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Effects of tool geometry – force ratio during tangential turning

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Abstract: *Effects of tool geometry – force ratio during tangential turning.* This article is dedicated to issues of force analysis for the effects of tangential turning. In general, during turning effect on the tool a total force, that covers the three basic components (F_c, F_p, F_f). Practical as well as theoretical knowledge of the impact of formation force enabling a deeper analysis of the effects of cutting process (chip formation, tool design, design and developing of clamping system). The main part of this article is the construction design of tool for tangential turning and the second part is focuses on the force analysis of tangential turning with obtained experimental results.

Keywords: tangential turning, design tools, cutting force, tool geometry

INTRODUCTION

The long-term global trends in industrial production are an effort to increase productivity and reduce production costs. In simultaneity one of the possibilities of increasing productivity is the introduction and development of automated NC and CNC machines and computerized adaptive management. Another object of interest is to optimize the use of cutting tools using and developing methods of monitoring the machining process [Audy 2009; Žižka and Linhart 2009].

In the works of authors Costes [2004], Ko [1999], Kious [2008], Sharma [2008] and Mckenzie [1961] presented experimental results of orthogonal cutting wood and modeling of cutting mechanism. One of the main objectives of this study was to develop a model to determine the size of the cutting forces. Group of equations expressing the relationship between cutting force, feed force, nominal thickness of cut and nominal width of cut for the calculation of coefficients for cutting force and the feed force was created. An important aspect of the machining is the effects of forces on the cutting tool. Knowledge of these cutting forces is necessary to determine energy consumption, design of the parts of tool, tool holders and clamp system that are sufficiently rigid and do not result in these vibrations. To measure the cutting forces in the tools, be used as devices such as dynamometers, which have high accuracy.

There were also attempts to use finite element analysis to create a model for studies of cutting wood, but wood as an anisotropic material is an important challenge to model the influence direction of wood fibers and changes in material properties in the direction of cutting. Although it is possible to except direction of faults in the wood, it is difficult to predict the cutting forces that result from unexpected changes in material properties.

MATHERIALS AND METHODS

The aim of the experiment was to verify the effects of selected technological parameters on the size of components of total force during turning with tool with skew cutting edge. From the obtained results for this type of turning we can propose appropriate technological conditions of the cutting tool.

Experimental investigation of force parameters were carried out by measuring apparatus, that involvement is on the (Fig. 1).

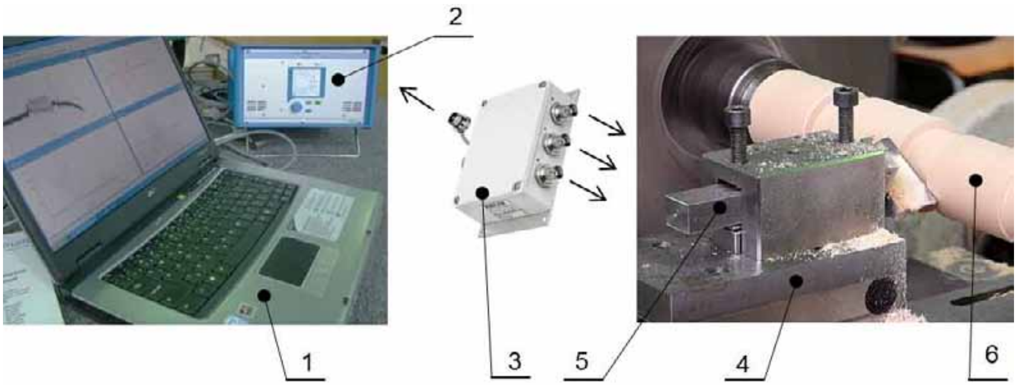

Fig. 1 Scheme of the measuring chain of the cutting forces
(1 – notebook with evaluation software, 2 – eight channel amplifier (type 5070A11000), 3 – distributing box with BNC connectors, 4 – dynamometer Kistler 9257B, 5 – tool with skew cutting edge and holder, 6 – workpiece)

Tool with skew cutting edge (Fig. 2) was used with assumption in improving the surface quality so that is possible exclude the last technological operations - sanding. The reason for this assumption is, of neglect feed per revolution f_n, the formation of cutting surface, which creates surface of one-piece rotating hyperboloid, whose generating line is a linear cutting edge, with slope at an angle with $\lambda_s \neq 0$.

