

Smart Bench Vise

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Abstract

Traditional bench vises require manual force to clamp work pieces, which often results in excessive tightening, inaccuracies in force application, and several safety limitations. One of the key safety concerns involves the lack of controlled force application, which can lead to unintended injuries or damage to the work piece due to unpredictable tightening. These challenges necessitate an improved design, leading to the development of a smart bench vise that incorporates stepper motors, load cells, and a user-friendly interface to prevent over-tightening while enhancing precision and safety. The technology driving this smart bench vise is based on Arduino programming, specifically utilizing the Arduino Uno due to its flexibility in managing multiple sensors and its ease of integration with other electronic components. The device automates the clamping and unclamping processes, enabling consistent and precise force application at the touch of a button. When the user inputs the desired clamping force (this force can be found through experiments or theoretical calculation) via the interface buttons, the motor initiates the clamping process, rotating the lead screw to close the moving jaw. This rotation is converted into linear motion, gradually increasing the clamping force on the work piece. Once the predetermined force is reached, the motor automatically halts, ensuring that the clamping force is applied accurately without exceeding the set limits, thereby preventing over-tightening and minimizing the risk of damage. Various materials, including plastic, aluminum, and steel, were used in the experimental phase to assess the required clamping force for different material thicknesses (10mm, 30mm, 50mm, and 60mm). The experimental results indicated that the smart bench vise significantly reduced clamping time compared to traditional vises while maintaining high precision and safety. While the current design effectively prevents over-tightening, future research could focus on expanding its force range, incorporating automated material detection, enhancing the user interface with touch screens, and adding wireless connectivity for remote operation.

Keywords: *Smart bench vise, force control, Arduino Uno, stepper motor, automated clamping*