

ISSN 1726-5479

SENSORS & TRANSDUCERS

12

vol. 99

/08



Sensor Market Trends

International Frequency Sensor Association Publishing





Sensors & Transducers

Volume 99
December 2008

www.sensorsportal.com

ISSN 1726-5479

Editor-in-Chief: professor Sergey Y. Yurish, phone: +34 696067716, fax: +34 93 4011989, e-mail: editor@sensorsportal.com

Editors for Western Europe

Meijer, Gerard C.M., Delft University of Technology, The Netherlands
Ferrari, Vittorio, Università di Brescia, Italy

Editors for North America

Datskos, Panos G., Oak Ridge National Laboratory, USA
Fabien, J. Josse, Marquette University, USA
Katz, Evgeny, Clarkson University, USA

Editor South America

Costa-Felix, Rodrigo, Inmetro, Brazil

Editor for Eastern Europe

Sachenko, Anatoly, Ternopil State Economic University, Ukraine

Editor for Asia

Ohyama, Shinji, Tokyo Institute of Technology, Japan

Editorial Advisory Board

- Abdul Rahim, Ruzairi**, Universiti Teknologi, Malaysia
Ahmad, Mohd Noor, Nothern University of Engineering, Malaysia
Annamalai, Karthigeyan, National Institute of Advanced Industrial Science and Technology, Japan
Arcega, Francisco, University of Zaragoza, Spain
Arguel, Philippe, CNRS, France
Ahn, Jae-Pyoung, Korea Institute of Science and Technology, Korea
Arndt, Michael, Robert Bosch GmbH, Germany
Ascoli, Giorgio, George Mason University, USA
Atalay, Selcuk, Inonu University, Turkey
Atghiaee, Ahmad, University of Tehran, Iran
Augutis, Vyngantas, Kaunas University of Technology, Lithuania
Avachit, Patil Lalchand, North Maharashtra University, India
Ayesh, Aladdin, De Montfort University, UK
Bahreyni, Behraad, University of Manitoba, Canada
Baoxian, Ye, Zhengzhou University, China
Barford, Lee, Agilent Laboratories, USA
Barlingay, Ravindra, RF Arrays Systems, India
Basu, Sukumar, Jadavpur University, India
Beck, Stephen, University of Sheffield, UK
Ben Bouzid, Sihem, Institut National de Recherche Scientifique, Tunisia
Benachaiba, Chellali, Universitaire de Bechar, Algeria
Binnie, T. David, Napier University, UK
Bischoff, Gerlinde, Inst. Analytical Chemistry, Germany
Bodas, Dhananjay, IMTEK, Germany
Borges Carval, Nuno, Universidade de Aveiro, Portugal
Bousbia-Salah, Mounir, University of Annaba, Algeria
Bouvet, Marcel, CNRS – UPMC, France
Brudzewski, Kazimierz, Warsaw University of Technology, Poland
Cai, Chenxin, Nanjing Normal University, China
Cai, Qingyun, Hunan University, China
Campanella, Luigi, University La Sapienza, Italy
Carvalho, Vitor, Minho University, Portugal
Cecelja, Franjo, Brunel University, London, UK
Cerda Belmonte, Judith, Imperial College London, UK
Chakrabarty, Chandan Kumar, Universiti Tenaga Nasional, Malaysia
Chakravorty, Dipankar, Association for the Cultivation of Science, India
Changhai, Ru, Harbin Engineering University, China
Chaudhari, Gajanan, Shri Shivaji Science College, India
Chen, Jiming, Zhejiang University, China
Chen, Rongshun, National Tsing Hua University, Taiwan
Cheng, Kuo-Sheng, National Cheng Kung University, Taiwan
Chiriac, Horia, National Institute of Research and Development, Romania
Chowdhuri, Arijit, University of Delhi, India
Chung, Wen-Yaw, Chung Yuan Christian University, Taiwan
Corres, Jesus, Universidad Publica de Navarra, Spain
Cortes, Camilo A., Universidad Nacional de Colombia, Colombia
Courtois, Christian, Universite de Valenciennes, France
Cusano, Andrea, University of Sannio, Italy
D'Amico, Arnaldo, Università di Tor Vergata, Italy
De Stefano, Luca, Institute for Microelectronics and Microsystem, Italy
Deshmukh, Kiran, Shri Shivaji Mahavidyalaya, Barshi, India
Dickert, Franz L., Vienna University, Austria
Dieguez, Angel, University of Barcelona, Spain
Dimitropoulos, Panos, University of Thessaly, Greece
Ding Jian, Ning, Jiangsu University, China
Djordjevic, Alexandar, City University of Hong Kong, Hong Kong
Ko, Sang Choon, Electronics and Telecommunications Research Institute, Korea South
Donato, Nicola, University of Messina, Italy
Donato, Patricio, Universidad de Mar del Plata, Argentina
Dong, Feng, Tianjin University, China
Drljaca, Predrag, Instersema Sensoric SA, Switzerland
Dubey, Venketesh, Bournemouth University, UK
Enderle, Stefan, University of Ulm and KTB Mechatronics GmbH, Germany
Erdem, Gursan K. Arzum, Ege University, Turkey
Erkmen, Aydan M., Middle East Technical University, Turkey
Estelle, Patrice, Insa Rennes, France
Estrada, Horacio, University of North Carolina, USA
Faiz, Adil, INSA Lyon, France
Fericean, Sorin, Balluff GmbH, Germany
Fernandes, Joana M., University of Porto, Portugal
Francioso, Luca, CNR-IMM Institute for Microelectronics and Microsystems, Italy
Francis, Laurent, University Catholique de Louvain, Belgium
Fu, Weiling, South-Western Hospital, Chongqing, China
Gaura, Elena, Coventry University, UK
Geng, Yanfeng, China University of Petroleum, China
Gole, James, Georgia Institute of Technology, USA
Gong, Hao, National University of Singapore, Singapore
Gonzalez de la Rosa, Juan Jose, University of Cadiz, Spain
Granel, Annette, Goteborg University, Sweden
Graff, Mason, The University of Texas at Arlington, USA
Guan, Shan, Eastman Kodak, USA
Guillet, Bruno, University of Caen, France
Guo, Zhen, New Jersey Institute of Technology, USA
Gupta, Narendra Kumar, Napier University, UK
Hadjiloucas, Sillas, The University of Reading, UK
Hashsham, Syed, Michigan State University, USA
Hernandez, Alvaro, University of Alcala, Spain
Hernandez, Wilmar, Universidad Politecnica de Madrid, Spain
Homentcovschi, Dorel, SUNY Binghamton, USA
Horstman, Tom, U.S. Automation Group, LLC, USA
Hsiai, Tzung (John), University of Southern California, USA
Huang, Jeng-Sheng, Chung Yuan Christian University, Taiwan
Huang, Star, National Tsing Hua University, Taiwan
Huang, Wei, PSG Design Center, USA
Hui, David, University of New Orleans, USA
Jaffrezic-Renault, Nicole, Ecole Centrale de Lyon, France
Jaime Calvo-Galleg, Jaime, Universidad de Salamanca, Spain
James, Daniel, Griffith University, Australia
Janting, Jakob, DELTA Danish Electronics, Denmark
Jiang, Liudi, University of Southampton, UK
Jiang, Wei, University of Virginia, USA
Jiao, Zheng, Shanghai University, China
John, Joachim, IMEC, Belgium
Kalach, Andrew, Voronezh Institute of Ministry of Interior, Russia
Kang, Moonho, Sunmoon University, Korea South
Kaniusas, Eugenijus, Vienna University of Technology, Austria
Katake, Anup, Texas A&M University, USA
Kausel, Wilfried, University of Music, Vienna, Austria
Kavasoglu, Nese, Mugla University, Turkey
Ke, Cathy, Tyndall National Institute, Ireland
Khan, Asif, Aligarh Muslim University, Aligarh, India
Kim, Min Young, Koh Young Technology, Inc., Korea South
Sandacci, Serghei, Sensor Technology Ltd., UK
Sapozhnikova, Ksenia, D.I.Mendeleyev Institute for Metrology, Russia

