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Tema :

"Peran Riset Teknik Mesin Dalam Membangun Daya Saing dan Kemandirian Bangsa"

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TOPIK SEMINAR NASIONAL

Tema Kegiatan :Peran Riset Teknik Mesin dalam Membangun Daya Saing dan Kemandirian Bangsa. Bidang Teknik Mesin sebagai salah satu pilar pengembangan teknologi terapan, memainkan peran penting dalam pengembangan dan pengelolaan sumber daya alam Indonesia. Untuk itu dituntut peran nyata bidang ini dalam pengembangan ilmu pengetahuan dan teknologi yang berguna bagi masyarakat luas yang terangkum dalam bidang-bidang kajian:

- Konversi Energi
- Manufaktur
- Konstruksi dan Perancangan
- Material
- Pendidikan Teknik Mesin

KEYNOTE SPEAKERS

1. Prof. Hiroomi Homma (Toyohashi University Technology of Japan)
2. Prof. Dr. Erry Yulian T. Andesta, IPM, CEng, (International Islamic University Malaysia).
3. Kementerian Energi dan Sumber Daya Mineral (Prof. Dr. IGN Wiratmaja Puja)

11	11:00 - 11:15	Yeny Pusvyta	KOMPLEKSITAS PADA PROSES PERANCANGAN PROTOTIPE ALAT PEMINDAH MASAKAN (COMPLEXITY OF A PROTOTYPE TRANSPORTER CUISINE DESIGN PROCESS)
12	11:15 - 11:30	Zainal Abidin, Andriansyah, dan Budi Heryadi	Meningkatkan Ketelitian Pengukuran Nilai RMS Getaran Mesin dengan Menentukan Parameter Pengukuran yang Benar
13	11:30 - 11:45	Dody Prayitno, Joko Riyono	Mesin Simulasi Sikat Gigi: Inovasi Sistem Pengikat Sikat Gigi
14	11:45 - 12:00	Jamiatul Akmal	SAMBUNGAN ADESIF MODEL TIRUS-DALAM UNTUK PIPA KOMPOSIT YANG MENDAPAT BEBAN TEKANAN INTERNAL
	12:00 - 13:00	LUNCH BREAK	
15	13:00 - 13:15	Ratna Ayu Wandini, Taufiq Mulyanto,Hari Muhammad	Pemodelan Matematika Dinamika Terbang Wahana Tanpa Awak Monocopter
16	13:15 - 13:30	Sandro Mihradi, Andi Isra Mahyuddin, Tatacipta Dirgantara, Robby	Perancangan, Pembuatan dan Pengujian Perangkat Kalibrasi Load Cell Enam Komponen
17	13:30 - 13:45	Fauzan Baananto dan Moch Agus Choiron	Evaluasi Prosedur Pengetatan *Flange* pada *Metal Gasket Tipe* 100A terhadap Distribusi *Contact Stress*
18	13:45 - 14:00	Hendra	Finite Volume Method Untuk Koefisien Perpindahan Panas Pada Desain Bantalan Lori Perebusan Sawit
19	14:00 - 14:15	Agus Triono, IGN Wiratmaja P, Satryo Soemantri, Aditianto R	Analisis Load Cell pada Perancangan Alat Uji Tekan, Bending dan Geser Sederhana
20	14:15 - 14:30	A Widodo, L Rozaqi, I Haryanto, Dj Satrijo	Pembuatan Sensor Getaran Berbasis MEMS untuk Pemantauan Kondisi Mesin dan Struktur
21	14:30 - 14:45	Lenny Iryani, Le Tan Loc, Sandro Mihradi, Tatacita Dirgantara, Ichsan Setya Putra	Pengukuran Medan Perpindahan Keluar Bidang dengan Teknik Korelasi Citra Digital (KCD) 3D pada Pengujian Beban Tekuk
22	14:45 - 15:00	Muhammad Sjahrul Annas, Kuat Rahardjo TS, Zainulsjah	Identifikasi Daftar Kebutuhan pada Perancangan Alat Bantu Operasi Tuas Kopling, Rem dan Gas untuk Pengemudi dengan Kendala Kaki
23	15:00 - 15:15	Rafiuddin Syam, Johanes Ohoiwutun	Uji Eksperimen untuk Trajectory Tracking Mesin Pemotong Rumput Tenaga Surya
24	15:15 - 15:30	Rafiuddin Syam, Randis	Aplikasi Model Mobile Manipulator pada Robot Penjinak Bom
	15:30 - 16:00	CLOSING CEREMONY	

