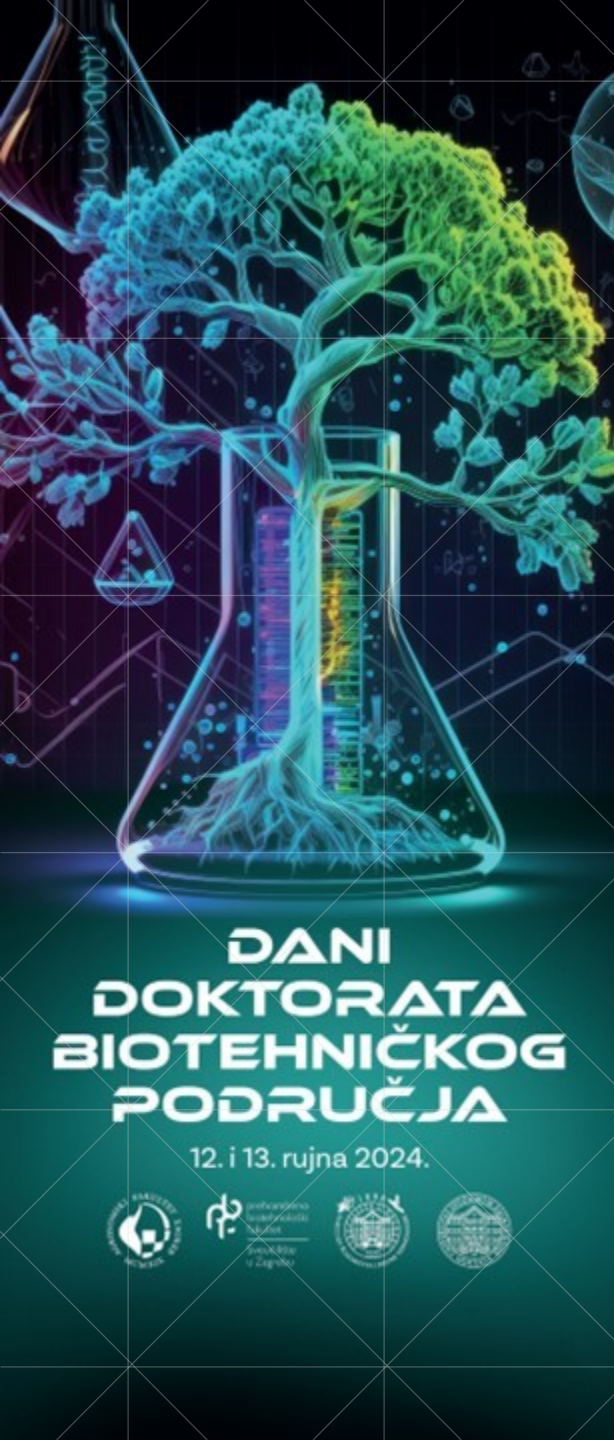


# Durability of coated tungsten carbide tools in peripheral milling of medium density fiberboard

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# Introduction

## Requirements for "state of the art" tools in woodworking

- Use of extremely high cutting speeds (↘ decreased tool life; ↗ increased production rate)
- Extreme sharp tools (↘ decreased tool life; ↗ increased surface quality)

**Tool Durability**– the time the tool spends in operation between two sharpenings

Depends on:

- Material
- Tool (type of tool material, tool geometry)
- Processing mode (feed per tooth, ...)





# Introduction

## Processing of abrasive wood and wood-based materials

- The use of hard-to-process wood-based composite materials is growing
  - Intensive abrasive wear
  - Possible high processing temperatures
  - Low thermal conductivity of the processing material
  - High anisotropy of the processing material



HPL ploča kao obloga:  
A - Visokotlačna laminirana oboja na oboje strane.  
B - Ivenica ili MDF.