Kockar, Hakan, Balikesir University, Turkey
Kotulska, Malgorzata, Wroclaw University of Technology, Poland
Kratz, Henrik, Uppsala University, Sweden
Kumar, Arun, University of South Florida, USA
Kumar, Subodh, National Physical Laboratory, India
Kung, Chih-Hsien, Chang-Jung Christian University, Taiwan
Lacnjevac, Caslav, University of Belgrade, Serbia
Lay-Ekuakille, Aime, University of Lecce, Italy
Lee, Jang Myung, Pusan National University, Korea South
Lee, Jun Su, Amkor Technology, Inc. South Korea
Lei, Hua, National Starch and Chemical Company, USA
Li, Genxi, Nanjing University, China
Li, Hui, Shanghai Jiaotong University, China
Li, Xian-Fang, Central South University, China
Liang, Yuanchang, University of Washington, USA
Liawruangrath, Saisune, Chiang Mai University, Thailand
Liew, Kim Meow, City University of Hong Kong, Hong Kong
Lin, Hermann, National Kaohsiung University, Taiwan
Lin, Paul, Cleveland State University, USA
Linderholm, Pontus, EPFL - Microsystems Laboratory, Switzerland
Liu, Aihua, University of Oklahoma, USA
Liu Changgeng, Louisiana State University, USA
Liu, Cheng-Hsien, National Tsing Hua University, Taiwan
Liu, Songqin, Southeast University, China
Lodeiro, Carlos, Universidade NOVA de Lisboa, Portugal
Lorenzo, Maria Encarnacio, Universidad Autonoma de Madrid, Spain
Lukaszewicz, Jerzy Pawel, Nicholas Copernicus University, Poland
Ma, Zhanfang, Northeast Normal University, China
Majstorovic, Vidosav, University of Belgrade, Serbia
Marquez, Alfredo, Centro de Investigacion en Materiales Avanzados, Mexico
Matay, Ladislav, Slovak Academy of Sciences, Slovakia
Mathur, Prafull, National Physical Laboratory, India
Maurya, D.K., Institute of Materials Research and Engineering, Singapore
Mekid, Samir, University of Manchester, UK
Melnyk, Ivan, Photon Control Inc., Canada
Mendes, Paulo, University of Minho, Portugal
Mennell, Julie, Northumbria University, UK
Mi, Bin, Boston Scientific Corporation, USA
Minas, Graca, University of Minho, Portugal
Moghavvemi, Mahmoud, University of Malaya, Malaysia
Mohammadi, Mohammad-Reza, University of Cambridge, UK
Molina Flores, Esteban, Benemérita Universidad Autónoma de Puebla, Mexico
Moradi, Majid, University of Kerman, Iran
Morello, Rosario, DIMET, University "Mediterranea" of Reggio Calabria, Italy
Mounir, Ben Ali, University of Sousse, Tunisia
Mukhopadhyay, Subhas, Massey University, New Zealand
Neelamegam, Periasamy, Sastra Deemed University, India
Neshkova, Milka, Bulgarian Academy of Sciences, Bulgaria
Oberhammer, Joachim, Royal Institute of Technology, Sweden
Ould Lahoucine, University of Guelma, Algeria
Pamidighanta, Sayanu, Bharat Electronics Limited (BEL), India
Pan, Jisheng, Institute of Materials Research & Engineering, Singapore
Park, Joon-Shik, Korea Electronics Technology Institute, Korea South
Penza, Michele, ENEA C.R., Italy
Pereira, Jose Miguel, Instituto Politecnico de Setebal, Portugal
Petsev, Dimiter, University of New Mexico, USA
Pogacnik, Lea, University of Ljubljana, Slovenia
Post, Michael, National Research Council, Canada
Prance, Robert, University of Sussex, UK
Prasad, Ambika, Gulbarga University, India
Prateepasen, Asa, Kingmoungut's University of Technology, Thailand
Pullini, Daniele, Centro Ricerche FIAT, Italy
Pumera, Martin, National Institute for Materials Science, Japan
Radhakrishnan, S., National Chemical Laboratory, Pune, India
Rajanna, K., Indian Institute of Science, India
Ramadan, Qasem, Institute of Microelectronics, Singapore
Rao, Basuthkar, Tata Inst. of Fundamental Research, India
Raouf, Kosai, Joseph Fourier University of Grenoble, France
Reig, Candid, University of Valencia, Spain
Restivo, Maria Teresa, University of Porto, Portugal
Robert, Michel, University Henri Poincare, France
Rezazadeh, Ghader, Urmia University, Iran
Royo, Santiago, Universitat Politecnica de Catalunya, Spain
Rodriguez, Angel, Universidad Politecnica de Cataluna, Spain
Rothberg, Steve, Loughborough University, UK
Sadana, Ajit, University of Mississippi, USA
Sadeghian Marnani, Hamed, TU Delft, The Netherlands
Saxena, Vibha, Bhabha Atomic Research Centre, Mumbai, India
Schneider, John K., Ultra-Scan Corporation, USA
Seif, Selemeni, Alabama A & M University, USA
Seifter, Achim, Los Alamos National Laboratory, USA
Sengupta, Deepak, Advance Bio-Photonics, India
Shankar, B. Baliga, General Monitors Transnational, USA
Shearwood, Christopher, Nanyang Technological University, Singapore
Shin, Kyuho, Samsung Advanced Institute of Technology, Korea
Shmaliy, Yuriy, Kharkiv National University of Radio Electronics, Ukraine
Silva Girao, Pedro, Technical University of Lisbon, Portugal
Singh, V. R., National Physical Laboratory, India
Slomovitz, Daniel, UTE, Uruguay
Smith, Martin, Open University, UK
Soleymanpour, Ahmad, Damghan Basic Science University, Iran
Somani, Prakash R., Centre for Materials for Electronics Technol., India
Srinivas, Talabattula, Indian Institute of Science, Bangalore, India
Srivastava, Arvind K., Northwestern University, USA
Stefan-van Staden, Raluca-Ioana, University of Pretoria, South Africa
Sumriddetchka, Sarun, National Electronics and Computer Technology Center, Thailand
Sun, Chengliang, Polytechnic University, Hong-Kong
Sun, Dongming, Jilin University, China
Sun, Junhua, Beijing University of Aeronautics and Astronautics, China
Sun, Zhiqiang, Central South University, China
Suri, C. Raman, Institute of Microbial Technology, India
Sysoev, Victor, Saratov State Technical University, Russia
Szewczyk, Roman, Industrial Research Institute for Automation and Measurement, Poland
Tan, Ooi Kiang, Nanyang Technological University, Singapore
Tang, Dianping, Southwest University, China
Tang, Jaw-Luen, National Chung Cheng University, Taiwan
Teher, Kasif, Frostburg State University, USA
Thumbavanam Pad, Kartik, Carnegie Mellon University, USA
Tian, Gui Yun, University of Newcastle, UK
Tsiantos, Vassilios, Technological Educational Institute of Kaval, Greece
Tsigara, Anna, National Hellenic Research Foundation, Greece
Twomey, Karen, University College Cork, Ireland
Valente, Antonio, University, Vila Real, - U.T.A.D., Portugal
Vaseashta, Ashok, Marshall University, USA
Vazques, Carmen, Carlos III University in Madrid, Spain
Vieira, Manuela, Instituto Superior de Engenharia de Lisboa, Portugal
Vigna, Benedetto, STMicroelectronics, Italy
Vrba, Radimir, Brno University of Technology, Czech Republic
Wandelt, Barbara, Technical University of Lodz, Poland
Wang, Jiangping, Xi'an Shiyong University, China
Wang, Kedong, Beihang University, China
Wang, Liang, Advanced Micro Devices, USA
Wang, Mi, University of Leeds, UK
Wang, Shinn-Fwu, Ching Yun University, Taiwan
Wang, Wei-Chih, University of Washington, USA
Wang, Wensheng, University of Pennsylvania, USA
Watson, Steven, Center for NanoSpace Technologies Inc., USA
Weiping, Yan, Dalian University of Technology, China
Wells, Stephen, Southern Company Services, USA
Wolkenberg, Andrzej, Institute of Electron Technology, Poland
Woods, R. Clive, Louisiana State University, USA
Wu, DerHo, National Pingtung University of Science and Technology, Taiwan
Wu, Zhaoyang, Hunan University, China
Xiu Tao, Ge, Chuzhou University, China
Xu, Lisheng, The Chinese University of Hong Kong, Hong Kong
Xu, Tao, University of California, Irvine, USA
Yang, Dongfang, National Research Council, Canada
Yang, Wuqiang, The University of Manchester, UK
Ymeti, Aurel, University of Twente, Netherland
Yong Zhao, Northeastern University, China
Yu, Haihu, Wuhan University of Technology, China
Yuan, Yong, Massey University, New Zealand
Yufera Garcia, Alberto, Seville University, Spain
Zagnoni, Michele, University of Southampton, UK
Zeni, Luigi, Second University of Naples, Italy
Zhong, Haoxiang, Henan Normal University, China
Zhang, Minglong, Shanghai University, China
Zhang, Quintao, University of California at Berkeley, USA
Zhang, Weiping, Shanghai Jiao Tong University, China
Zhang, Wenming, Shanghai Jiao Tong University, China
Zhou, Zhi-Gang, Tsinghua University, China
Zorzano, Luis, Universidad de La Rioja, Spain
Zourab, Mohammed, University of Cambridge, UK