DAY 2: 24 OCTOBER 2013 — ROOM V

No	WAKTU	PEMAKALAH	JUDUL
1	08:00 - 08:15	Rachmat Sriwijaya	PENGARUH KOMPOSISI TANAH LIAT, KAOLIN DAN KWARSA SERTA SUHU PEMBAKARAN TERHADAP SIFAT KERAMIK TRADISIONAL
2	08:15 - 08:30	Reny Afriany, Kusmono, R. Soekrisno	Pengaruh Jenis Larutan, Kuat Arus dan Waktu Pelapisan Nikel pada Aluminium terhadap Kekerasan
3	08:30 - 08:45	S. Fonna, J. Supardi, R. Suvera, S. Huzni, dan M. Ridha	Pengaruh Lokasi Eksposur dari Garis Pantai terhadap Laju Korosi Atmosferik Baja Konstruksi
4	08:45 - 09:00	S. Huzni, J Rahmaddireja, S. Fonna, M. Ridha	S-N Curve Estimation of AISI 304 in Air and Corrosive Environment Using Finite Element Method
5	09:00 - 09:15	Sahlan	ANALISIS STRIASI DAN CREEP SUDU TURBIN GAS PLTGU MUARA TAWAR UNIT II
6	09:15 - 09:30	Sahlan	ANALISIS ABRASIF TUBE DINDING BOILER PLTU TARAHAN

7	09:30 - 09:45	Sri Candrabakty, Leo Soemardji, Bakri, Anwar Badaruddin, Sadri, dan Zulkifli	Analisis kekuatan tarik dan lentur pada komposit epoxy resin/serat batang melinjo dan polyester/serat batang melinjo untuk aplikasi komponen otomotif
8	09:45 - 10:00	Subarmono	PEMBUATAN PISTON SECARA HOT PREESING (POWDER METALLURGY)
	10:00 - 10:30	BREAK	
9	10:30 - 10:45	Sudarisman, Muh. Budi Nur Rahman, dan Irvan M. Ishaq	Pengaruh Konsentrasi NaOH dan Diameter Serat Terhadap Kuat Geser Rekatan pada Antar-muka Serat Sabut Kelapa-Poliester
10	10:45 - 11:00	Sulaiman Thalib, Husni, dan Samsul Rizal	PERILAKU MORFOLOGY KOMPOSIT POLIESTER/SERAT BUAH RUBEK (CALOTROPIS GIGANTEA)
11	11:00 - 11:15	Sunaryo, Gatot Prayogo, Sri Lestari Maharani, dan Gerry Liston Putra	Analisis Kekuatan Lambung Kapal Bermaterial Komposit Yang Dibuat Menggunakan Metode VARTM
12	11:15 - 11:30	Tjokorda Gde Tirta Nindhia	Preparasi Benda Uji Keramik Maju Untuk Pengujian Ketangguhan Retak Dengan Metode Balok Takik V Tepi Tunggal Berdasarkan Standar ISO/FDIS 23146:2008(E)
13	11:30 - 11:45	Syarif Hidayat, Bambang K Hadi, dan Hendri Syamsudin	ANALISIS TEGANGAN DI SEKITAR LUBANG PADA PELAT KOMPOSIT PIN-LOADED DENGAN PENDEKATAN NUMERIK DAN EKSPERIMENTAL
14	11:45 - 12:00	Khairil dan Sarwo Edhy	Kaji Eksperimental Pengaruh Material Perekat Terhadap Degradasi Briket Kokas Pada Temperatur Rendah
	12:00 - 13:00	BREAK	
15	13:00 - 13:15	Triyono dan Yustiasih Purwaningrum	Model Kegagalan Sambungan Las Titik (Resistance Spot Welding) Material Baja Tahan Karat
16	13:15 - 13:30	Tugiman, Suprianto, dan Ramadhan Daulay	Analisa Pemanfaatan Palm Oil Fly Ash Sebagai Bahan Alternatif Pada Pembuatan Metal Matrix Composite (MMC) Menggunakan Metode Stir Casting
17	13:30 - 13:45	Harnowo Supriadi, Irwanto, dan Zulhanif	Pengaruh Jarak Anoda-Katoda dan Pemerata Arus pada Elektroplating Tembaga terhadap Baja AISI 1045 terhadap Ketebalan Lapisan dan Efisiensi Katoda
18	13:45 - 14:00	Mohammad Badaruddin dan Suharno	KOROSI TEMPERATUR TINGGI BAJA AISI 1020 YANG DILAPISI ALUMINIUM DALAM LINGKUNGAN YANG MENGANDUNG KLORIDA DAN SULFUR
19	14:00 - 14:15	Urip Agus Salim, Suyitno, Rahadian Magetsari, dan Muslim Mahardika	Kekerasan pada lubang baja AISI 316L yang dideformasi plastis
20	14:15 - 14:30	Viktor Malau, Clara Nova, Edy Iriyanto, dan Tjipto Sujitno	Studi Korosi Lapisan Plasma Nitriding dan Plasma Nitrocarburising pada Permukaan Baja AISI 410
21	14:30 - 14:45	Yuniati, Irwin Syahri Cebro, dan Nurlaili	PENGARUH BAHAN PENGISI KARBON TEMPURUNG KELAPA DAN KARBON SINTETIS TERHADAP SIFAT MEKANIS PRODUK LATEX
22	14:45 - 15:00	Suryadiwansa Harun, Toshiroh Shibasaka	The Experimental Investigation of Cutting Forces and Chip Formation on Turning with Actively Driven Rotary Tool
23	15:00 - 15:15	Amrizal	Dynamic characterization for flat-plate solar collectors
24	15:15 - 15:30		
	15:30 - 16:00	CLOSING CEREMONY	