**Proposed Solution: Use of hard tool coatings on hard metal tools**



# Introduction

## Hard tool coatings

### Pros:

- Significantly better tribological and mechanical properties of the Tool contact surfaces
- Films with a thickness of several micrometers can significantly slow down the intensity of abrasive and adhesive wear of cutting tools
- Reduction of mechanical and thermal stresses on the tool

### Cons:

- Increasing the rounding radius (wood surface quality)
- After sharpening, it is necessary to reapply the coating



# The aim of the study

- Investigate the stability of coated hard metal tools for circumferential milling of medium density fiberboards, under selected processing conditions and given quality of the processed surface, and propose a method for choosing the optimal coating

## Hypotheses

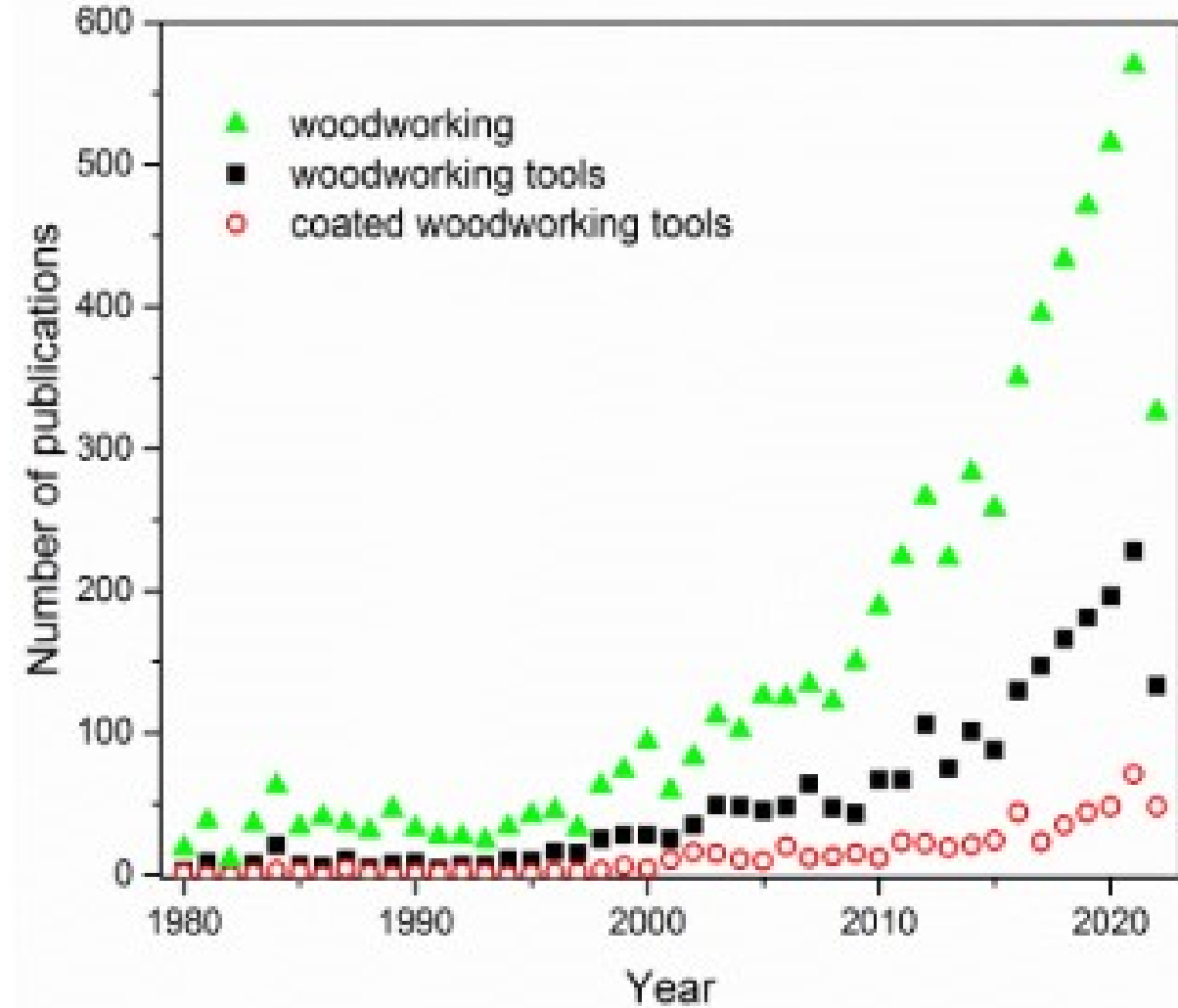
- H1:** By applying hard coatings, it is possible to multiply the durability of tools for processing medium density fiberboards compared to the application of conventional coatings
- H2:** By applying hard coatings, it is possible to achieve the quality of the machined surface, which can be predicted by mathematical modeling depending on tool wear.





