing desired shear stresses into the forming zone. Until now, this fundamental aspect of 3D profile bending has not been studied in a coherent fashion. To take into account the reciprocal effects of the various stresses applied to the forming zone and their effect on the bending moment and, thus, on springback, a comprehensive analytical process model was set up. The model is validated by experimental investigations performed using the Torque Superposed Spatial (TSS) profile bending machine and by comprehensive numerical investigations. Analyses were performed during plane bending as well as during bending superposed with torsion. The