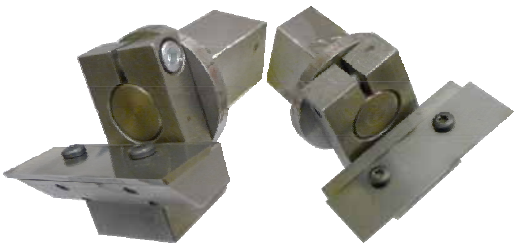
Fig. 2 Tool with skew cutting edge

EXPERIMENT CONDITION

Material of workpiece:

- Beech,
- Moisture content w = 12 ± 2 %.

Technological parameters:

- Engagement of a cutting edge: a_p = (1, 2, 3, 4) mm,
- Tool cutting edge inclination: λ_s = (15°, 30°, 45°),
- Rake angle: γ = (3°, 6°, 9°, 12°),
- Spindle speed: n = 1000 min^{-1},
- Feed per revolution: f_n = 0,45 mm.

RESULTS AND DISCUSSION

Course of the total force F has an expected increasing tendency (with respect to each level of the observed factor), where the largest share of its size, has a passive force F_p. Increasing of the engagement of a cutting edge, when growing the nominal cross-sectional area of the cut and hereby increasing the value of the components forces F_f, F_p, F_c, and also the total force F. Increasing of the engagement of a cutting edge attend of a gradual penetration of the cutting edge into to workpiece, and it occurred in the friction on the flank of cutting edge with the workpiece, which is negatively reflected in the increase or decrease the components of total force (Fig. 3).