## Literature review

- A small proportion of scientific works in which they apply coated tools in woodworking from 1980.-2022. (Warcholinski 2022.)



## Literature review

With the rapid development of new, difficult-to-process wood-based composite materials, efforts are being made to respond to the set requirements for durability and reliability of tools, and thus to the productivity and economy of tools (Nadolny et al. 2020).

There is no universal coating (Sheik-Ahmad et al 2007)

It is necessary to look for alternative solutions to increase the durability and service life of hard metal tools in woodworking, especially in the processing of abrasive wood composites (Warcholinski et al. 2022).



# Methodology and research plan

## Phase 1 – Selection and characterization of coatings, substrates and processing materials

- Mechanical properties of processing material, substrate, substrate preparation - edge pretreatment
- Mechanical properties of coatings (adhesion, microhardness, thickness, friction factor)

## Phase 2 – Exploitation wear of coated tools – **IN PROGRESS (1/2 completed)**

- All 7 systems (6 coatings + uncoated tool)
- 1. AlCrSiN; 2. TiAlSiN; 3. TiN; 4. TiAlN; 5. TiB<sub>2</sub>; 6. TiAlN + WC+C

## Phase 3 – Processing and analysis of results

- Mechanical and physical properties of used coatings
- Tool Durability
- Surface quality



# Research plan

## Phase 1-Selection and characterization of hard tool coatings

Selected systems of PVD multi-layer and single-layer hard tool coatings:

- **Uncoated tool (referent value for durability)**

### Selected Hard tool coatings:

1. AlCrSiN
  2. TiAlSiN
  3. TiN
  4. TiAlN
  5. TiB<sub>2</sub>
  6. TiAlN + WC+C - DLC – Diamond like carbon
-

# Research plan

## Phase 1 – Selection and characterization of coatings, substrates and processing materials

### 1. Surface roughness of the coating

*Bifocal microscope*

### 2. Coating adhesion test

*Scratch test*

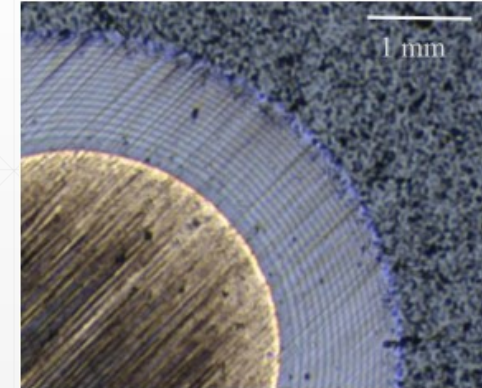
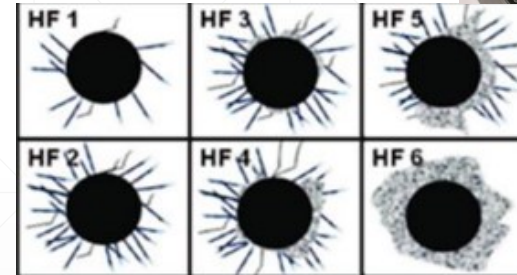
*Daimler Benz Rockwell C*

