FE NONLINEAR STATIC ANALYSIS OF DISC TOOL PENETRATION IN WOOD

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Abstract

While turning wood In spite of using knives with straight cutting edges one can also use knives with round cutting edges as well as circular ones. Penetration of the latter ones in wood was analysed by FE method. A non linear static analysis of assumed dislocation of knife penetration in a wooden roller in its symmetry plane was held. An orthotropic Loblolly pine model was used. The obtained stress schedules were tangential and parallel to fibres. The obtained data show that even very slight dislocation of knife cause longitudinal cutting of wood fibres. The numerical analysis with usage of the orthotropic Loblolly pine. Model gives reliable data only in the range of very slight dislocations.

Key words*: turning, disk knife, numerical non linear analysis, Loblolly pine*

INTRODUCTION

The result of wood machining, namely turning are rotary elements in shapes of solid revolutions.Turning from ancient ages is used mainly to receive cylindrical, conical and spherical surfaces. In turning a machined unit performs rotary movement when lathe tool is pushed in parallel or perpendicularly to rotary axis. It can also perform both above mentioned movements simultaneously. The nature of work of lathes is rotary movement of a machined units. For turning and reeling of wood flat knives of different shapes are commonly used.
Among them we distinguish:

- punctual edge tools (which when used touch the machined surface only with its top)
- one-edged tools [2]
- round-nose tools

The latter are used mainly during rough turning /heavy-duty tool/ with high feed speed per revolution. The development of round knife is disc knife which has cutting edge on the whole circle [3].
The basic advantages of such a knife are:

- increase of knife durability – by lengthening its edge,
- possibility of usage of bigger feed,
- higher precision of machining,
- smaller unitarny load of cutting edge.

In Department of Woodworking Machine and Basis of Machine Construction Agricultural University in Poznań wide range of research concerning usage of disco tools [3, 4] and their construction [1] which was the basis to engage in the problem of numerical analysis of penetration of disc tool in wood.

MATERIAL AND METHODS

The analysis assumed a model of disc tool based on one previously used during experiments (shape and dimensions). Geometrical characteristic of elements used to numerical analysis are shown in Fig.1.

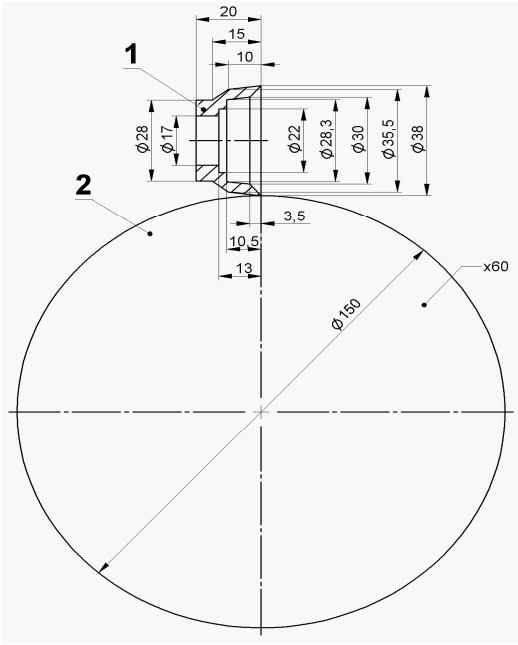


Fig. 1 Geometrical characteristics of cooperating elements:
1 – knife;
2 – fragment of pine roller

Full three-dimensional model of elements was engaged for FE numerical analysis. It was assumed that the cutting edge meets symmetry plane of a wooden roller (both across and longitudinally) (Fig.1). It enabled to limit the analysis to half of the model. To digitize solid linear trick and solid linear wedge were used. Altogether FE model had 8830 elements. The Finite elements net and assumed marginal conditions are shown in Fig. 2.
A Nonlinear static analysis was conducted assigning dislocation of knife penetration in a wooden roller in its symmetry plane. The plane set by knife cutting edge was perpendicular to tangential plane of the roller.
Calculations were conducted for 0.0001 mm, 0.005 mm, 0.001 mm, 0.25 mm, 0.5 mm, 0.75 mm, 1 mm dislocations.
The FE analysis used orthotropic *Loblolly* pine model [7] which properties are shown in Table 1. The directions of orthotropic introduce show on fig.3

Table 1 Material properties of *Loblolly Pine*

E_L [MPa]	E_R [MPa]	E_T [MPa]	ν_{RT}	ν_{LT}	ν_{LR}	G_{RT} [MPa]	G_{LT} [MPa]	G_{LR} [MPa]
13530	1529	1055	0.382	0.292	0.382	176	1096	1109

Strength parallel to grain [MPa]	0.08
Strength parallel to grain [MPa]	0.0032
Shear parallel to grain [MPa]	0.0096

