Ain Shams University
Faculty of Engineering
Design and Production Department
Master of Science in Mechanical Engineering

Study of parameters affecting the skinning process of palm midribs

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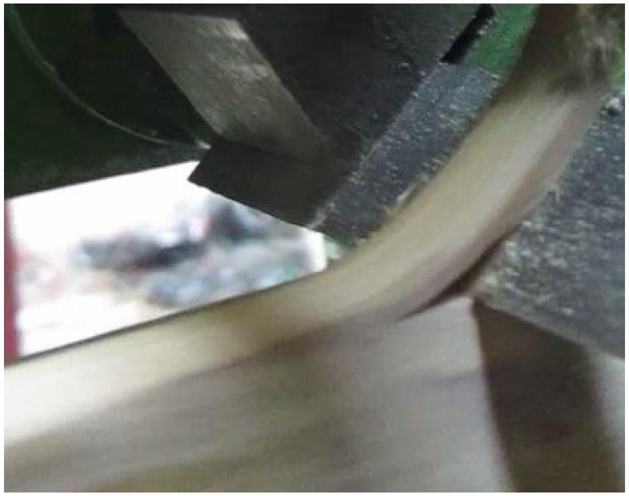


Table of contents

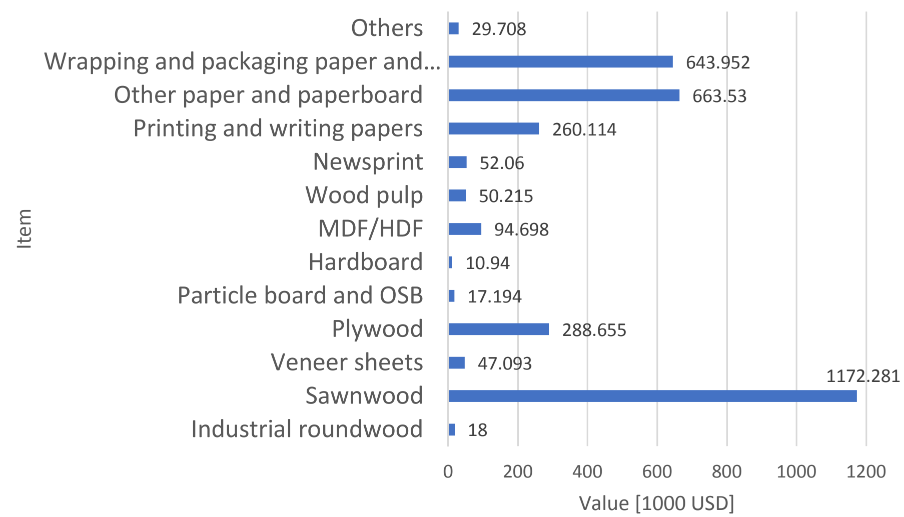
Background of selection of the research area

- The use of renewable materials as alternatives to the non-renewable ones (exhaustable).
- Agriculture residues are one type of renewable materials.
- Egypt is mostly desert, arid and semi-arid rangelands.
- Agricultural land base is 3.6% of the total area in 2014[*].
- The value of imports of Egypt from wood, paper, and their derivatives was 4.3 billion USD in 2016 [**].

[*] Central Agency for Public Mobilization and Statistics, “Egypt in Figures,” 2016.
[**] FAO, “Forestry Production and Trade database, Import quantity and value in 2016.” .

Background of selection of the research area

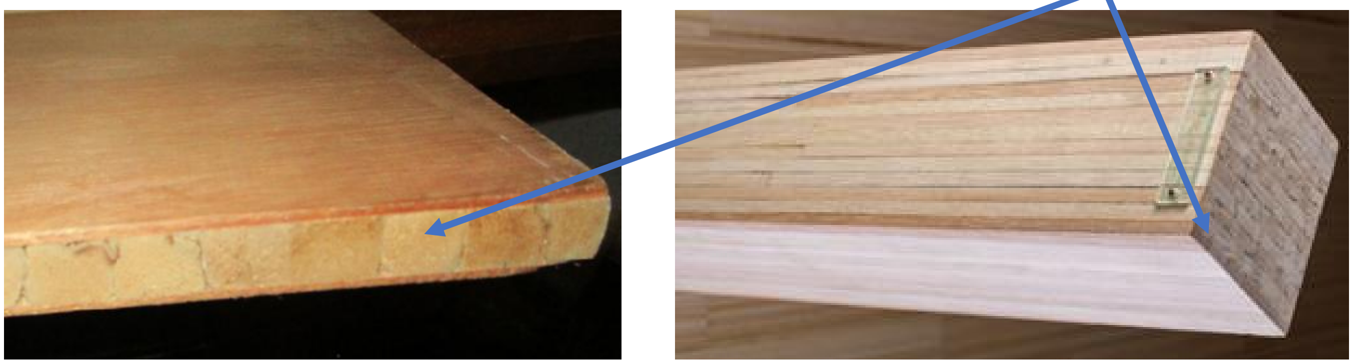
- Sawnwood represents about 40% of the total value of imports.
- Sawnwood is estimated to weigh about 4.8 million ton (for 800 kg/m^3 density).
- The quantity of the agriculture residues in Egypt was 50 million ton in 2010 [*].
- These residues are open field-burnt or used in low added-value products.



[*] Minsitry of Environment, “Guide to recycling of agricultural residues,” 2010. [Online]. Available: http://www.eeaa.gov.eg/ar-eg/التوعيةالبيئية/تدويرالمخلفاتالزراعية/المركزالاعلامى.aspx. [Accessed: 03-Jun-2017]

Background of selection of the research area

- The use of palm midribs in the production of high added-value products. The unit of these products is the strip.



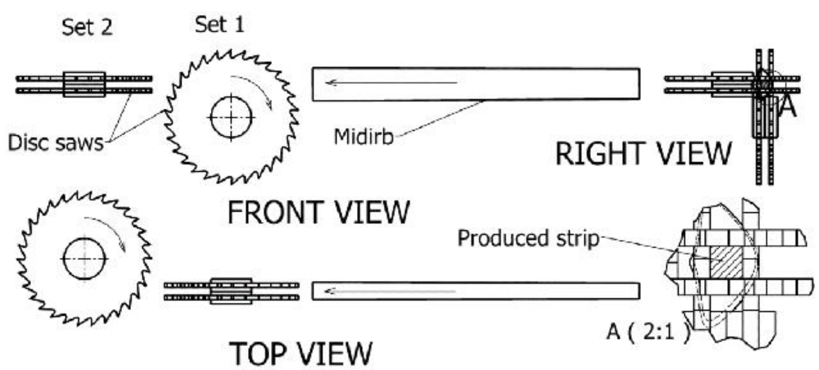
- The number of productive date palms is about 12 millions in 2013 [*].
- The quantity of midribs/year is about 15 kg/yr [**]. Total quantity is about 180,000 tons/yr.

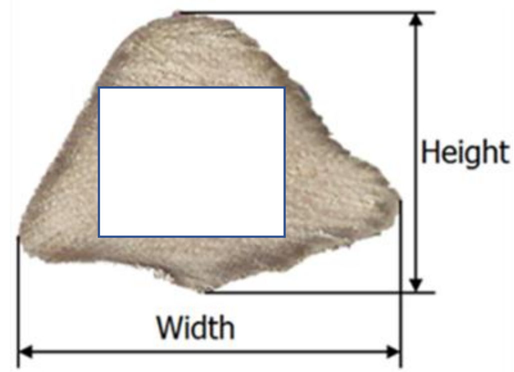
[*]   M. of agriculture and land Reclamation, “Annual agriculture publication 2012/2013,” 2014.
[**] H. El-Mously, “Improvement of the environmental conditions, care of the palms and the economic use of their secondary products in Al-Wahat Al-Baharia project,” *Ain Shams Univ. Fac. Eng.*, 2016.