### 3. Vickers microhardness test

*Indenter*

### 4. Coating thickness measurement

*Kalotest (all coatings have aprox. Same tickness)*

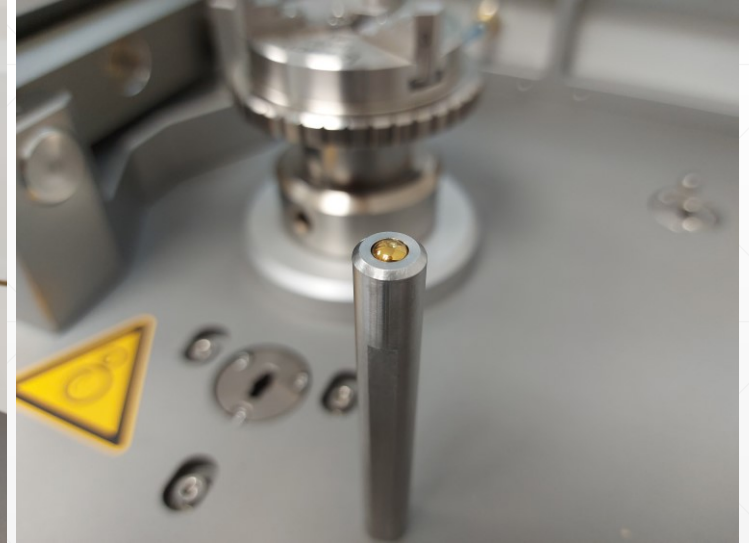
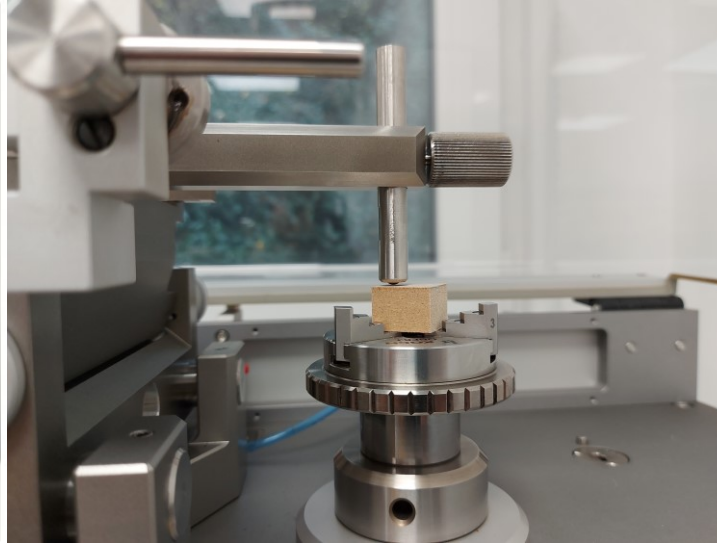
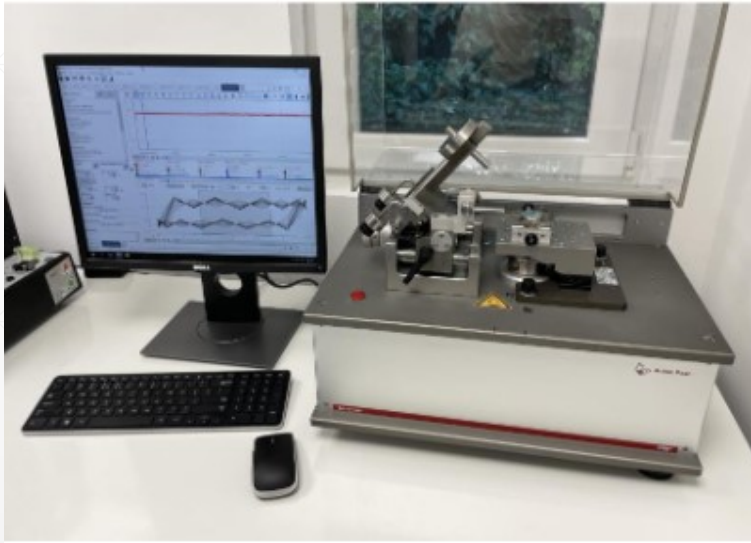


# Research plan

## Phase 1 – Selection and characterization of coatings, substrates and processing materials

### 5. Testing the friction factor and sliding wear using the ball-on-plate method

Tribotester - Determination of COF in interaction: Coating - MDF





# Research plan – Currently in Progress

## Phase 2 - Exploitation wear of prepared knives

- Peripheral Milling Operation – Head with replaceable knife
- **Adjusted according to recommendations ISO 8688:2:1989 *Tool life testing in milling***
- Substrate material– Hard metal (WC-Co) commercially called „Widia”
- Exploitation conducted on MDF