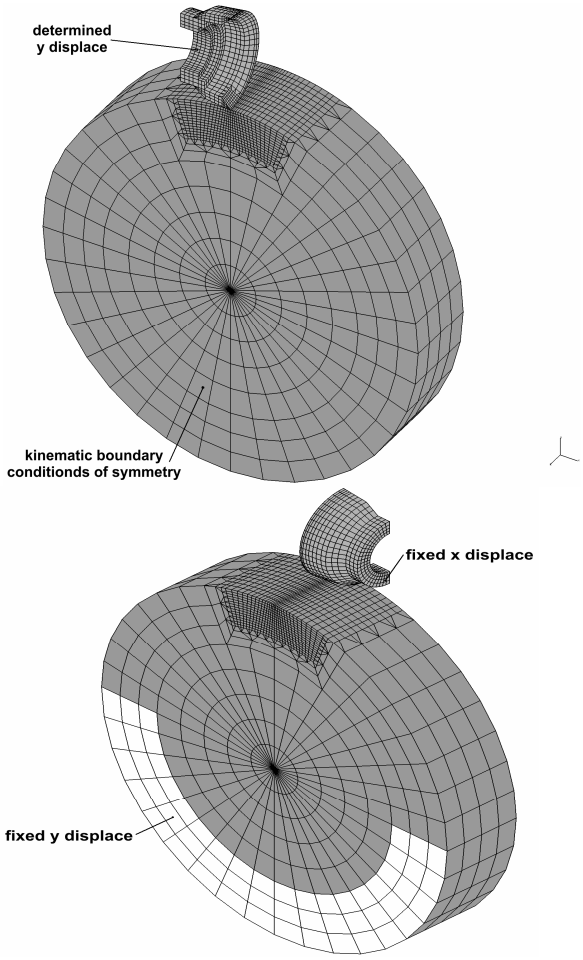


Fig. 2 FE model of knife plunged in pine roller

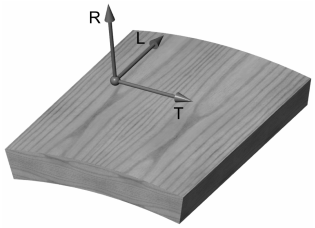


Fig. 3 Directions of orthotropism

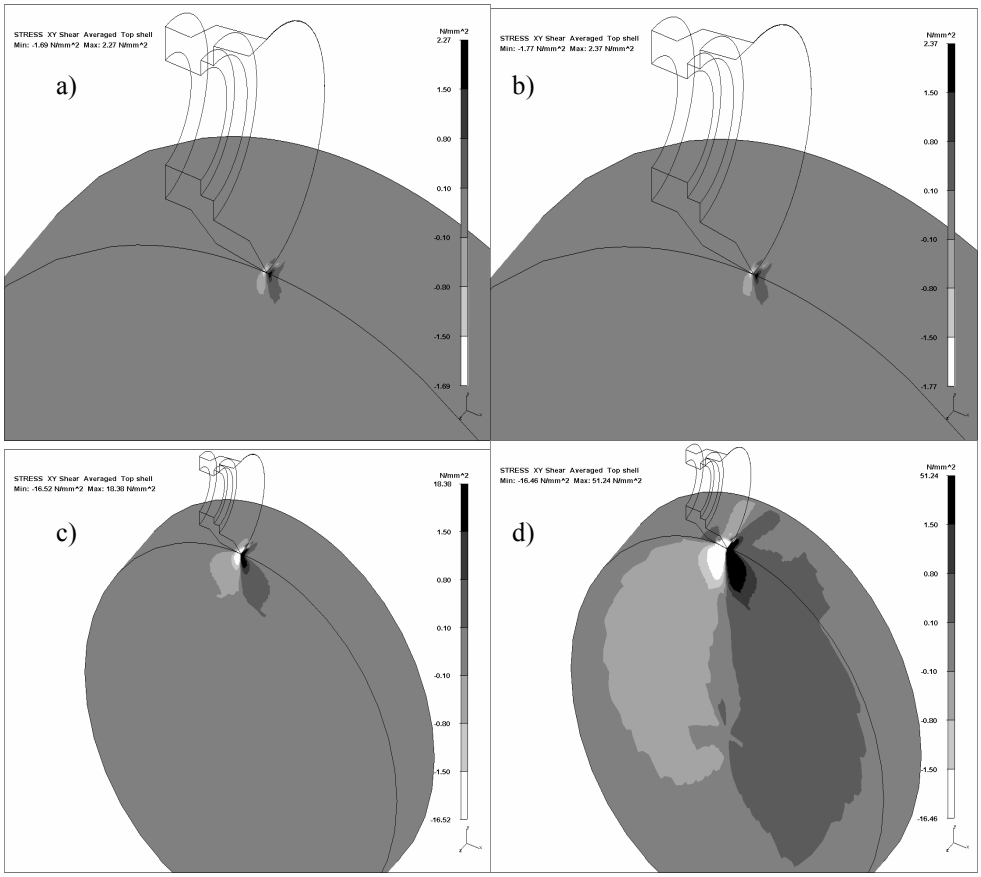
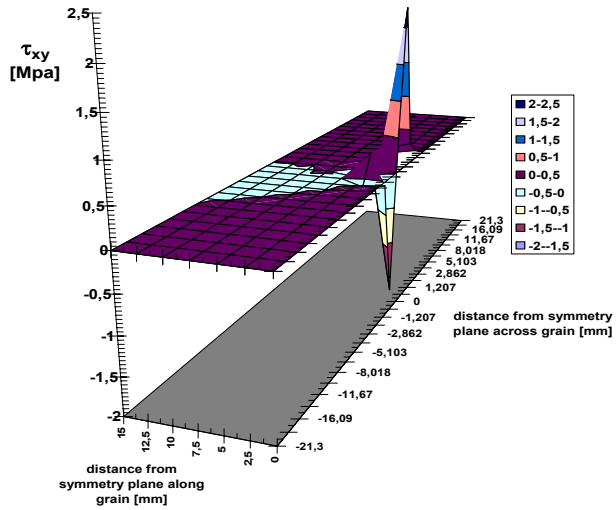