DAY-2: 24 October 2013 ROOM VI

No	WAKTU	PEMAKALAH	JUDUL
1	08:00 - 08:15	Ismoyo Haryanto, Rusnaldy, Prasetiyo Adi Prabowo, Achmad Widodo, dan Toni Prahasto	Simulasi Numerik Perilaku Tumbukan Pelat Baja Terhadap Berbagai Konfigurasi Proyektil

KATA PENGANTAR

Dengan memanjatkan doa syukur kepada Allah SWT, telah diterbitkan ***Edisi Revisi*** dari prosiding Seminar Nasional Tahunan Teknik Mesin (SNTTM XII). Seminar Nasional Tahunan Teknik Mesin (SNTTM XII) menyajikan makalah yang berkualitas yang berasal dari tulisan peneliti di bidang Teknik Mesin dari seluruh Indonesia. Makalah yang dipresentasikan dalam seminar ini meliputi lima konsentrasi Teknik Mesin yaitu konversi energi, material, mekanika terapan, produksi dan pendidikan teknik mesin.

Pada Seminar Nasional Tahunan Teknik Mesin (SNTTM XII) terdapat makalah tambahan berbahasa Inggris dari sesi Internasional yang pesertanya terdiri dari peserta Nasional dan dari Japan Society of Mechanical Engineering (JSME). Adanya sesi Internasional ini diharapkan akan menjadi sarana berbagi ilmu antara anggota Badan Kerjasama Teknik Mesin Indonesia (BKSTM) dengan JSME.

Edisi Revisi ini merupakan penyempurnaan dari edisi sebelumnya. Perubahan yang dilakukan diantaranya adalah memasukkan makalah baru yang belum sempat dimuat pada edisi sebelumnya, menyesuaikan kembali letak makalah berdasarkan bidang konsentrasinya, memperbaiki judul makalah serta melakukan perbaikan lainnya. Dengan demikian akan terjadi perubahan susunan dan penomoran halaman dari prosiding ini. ***Edisi Revisi*** diterbitkan bertujuan untuk mengakomodasi seluruh peserta yang telah mengirimkan makalahnya agar dapat mempergunakan prosiding ini sesuai dengan keperluannya.

Kami ingin mengucapkan terima kasih kepada semua penulis yang telah mengkontribusikan makalahnya dalam seminar ini. Terima kasih juga kepada para anggota komite yang telah mencurahkan segala waktu dan usaha sehingga terselenggaranya seminar dengan sukses. Lebih lanjut ucapan terima kasih atas dukungannya kepada civitas akademika Fakultas Teknik UNILA pada khususnya dan UNILA pada umumnya.

Kami juga berterima kasih atas dukungan dari sponsor yaitu PT. Sugar Group, Autodesk (Tekno+Logika), Esindo Karya Lestari, PT. Sahabat Motor, PT. Gunung Madu dan PT. Kawan Lama.