Contents

Volume 99
Issue 12
December 2008

www.sensorsportal.com

ISSN 1726-5479

Research Articles

Pushing Low-Cost Sensors to Market

A NanoMarkets White Paper, NanoMarkets, 1

Design and Development of an Embedded System for Measurement of Temperature and Remote Communication Using Fiber Optic Cable

Raghavendra Rao Kanchi, Sreelekha Kande and Ramanjappa Thogata..... 7

Reflective Type Small-Angle Sensor Based on Multiple Total Internal Reflections in Heterodyne Interferometry

Shinn-Fwu Wang, Po-Chin Chiu, Tsung-Hsun Yang 18

An Inter-digital Capacitive Electrode Modified as a Pressure Sensor

T. J. Ginson and J. Philip..... 25

A New Rotational Velocity Meter for Dynamic Testing

Hou Xiaoyan 33

Fault Diagnosis and Condition Monitoring of an All Geared Lathe Machine Using Piezoelectric Sensor

Amiya Bhaumik, Nabin Sardar, Nirmal Kumar Mandal 43

Modal Analysis and Experimental Determination of Optimum Tool Shank Overhang of a Lathe Machine

Nabin Sardar, Amiya Bhaumik, Nirmal Kumar Mandal 53

Test Device for Under Water Tidal Flow Power Generation Measurement

Ibrahim Al-Bahadly and Paul Pinfold..... 66

Development of Portative System for Quality Detection in Indian Honey Using Gas Sensor

Rohini P. Mudhalwadkar, Dr. Ashok Ghatol..... 82

Electrostrictive Effect in Cancer Cell Reflected in Capacitance Relaxation Phenomena

Tapas Kumar Basak, T. Ramanujam, Suman Halder, Poonam Goyal, Prachi Mohan Kulshreshtha, Shweta Pandey, Himanshu Tripathi 90

Wireless Pressure Sensor Using Non-contact Differential Variable Reluctance Transducer

K. Prabakar, Usharani Ravi and J. Jayapandian..... 102

Authors are encouraged to submit article in MS Word (doc) and Acrobat (pdf) formats by e-mail: editor@sensorsportal.com
Please visit journal's webpage with preparation instructions: <http://www.sensorsportal.com/HTML/DIGEST/Submission.htm>

Modal Analysis and Experimental Determination of Optimum Tool Shank Overhang of a Lathe Machine

Nabin SARDAR, Amiya BHAUMIK, Nirmal Kumar MANDAL

Department of Mechanical Engineering

National Institute of Technical Teachers' Training & Research,

Block-FC, Sector-III, Saltlake City, Kolkata-700106

E-mail: nabin.sardar@rediffmail.com, amiya67@rediffmail.com, mandal_nirmal@yahoo.com

Received: 19 November 2008 /Accepted: 22 December 2008 /Published: 30 December 2008

Abstract: Vibration of Tool Shank of a cutting tool has large influence on tolerances and surface finish of products. Frequency and amplitude of vibrations depend on the overhang of the shank of the cutting tool. In turning operations, when the tool overhang is about 2 times of the tool height, the amplitude of the vibration is almost zero and dimensional tolerances and surface finish of the product becomes high. In this paper, the above statement is verified firstly by using a finite element analysis of the cutting tool with ANSYS software package and secondly, with experimental verification with a piezoelectric sensor. *Copyright © 2008 IFSA.*

Keywords: Modal testing, Tool shank, Piezoelectric sensor, Signal conditioner, Analyzer

1. Introduction

Vibration is a common problem of almost all types of machining, and particularly when the tool overhang exceeds about 2 times the tool depth. It becomes significant when the requirements of dimensional tolerances and surface finish are high. A stable tool holder is of the utmost importance for increasing the precision of the machining process.

Generally in turning operations there will be some level of relative dynamic motion between cutting tool and work piece. Energy from the chip formation process excites the mechanical modes of the machine-tool system. Modes of the work piece may also influence tool vibration. The dynamic properties of the excitation, i.e. the chip formation process are correlated to the material properties and

the geometry of the work piece. The vibrations may lead to unwanted noise, degraded surface finish and reduced tool life.

The dynamic performance of mechanical systems is mostly represented by their modal parameters. The modal parameters which govern the dynamic performance of the mechanical systems can be identified by modal testing which is usually used to study the mechanical systems. The majority of traditional modal testing techniques include excitation of the structure via a function of known frequency characteristics (impulse, random, periodic) using, e.g. an impact hammer or an exciter, and measuring the associated response using force or motion sensors. Finally, a description of system dynamic characteristics is obtained by establishing frequency response functions (FRF).

