Annals of Warsaw University of Life Sciences – SGGW
Forestry and Wood Technology No 72, 2010: 433-437
(Ann. WULS-SGGW, For and Wood Technol. 72, 2010)

New idea in construction and performance of turning rotary knife.

GRZEGORZ WIELOCH[1], MARCIN OSAJDA[2], LUBOMIR JAVOREK[3]
MAREK ZASADA[3], JANUSZ CIELOSZYK[3], KRZYSZTOF CHMIELEWSKI[4]

[1/] Poznan University of Life Sciences, Poznań, Poland
[2/]Marcin Osajda; „Nowy Styl" Factory, Rzepedź, Poland
[3/] Lubomir Javorek: Technical University in Zvolen, Slovakia
[4/]Krzysztof Chmielewski, Janusz Cieloszyk, Marek Zasada: West Pomeranian University of Technology, Szczecin, Poland

Abstract: The paper describes problems connected with tools having self-propelled rotary cutting edges. In comparison with tools having immovable edges they are characterised by multiple increase of edge durability. In spite of obvious advantages SPRT(e.g. durability of edges) problem causes their construction complexity as well as limitation in machining of surface complexity .Thus there is a concept of their modernisation via fixing edge engine spindle which creates driven rotary tool.

Keywords: turning wood, DRT – Driven Rotary Tools

INTRODUCTION

Among many different kinds of machining methods for machining cylindrical and changing shapes mainly turning sanding and partly planning or milling are used.
For mass production of cylindrical rolls having invariable cross-section are usually used very efficient turning methods like in the case of performing rolls in production of wooden "garden" elements.

As far as machining of cylindrical cross-section is concerned a significant problems are: a) low durability of edges, b) difficulty in obtaining required quality, c) low efficiency. Individual support knives for lathes have shape and destination similar to known for ages hand knives for turning. These are the reasons for research and adaptation of new ways of turning used in metal machining for wood machining.

Fig.1. Pine rolls of 10 cm diameter, length 300 i 400 cm.

Interest in SPRT kind of tools for metal materials gave also opportunity to turning to this kind of machining in wood machining [1,4,7,5,6,9,11].

It is justifiable because this kind of immovable disc edges were for a long time successfully used in profilling because of lengthening of working time – longer cutting edge for dulling [9,10].

SELF – PROPELLER ROTARY TOOLS – SPRT

SPRT – Self-Propelled Rotary Tools are characterized by multiple edge durability growth in comparison with immovable edges. They are also characterised by substantial reduction of temperature in cutting area [2,11]. Described features of these tools enable to solve effectively problems of machining for example [1-3, 7-11]. The principle of work of SPRT is shown on Fig 2a .

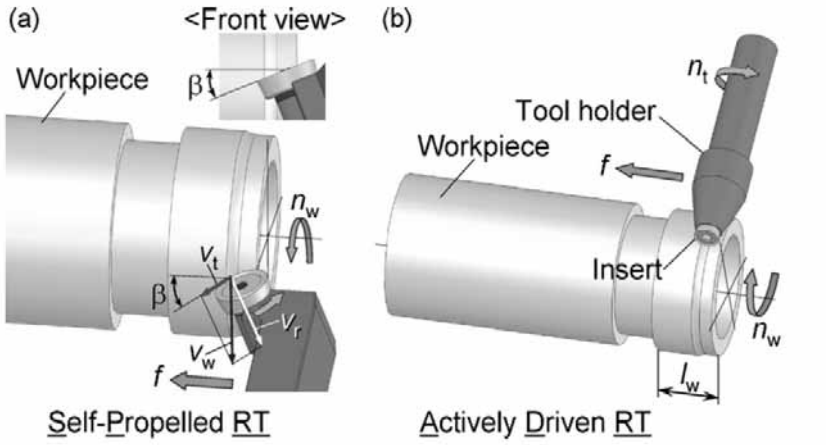

Fig. 2. Two types of rotary tools: (a) self-propelled RT and (b) actively driven RT.
A. Hosokawa et al.