Diharapkan prosiding ini akan dapat memberikan manfaat bagi kalangan akademisi, industri, praktisi dan seluruh masyarakat. Untuk para penulis agar berkenan untuk terus mempublikasikan hasil penelitiannya pada seminar-seminar SNTTM yang akan datang.

Bandar Lampung, 14 Januari 2014

Koordinator Pelaksana Seminar SNTTM XII

Dr.Eng.Shirley Savetlana, S.T., M.Met

JSME

The Experimental Investigation of Cutting Forces and Chip Formation on Turning with Actively Driven Rotary Tool

Suryadiwansa Harun[1], Toshiroh Shibasaka[2]

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[2]Graduate School of Engineering, Kobe University, Kobe, Japan

Abstrak: This paper presents an experimental investigation on chip deformation of the actual turning with actively driven rotary tool. The main purpose of the present work is to make clearly the effect of tool rotational speed and its direction upon the cutting force components, and the chip formation. In order to investigate the effect of tool rotation with a wide range of speed, the cutting tool is driven by the high speed motor of main spindle machine and its rotation is controlled by NC Programmable. The components of cutting force were measured using the piezoelectric force transducers of a force ring dynamometer. Experimental results show that the tool rotational speed can lead an increase in the dynamic inclination angle so that causes the helix angle and the pitch of chip were increased. This indicates the cutting mechanics changed from the orthogonal to the oblique cutting. It was also found that the tool rotational speed has a significant effect on the cutting forces. The resultant and tangential cutting forces decrease with increasing the tool rotational speed to certain value and then constant. The resultant cutting force of rotary tool was approximately 18% lower than the resultant cutting force recorded by the cutting with a non-rotating tool. The axial force increases with an increase in tool rotational speed in a certain speed range and then constant. Interestingly, the constant of the cutting forces as mentioned above along with the increase of the tool rotational speed was obtained at the dynamic inclination angle higher than 45deg. or the velocity ratio higher than 1.
Keywords: Turning with actively driven rotary tool, Tool rotational speed, Cutting forces, and Chip formation.

1. Introduction

High speed cutting has become one of the most promising advanced manufacturing technologies in recent years. The advantages of high speed cutting are high productivity and lower cost. However, as a consequence of high speed cutting, the cutting temperature rises and the life of the cutting tool is shortened. The temperature at the primary shear zone affects the mechanical properties of work material, and high temperature along the tool-chip interface greatly influences the tool wear which leads to drastic reduction of the tool life. When the tool wear progresses, the cutting force, the vibration and the cutting temperature are increased, and hence it causes deterioration in the surface integrity and the dimensional accuracy. Finally the cutting tool reaches to its life, and then the cutting tool must be replaced. Many researches have been carried out to seek for effective methods to overcome the cutting temperature rise when high speed cutting is applied. One of the possible novel methods to decrease the cutting temperature as well as to increase the machining productivity is to apply a rotary cutting tool in turning (Shaw et al., 1952). As the cutting tool rotates and it is cooled during the non-cutting time in one rotation of the tool, it is expected that the temperature of the tool will decrease compared with conventional turning. It is also expected that the rotary cutting tool can be used for high speed cutting of difficult-to-cut materials such as nickel based and titanium based alloys (Lei et al., 2002). However, The state of art of cutting with rotary tools in turning is still at pre-matured stage, and it requires systematic researches before applying the technology to actual production.
The forces acting on the tool are the important aspect of the machining, which is needed for estimating the required power. Also, they have a significant effect on the quality of machined

part. In case of the actual turning with circular cutting edge, the tool-workpiece contact arc is long, thus it can lead to the larger trust radial force (Chou et al., 2004). Therefore, if the structure of the rotary turning tool-holder is lack in stiffness, the deflection of tool could possibly occur. In fact, it is quite often that the occurrence of chatter or poor surface finish can be directly traced to deflection of the tool due to the lack of tool stiffness itself. In order to enhance the stiffness of tool holder system so that the deflection of the tool can be prevented, knowledge about the forces acting on the tool during machining process of the actual turning by circular cutting edge motion is essentially required. Therefore, investigation of cutting force on chip deformation mechanism of the actual turning with rotary tool should be carried out.