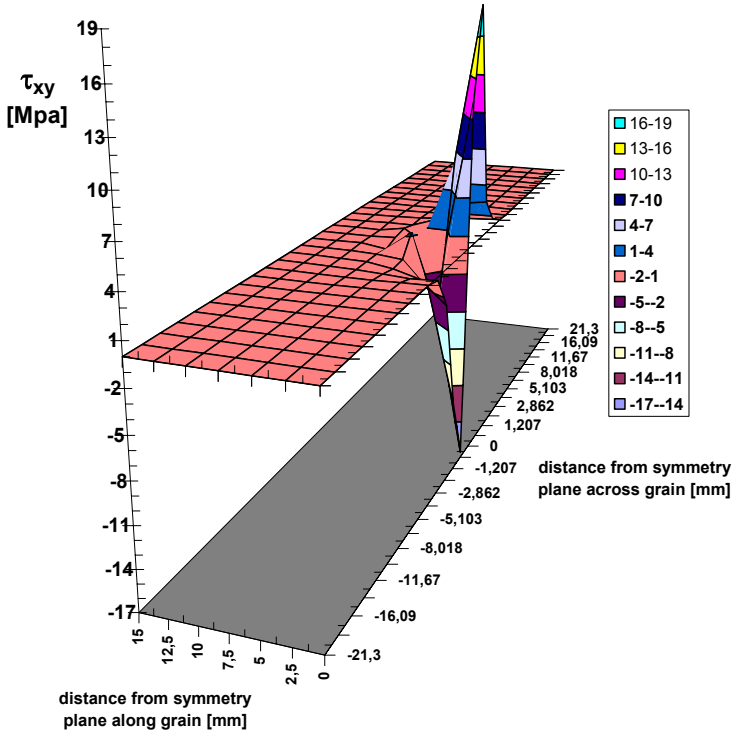


Fig. 4 Stress distribution tangential parallel to fibres (τ_{xy}):
a) dislocation 0.0001 mm; b) dislocation 0.001 mm; c) dislocation 0.25 mm;
d) dislocation 1 mm.

a)



b



c)