Background of selection of the research area

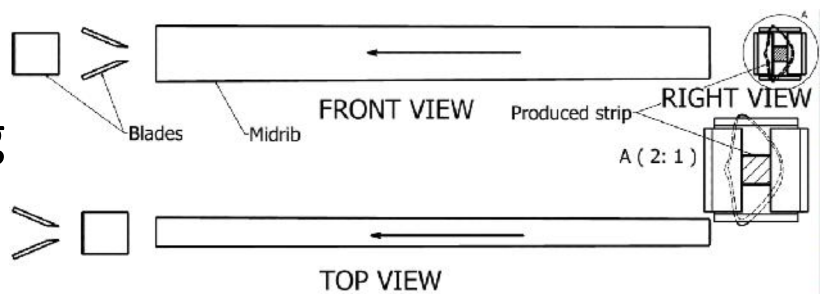
Stripping

1. Cutting



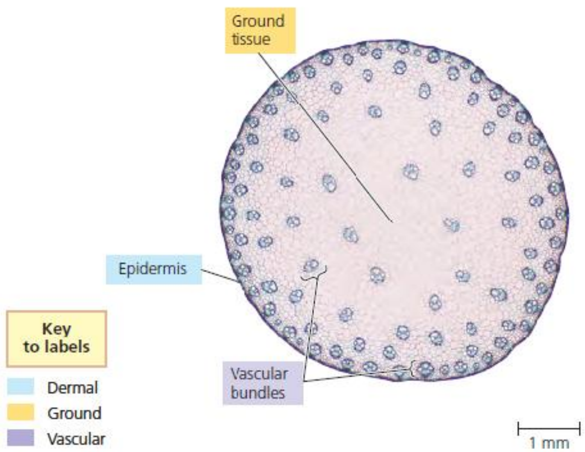


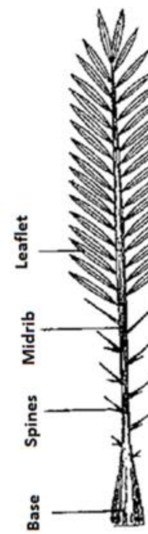
2. Skinning

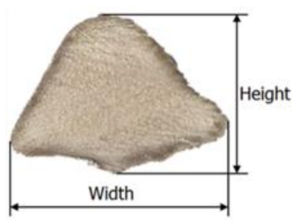


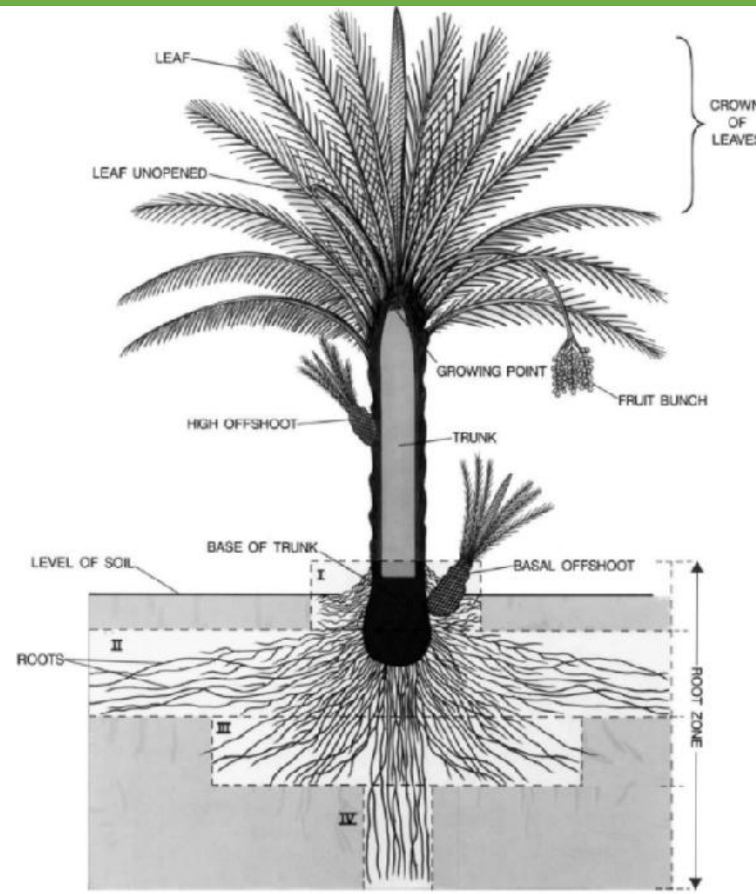
Palm midrib: general morphology, anatomy, and properties

- Midrib is a part of the compound leaf.
- It has triangular tapered cross section.
- It is one of monocotyledons.