# Research plan – Currently in Progress

## Phase 2 - Exploitation wear of prepared knives

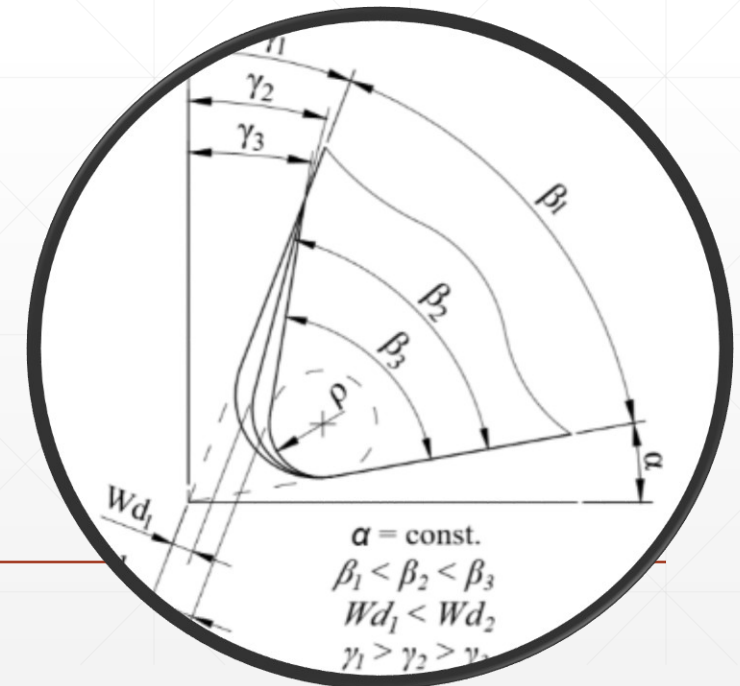
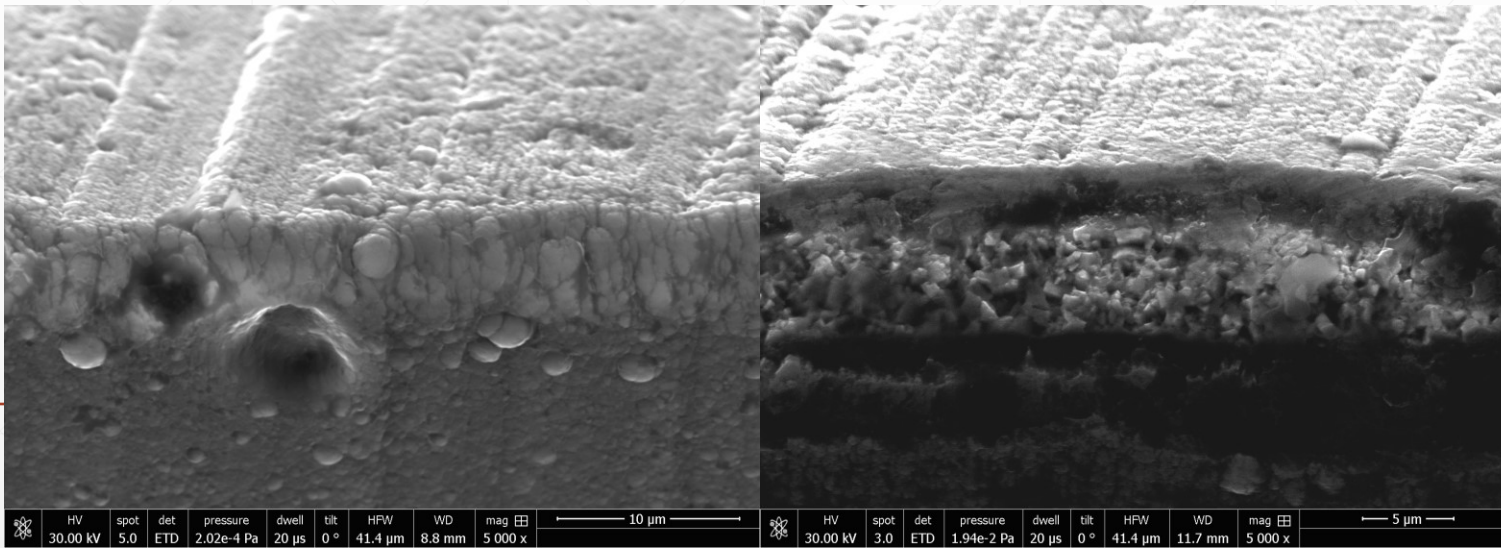
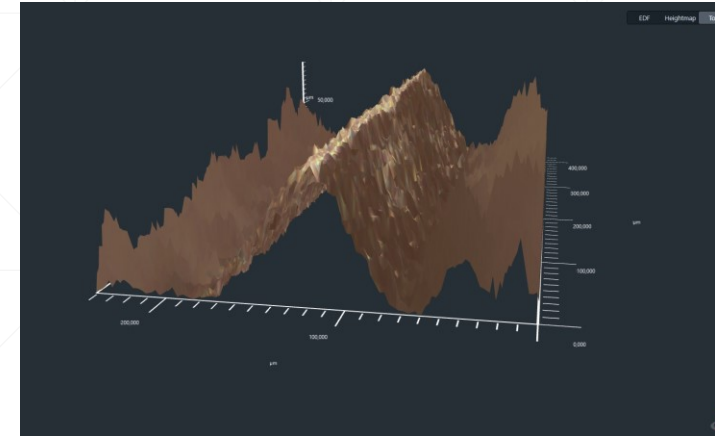
Control of changes in tool radius increase and other tool-wear parameters

