International Journal of Advanced Manufacturing and Material Processing

Development of a Mini CNC Milling Machine for Educational Purposes at JMTI

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RESEARCH ARTICLE

ARTICLE INFO

Keywords:

Arduino-based control; CNC milling machine; Educational machining; GRBL firmware; Mini CNC system

Article History

*Received:*24 October 2025
*Revised:*19 February 2026
*Accepted:*28 February 2026
Published:

The continuous advancement of modern manufacturing requires highly skilled personnel proficient in Computer Numerical Control (CNC) technology, making it an essential component of Technical and Vocational Education and Training (TVET). However, hands-on training is often limited by the high capital cost, large footprint, and maintenance complexity of industrial CNC machines. This study reports the design, fabrication, and performance evaluation of a Mini CNC Milling Machine developed as a compact and affordable training tool for the Japan-Malaysia Technical Institute (JMTI). The machine was designed using Autodesk Inventor and fabricated from aluminium 6061 through in-house processes including CNC milling and Wire Electrical Discharge Machining (WEDM), followed by anodizing for durability. The control system utilised an Arduino platform running the Grbl open-source G-code interpreter firmware to enable simplified G-code execution. Performance validation included motion accuracy testing, Manual Data Input (MDI) functionality assessment, and cutting accuracy evaluation. Motion testing using a 0.01 mm resolution dial gauge showed a maximum deviation of ±0.05 mm. The MDI test confirmed stable and immediate system response without errors. Cutting trials on acrylic (15 mm × 20 mm geometry) achieved an average dimensional deviation of ±0.01 mm. The results demonstrate that the developed system provides adequate precision for CNC programming education, prototyping, and light-duty machining applications.