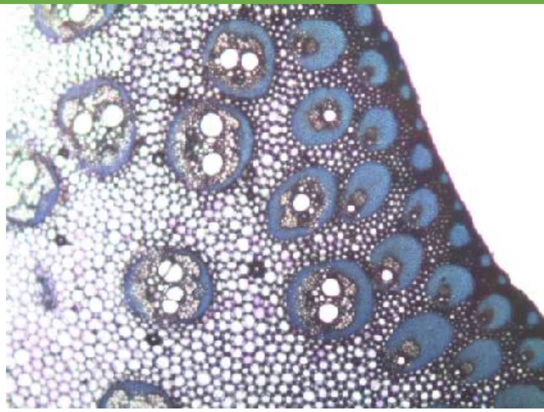


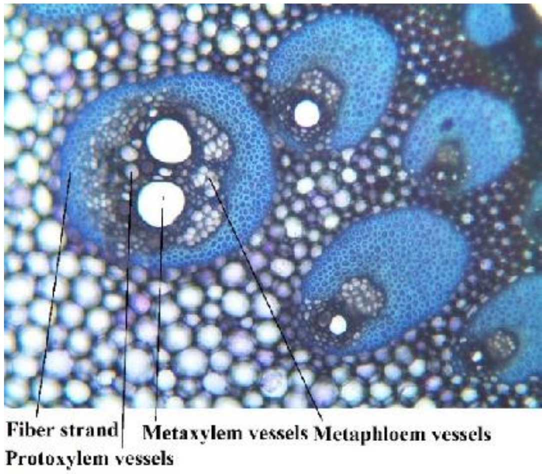


Palm midrib: general morphology, anatomy, and properties

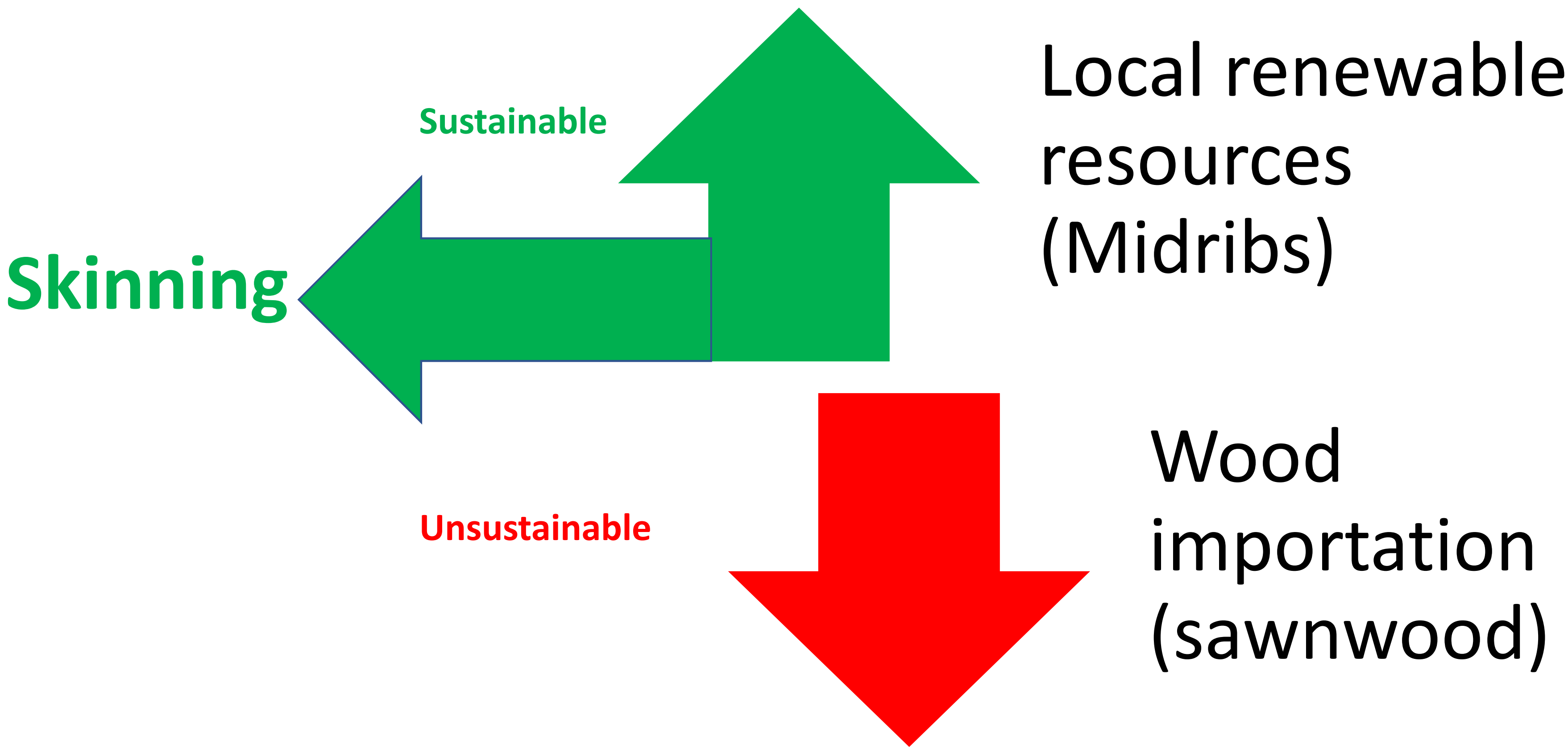
- Midrib has a structure as monocotyledons.

Material	Density [Kg/cm^3]	Ultimate tensile strength (σ_u) [N/mm^2]	Modulus of elasticity (MOE) [N/mm^2]	Specific σ_u [(N/mm^2)/(Kg/cm^3)]	Specific MOE [(N/mm^2)/(Kg/cm^3)]
DPLM					
Outer layer	1.14	248	15400	218	13520
2nd layer	0.885	78	5670	88.5	6410
3rd layer	0.823	67	4670	81.4	5670
4th layer	0.707	63	4250	88.9	6000
Beech	0.68	97	5310	143	7845
Red pine	0.55	78	6370	143	11800





Problem definition and research strategy



Literature review (cutting forces)

- Mechanics of wood cutting has been studied by:

1. Franz (1958).
2. Williams (1998)
3. Atkins (2009).
4. Csanády and Magoss (2012).

They studied how the wood behaves during its cutting and the factors affecting this process.

Literature review (cutting forces)

- Mathematical models for the cutting forces of wood has been deduced by:

1. Franz (1958).
2. Atkins (2009) based on Williams (1998) findings
3. Csanády and Magoss (2012).

- Statistical models for the cutting forces has been carried out based on experimental works by:

1. Axelsson et al. (1993).
2. Porankiewicz et al. (2011).

Literature review (cutting forces)

- Experimental studies for the cutting forces has been carried out by:

1. Koch (1955 and 1956).
2. Mckenzie (1961).
3. Aguilera and Martin (2001).
4. Dowgiallo (2005)
5. Lhate et al. (2011).
6. Cristóvão et al. (2012 and 2013)

7. A. S. A. Mohamed and El-Mously (1993).
8. El-Mously and his research team (1994)

Literature review (surface roughness and wear)

- The factors affecting the surface roughness are studied by:

1. Hiziroglu (1996): Stylus method.
2. Dundar (2008).

- The factors affecting the tool wear are studied by:

1. Beer et al. (1999).
2. Okai et al. (2006).
3. Porankiewicz et al. (2005, 2006).
4. Darmawan et al. (2006).

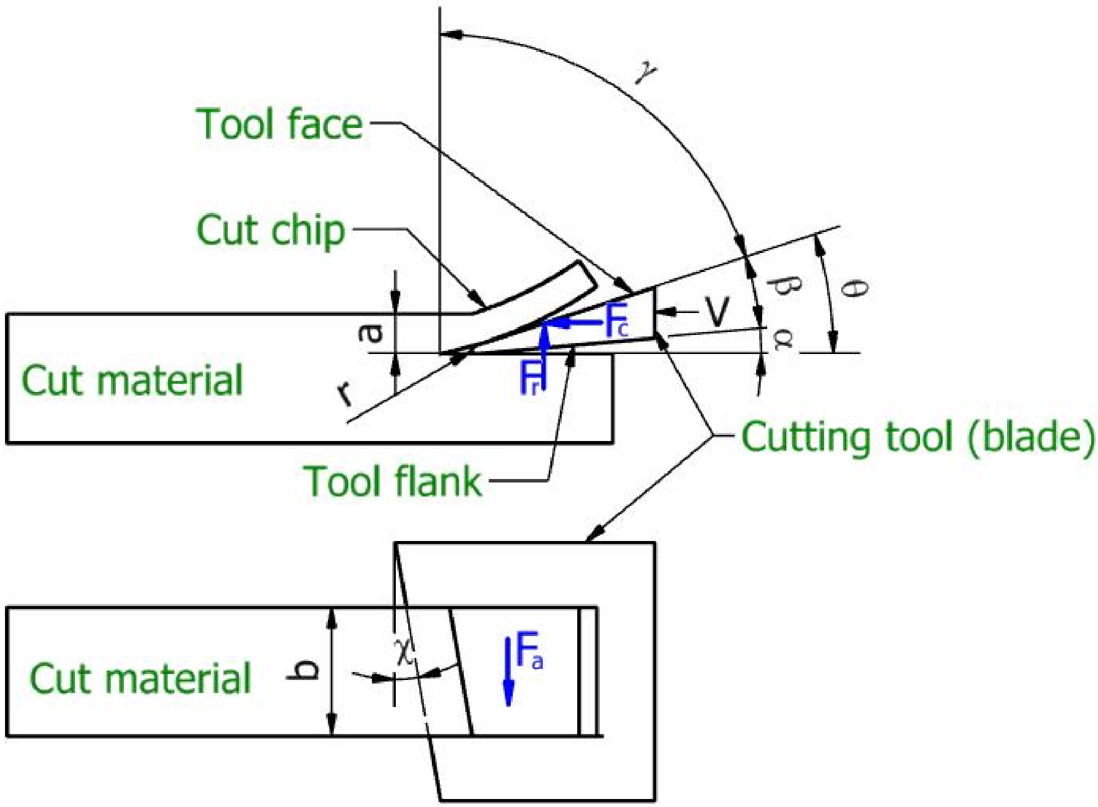
5. El-Mously et al. (2000).

