ANALYSIS OF CNC MILLING PARAMETERS ON ROUGHNESS OF ORDINARY, STEAM TREATED AND HEAT-TREATED BEECH WOOD, USING SPIRAL CUTTER

Ibrahim Busuladzic, Alen Ibrisevic, Murco Obucina, Seid Hajdarevic

Faculty of Mechanical Engineering of Sarajevo

University of Sarajevo

Bosnia and Herzegovina

INTRODUCTION

- Important characteristics of beech wood are its density, anatomical structure, hardness…
- Beech wood is used to make massive wooden furniture, especially tables, chairs and sets.
- Producing all types of furniture, final processing of the wood is very important, especially when milling.
- The roughness of the processed wood surfaces is an important indicator of the processing quality.

INTRODUCTION

- The surface roughness after milling wood depends on many different factors; processing parameters and of course the type of wood (i.e., the same kind of wood but differently treated).
- Processing parameters such as cutting speed and displacement are mainly important to obtain the decent quality of treated surface i.e. surface with lowest roughness.
- Also, the type of milling tool and its geometric properties influences a lot the surface roughness.

TOOL

- Different tools for milling on CNC machines can be used for different operations and shapes of processed material.
- Depending on the needed operation one or more types of milling tools can be used.
- Sometimes different tools give different quality of processed material surface depending mostly on sharpness of cutting edge of tool, the milling parameters of CNC machine and of the geometry of the tool.
- With the development of new technologies, new advanced tools for woodworking appears, known as "spiral routers".

- In this work, we have used the spiral milling cutter shown in figure, with a diameter of 8 mm.
- This tool is made of high-speed steel (HSS).
- Regarding the geometry, spiral milling cutters appear very similar to standard spiral drills.
- The top of the milling cutter is always displaced from the central point for a small distance. It results that the spiral cutters cut in a hybrid path that is a mixture of cutting with classic straight cutters and drilling with spiral drills.
- The bevel cut with spiral milling cutters gives much less unwanted effects, and the resulting profile is cleaner and less exposed to heating.
- The next big advantage is that the spiral milling cutters continuously remove the sawdust, so it does not get further crushed.

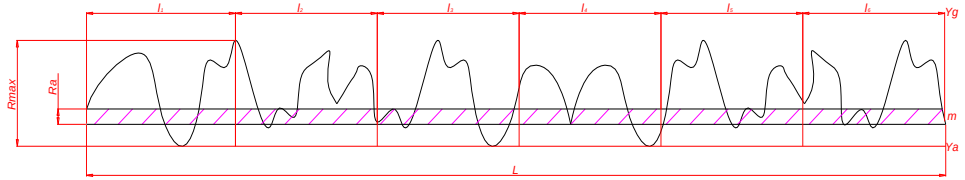
MATERIALS

- Three types of treated beech wood were used in this work:
  - ordinary,
  - heat-treated and
  - steamed beech wood.

- ‘’steamed beech’’ designates the purple beech which has been steamed while still green, at the latest two weeks after its cut.
- Heat modification of wood is a process that ensures the improvement of certain properties of wood, without imposing an additional burden on the environment.
- Thus, heat modification improves dimensional stability and biological durability of wood, although some mechanical properties seem to deteriorate.

SOURFACE ROUGHNESS

- Finishing treatment, is a subjective term that denotes surface smoothness and general quality.
- Surface finishing is often used as a synonym for surface roughness.
- Surface roughness represent the totality of micro geometrical irregularities.
- In wood processing, the surface roughness depends on processing parameters, tool geometry and sharpness, wood species (hard and soft wood), wood moisture and the direction of cutting.
- Surface roughness is a calculation of the relative roughness of the surface profile based on the numerical parameter Ra. Ra is arithmetic mean deviation of the profile across the surface.

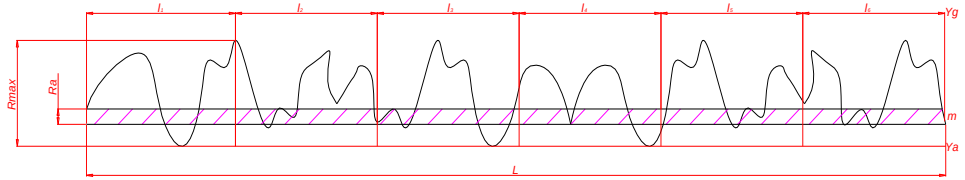


SOURFACE ROUGHNESS

- A profile meter or surface profile measuring instrument, is used to measure surface roughness. It is the average height of the roughness irregularity of the part from the center line. Arithmetic mean deviation of the profile Ra can be calculated by the formula:

$$R_a = \frac{1}{n}\sum_{i=1}^{n}|y_i| \quad (1)$$

- l [µm] - length on which the surface roughness is measured,
- y(x), yi [µm] - the heights of the roughness profile with respect to the middle reference line,
- n - number of points for assessing the heights of the profile along the measuring length.