In this paper both theoretical and experimental analyses of the tool shank have been performed. Theoretical investigation deals with the designs and characteristics of the tool shank. The first step is to develop a mathematical model using Finite Element Method (FE-Model) of the problem using reliable finite element software, ANSYS to get an understanding of the dynamics involved. In order to verify the result of the model an Experimental Modal Analysis (EMA) is done. Based on the experimental results the FE-model is adjusted and when the FE-model and the experimental model correlates accurately the FE-model of the tool holder shank is accepted. The agreement between FE-models and the experimental models gives opportunity to use the FE-models for more extensive studies without further extensive experimental measurements.

2. Literature Review

The theory of chatter vibrations is known for a long time. The first [1] studies about self-excited vibrations have been started in the second half of the past century. Tlustý and Poláček [2] and Tobias [3] determined the most important source of self-excitation which is associated with the structural dynamics of the machine tool and the feedback between the subsequent cuts on the same cutting surface resulting in regeneration of waviness on the cutting surfaces, and thus modulation in the chip thickness [2].

Although chatter stability has been studied in detail in last half a century, chatter vibrations still continue to be one of the most important limitations in production operations. Shi and Tobias [4] showed that the boundaries of the stability increases as the feed rate increases until a nominal value. Important contributions about chatter stability came from Budak and Altintas [5] and, Jensen and Shin [6] in recent years.

Tlustý [7] pointed out that the flank wear flat is critical in positive damping in the occurrence of self-excited vibrations. Chiou et al. [8] demonstrated that chatter instability is delayed to a greater overhang distance as a result of flank wear, and chatter limit increases especially at lower cutting speeds, as the tool wear increases. Chiou and Liang [9] demonstrated the effect of tool wear on chatter stability in turning. The chatter stability increases as the tool wear flat of the cutting tool enlarges.

Chiou and Liang [10] analyzed the acoustic emission in chatter vibration with tool wear effect in turning. Fofana et al. [11] investigated machining stability in turning by using worn tool inserts. Cutting forces varying with depth of cut and feed rate and cutting force coefficients are investigated as the tool wear progresses and it is demonstrated that tool wear and dynamic instability are both contributed by the combined effect of the contact and friction mechanisms between work piece-tool, tool-chip and work piece-tool-machine tool interactions.

3. The Tool Shank

The tool shank that is used for the experimental procedures has a cross section of 20 x 20 mm and the length is 140 mm. The geometry of the tool shank is presented in Fig. 1 and Table 1. Particularly for this experiment we used carbon steel as shank materials and the tip is tungsten carbide.

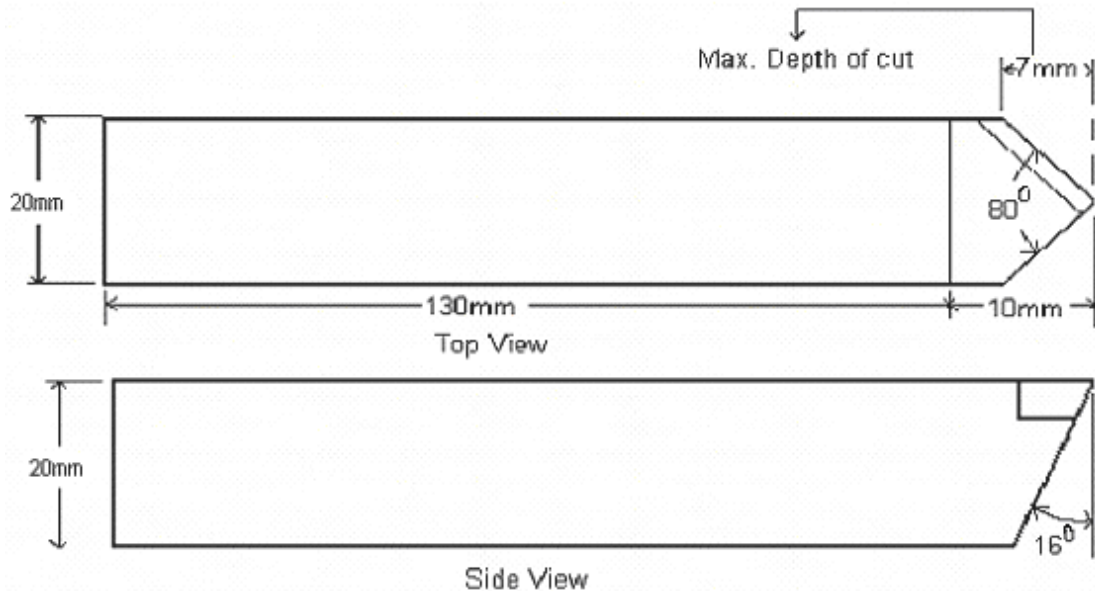


Fig. 1. The geometry of the tool shank.

Table 1. Specification of tool shank.

Tool No.		Max. Depth of cut	Tip No.	Tool Dimensions			
0° Top Rake	R.H. Lipped			Height	Width	Length	Nose radius
60*	62	7 mm	60*	20 mm	20 mm	140 mm	1.5 mm

4. The Theoretical Model

The shank of a cutting tool is generally analyzed for strength and rigidity. This is assumed to be loaded as a cantilever by tool forces at the cutting edge as shown in Fig. 2. The main design criterion for shank size is rigidity. The deflection at the cutting edge is limited to a certain value depending on the size of the machine, cutting conditions and tool overhang. The Tool overhang (L_e) is related also to the shank size as well as to end fixing conditions. It is seen that only below (L_e/H) of 2, the amplitude is practically zero. The recommended value of (L_e/H) is between 1.2 and 2.

Knowing the chatter frequency f and the shank deflection can be calculated from the well-known equation (12),

$$f = 15.76 / \sqrt{\Delta} \text{ c.p.s.}, \quad (1)$$

where Δ is deflection, in mm.

The shank deflection is given by the equation,

$$\Delta = P_z L_e^3 / 3EI , \quad (2)$$

where P_z is applied force in Newton;
 L_e is overhang length in mm;
 E is modulus of elasticity;
 I is the area moment of inertia of the shank.

The force P_z for a given size of lathe, is given by

$$P_z = s \times t \times k , \quad (3)$$

where s is feed in mm,
 t is depth of cut in mm,
 k is cutting force constant.

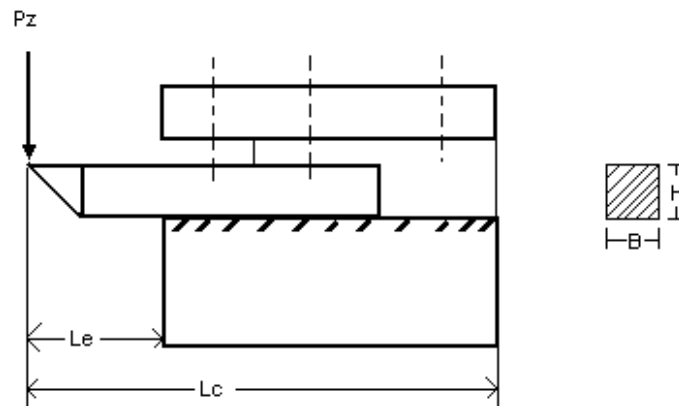


Fig. 2. Cutting tool overhang.