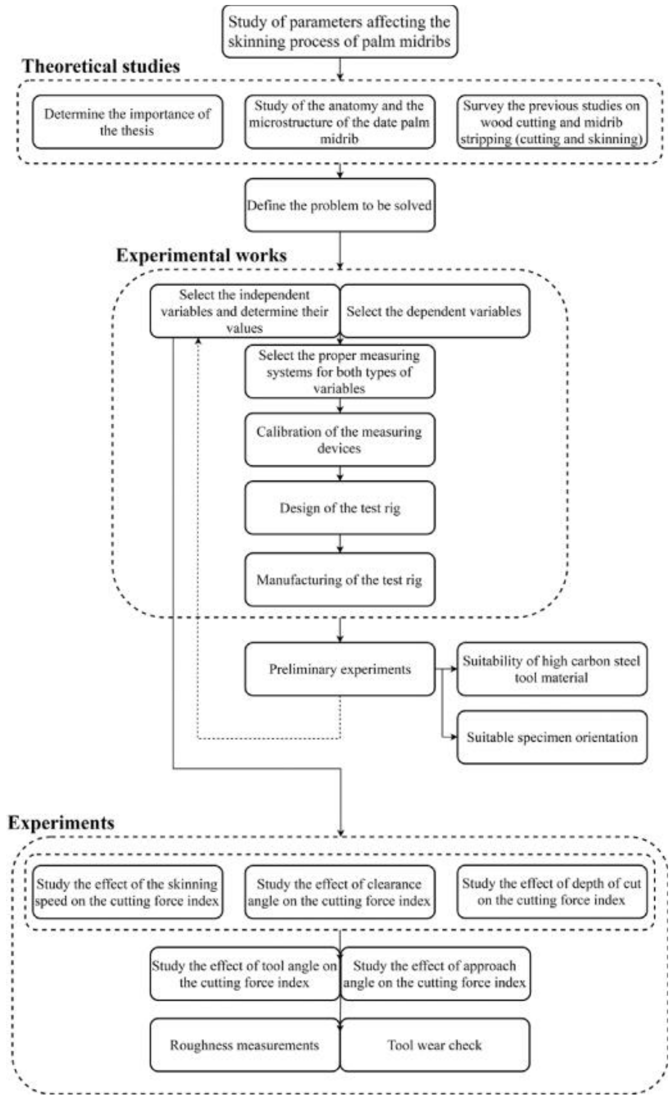
Problem definition and research strategy

- Study of the skinning mechanism.
- Study of the effect of the **independent variables**

1. Tool material.
2. Clearance angle (α).
3. Tool angle (θ).
4. Approach angle (χ).
5. Depth of cut (a).
6. Skinning speed (V).

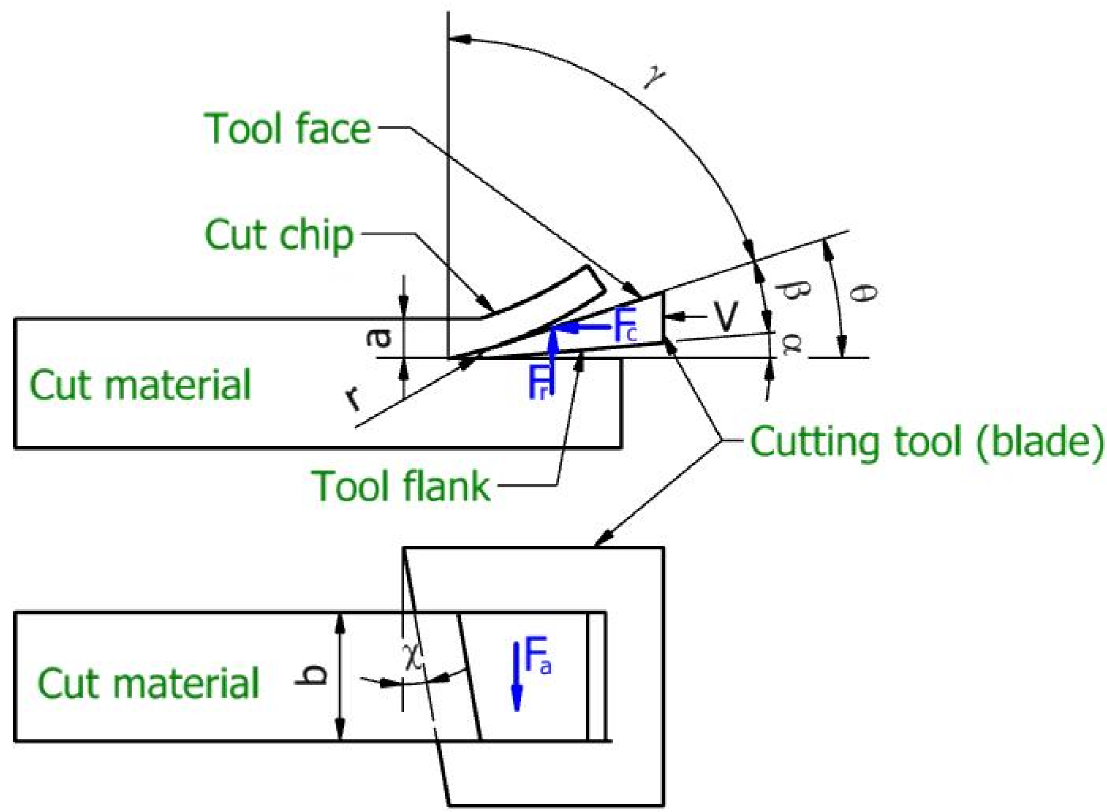
on the **dependent variables**: skinning force (F_c) and surface roughness (R_a).




Study of parameters affecting the skinning process of palm midribs
Theoretical studies
Determine the importance of the thesis
Study of the anatomy and the microstructure of the date palm midrib
Survey the previous studies on wood cutting and midrib stripping (cutting and skinning)
Define the problem to be solved
Experimental works
Select the independent variables and determine their values
Select the dependent variables
Select the proper measuring systems for both types of variables
Calibration of the measuring devices
Design of the test rig
Manufacturing of the test rig
Preliminary experiments
Suitability of high carbon steel tool material
Suitable specimen orientation
Experiments
Study the effect of the skinning speed on the cutting force index
Study the effect of clearance angle on the cutting force index
Study the effect of depth of cut on the cutting force index
Study the effect of tool angle on the cutting force index
Study the effect of approach angle on the cutting force index
Roughness measurements
Tool wear check

Experimental work

Variable	Values				
Tool					
Material	High carbon steel. High alloy steel.				
Clearance angle [°]	3	6	8	10	12
Tool angle [°]	24	26	28	30	32
Approach angle [°]	0	10	20		
Edge radius [mm]	10-20				
Workpiece					
Moisture content [%]	$10^{\pm 2}$				
Process					
Depth of cut [mm]	0.5	1	2	3.5	5
Direction of cut	Parallel to vascular bundles.				
Cutting speed [m/min]	8	10	12	14	16
Temperature [°C]	Neglected.				



Experimental work

- A test rig has been designed and manufactured.
- All measuring instruments has been calibrated to their references.

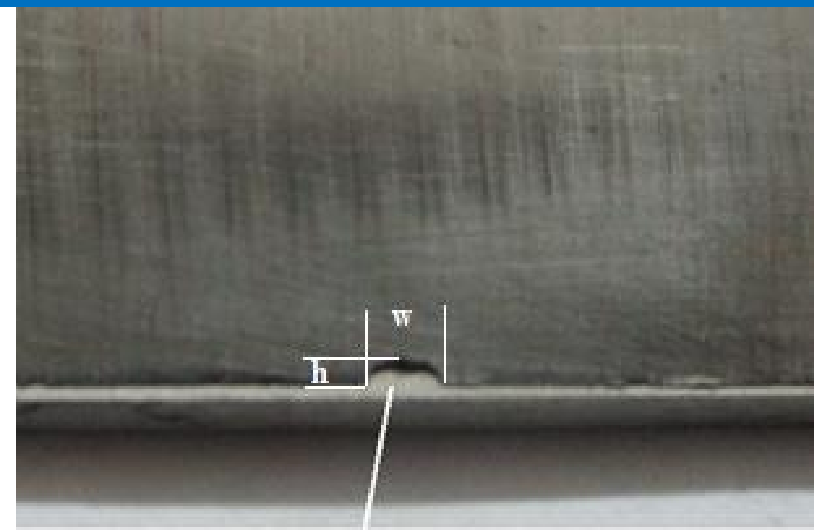
Results: skinning mechanism

- Chip formation in skinning
- Produced surface is satisfactory.
- Failure of skinning occurs due to distortion of specimen morphology, producing a distorted surface.