Self-rotation of a knife during machining process appears under influence of friction forces which appear in the point of contact of tool flank surface and machined surface. In the case of when angle $\lambda=0°$ then the knife during machining doesn't rotate but when angle $\lambda\neq0°$, a substantial contribution to self-rotation of knife has friction of a moving chip on the rake face. Form dependences given in literature [3,7,8,9] it appears that rotation speed of knife v_0 is directly proportional to machining speed v and of cutting edge inclination λ. So when cutting edge inclination λ growth, rotation speed of knife v_0 growth as well.

EXPERIMENTS CONNECTED WITH SPRT KNIVES

Tests of SPRT tools when machining metals were conucted lately in ITM ZUT in Szczecin and in KOIPKM UP in Poznań fully certify effectiveness of application of these tools [11].

In spite of evident advantages of SPRT like for example: lower cutting forces than in fixed knives and higher durability there exist some disadvantages like their construction complexity and limitations in diverse surfaces machining. Basic factor influencing quality and cost of the tool is bearing unit which fixes cutting blade - Mitsubishi Carbide, Japan and Rotary Technologies, USA, which not long ago started producing SPRT widely accepted and used in industry.

NEW IDEAS IN CONSTRUCTION AND WORK OF KNIFE

The above listed and described technological limitations and relatively high cost of SPRT induce new construction developments and new kinematics of such tools [1,2,3]. The main stress is put on elimination of individual equipment of each tool in bearing unit which fixes cutting blade. The promising development direction of idea of cutting with tools having rotating blade is utilization of multi-axial turning centers having kinematic-moving structure fitting the way of work of these tools. Fig. 3 shows conception of SPRT and the idea of work of it in multi-axial turning centre with possibility of DRT (Fig 2b)

This idea gives possibility of utilization of disc knife in conventional lathes and moulding machines with special equipment. The above described principle of work of SPRT knife eliminates the problem of precise bearings work of cutting blade in each particular tool.

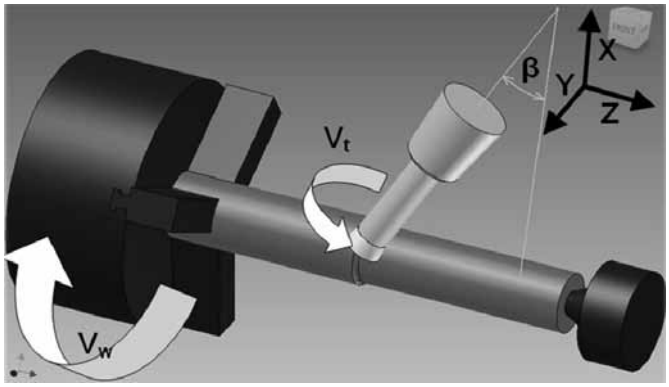

Fig. 3. SPRT: the conception of fixing and work of SPRT knifing multi-axial turning centre.

The role of bearings work takes moulding machine spindle. Simultaneously the problem of alternative choice of SPRT or DRT is solved. The tool can work as SPRT after uncoupling tool`s spindle drive or as DRT when driven directly from spindle. DRT performance can be in such situation considered as basic (more general containing also SPRT alternative). The construction of the tool becomes exceptionally simple (Fig.4) and the cost of production many times smaller. One should however become acquainted with patent restrictions which appeared lately like for example: patent US7156006 of Gregory Hyatta form 2007 (Fig. 4). Cutting force during machining with above described knives works in the direction of their biggest stiffness (direction similar to direction of rotation axis of a tool) which profitably influences course and stability of machining process. Stiffness in direction perpendicular to axis depends on throat distance and .cutter arbor diameter of a chosen knife edge.