One of the most important choices when making a finite element model is which element type to use. There are many different types of element that we can choose. These elements are beam element, shell element and solid element. In this paper, finite element modeling is done by using ANSYS software and the modeling was done by using solid element. Beam elements can be used to make a very efficient finite element model to predict overall deflection and bending moments but will not be able to predict the local stress concentrations at the point of application of a load or at joints. A beam has three translational degrees of freedom and three rotational degrees of freedom. The most general elements are the solid elements. The disadvantage is that more elements and nodes are usually required. However, many devices designed by engineers have highly three-dimensional geometry, which makes it necessary to use three-dimensional elements.

4.1. FE-model

The boundary condition includes loads, temperature restraints, and displacement restraints. The FE-model is built up with solid elements. To simulate the boundary conditions the FE-model is clamped at 100 mm, 80 mm, 60 mm and 50 mm hang out respectively. The finite element models show the natural frequencies of different overhang length (Fig. 3-6).

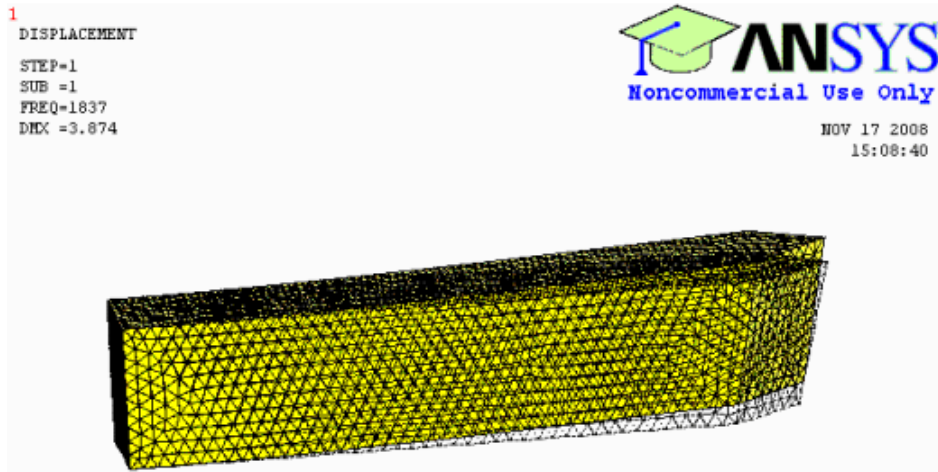


Fig. 3. Tool shank overhang 100 mm.

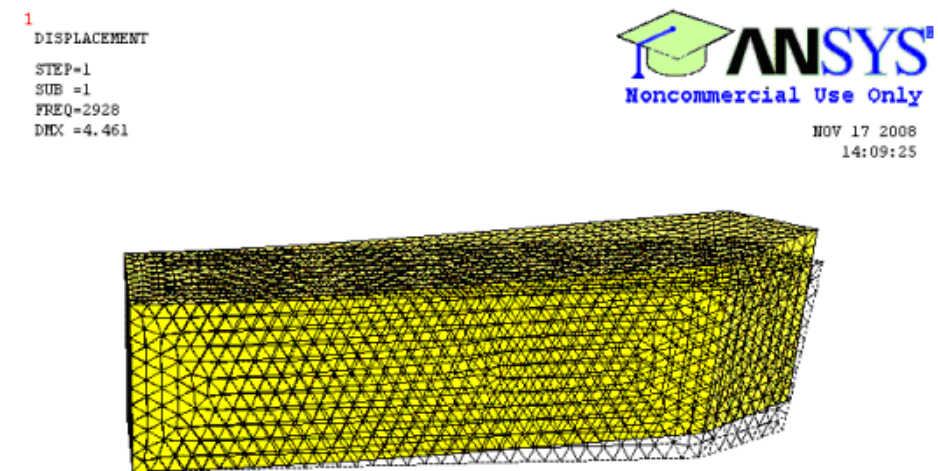


Fig. 4. Tool shank overhangs 80 mm.

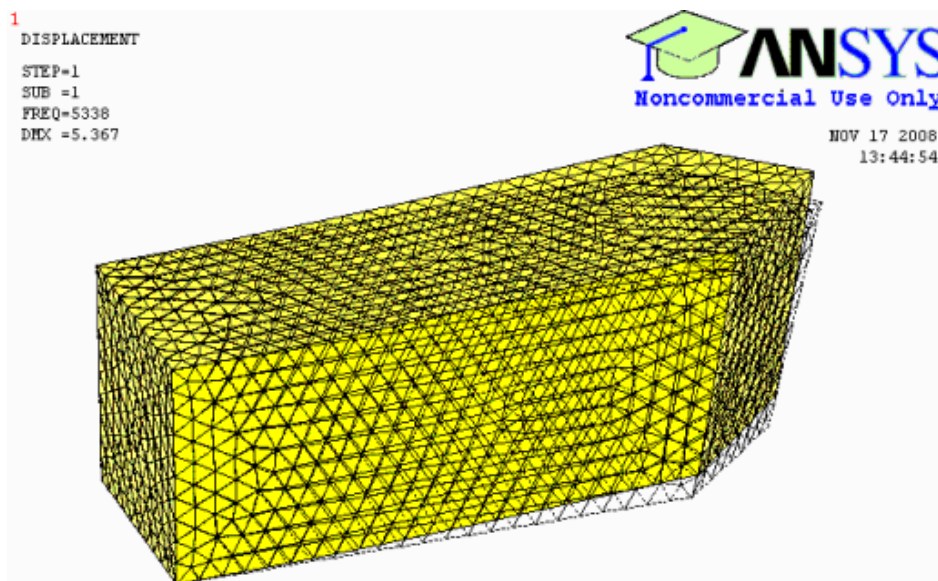


Fig. 5. Tool shank overhang 60 mm.

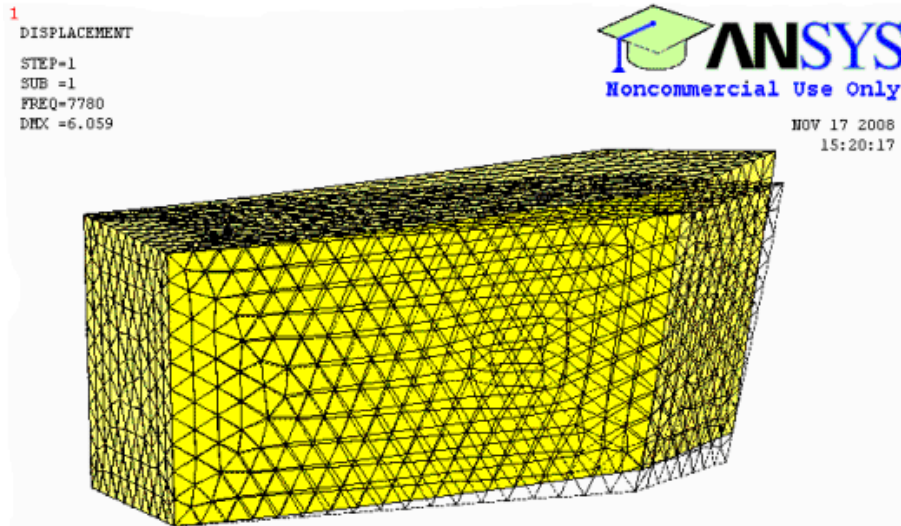


Fig. 6. Tool shank overhang 50 mm.

