

Application of Siemens NX in Integrated Design and CNC Machining of a Battery Press Jig

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ABSTRACT: *This paper presents an integrated workflow for the design and CNC machining of a battery press JIG using Siemens NX. The study covers the entire process from 3D modeling, assembly validation, and machining setup to toolpath generation, simulation, and NC code output. The jig is designed to ensure precise positioning and stable pressing of battery components under compressive loads up to 1000 N. Special attention is given to tool selection, cutting parameters, and machining strategies for Aluminum 6061. The simulation and experimental results show that the proposed approach improves machining accuracy (± 0.02 mm), reduces production time, and enhances surface quality. The methodology demonstrates the effectiveness of NX in integrating design and manufacturing processes for industrial applications.*

Keywords: *Siemens NX; JIG design; CNC machining; CAM; toolpath optimization; battery press JIG, ...*

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I. INTRODUCTION

In modern manufacturing industries, the demand for high precision, repeatability, and efficiency has significantly increased due to the rapid development of advanced production technologies. JIGs and fixtures play a crucial role in ensuring dimensional accuracy, process stability, and productivity in assembly and machining operations. In particular, battery press JIGs are widely used in battery manufacturing processes to guarantee proper alignment and controlled pressing force during assembly, which directly affects product quality and reliability [1].

Conventional design and manufacturing methods for JIGs often involve separate stages of CAD modeling and CNC programming. This fragmented workflow may lead to increased design errors, longer production cycles, and difficulties in process optimization. Moreover, manual CNC programming requires high operator skill and is prone to inconsistencies, especially when dealing with complex geometries [2].

The NX software provides a wide range of advanced features, including parametric modeling, assembly design, toolpath generation, machining simulation, and post-processing. These capabilities allow engineers to develop optimized machining strategies and validate the manufacturing process before actual production. As a result, the use of NX can reduce machining time, improve surface quality, and enhance dimensional accuracy [3].

In the context of battery manufacturing, the design of a reliable battery press JIG requires careful consideration of structural rigidity, positioning accuracy, and manufacturability. The integration of CAD and CAM within NX enables engineers to quickly iterate design concepts, verify assembly constraints, and generate efficient CNC programs [4].

This study presents a complete workflow for the design and CNC machining of a battery press JIG using NX. The process includes 3D modeling, assembly validation, machining setup, toolpath optimization, simulation, and NC code generation. The objective is to demonstrate how the application of NX can improve machining efficiency, reduce production errors, and ensure high-quality JIG fabrication in industrial environments [5].

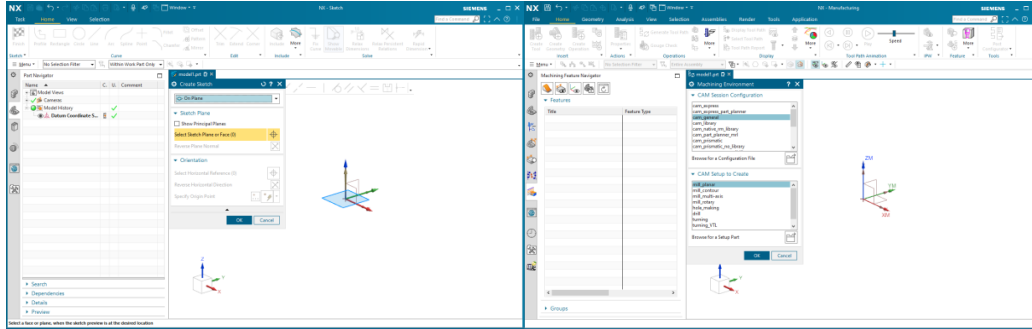


Figure 1: CAD modeling environment

Figure 2: CAM environment

II. DESIGN REQUIREMENTS AND ENGINEERING SPECIFICATIONS

A. Functional and Operational Requirements

The battery press JIG is designed to support precision assembly processes in battery manufacturing. The primary functional requirements are defined as follows:

- Positioning accuracy: The JIG must maintain dimensional tolerance within ± 0.02 mm to ensure proper alignment of battery components.
- Load capacity: The structure must withstand compressive forces ranging from 500 N to 1000 N without permanent deformation.
- Repeatability: The JIG should ensure consistent positioning over multiple operation cycles.
- Ease of operation: The design must allow quick loading and unloading of workpieces to improve productivity.
- Safety and stability: The JIG must remain stable during pressing without vibration or displacement.

B. Engineering Constraints

Several engineering constraints are considered during the design process:

- Material machinability: Components must be easily machinable using standard CNC milling operations.
- Tool accessibility: The geometry must allow efficient toolpath generation without collision.
- Manufacturing cost: The design should minimize machining time and material waste.
- Assembly feasibility: Components must be easy to assemble and disassemble for maintenance.