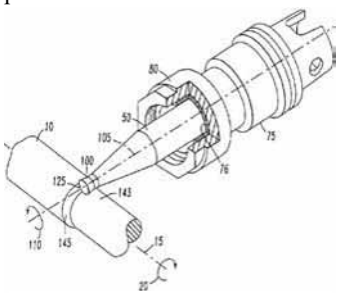

Fig.4. Tool for turning fixed to spindle.patent US7156006

Currently used systems of multi-axis steering CNC make possible programming both linear displacement (axis X, Y, Z), and angle displacement of spindle axis. It enables any tool position to machined surface.

Programmed in CNC change in setting is of significant importance when choosing optimal cutting conditions.

Thanks to continuous and simultaneous positioning of required axis of machine tool the problem connected with machining of rolls having non-standard profile is resolved which is of great importance in wood industry. Continuous positioning of tool axis during machining of non-standard profiles (for example curvilinear) is vital for constant machining conditions along turned roll profile. It ensures precise rotations of cutting disc in SPRT method. The effective programming of rolls machining when they have non-standard profiles needs in future enlarging of appropriate programming options in CAD/CAM systems.

EXPERIMENTS AT UTILISATION OF PROPELLED KNIFE ON SPINDLE
IN WEST POMERANIA UNIVERSITY OF TECHNOLOGY

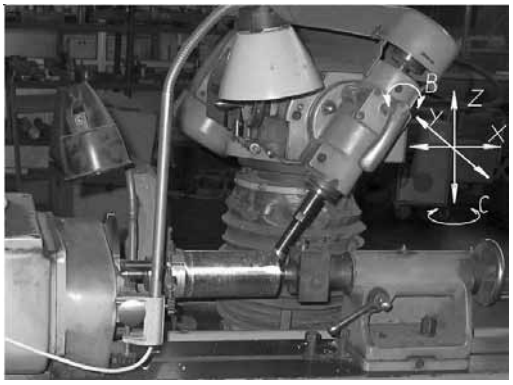

Fig. 5. Adaptation of lathe grinder for machining tests with rotating disc . Linear and rotary axis movements are drawn in the picture

In Institute of Mechanical Technology in West Pomerania University of Technology were conducted introductory tests verifying development legitimacy of new concept of SPRT and DRT knives work fixed to spindle. The tests were conducted on two stands which had required kinematic-movement unit. One stand was based on kinematic unit of lathe grinder (Fig.5), the other one was based on vertical milling machine.

On stand one machining tests on maily soft materials were conducted (for example wood, plastic, aluminium).

For this purpose a rotary disc folded knife was projected (Fig.6).

It had cutting edge from high-speed. steel HS18-0-1-0 (SW18), diameter $D_c = 33$ mm and geometry suting machining of above mentioned materials.

Fig.6. Rotating disc knife for soft materials [11]

The course of machining with above mentioned knid of knife was characterized by results very similar to results obtained during earlier SPRT [5-10]. The work effect of SPRT that is forcing rotation of disc only by cutting forces was obtained by uncoupling of tool spindle drive.

CONCLUSIONS

The above described conception of machining with rotary disc knives solves significant technological and working difficulties typical SPRT tools [1,4-8]. The expected effects of their usage can be characterized as following:

1. Simplification of construction and production technology of tools which results in substantially lower costs. The construction of such knives is less complex than conventional knives with fixed discs.
2. Removal of limitations of usage of a tool either as SPRT or DRT.
3. Enlargement of technological possibilities of new machining way SPRT/DRT.

Typical SPRT knives are basically destined for machining of cylindrical or tool face plains which is the result of necessity of remaining stability of tool angles in the setting unit. Using lathe centres programmed in many axis one can provide stability of working angles of cutting edge also during turning of conical, spherical and curvilinear surfaces [1,2,3].