Produced surface due skinning failure (bending)   Good produced surface (no bending exists)

Results: Preliminary results

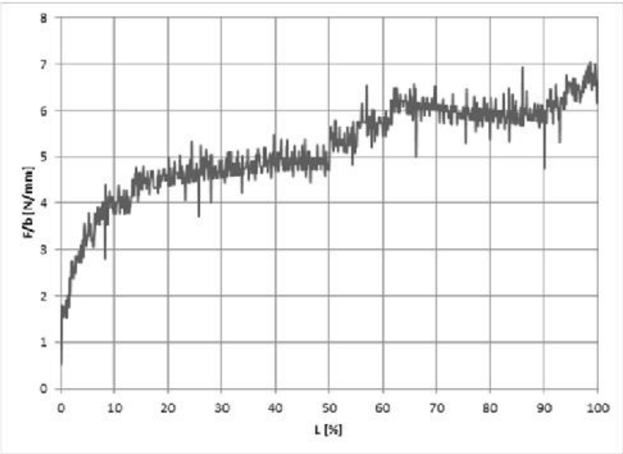
- High carbon steel is not suitable for skinning. (w=2.01 mm, h=0.9 mm).
- The midrib should be oriented in which the smaller cross section is at the start of skinning.

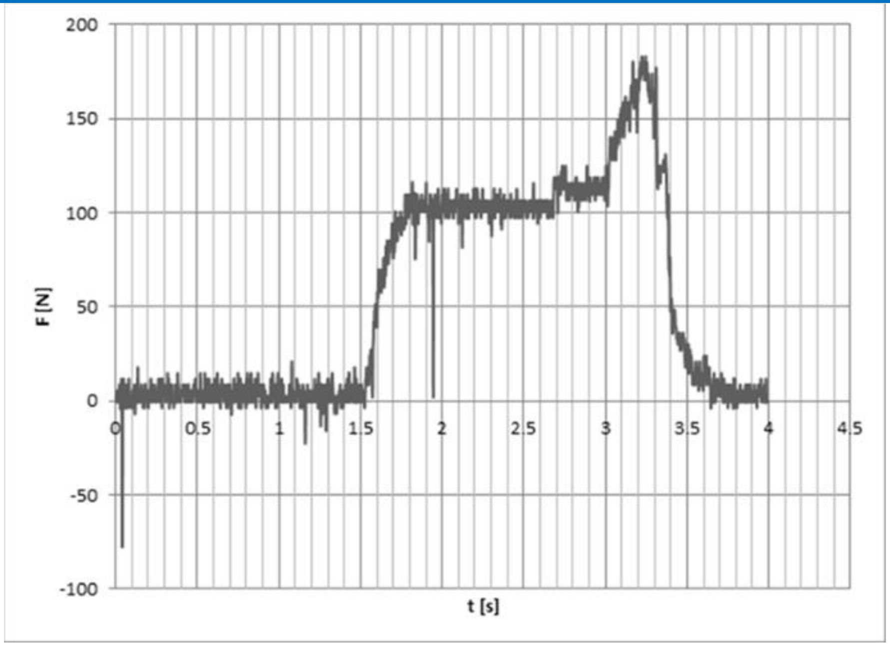


The fracture tool

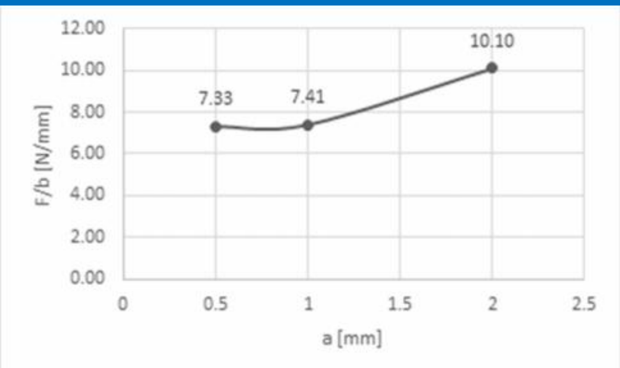
Results: skinning force and skinning force index

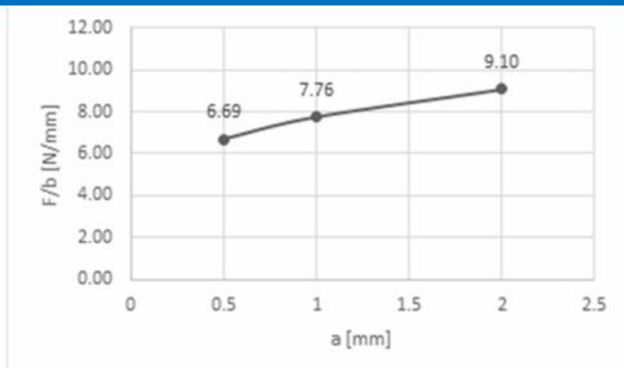
- Skinning force is not a suitable dependent variable.
- Skinning force index (force/width) is used instead of the skinning force.