5. Experimental Setup

5.1. Vibration Exciters

The vibration exciter or shaker can be used in several applications such as determination of the dynamic characteristics of machines and structures and fatigue testing of materials. The vibration exciters can be mechanical, electromagnetic, or hydraulic type.

One of the most commonly used equipment in producing excitation forces is the electromagnetic exciter. Fig. 7 depicts the schematic diagram of an electromagnetic exciter. It consists of a coil over a central core of permanent magnet. The coil can be moved freely with respect to the magnet. When a sinusoidal signal is applied to the coil, because of electromagnetic interaction, the coil will move in a sinusoidal fashion with respect to the coil. If the coil is attached to any structure then the structure will in turn be forced to move sinusoidally.



Fig. 7. Electromagnetic Exciter.

5.2. Piezoelectric Accelerometer

An accelerometer is an instrument that measures the acceleration of a vibrating body. Accelerometers are widely used for vibration measurements and to record earthquakes. The accelerometer can be used for measuring acceleration, velocity, and amplitude of an oscillating body. Accelerometers are secured as firmly as possible to the body of which the movements are to be investigated. The most commonly used type of sensor for vibration measurements is the piezoelectric acceleration sensor. As the spring constant is very high, the resonant frequency of such devices is of the order of 10000 Hz or higher. The force to which the crystal is subjected is a linear function of the position of the moving body relative to the fixed body, as the crystals are deformed elastically.

Piezoelectric accelerometers as shown in Fig. 8 operate on the principle that a mass moves will stresses a piezoelectric crystal. Acceleration forces cause the amount of applied force on the crystal to vary cyclically and this, by the very nature of the piezoelectric effect, produces an electric output signal proportion to compression. Since this stress is it directly related to acceleration, such a signal is proportional to the vibratory acceleration of the surface on which it is mounted. Since the electric output is charges, a charge amplifier has to be used to convert the signal to voltage signal.



Fig. 8. Piezoelectric accelerometer.

Specification of the piezoelectric accelerometer is given below:

Vibration Sensor:	Piezoelectric accelerometer 100 mV/g with magnetic base, probe and 5 foot cable to BNC
Display:	LCD 3.5 digit, measurement, hold, low battery indicator
Measurement:	Acceleration 0.01-19.99 g (RMS)
Range:	Velocity 0.01-19.99 in/sec., 0.1-199.9 mm/sec (RMS) Envelope 0.01-19.99 ge (peak)
Frequency Range:	Overall 10 Hz - 10 kHz Envelope 0.5 kHz-10 kHz
Output:	Sensor Excitation: 12 Vdc @ 2 mA (BNC) Audio Out: 3.5 mm mini plug; 250 mW into 8 Ohms, 150 mW into 32 Ohms; Adjustable volume control with off position
Power:	(2) "AA" cells
Operating Time:	20 hours continuous without headphones
Weight: Instrument:	7 oz. (0.19 kg); Complete Kit: 2.85 lb (1.30 kg)
Dimensions:	6.3 x 3.3 x 1.25" (152 x 83 x 32 mm)
Operating conditions:	-14° to 122°F (-10° to 50°C)

5.3. Signal Conditioner

Signal conditioning means manipulating an analogue signal in such a way that it meets the requirements of the next stage for further processing. More generally, signal conditioning can include amplification, converting, and any other processes required to make sensors output suitable for conversion to digital format. Since the output impedance of accelerometers is not suitable for direct input in the signal analysis equipment, signal conditioners, in the form of charge or voltage amplifiers, are used to match and amplify the signals before signal analysis. It is primarily utilized for data acquisition, in Fig. 9 which sensor signals must be normalized and filtered to levels suitable for analog-to-digital conversion so they can be read by computerized devices.



Fig. 9. Signal conditioner.

Specification of signal conditioner is given below:

Model 480E09,

1-channel, battery-powered, ICP® sensor signal conditioner, gain x1, x10, x100, BNC input/output connection.

Frequency Range (-5 %)(x1, x10 Gain)	0.15 to 100,000 Hz
Voltage Gain ($\pm 2\%$)	1:10
Excitation Voltage (To Sensor)	27 to 29 VDC
Internal Battery (Type)	9V
Electrical Connector (Input, sensor)	BNC Jack

5.4. Analyzer (Pico Scope 2202)

An *analyzer* (Fig. 10) is used to perform the tasks of signal processing and modal analysis using suitable software. The response signal, after conditioning, is sent to an analyzer for signal processing. A commonly used analyzer is called a Fast Fourier Transform (FFT) analyzer. Such an analyzer receives analog voltage signals (representing displacement, velocity, acceleration, strain, or force) from a signal conditioning amplifier, filter, and digitizer for computations. The analyzed signals can be used to find the natural frequencies, damping ratios, and mode shapes either in numerical or graphical form. The analyzer converts the analog time-domain signals, $x(t)$, into digital frequency-domain data using Fourier series relations given by Eqs. (4) to (7), to facilitate digital computation. Thus the analyzer accepts the analog output signals of accelerometers or force transducers, $x(t)$, and computes

the spectral coefficients of these signals a_0 , a_n and b_n using above equations in the frequency domain. The process of converting analog signals into digital data is indicated in figure below for two representative signals. In figure $x(t)$ denotes the analog signal and $x_i = x(t_i)$ represents the corresponding digital record, with t_i indicating the i th discrete value of time. This process is performed by an analog-to-digital (A/D) converter, which is part of a digital analyzer.

If $x(t)$ is a periodic function with period τ , its Fourier's Series representation is given by

$$\begin{aligned} x(t) &= \frac{a_0}{2} + a_1 \cos \omega t + a_2 \cos 2\omega t + \dots + b_1 \sin \omega t + b_2 \sin 2\omega t + \dots \\ &= \frac{a_0}{2} + \sum_{n=1}^{\infty} (a_n \cos n\omega t + b_n \sin n\omega t) \end{aligned} \quad (4)$$

where the digital spectral coefficients a_0 , a_n , b_n are given by

$$a_0 = \frac{2}{N} \sum_{i=1}^N x_i ; \quad (5)$$

$$a_n = \frac{2}{N} \sum_{i=1}^N x_i \cos \frac{2n\pi t_i}{\tau} ; \quad (6)$$

$$b_n = \frac{2}{N} \sum_{i=1}^N x_i \sin \frac{2n\pi t_i}{\tau} \quad (7)$$



Fig. 10. PicoScope.

Specification of PicoScope 2202:

Vertical Resolution:	8 bits
Analog Bandwidth:	2 MHz
Maximum Sampling Rate:	Single-channel-20MS/s Dual-channel-10 MS/s per channel
Buffer Size:	Dual-channel-16k samples per channel
Inputs:	2 channels with BNC sockets.
Voltage Ranges:	± 50 mV to ± 20 V ranges in 9 ranges.

Accuracy: 3 % (voltage) 100 ppm (time)
Operating Environment: Temperature range- 0°C to 70°C.
Humidity-25% to 75% RH
Overload Protection : ± 100 V.
PC Connection: USB 2.0 Compatible with USB 1.1.
Power Supply: From USB port- 4.6 to 5.25 V; 500 mA.
Maximum Dimensions: 140 mm x 190 mm x 45 mm.