This paper presents an experimental investigation on chip deformation of the actual turning with actively driven rotary tool. The main purpose of the present work is to make clearly the effect of tool rotational speed and its direction upon the cutting force components, and the chip formation. In order to investigate the effect of tool rotation with a wide range of speed, the cutting tool is driven by the high speed motor of main spindle machine and its rotation is controlled by NC Programmable.

2. A Feature of Turning With Actively Driven Rotary Tool

Figure 1 shows the basic feature of the turning with actively driven rotary tool process used in this work. Geometrically, this method is characterized by the circular cutting edge, the normal rake angle and the clearance angle. In addition, it is possible to have two positions of the tool cutting edge relative to the work. The inclination angle *i* of the tool holder and offset height *h* (offset angle θ) are defined in Fig. 1. Kinematically, three motions are involved in this method: (1) Cutting motion, work velocity V_W, (2) Feed rate of the tool *f* into workpiece, and (3) The tool rotation speed V_T as the main feature in this method, which causes sidewise motion of tool. It is assumed that when the tool rotates from point of large chip thickness to point of small chip thickness, the rotational direction of the tool is defined to be counterclockwise. Further, the incline angle (that called as the dynamic inclination angle i_d) of the resultant vector of both cutting velocity of work and tool rotational speed was also formed, which it can be expressed as shown in Eq. 1. The increase of the tool rotational speed can leads an increase in the dynamic inclination angle. This causes the change of chip flow direction (Shaw et al., 1952) so that the cutting mechanics change from orthogonal to oblique cutting.

$$\tan i_d = \frac{V_T}{V_w \cdot \cos\theta \cdot \cos i} \qquad (1)$$

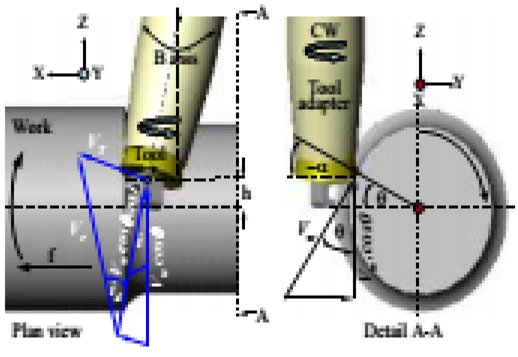

Figure 1. Principle of turning with actively driven rotary tool (Harun, 2008)

3. Experimental Procedure

3.1. Experimental Equipment and Condition

Figure 2 shows a photograph of the experimental equipment. In order to measure the cutting force in this equipment, an additional spindle is mounted on the table of a vertical machining center (Hitachi Seiki VM-3) to which the workpiece is attached as shown in Fig. 2. A 16 mm diameter insert tool made of PVD Coated Cermet having a normal rake angle of 11° was used. The insert tool was clamped on the special tool adapter, and then they were fixed on the milling spindle, which is its rotation changed easily and elevated by the programmable control. The work materials employed for the cutting experiment were plain carbon steel JIS:S45C, which were finished prior to the cutting test in the form solid bar of 50 mm diameter and 120 mm length. Cutting forces were measured using the piezoelectric force transducers of a force ring dynamometer. The major cutting conditions are summarized in Table 1.

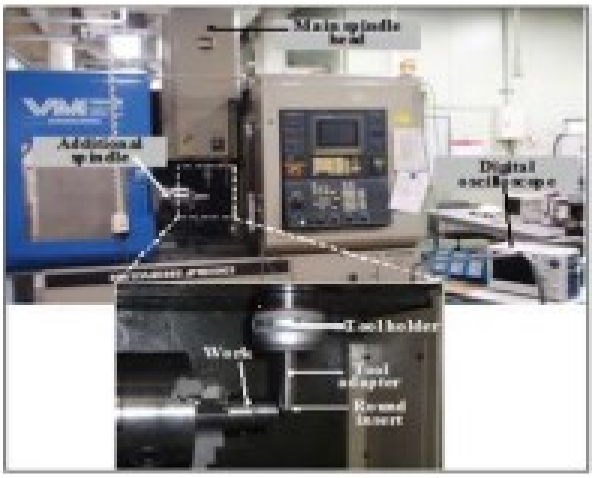

Figure 2. Photograph of experimental equipment of the vertical machine center (Harun, 2011)

