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Design and simulation-based evaluation of a human-in-the-loop automated rebar bending system

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Abstract

The bending process for reinforcement bars in most small and medium scale fabrication shops includes manual preparatory steps before actual mechanised bending operation which results in delay and inconsistencies in dimensions. To address this, an automated rebar bending system that uses sensing, powered motions, control, and human supervision is designed for rebars between 6 and 32 mm in diameter. Mechanical sizing was conducted using a 32 mm rebar as the governing loading case. The proposed operating sequence was assessed through calculations, motion simulation, and linear-static finite element analysis. The nominal cycle consists of 5 s for feeding and positioning, 2 s for clamping and bending, and a 2 s allowance for manual unloading and disc return. This gives an ideal production rate of 400 bars/h, assuming that the next bar is available and inspection of the finished bar does not delay the cycle. At an assumed availability of 90% and a rejection fraction of 1% related to positioning, output after these stated losses is estimated as 356.4 bars/h. The partial-cost analysis gives hourly accounting costs of $31.97 for the reference system and $30.12 for the proposed system, with corresponding nominal unit costs of $0.133 and $0.075 per bar. The estimated simple payback period is 1.04 years.

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