INPLASY

Influence of process and material factors on the quality of machine processing of laminated particleboard

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ADMINISTRATIVE INFORMATION

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 9 July 2025 and was last updated on 9 July 2025.

INTRODUCTION

Review question / Objective Review Question: What are the key factors influencing the machining of laminated particleboard, how do these factors affect the quality of the machining process, and what gaps exist in the current research on this topic?
Objective: This paper aims to present the current state of knowledge regarding the machining processes of laminated particleboard, with a focus on identifying and analyzing the factors that influence these processes and their impact on machining quality. Furthermore, it seeks to highlight existing research gaps and suggest directions for future studies.Review question – what are the factors infulencing laminated particleboard processing, how they influence the quality, what is the research gap in that field. Objective – paper presents the current state of knowledge regarding machining processes of laminated particleboard and the factors influencing them.

Rationale Laminated particleboard is widely used in the furniture industry due to its cost-effectiveness and favorable mechanical properties. However, its layered structure and heterogeneous composition pose significant challenges during machining, often resulting in defects such as laminate damages and tool wear. Optimizing the machining process is critical for ensuring product quality, extending tool life, and improving manufacturing efficiency. While various studies have investigated aspects of particleboard machining, the literature remains fragmented, with limited comprehensive evaluations of the interacting factors influencing machining quality (espacially material factors). A systematic review is therefore warranted to consolidate existing knowledge, identify key process parameters, and uncover research gaps that must be addressed to

advance precision machining of laminated particleboards.

Condition being studied The machining performance of laminated particleboard under various cutting conditions and techniques (e.g., cutting, drilling and milling,), with a focus on how process and material-related factors affect surface finish, edge chipping, and tool wear.

METHODS

Search strategy The literature search was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure a transparent and reproducible review process. Scopus and Web of Science were analyzed as the two most reliable and relevant article databases. Additionally, due to the high number of articles retrieved and to obtain a broader perspective, the Google Scholar database was also consulted. The gray literature was excluded from the analysis to ensure methodological rigor. For the SCOPUS database, the query phrase was as follows: TITLE-ABS-KEY (particleboard AND machining OR particleboard AND milling). For the Web of Science database, the query was: particleboard (machining OR milling), while for Google Scholar, it was "particleboard machining" OR "particleboard milling".

Participant or population The subject of this review is laminated particleboard used in industrial applications, particularly within the furniture industry. The review focuses on studies examining the machining behavior of this material, including its response to various cutting tools, parameters, and techniques.

Intervention The interventions considered involve machining processes applied to laminated particleboard, specifically drilling, cutting (sawing), and milling. These interventions are analyzed in terms of process parameters such as cutting speed, feed rate, tool geometry, and tool material, as well as material properties such as board composition, laminate adhesion, and surface coatings.

Comparator The comparators in the reviewed studies vary depending on the investigated factor. For process-related interventions, comparisons were made between different machining parameters (e.g., cutting speeds, feed rates, tool geometries, tool materials). For material-related factors, laminated particleboards were compared based on differences in core composition (e.g., type of wood chips, addition of synthetic materials or agricultural residues), laminate adhesion strength, or surface coatings. In many cases, machining outcomes were compared to reference materials such as standard industrial particleboard or baseline tool conditions (e.g., unworn tools).

Study designs to be included This review included original research studies that investigated the machining of laminated particleboard, focusing on both process-related and material-related factors affecting machining quality.

Eligibility criteria Studies were considered eligible for inclusion in the review if they met the following criteria:

Topic relevance: The study investigated the machining of laminated particleboard, specifically addressing the influence of process parameters (e.g., cutting speed, tool geometry, feed rate) or material-related factors (e.g., board composition, laminate adhesion) on machining quality.

Study type: Included were experimental, comparative, modeling/simulation, and data-driven studies with measurable outcomes related to machining quality (e.g., delamination, surface roughness, tool wear).

Material type: The primary material studied must be laminated particleboard (e.g., melamine-faced chipboard). Studies focusing solely on raw particleboard, MDF, or unrelated materials were excluded unless results were directly comparable to laminated particleboard.

Language: Only studies published in English were included.

Publication type: Only peer-reviewed journal articles and conference proceedings were considered. Gray literature, theses, and non-reviewed reports were excluded.

Publication date: No explicit date restrictions were applied; however, emphasis was placed on recent publications to reflect current industry practices.

Information sources The literature search was conducted using three major academic databases: Scopus, Web of Science, and Google Scholar. These sources were selected due to their comprehensive coverage of peer-reviewed publications in the fields of materials science, wood technology, and manufacturing engineering. The search included articles published up to April

2024, without a fixed start date, to ensure the inclusion of both foundational and recent studies.

Main outcome(s) The primary outcomes of this review are the quality indicators used to evaluate the machining performance of laminated particleboard. These include:

Delamination area (surface damage to the laminate layer),

Maximum damage depth (penetration of laminate defects),

Surface roughness after machining,

Tool wear and its impact on machining quality,

Dimensional accuracy and edge integrity of machined components.

These outcomes were assessed in relation to various process parameters (e.g., cutting speed, feed rate, tool geometry) and material properties (e.g., board composition, laminate adhesion strength, surface coatings).