3.2. Cutting Force Measurement

Figure 3 shows a schematic illustration of the cutting force measurement system in turning with the rotary cutting tool. There are three components of the cutting forces, consist of the tangential force, F_Z, which acts in the tangential direction of the rotating work and represents the resistance to the rotation of the work. The axial fore, F_X is longitudinal force component acting in the direction parallel to the axis of the work rotation. The radial force, F_Y is acting in the radial direction of the work from the centre of rotation. The resultant force, F_R is given by,

$$F_R = \sqrt{(F_X)^2 + (F_Y)^2 + (F_Z)^2} \qquad (2)$$

The three cutting force components as mentioned above were measured with the force ring dynamometer as shown in Fig. 3.b. The force ring is composed of eight piezoelectric force sensors embedded in ring like frame, which is installed at the fixing point of the main spindle head as shown in Fig. 3.b. In order to record the output of cutting force signal from those sensors, they should be sent to change amplifiers prior they recorded by using the digital oscilloscope. In order to get an accurate measurement ofthe cutting force components, calibration of the dynamometer was carried out prior to the cutting tests to calibrate the

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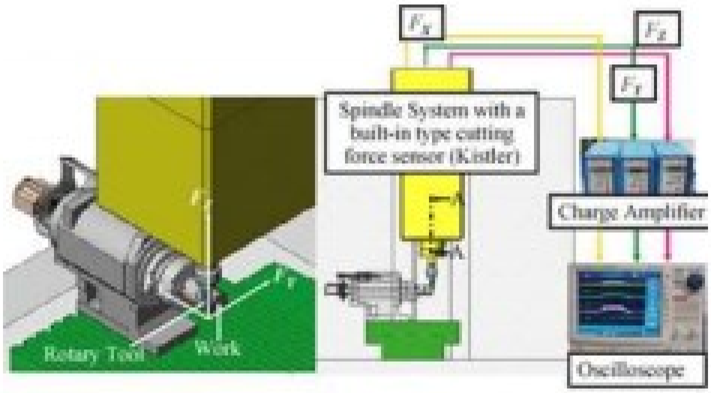
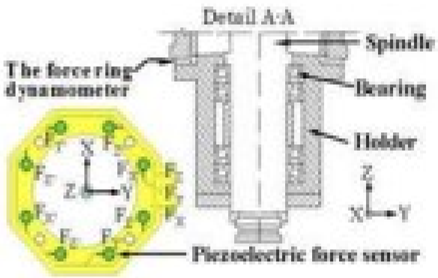
sensitivities of the dynamometer with use of the table-type dynamometer and also the cross talks of the output signals was compensated (Harun, 2011).



a. Principle of cutting force measurement

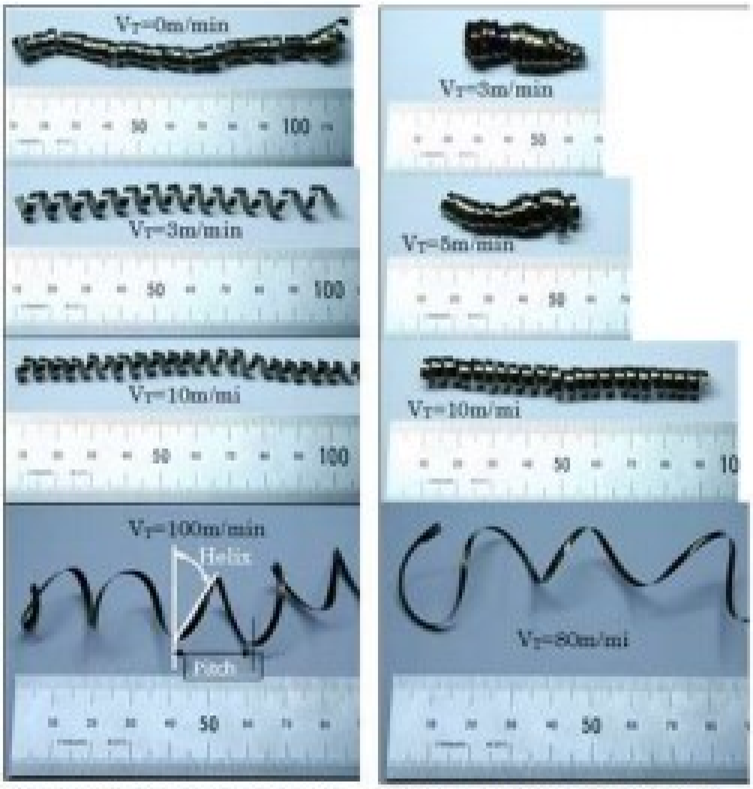


b. Built-in type cutting force sensor system

Figure 3. Schematic illustration of cutting force measurement (Harun, 2011)