The choice of experimental excitation method depends on several factors, such as the geometry and shape of the structure. It took several tests to establish a method to use for our application. The structure excited by using an exciter connected with an impedance head by a flexible drive rod, Fig. 11. The exciter gives rise to a vibrating excitation signal that is transferred into the structure by an impedance head. The impedance head is an accelerometer and it measures the acceleration in the defined point. The requirements for the excitation method were that the frequency range amount to 10 kHz and that sufficient energy are still in the system at least up to 2.4 kHz. These requirements were thought to be fulfilled by both excitation methods at the beginning, but after several tests it became clear that the shaker excitation only has sufficient energy up to approximately 1 kHz. The problems when measuring with the exciter is that it is very important to mount the impedance head in the centre of the tool shank to avoid undesired movements and moments into the structure. Another problem is the mass spring system of the impedance head that could affect the natural frequencies of the system.



Fig. 11. Experimental set-up.

Frequency Response Function Curves at different overhang length are shown in Fig. 12-15.

Tool Overhang 100mm

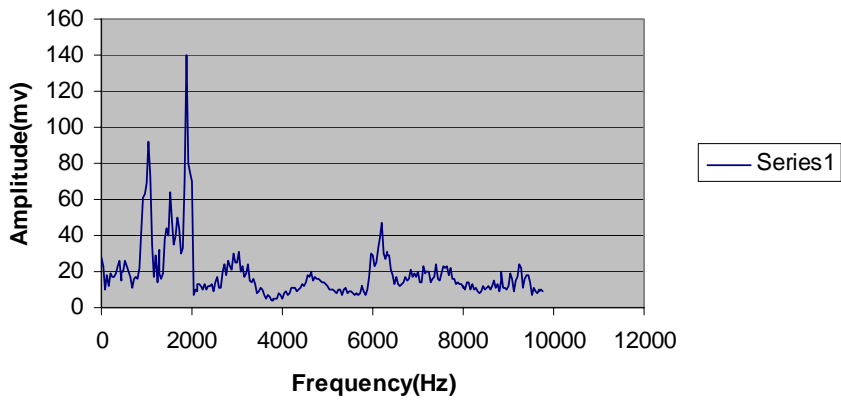


Fig. 12. Tool overhang of 100 mm.

Tool overhang 80mm

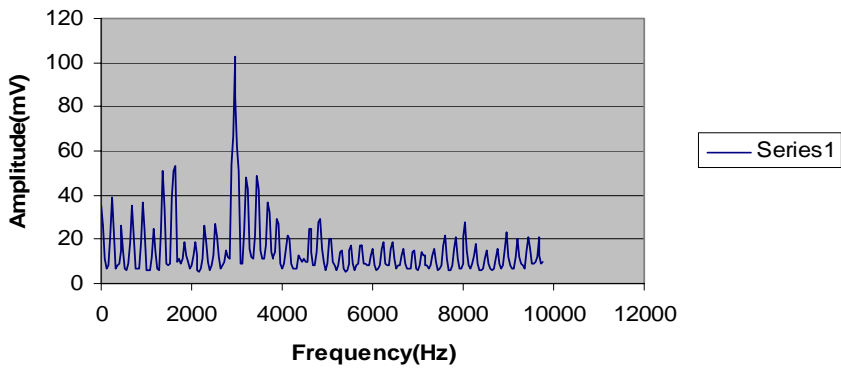


Fig. 13. Tool Overhang of 80 mm.

Tool overhang 60mm

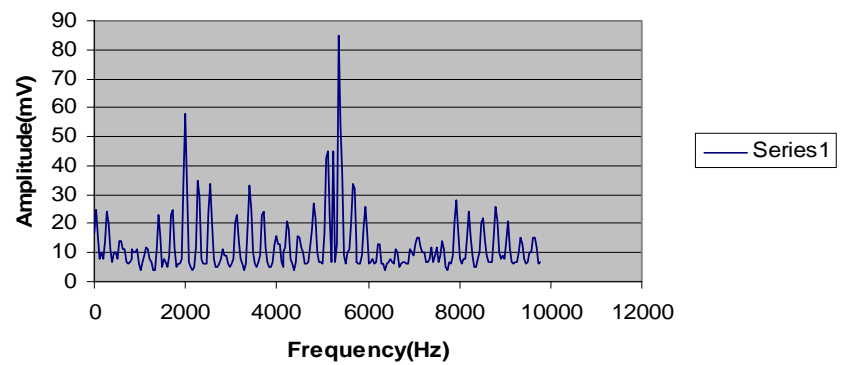


Fig. 14. Tool overhang of 60 mm.

Tool Overhang 50mm

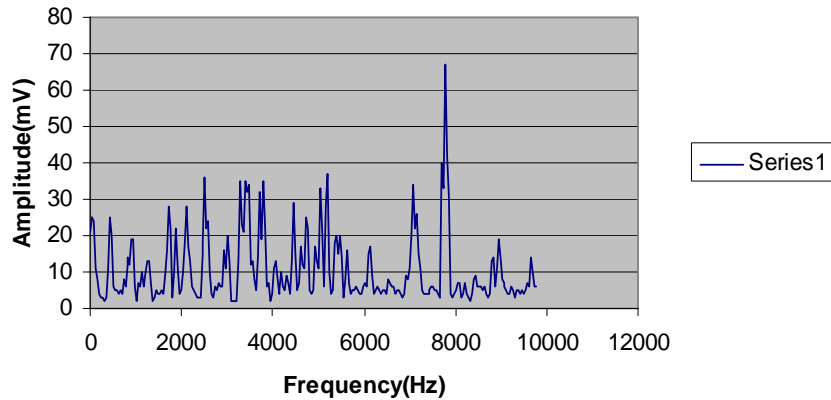


Fig. 15. Tool overhang of 50 mm.

6. Results and Conclusions

Tools shanks were positioned in different overhang, 100 mm, 80 mm, 60 mm and 50 mm respectively. Firstly, Finite Element Analysis of the Tool shank was performed using ANSYS software and frequency and Amplitude were found out in different overhang positions. Secondly, Experimental measurement of frequency and amplitude of the Tool shank were taken at defined overhang position. In Frequency Response Function (FRF) curves, in which the vertical y-axis shows the magnitude of the out put signal in volts (mV) and in the x-axis is the frequency interval f (Hz) shown in Figs. 12-15. The greater the amplitude, the stronger is the effect of vibrations. Fig. 16 shows the curve at different overhang length with the corresponding natural frequency of tool shank.

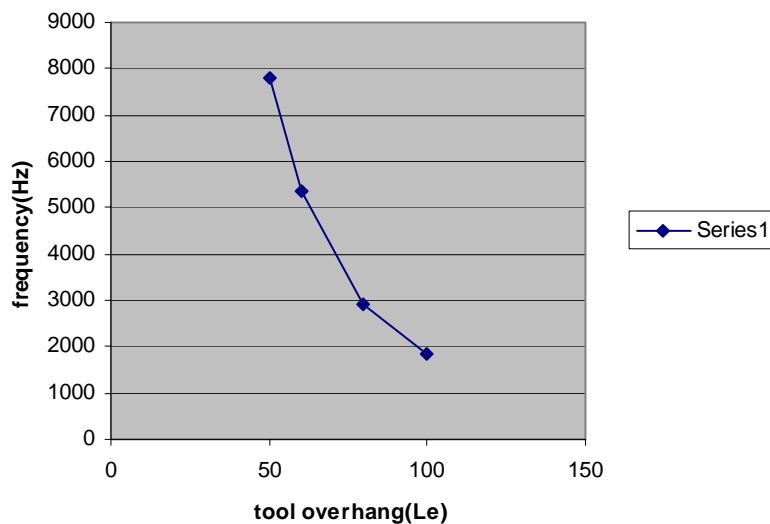


Fig. 16. Relation between frequency with tool overhang.