C. Material Selection

Material selection is based on mechanical properties and machinability:

- Base plate: Aluminum 6061
Advantages: lightweight, good machinability, corrosion resistance
- Locating pins: Hardened steel
High wear resistance and dimensional stability
- Pressing surface: Tool steel
High hardness and durability under repeated loading

III. CAD MODELING AND STRUCTURAL DESIGN

The JIG is designed using the CAD module of Siemens NX with a parametric modeling approach, enabling flexible modification of design parameters.

A. Base Plate Design

The base plate serves as the main structural component of the JIG. Its dimensions are defined as:

- Length: 180 mm
- Width: 180 mm
- Thickness: 20 mm

The increased size enhances stiffness and reduces deflection under applied loads.

Key features of the base plate include:

- Central pocket: Designed to accurately position the battery component
- Locating holes ($\text{\O}6\text{H}7$): Provide precise positioning using pins
- Mounting holes: Enable secure fixation on the machine table

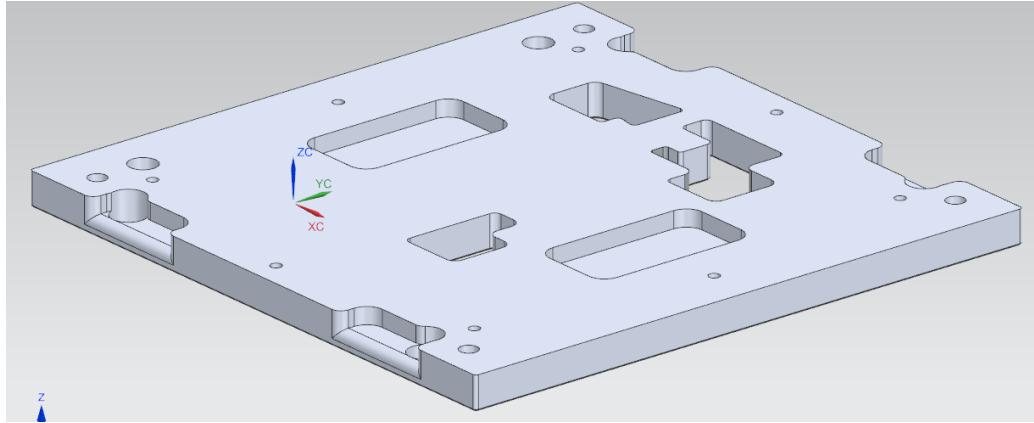


Figure 3: The base plate

B. Structural Rigidity Consideration

The thickness of 20 mm is selected to ensure sufficient stiffness. Under a maximum load of 1000 N, the deformation of the base plate is negligible and does not affect machining accuracy.

The design also considers:

- Uniform load distribution
- Minimization of bending deformation
- Resistance to vibration during operation

Flatness of the top surface is maintained within 0.01 mm to ensure proper contact during pressing.

C. Parametric Design Approach

Parametric modeling in Siemens NX allows key dimensions such as hole spacing, pocket size, and plate thickness to be easily modified. This improves design flexibility and enables rapid iteration.

D. Assembly Modeling and Validation

All components are assembled virtually to verify:

- Geometric compatibility
- Interference detection: No collision detected
- Alignment accuracy: < 0.01 mm
- Constraint definition: Fully constrained assembly

This step significantly reduces design errors before manufacturing.

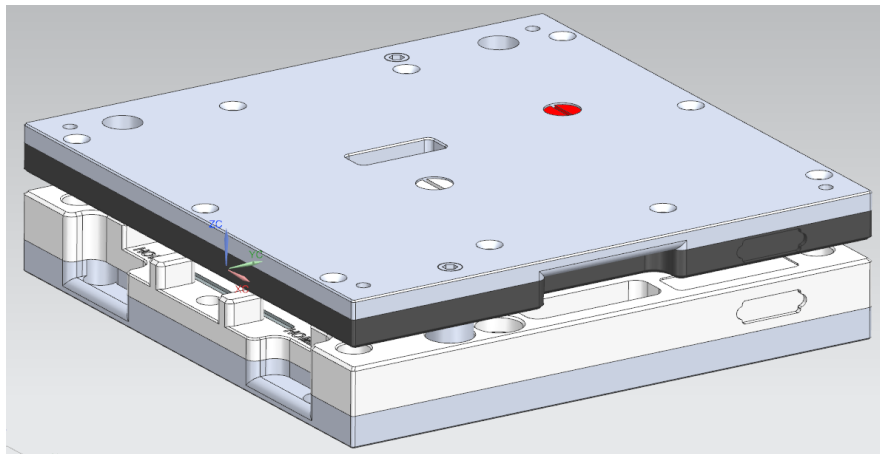


Figure 4: The Battery Press Jig

IV. CAM PROCESS PLANNING AND MACHINING STRATEGY

The machining process is developed using the CAM module of Siemens NX.