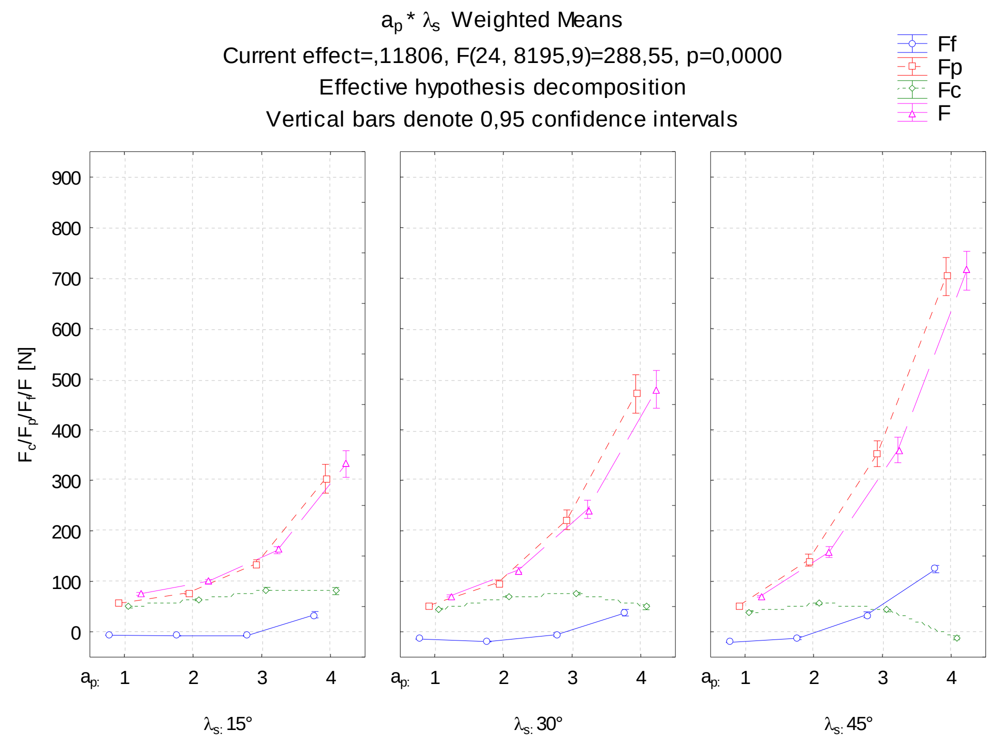

Fig. 3 Interaction of engagement of a cutting edge a_p and tool cutting edge inclination $+\lambda_s$

In the whole range of levels of factor the tool cutting edge inclination λ_s can be observed for the cutting force F_c decreased tendency and conversely in the feed and passive force F_f, F_p can observe increasing tendency. Although it is shown that the enlarge raising tool cutting edge inclination λ_s the total force F increases in turning, but the cutting force Fc is declining which positively affects the energy consumption of turning.

Due to the position of the tool against the workpiece has been changing the kinematic work angles and if taking into account the tool cutting edge inclination $+\lambda_s$ the each points of the cutting edge is positioned above the axis of the workpiece, which causing enlargement of the rake angle and reducing clearance angle. This leads to friction of flank of the cutting edge with the workpiece resulting in heat generation at the cutting edge. The best values of rake angle during turning beech can be $\gamma = 3°$ a $\gamma = 6°$ which confirms (Fig. 4 and Fig. 5). At these values of rake angles are the components of force F_f, F_p, F_c, and the total force F have a slight increasing tendency.