Additional outcome(s) The review also considered the following supplementary outcomes:

Cutting forces and torque during machining operations, particularly in drilling and milling,

Energy consumption associated with different machining parameters and material compositions,

Machinability assessments (e.g., simplified testing methods for industrial applications),

Tool life extension techniques, such as surface modifications or coating methods (e.g., ion implantation, SAW),

Predictive modeling accuracy, including the use of neural networks and simulation tools (e.g., FEM),

Industrial applicability of machining strategies in the context of Industry 4.0 and smart manufacturing systems.

These outcomes provide broader insights into the process efficiency, tool durability, and potential for automation in the machining of laminated particleboard.

Data management The initial search results from the three selected databases (Scopus, Web of Science, and Google Scholar) were exported as .csv files. These files were then combined using the Publish or Perish 8 software to consolidate all retrieved records into a single dataset. The resulting dataset was converted into a Microsoft Excel (.xls) file, where duplicate entries were manually removed.

Following this, the list of unique articles was subjected to a preliminary screening based on titles and abstracts. The remaining articles were then imported into Mendeley, where full texts were reviewed by the authors. Mendeley was used to manage and organize the selected references throughout the writing process. Final article selections were based on relevance to the defined eligibility criteria, and key information from each study was extracted and summarized in structured tables for analysis.

Quality assessment / Risk of bias analysis A formal risk of bias assessment was not performed using standardized tools, as the included studies were primarily experimental and engineering-focused rather than clinical or observational in nature. However, to ensure methodological rigor, each selected article was qualitatively assessed based on the following criteria:

Clarity and transparency of experimental design, including description of machining processes and measurement methods;

Relevance and consistency of reported outcome indicators (e.g., delamination area, surface roughness, tool wear);

Completeness of data reporting, including statistical analysis, replication of trials, and use of control conditions or reference materials;

Credibility of sources, limited to peer-reviewed journals and conference proceedings only.

Studies with insufficient methodological detail, unclear variable definitions, or lack of direct relevance to laminated particleboard machining were excluded during the full-text review stage. The inclusion of only peer-reviewed literature and the manual review process by multiple authors helped mitigate potential bias in study selection and data interpretation.

Strategy of data synthesis Given the heterogeneity of the included studies in terms of machining processes, parameters, material types, and outcome measures, a narrative synthesis approach was employed. The data were

synthesized thematically by grouping findings according to:

Machining process type – drilling, cutting, and milling;

Source of influencing factors – process-related vs. material-related;

Quality indicators used – including delamination area, surface roughness, damage depth, and tool wear.

For each category, results were compared and summarized to identify consistent patterns, divergences, and trends across studies. Tables were constructed to systematically present the key influencing factors, their effects on machining quality, and corresponding references.

Due to the diversity of methodologies and outcome definitions, quantitative meta-analysis was not feasible. Instead, the review focused on identifying qualitative relationships and highlighting under-researched areas, particularly in the context of material-related influences on milling quality.

Subgroup analysis Subgroup analysis was conducted by categorizing the included studies based on the type of machining process (drilling, cutting, and milling) and the source of influencing factors (process-related vs. material-related). This allowed for a more detailed examination of how specific variables affect machining quality within each technological context.

Within each subgroup, the following distinctions were analyzed:

Process-related factors, such as cutting speed, feed rate, tool geometry, and tool material;

Material-related factors, including board composition, raw material origin, surface coatings, laminate adhesion, and additive content (e.g., thermoplastics or agricultural waste);

Quality indicators, such as delamination area, surface roughness, maximum damage depth, and tool wear progression.

This stratification enabled the identification of trends and critical differences in how various factors influence machining quality across different processes. It also revealed that material-related factors in milling represent a notable research gap, particularly regarding their interaction with tool wear and delamination.

Sensitivity analysis A formal sensitivity analysis was not conducted using statistical methods, as the review did not include quantitative meta-analysis due to the heterogeneity of study designs, measurement approaches, and outcome indicators. However, a qualitative sensitivity assessment was performed to evaluate the robustness of the findings.

This involved:

Comparing results across studies with varying levels of methodological detail and experimental control;

Examining whether the inclusion or exclusion of older publications (e.g., pre-2010) affected the consistency of conclusions, especially in under-researched areas such as material-related factors in milling;

Assessing whether studies conducted under industrial versus laboratory conditions reported significantly different trends or findings.

This approach confirmed that the core conclusions – particularly regarding the influence of tool wear, cutting speed, and laminate adhesion on machining quality – remained stable across different sources and experimental setups.

Language restriction Only studies published in English were included in this systematic review.

Country(ies) involved Poland.

Keywords Particleboard; machining; machining quality; laminate breakout; delamination; tool wear.

Dissemination plans The findings of this systematic review will be disseminated through publication in a peer-reviewed open-access journal to ensure broad accessibility to researchers, industry professionals, and academic institutions. Additionally, the results may be presented at relevant scientific conferences and industry workshops in the field of wood science, materials engineering, and furniture manufacturing. Where applicable, the outcomes may also inform internal process optimization and material quality evaluation strategies within industrial settings.

Contributions of each author

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