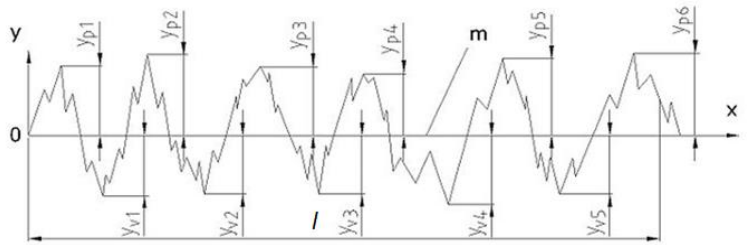


SOURFACE ROUGHNESS

- One can use also the mean height of bumps Rz, as a parameter of surface roughness. It is equal to the sum of arithmetic mean of the heights of the five highest peaks and arithmetic mean of the values of the five largest valley depths, on the length l, on which the surface roughness is measured. The International ISO system defines Rz as follows:

$$R_z = \frac{1}{n}\left(\sum_{i=1}^{n} y_{p_i} - \sum_{i=1}^{n} y_{v_i}\right) \quad (2$$

- y_{p_i}[μm] - height of the i_{th} highest peak,
- y_{v_i}[μm] - depth of the i_{th} lowest valley.

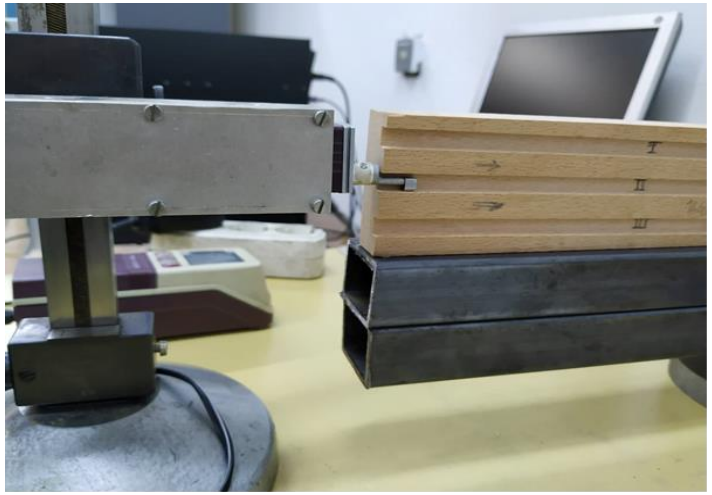


EXPARIMENTAL SETUP

- The processing of the notches on samples are made with the CNC machine, as shown in the picture.
- Several spindle speeds are randomly chosen to analyze their influence on the quality of processing i.e. the surface roughness.
- The displacement speed was constant, equal to 5 m/min.
- The following spindle speeds are chosen within the machine's operating range: 8400 rpm, 9600 rpm, 10800 rpm, 12000 rpm, and 14400 rpm.

MEASUREMENTS OF SURFACE ROUGHNES OF SAMPLES

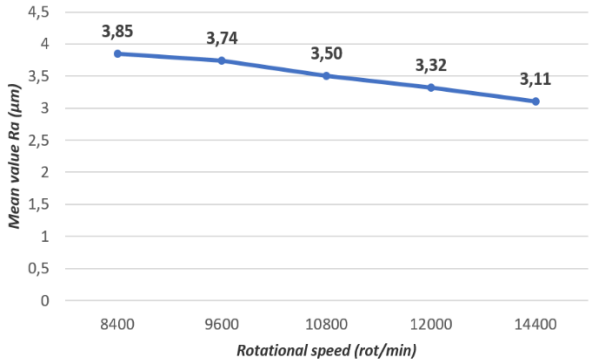
- We distinguish two types of methods to test surface roughness: quantitative methods (optical and contact) and qualitative methods.
- The surface roughness, in this work, was measured along the processed surface, using an electromechanical profile meter Mitutoyo SJ-201.