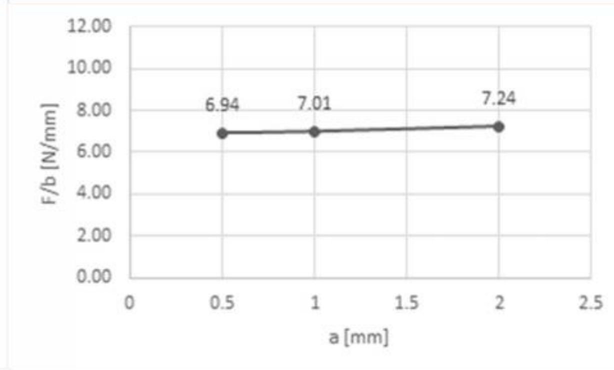


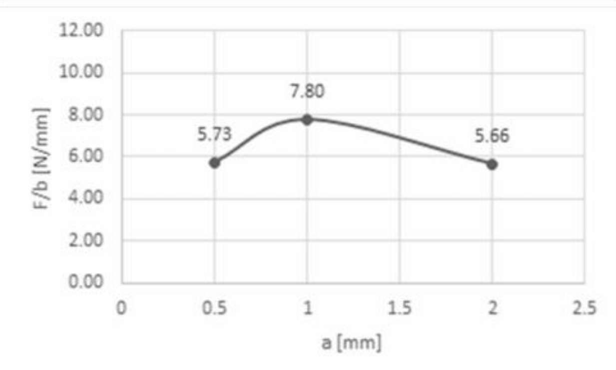


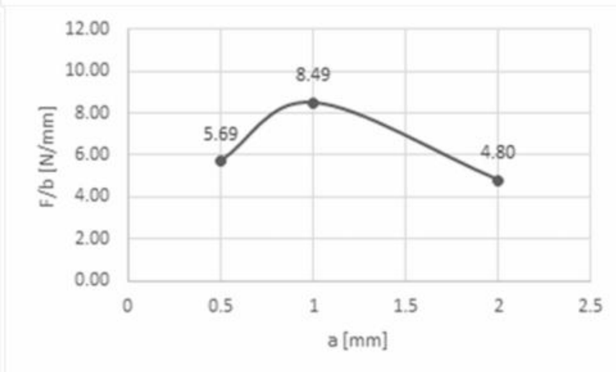
Results: Depth of cut effect





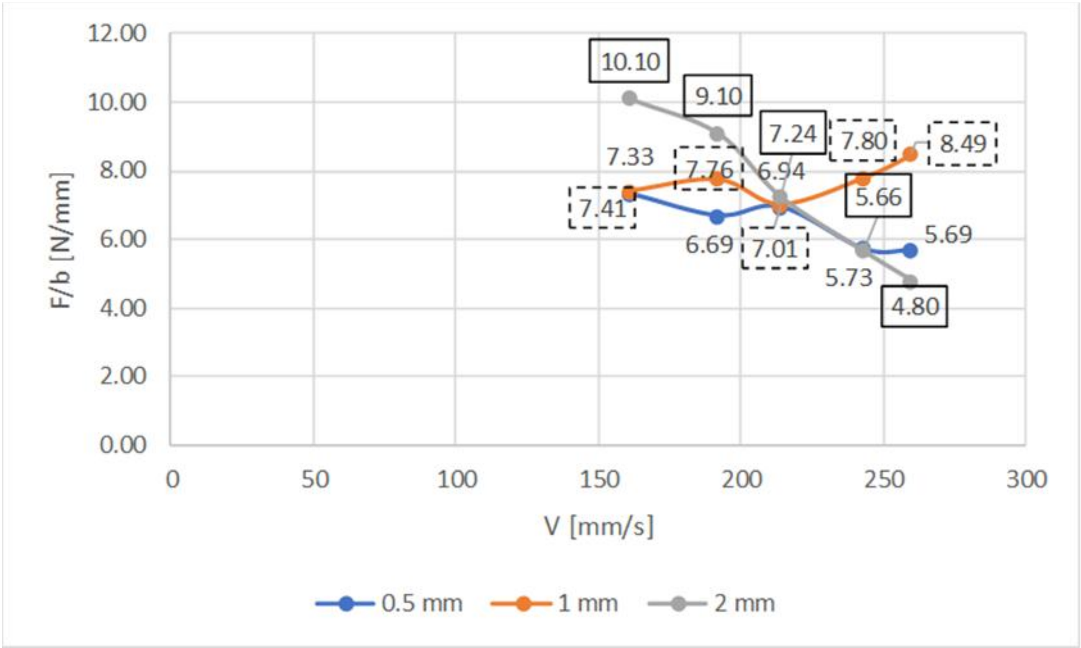




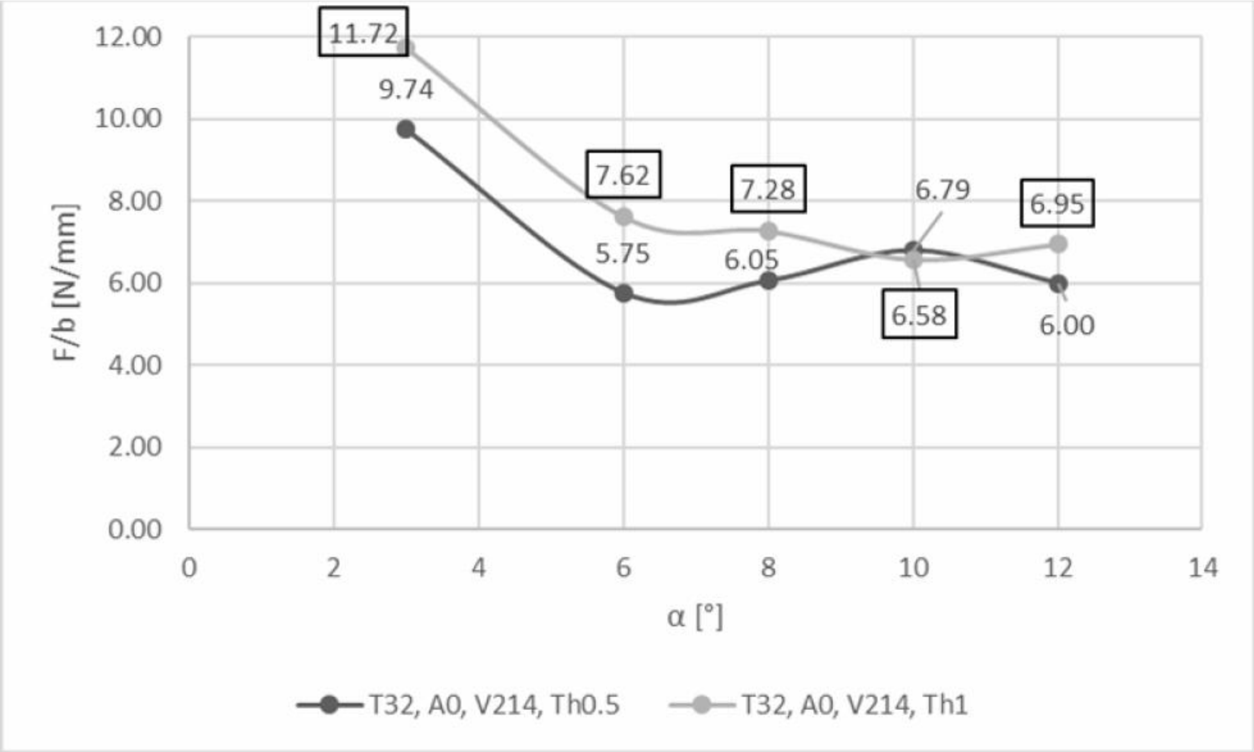


- θ=36°,α=16°, χ=0°, v= 161, 192, 214, 243,260 mm/s.