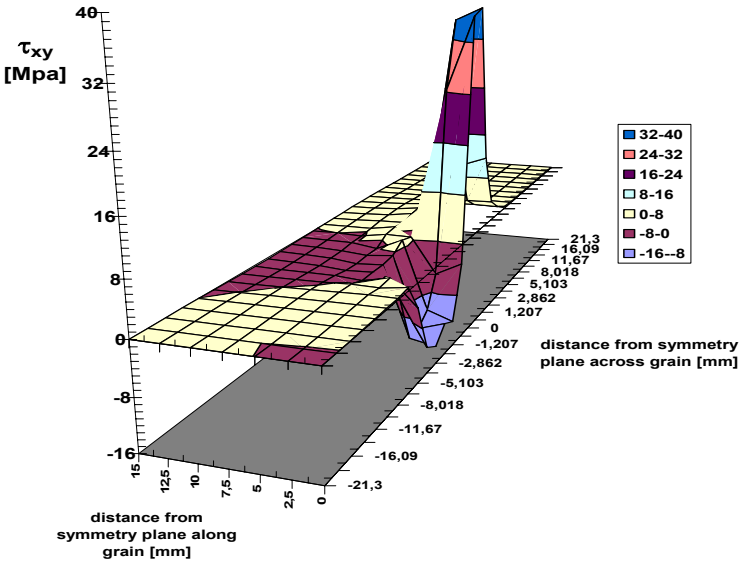
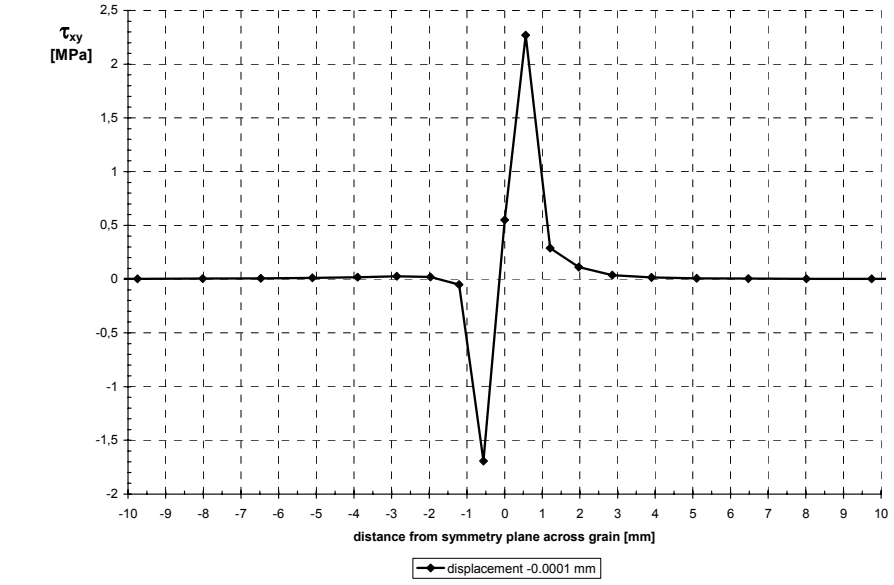


Fig.5 Maps of tangential stresses, parallel to fibres on roller in plane of symmetry of cooperating elements.
a)dislocation 0.0001 mm; b) dislocation 0.001 mm; c) dislocation 0.25 mm;

For better illustration of stress distribution Fig 5 shows 3-dimentional stress maps tangential to roller plane for chosen examples. Comparison of numeral values of the same stresses is illustrated in the plane of knife and roller (Fig.6).



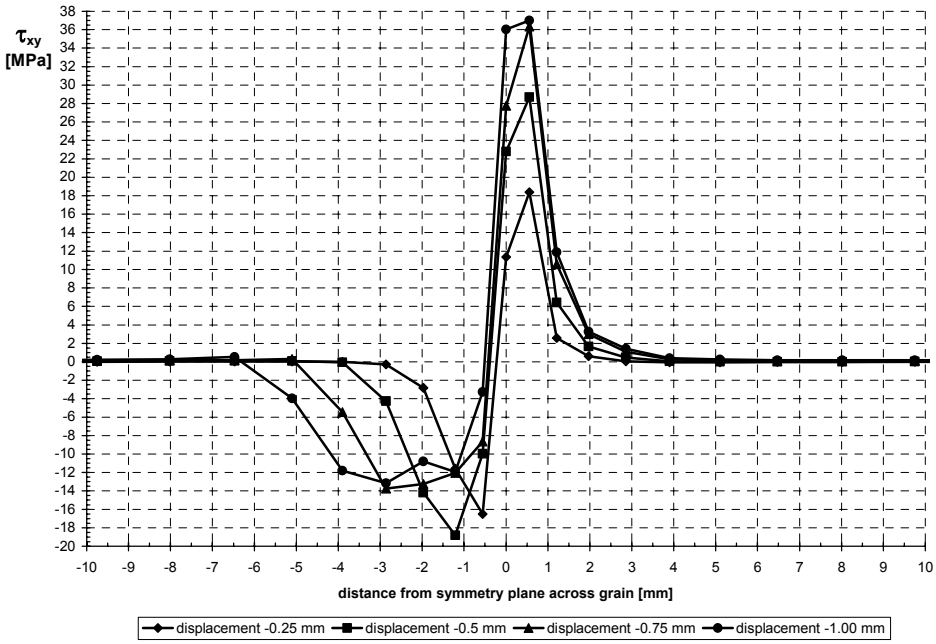


Fig. 6 Schedules of tangential stresses, parallel to fibres on roller surface in plane of symmetry of cooperating elements.

CONCLUSION

The obtained data allow to conclude that even very slight dislocation of knife cause longitudinal cutting of wood fibres. The numerical analysis with usage of orthotropic Loblolly pine model giver reliable data only in the range of very slight dislocations. The complexity of phenomena taking place in wooden elements as a result of their loading causes that numerical analysis for such models is only possible when we take into consideration microstructure of wood [6]. In macro scale it requires determination of elements of connector type depending on fundamental agreement, fixed on the basis of the experiment.

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