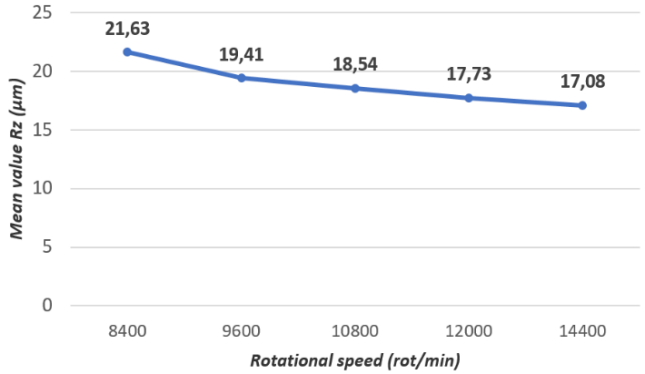


RESULTS

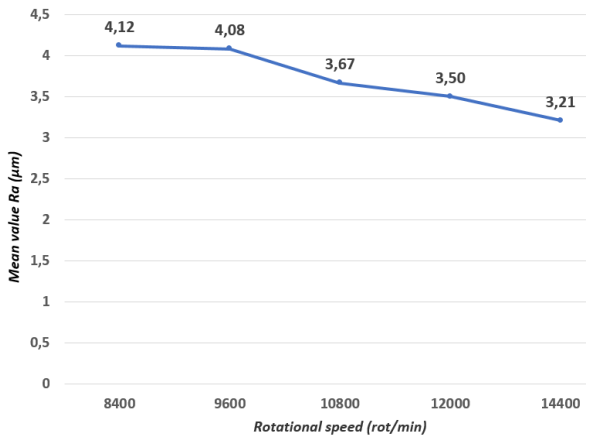
- After performing the milling process on CNC machine with spiral router, the results are read on the measuring device.
- Arithmetic mean deviation of the profile Ra and mean height of unevenness Rz are used to quantify the surface roughness results for three different types of beech wood.
- For those tests the rotational spindle speeds are 8400, 9600, 10800, 12000 and 14400 rpm.
- 12 measurements were made for each sample.

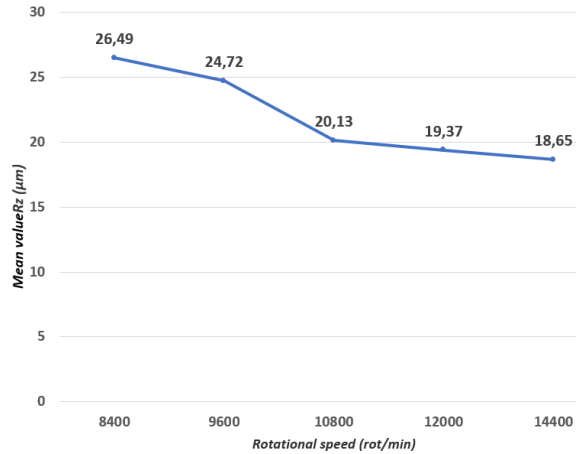
Beech wood



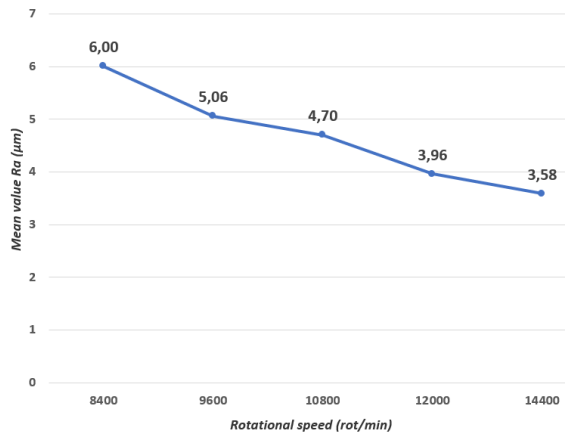


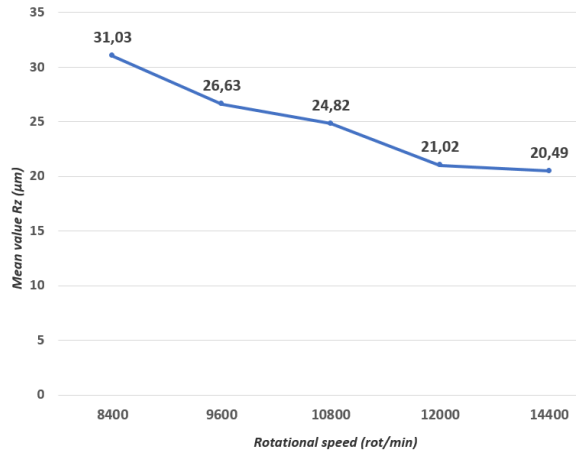
Heat-treated beech wood





Steamed beech wood





DISCUSSION

- If we look at the type of processed wood, we can conclude that the lowest surface roughness was achieved on ordinary beech wood, then on heat-treated and the highest on steamed beech, leading to the poorer processing quality.
- Looking at the results in relation to the spindle speed, we can see that as the spindle rotation speed increases, the surface roughness decreases for all three types of wood.
- The best surface quality, i.e. the lowest roughness of the processed surface, was achieved at a spindle speed of 14400 rpm, while the highest roughness was at the spindle speed of 8400 rpm.
- Also, the difference of surface roughness is insignificant between ordinary and heat-treated beech wood, and compared to steamed beech wood, surface roughness is significantly smaller for the ordinary and heat-treated beech wood.