Table 1. Major cutting condition

Work material	Plain Carbon Steel (JIS:S45C) Diameter=50mm
Tool	Type: RPMT 1604 MO-BB (Kyocera) Material: PVD Coated Cermet Geometry: Normal rake and relief angle α=11^0, Diameter D=16 mm
Tool rotational speed N_T, min^{-1}	0 ~ ±4000
Work speed V_W, m/min	60 ~ 160
Feed f, mm/rev	0.1 ~ 0.25
Depth of cut a, mm	0.5; 1
Inclination angle i, deg.	0
Offset angle θ, deg.	0
Cutting fluid	Dry
Direction of the spindle rotation	Tool spindle: CW; CCW



(a) Tool rotational direction of clockwise, CW

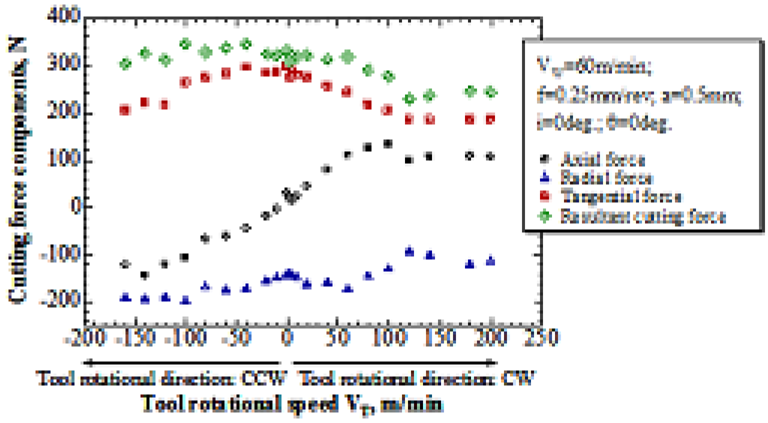
(b) Tool rotational direction of counterclockwise, CCW

Figure 4. Photographs of chip obtained during machining with various tool rotational speed (cutting conditions: V_W=60m/min; a=0.5mm; i=0deg.; θ=0deg.)

4. Result and Discussion

4.1. Chip formation

Figure 4 shows the photograph of chips obtained during machining with various tool rotational speeds and in either direction ofthe clockwise (CW) and the counterclockwise (CCW). In case ofthe tool was rotated in CW direction, see Fig. 4.a, with increasing the tool rotational speed, the helix angle of chips and the pitch of chip were increased, and then it seems that the chip flow becomes smooth, also its flow direction was changed. This indicates the cutting mechanics change from the orthogonal to the oblique cutting.
Interestingly, the chip produced during machining when the tool was rotated in CCWis somew hat different as compared to the opposite direction as shown in Fig. 4.b. As observed in this fi gure, it was rather broken especially at the low tool speeds (3 and 5 m/min). It is further obser ved that its helix angle and its pitch were smaller as compared to the case of the tool rotate in opposite direction. This caused by the chip stacked on the work surface so that the chip flow b ecomes not smooth.