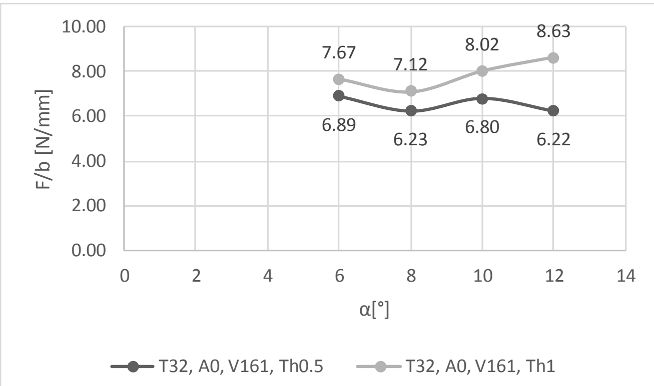
Results: Skinning speed

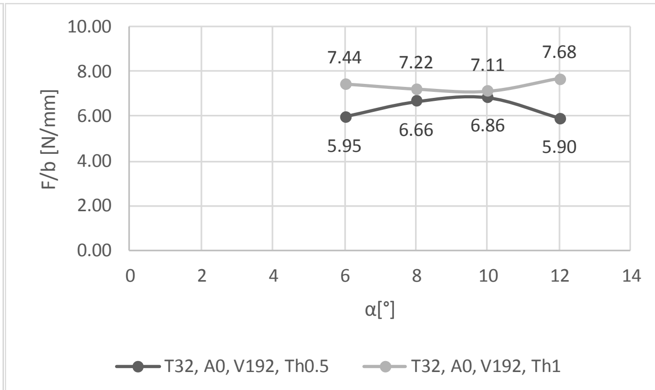


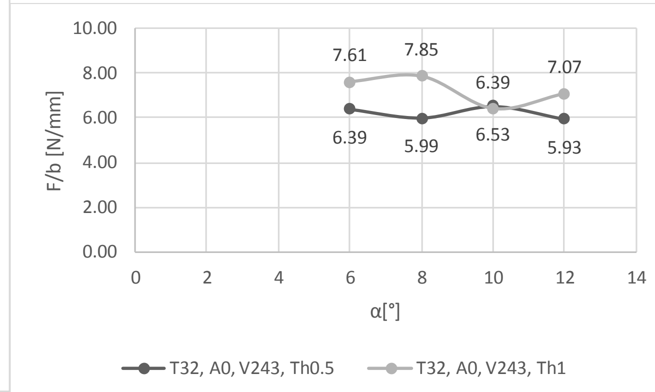
Results: Clearance angle

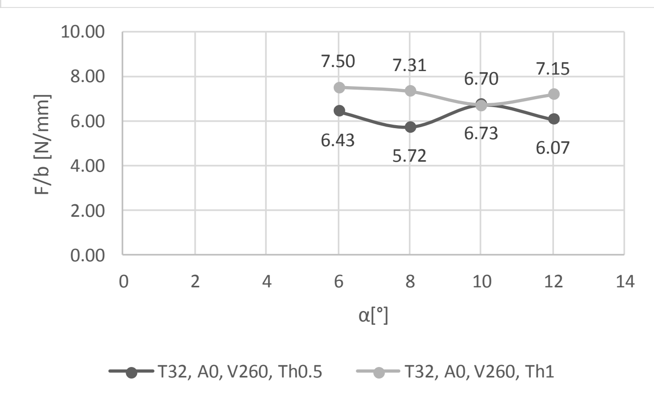


Results: Clearance angle

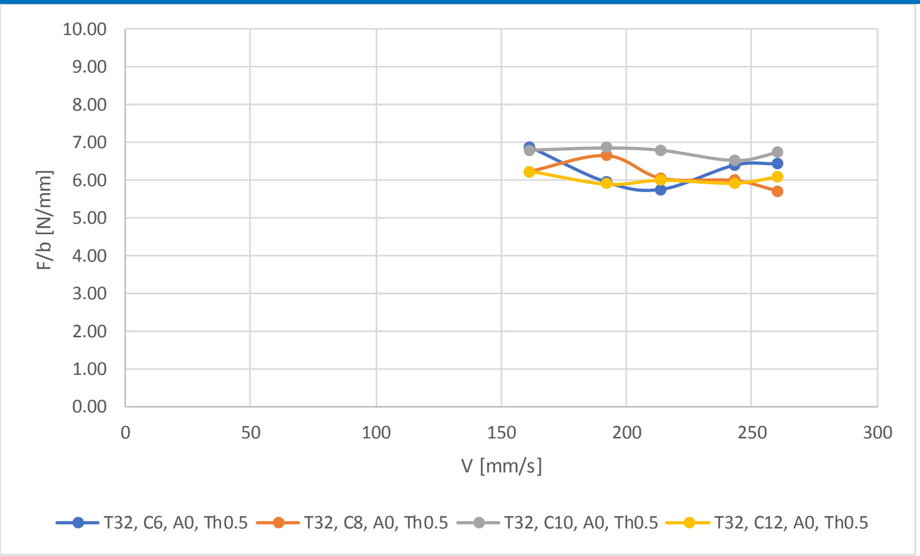


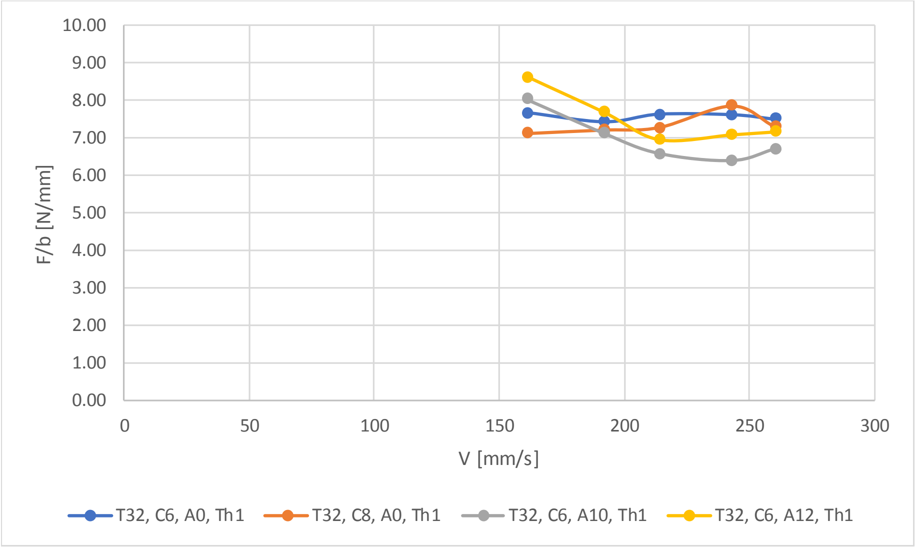




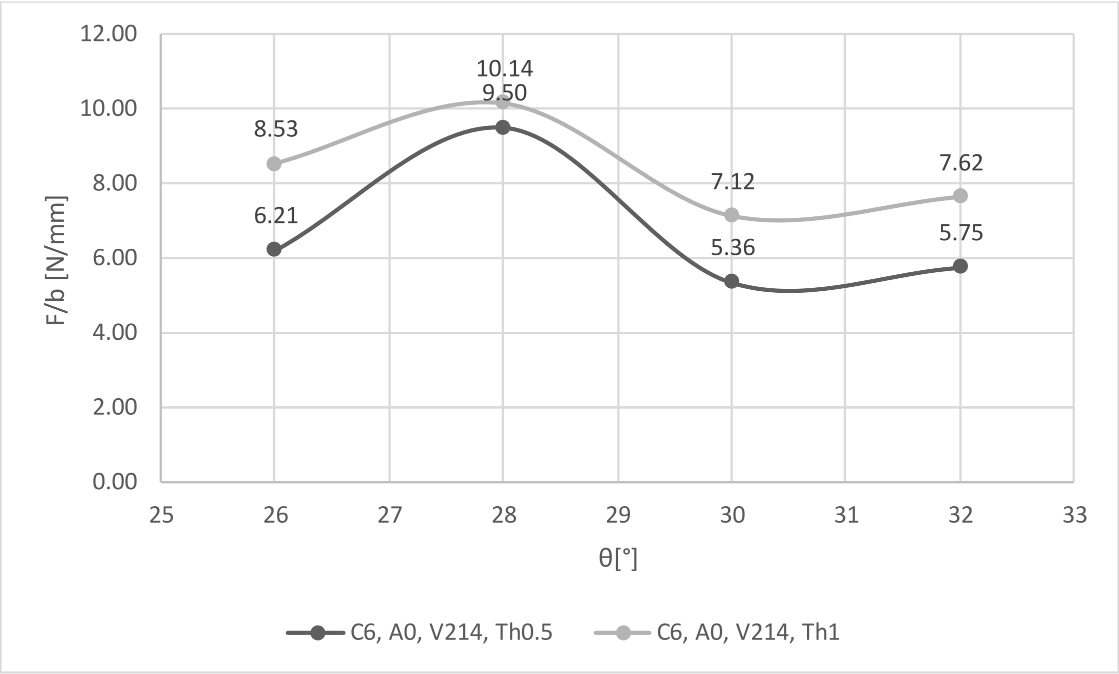


Results: Skinning speed

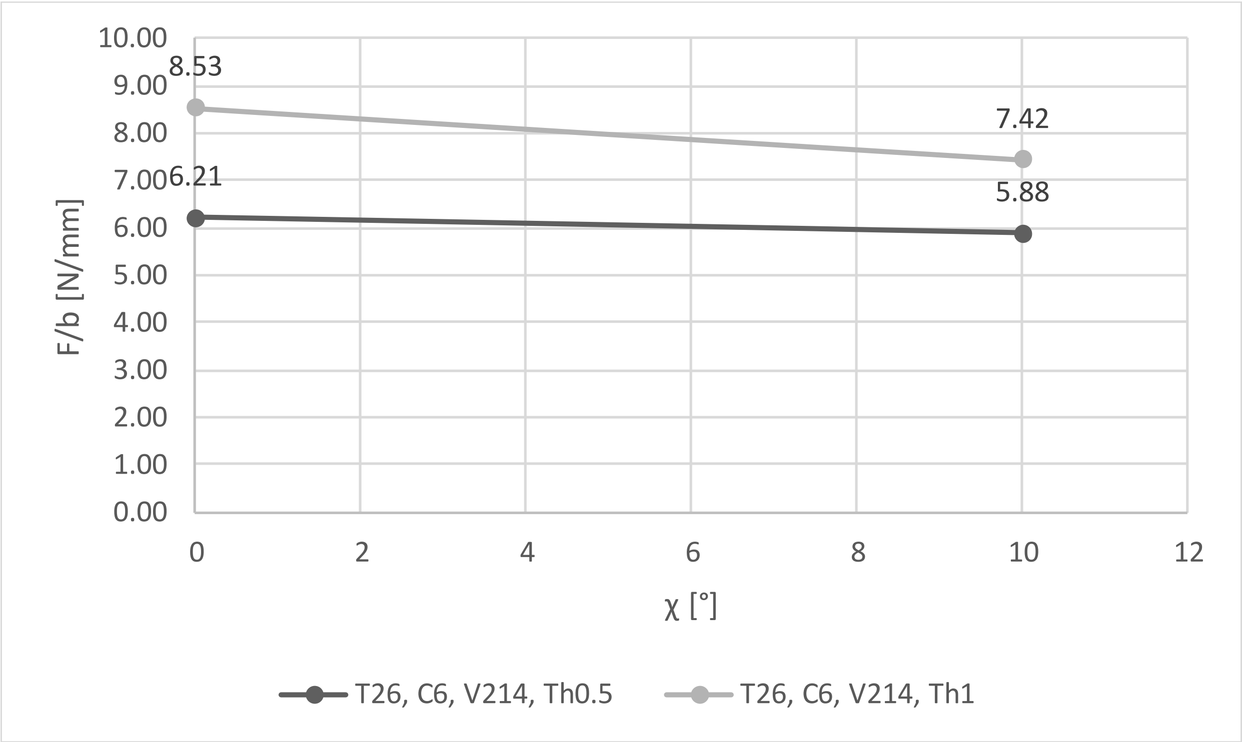




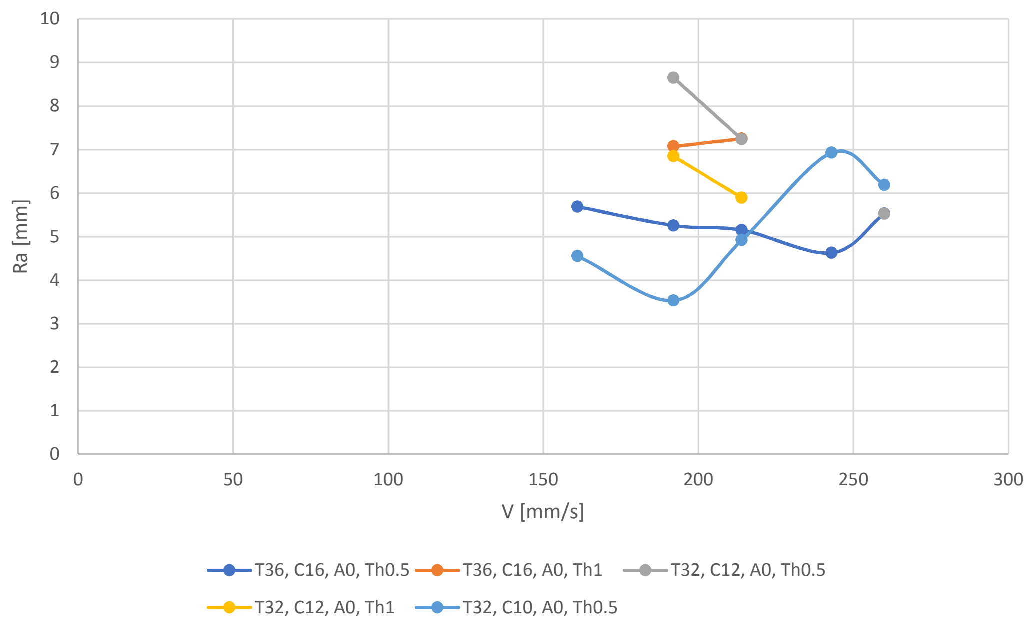
Results: tool angle



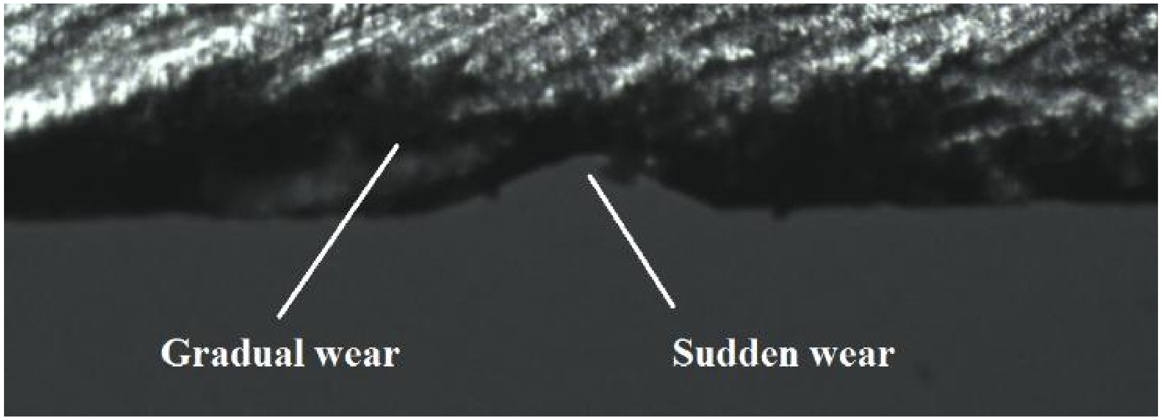
Results: approach angle



Results: surface roughness



Results: tool wear



Conclusions

- Skinning is the process of the removal of a continuous rigid chip by splitting from the specimen.
- The skinning mechanism, split-type chip formation, is similar to that of wood cutting. Skinning starts with the formation of initial crack by the skinning tool. The crack propagates as the tool moves to accomplish skinning of the whole specimen.

Conclusions

- High carbon steel tool material is not suitable for .
- High alloy steel material is suitable for skinning under the condition of correct sharpening of the tool.
- Orientation of the specimen in which the smaller cross section is at the start of the skinning is more suitable than the other orientation.
- The depth of cut affects the skinning force index in interaction with the skinning speed. The increase of the depth of cut from 0.5 mm to 1 mm, increases the force index with a rate, which increases increasing the skinning speed. The increase of the depth of cut from 1 mm to 2 mm, increases the force index with a rate, which decreases increasing the skinning speed.

Conclusions

- Minimum clearance angle suitable for all conditions is 6°.
- The skinning speed has low effect on the skinning force index.
- The tool angle increase, increases the skinning force index till 28°, at which the index decreases and returns to increase due to the increased crack length.
- The approach angle has a good effect in decreasing the force index till 10°.

Conclusions

- The surface roughness depends on the specimen material more than any other variable.
- The wear type of the tool during the skinning process is the mechanical sudden type, i.e. fracture of the tool edge occurs.

Thanks