REFERENCES**:**

1. CHMIELEWSKI K., CIELOSZYK J., ZASADA M.: *Narzędzia z obrotowymi płytkami skrawającymi – możliwości technologiczne i efekty stosowania.* Konferencja Naukowo-Techniczna „Projektowanie Procesów Technologicznych". Poznań 2006.
2. HOSOKAWA A., UEDA T., ONISHI B R., TANAKA R., FURUMOTO T.: *Turning of difficult-to-machine materials with actively driven rotary tool.* CIRP Annals - Manufacturing Technology 2010.
3. HARUN S.: *Cutting Mechanics of Turning with Actively Driven Rotary Tool*. Department of Mechanical Engineering, Kobe University, Japan, 2008.
4. JAVOREK L., HRIC J.: *Obróbka drewna narzędziami z obracającą się krawędzią skrawającą*. Obróbka Skrawaniem, Innowacje, IOS Kraków, 2008.
5. NAKAJIMA K.: Effect of Rotary Cutting Tool Posture on Machining Performance Utilizing Multi-Tasking Lathe. Tokyo University of Agriculture and Technology, Japan, 2008.
6. STJERNSTOFT T.: *Machining of some difficult-to-cut material e with rotary cutting tools*. The Royal Institute of Technology, KTH, Stockholm 2004.
7. WIELOCH G., OSAJDA M., MOSTOWSKI R.: Narzędzia do toczenia z samoobracającymi się płytkami i ich zastosowanie przy skrawaniu drewna, Obróbka Skrawaniem, Innowacje, IOS Kraków 2008, 408–416.
8. WIELOCH G., OSAJDA M.: Construction of self-propelled rotary tool (SPRT) for wood turning. Annals of Warsaw Agricultural University – SGGW, Forestry and Wood Technology No, 2007.
9. ЛЮБЧЕНКО В. И.: Резание древесины и древесных материалов." Лесная промышленность, Москва 1986.
10. ЯЩЕРИЦЫН П. И., БОРИСЕНКО А. В., ДРИВОТИН И. Г. ЛЕБЕДЕВ В. Я. Ротационное резание материалов. Наука и Техника, Минск 1987.
11. ZASADA M., CIELOSZYK J., CHMIELEWSKI K.: Nóż tokarski czołowy – narzędzie z obrotowym ostrzem skrawającym. w Obróbka skrawaniem. T.3. Zaawansowana technika, H. Latoś (red.). Uniwersytet Technologiczno-Przyrodniczy w Bydgoszczy, Bachorze 2009.

Streszczenie: *Nowa koncepcja konstrukcji i działania obrotowego noża tokarskiego.* W pracy przedstawiono problemy związane z narzędziami z samo-obrotowymi ostrzami skrawającymi (SPRT – Self-Propelled Rotary Tools) Odznaczają się one kilkudziesięciokrotnym wzrostem trwałości ostrza w porównaniu z narzędziami o ostrzach mocowanych na stałe. Cechuje je również znaczące obniżenie temperatury w strefie skrawania. Pomimo oczywistych zalet narzędzi SPRT problemem jest nadal ich złożoność konstrukcyjna oraz ograniczenia możliwości obróbki złożonych powierzchni. Stąd koncepcja ich modernizacji polegająca na mocowaniu ostrza na wrzecionie silnika i wymuszonym napędzaniu ostrza (DRT – Driven Rotary Tools).

ACKNOWLEDGEMENT: This research has been realized with support of the grant 68/2009/gp

Autors adresses:
[1/] Grzegorz Wieloch: Poznan University of Life Sciences, 60-627 Poznań, Wojska Polskiego 38
[2/]Marcin Osajda; „Nowy Styl" Factory, Rzepedź,
[3/]Lubomir Javorek: Technical University, 960-53 Zvolen, T.G.Masaryka 24,Slovakia.
[/]Krzysztof CHMIELEWSKI, Janusz CIELOSZYK, Marek ZASADA: West Pomeranian University of Technology, Al. Piastów 19, 70-310 Szczecin