7. References

- [1]. Nathan, H., Cook, Self-excited Vibrations in Metal Cutting, Trans. of ASME, *Journal of Engineering for Industry*, 8, 1959, p. 183.

- [2]. Tlusty, J. and Polacek, The Stability of Machine Tools Against Self Excited Vibrations in Machining, *International Research in Production Engineering*, 1963, pp. 465-474.
- [3]. Tobias, S. A., Machine Tool Vibration, *Blackie and Sons Ltd.*, Glasgow, 1965.
- [4]. Tlusty, J. and Ismail, F., Basic Nonlinearity in Machining Chatter, *CIRP Ann.*, 30, 1981, pp. 21-25.
- [5]. Budak, E. and Altintas, Y., Analytical Prediction of Chatter Stability in Milling-Part I: General formulation, Proceedings of ASME, *Dynamic Systems and Control Division*, 57, 1, 1995, pp. 545-556.
- [6]. Jensen, S. A. and Shin, Y. C., Stability Analysis in Face Milling Operations-Part I: Theory for Stability Lobe Prediction, Trans. ASME, *Journal of Manufacturing Science and Engineering*, 21, 4, 1999, pp. 600-605.
- [7]. Tlusty, J., Analysis of the State of Research in Cutting Dynamics, *CIRP Annuals*, 27, 2, 1978, p. 583.
- [8]. Chiou, Y. S., Chung, E. S. and Liang, S. Y., Analysis of Tool Wear Effect on Chatter Stability in Turning, *Int. Journal of Mech. Science*, Vol. 37, No. 4, 1995, pp. 391-404.
- [9]. Chiou, R. Y. and Liang, S., Chatter Stability of a Slender Cutting Tool in Turning with Tool Wear Effect, *Int. Journal of Machine Tool & Manufacture*, 38, 1998, pp. 315-327.
- [10]. Chiou, R. Y. and Liang, S. Y., Analysis of Acoustic Emission in Chatter Vibration with Tool Wear Effect in Turning, *Int. Journal of Machine Tool & Manufacture*, 40, 2000, pp. 927-941.
- [11]. Fofana, M. S., Ee, K. C. and Jawahir, I. S., Machining Stability in Turning Operation when Cutting with a Progressively Worn Tool Insert, *Wear*, 255, 2003, pp. 1395-1403.
- [12]. A. Bhattacharyya, Metal Cutting Theory and Practice, *New Central Book Agency (P) Ltd.*

2008 Copyright ©, International Frequency Sensor Association (IFSA). All rights reserved.
(<http://www.sensorsportal.com>)

SENSORS WEB PORTAL 

- MEMS
- NEMS
- NANOSENSORS
- SMART SENSORS

All about SENSORS
<http://www.sensorsportal.com>

Guide for Contributors

Aims and Scope

Sensors & Transducers Journal (ISSN 1726-5479) provides an advanced forum for the science and technology of physical, chemical sensors and biosensors. It publishes state-of-the-art reviews, regular research and application specific papers, short notes, letters to Editor and sensors related books reviews as well as academic, practical and commercial information of interest to its readership. Because it is an open access, peer review international journal, papers rapidly published in *Sensors & Transducers Journal* will receive a very high publicity. The journal is published monthly as twelve issues per annual by International Frequency Association (IFSA). In addition, some special sponsored and conference issues published annually.

Topics Covered

Contributions are invited on all aspects of research, development and application of the science and technology of sensors, transducers and sensor instrumentations. Topics include, but are not restricted to:

- Physical, chemical and biosensors;
- Digital, frequency, period, duty-cycle, time interval, PWM, pulse number output sensors and transducers;
- Theory, principles, effects, design, standardization and modeling;
- Smart sensors and systems;
- Sensor instrumentation;
- Virtual instruments;
- Sensors interfaces, buses and networks;
- Signal processing;
- Frequency (period, duty-cycle)-to-digital converters, ADC;
- Technologies and materials;
- Nanosensors;
- Microsystems;
- Applications.

Submission of papers

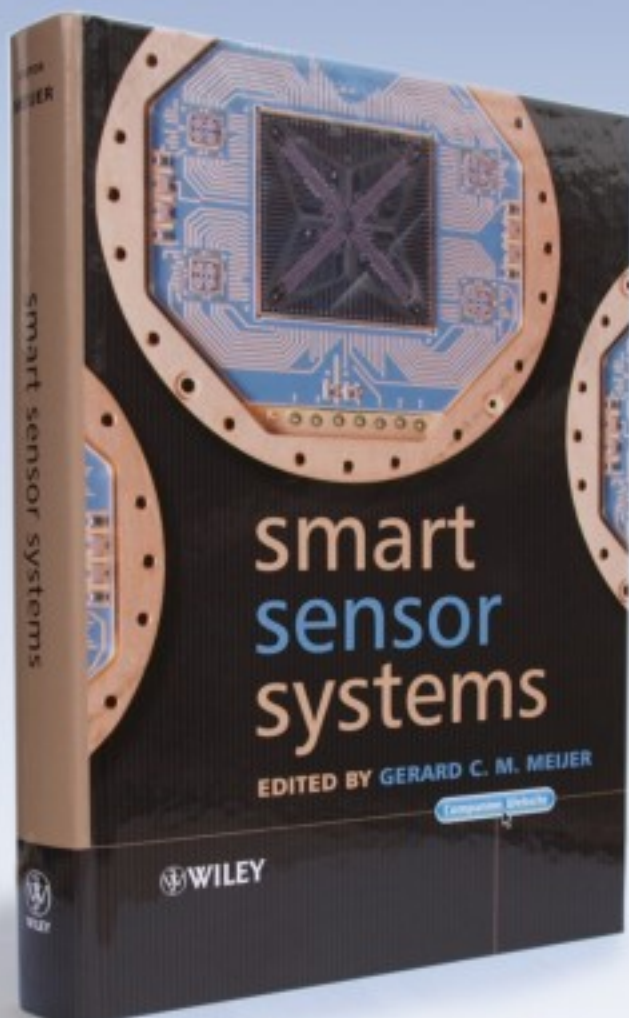
Articles should be written in English. Authors are invited to submit by e-mail editor@sensorsportal.com 6-14 pages article (including abstract, illustrations (color or grayscale), photos and references) in both: MS Word (doc) and Acrobat (pdf) formats. Detailed preparation instructions, paper example and template of manuscript are available from the journal's webpage: <http://www.sensorsportal.com/HTML/DIGEST/Submission.htm> Authors must follow the instructions strictly when submitting their manuscripts.

Advertising Information

Advertising orders and enquires may be sent to sales@sensorsportal.com Please download also our media kit: http://www.sensorsportal.com/DOWNLOADS/Media_Kit_2008.pdf

 **WILEY**
1807-2007

KNOWLEDGE FOR GENERATIONS



'Written by an internationally-recognized team of experts, this book reviews recent developments in the field of smart sensors systems, providing complete coverage of all important systems aspects. It takes a multidisciplinary approach to the understanding, design and use of smart sensor systems, their building blocks and methods of signal processing.'



Order online:

http://www.sensorsportal.com/HTML/BOOKSTORE/Smart_Sensor_Systems.htm

www.sensorsportal.com