A. Machine Setup

- Machine type: 3-axis CNC milling machine
- Workholding: Mechanical vise
- Coordinate system: Defined at the center of the top surface
- Workpiece (blank): Aluminum block slightly larger than final dimensions

B. Tool Selection and Justification

No.	Operation	Tool Type	Diameter (mm)	Purpose
1	Facing	Face mill	50	Surface leveling
2	Rough milling	End mill	10	Bulk material removal
3	Finishing	End mill	6	Surface finishing
4	Drilling	Twist drill	6	Hole machining

Tool selection is optimized based on:

- Cutting efficiency
- Tool rigidity
- Surface quality requirements

C. Cutting Parameters Optimization (Al6061)

No	Parameter	Value	Unit	Description
1	Spindle speed	3000 – 6000	rpm	Rotation speed of cutting tool
2	Feed rate	500 – 1200	mm/min	Linear movement speed
3	Depth of cut	0.5 – 2	mm	Material removed per pass
4	Step-over	40 – 60	% (tool dia)	Lateral engagement of tool
5	Coolant	Flood	—	Cooling and chip removal method

These parameters are selected to balance:

- Material removal rate
- Tool life
- Surface finish

V. TOOLPATH GENERATION AND OPTIMIZATION

A. Facing Operation

- Zig-zag strategy
- Constant step-over
- Ensures uniform surface flatness

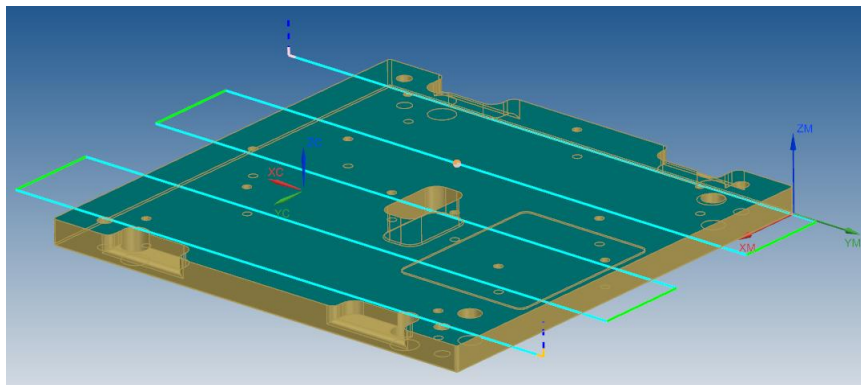


Figure 5: The facing toolpath

B. Finishing Operation

- Small step-over (0.2–0.3 mm)
- Fine surface generation
- Achieved roughness: $R_a \approx 1.6 \mu\text{m}$

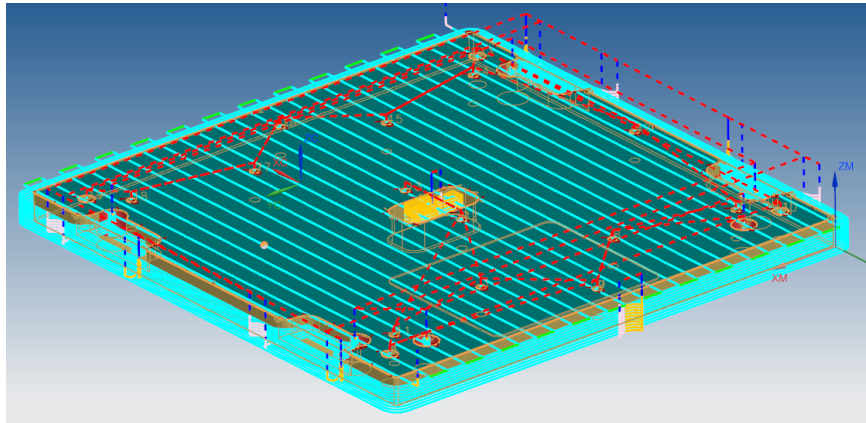


Figure 6: The finishing toolpath

VI. RESULTS AND DISCUSSION

The application of Siemens NX provides significant advantages:

- Reduction in machining time (~20%)
- Improved dimensional accuracy (± 0.02 mm)
- Enhanced surface finish ($R_a < 2 \mu\text{m}$)
- Elimination of manual programming errors

The integration of CAD and CAM improves both productivity and process reliability.

VII. CONCLUSION

This study presents an integrated workflow for the design and CNC machining of a battery press JIG using Siemens NX. The process combines CAD modeling, CAM programming, simulation, and NC code generation within a single platform.

The results show that the proposed approach ensures high dimensional accuracy (± 0.02 mm), stable machining performance, and improved surface quality. The use of optimized toolpaths and cutting parameters contributes to a reduction in machining time of approximately 20% compared to conventional methods.

Overall, the integration of design and manufacturing in Siemens NX enhances productivity, reduces programming errors, and improves process reliability. The proposed method can be effectively applied to the design and production of JIGs and similar mechanical components.

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