a. Case of VW = 60m/min

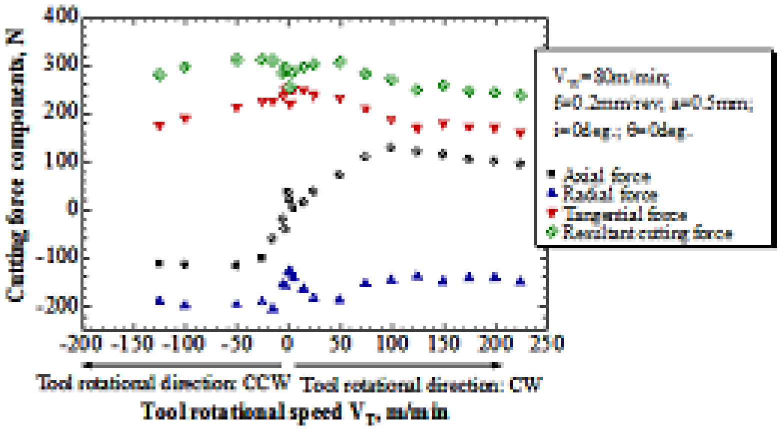


Figure 5. Effect of tool rotational speed on cutting forces

4.2. Cutting Force

Figure 5 shows the effect of the tool rotational speed on cutting forces when the tool was rotated in either direction of CW and CCW. In case of the cutting speed V_W of 60 m/min, the tangential force decreases with increasing the tool rotational speed in either tool rotation direction of CCW and CW, see Fig. 5.a. This can be attributed to reduced amount of work done in chip deformation of turning with actively driven rotary tool. According to Eq.1, the increase of tool rotational speed can lead an increase in the dynamic inclination angle so that causes the helix angle and the chip pitch increased. This indicates an increase in chip flow angle, and then leads the effective rake and shear angle was increased. These factors cause the cutting force decreases along with the increase of tool rotational speed. Interestingly, the decrease of the tangential force with an increase in clockwise tool rotational speed was effective to a speed limit of approximately 100 m/min or the velocity ratio is higher than 1 (calculated from Eq.1) and then constant. It means that the decrease of that cutting force based on the increase of tool rotational speed already reaches the saturation state. In others word, the effect of effective rake and shear angle to decrease the cutting force was limited by the increase of tool speed cutting itself. Furthermore, it is interested that the variation of tangential force along with the increase of counterclockwise tool rotational speed was almost constant in a speed range from 0 to -40 m/min. This seems caused by the chip stacked on the work surface so that the chip flow becomes not smooth.

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In contrast to those cutting forces, the axial force increases with an increase in clockwise tool rotational speed and then constant as shown in Fig. 5.a. When the tool is rotated in CW direction, the tangential velocity of the tool has the same direction with feed direction. That results in large axial direction velocity, which is the sum of the tangential velocity of tool and feed speed. This factor increases the axial force component with an increase in the tool rotational speed (Harun, 2008). However, the change of axial force with increasing the tool rotational speed was almost constant in a speed range is higher than approximately 60 m/min, which is the equal to the dynamic inclination angle of 45deg (case of V_w= 60 m/min) or the velocity ratio of 1 as calculated from Eq.1. When the tool rotational speed is higher than the work cutting speed V_W (the dynamic inclination angle is higher than 45deg.), the chip will sliding on the rake face of the tool. It is seemed that the sticking region at chip-tool interface is eliminated, and this tends to reduce of the frictional drag. The drop in the frictional drag was invoked to explain the observed constant change in the magnitude axial cutting force at the velocity ratio range is higher than 1.

The radial force decreases slightly as increasing tool rotational speed in clockwise tool rotation direction, while it was almost constant as increasing tool rotational speed in opposite direction. As consequence of magnitude all cutting force components, the resultant cutting force also decreases along with the increase of tool rotational speed in experimental range of the tool rotational speed.

In addition, the resultant cutting force of rotary tool was found to be smaller, which was approximately 18% lower than the resultant cutting force recorded by the cutting with a non-rotating tool. The similar trend was also observed at the case of the cutting speed was changed from 60 to 80 m/min as shown in Fig. 5.b. It is importantly noted that the results as mentioned above were not reported by the past researchers.

5. Conclusion

In this paper, an experimental examination of the effects of the tool rotational speed and direction upon the chip formation and the cutting forces during turning with the actively driven rotary tools were carried out. The following remarks are concluded in this paper from the experiments.

1. It was found that the increase of the tool rotational speed can lead an increase in the dynamic inclination angle so that causes the helix angle and the pitch of chip were increased.
2. It was further found that the tool rotational speed has a significant effect on the cutting forces. The resultant and tangential cutting forces decrease with increasing the tool rotational speed to certain value and then constant. The resultant cutting force of rotary tool was approximately 18% lower than the resultant cutting force recorded by the cutting with a non-rotating tool.
3. The axial force increases with an increase in tool rotational speed in a certain speed range and then constant.
4. Interestingly, the constant of the cutting forces as mentioned above along with the increase of the tool rotational speed was obtained at the dynamic inclination angle higher than 45deg. or the velocity ratio higher than 1.
5. However, the radial force decreases slightly as increasing tool rotational speed in clockwise tool rotation direction, while it was almost constant as increasing tool rotational speed in opposite direction.

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