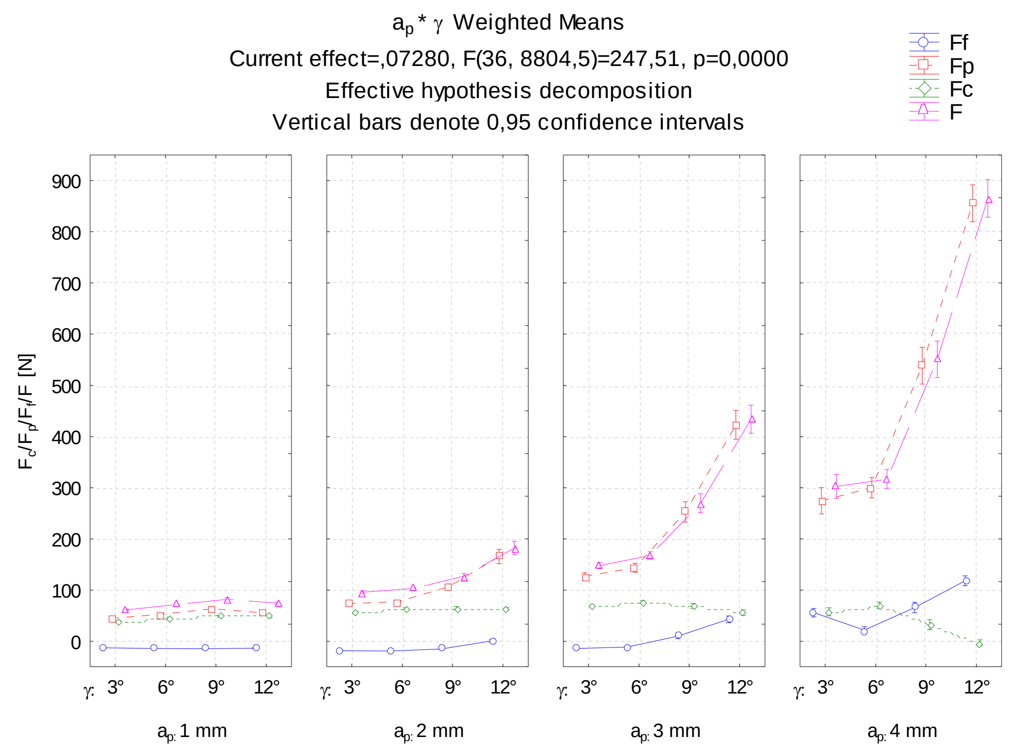

Fig. 4 Interaction of engagement of a cutting edge a_p and rake angle γ

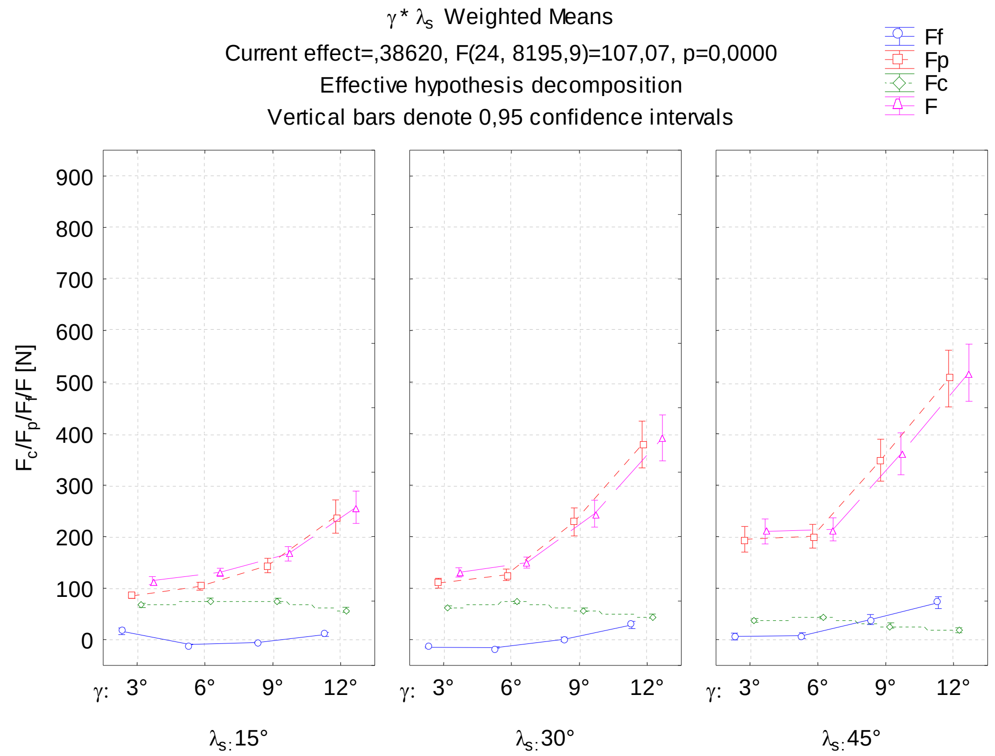

Fig. 5 Interaction of rake angle γ and tool cutting edge inclination $+\lambda_s$

CONCLUSION

Turning with tool with skew cutting edge is fundamental, but also finishing methods of machining and thus becomes an alternative to sanding. Nowadays is sanding the most common way of finishing machining, but for some of the deficiencies are not always satisfactory. The problem is particularly dusty environment in terms of quality and hygiene of working environment, but also lengthy the production process. Turning with tool with skew cutting edge can significantly contribute to the reduction of working time, changes in energy consumption of turning, even wear the cutting edge, changes forces relationships in turning and that is possible exclude - sanding.

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Streszczenie: *Wpływ geometrii narzędzia - stosunek sił podczas toczenia stycznego.* Celem pracy była analiza wpływu sił skrawania przy toczeniu. Praktyczne jak i teoretyczne wpływ sił umożliwienia pogłębioną analizę skutków procesu cięcia (naprężenia, projektowanie narzędzi, projektowanie i rozwijanie systemu mocowania). Główna część tego artykułu poświęcona jest projektowaniu konstrukcji narzędzia do toczenia natomiast druga część koncentruje się na analizie siły stycznych z uzyskanych wyników doświadczalnych.

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