### 1. State of the blade during exploitation at control points

Light microscope using topography method

### 2. Initial and final state of the blade

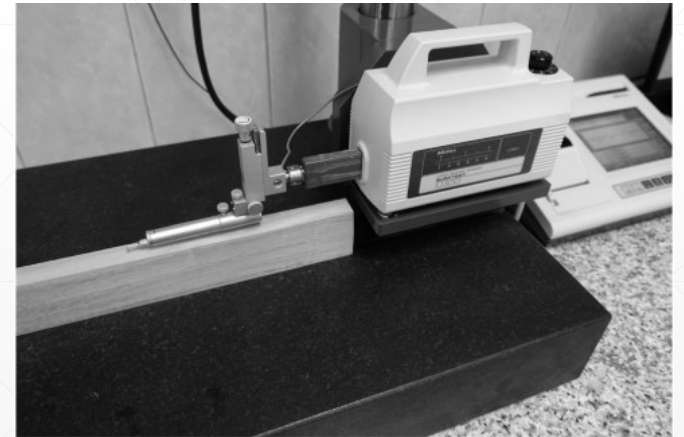
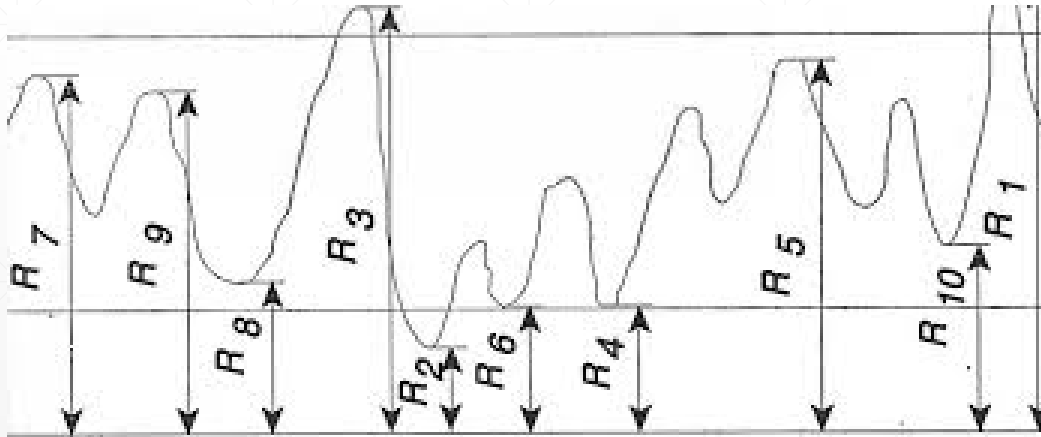
SEM (Scanning electron microscope)



# Research plan – Currently in Progress

## Phase 2 - Exploitation wear of prepared knives

- **Measuring the quality of the surface**
  - Contact profiler with stylus
  - In accordance with the standard: ISO 4287:1996
  - Surface quality is expressed through the parameters  $R_a$ ,  $R_q$ ,  $W_z$





# Research plan

## Phase 3 - Processing and analysis of results

- **Processing of results:**
  - **Mechanical properties** of hard coatings (hardness, COF, adhesion, surface roughness of coatings)
  - **Tool durability** (Edge recession, edge radii, and other indicators of tool wear)
  - **Quality of milled surface** ( $R_q$ ,  $R_a$ ,  $W_z$ )
- **Analysis of results:**
  - ANOVA
  - T-test
  - Other parameter comparison tests



## Expected scientific contribution

- 1. Method of choosing the optimal coating for processing wood based material
- 2. Mathematical model of coating wear depending on the amount of processed medium-density fiberboard (MDF)
- 3. Mathematical model of the dependence of the quality of the processed surface on tool wear





**Thank you for attention!**





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