MECHATRONICS BOOK SERIES
SELECTED PAPERS FROM ICOM'01, ICOM'05 AND ICOM'08

Editors

Asan G. A. Muthalif
Amir A. Shafie
Momoh J.E. Salami

IIUM Pres

Published by:
IIUM Press
International Islamic University Malaysia

First Edition, 2011

Perpustakaan Negara Malaysia Cataloguing-in-Publication Data

ISBN: 978-967-0225-68-5

Member of Majlis Penerbitan Ilmiah Malaysia – MAPIM
(Malaysian Scholarly Publishing Council)

Printed by :
IIUM PRINTING SDN. BHD.
No. 1, Jalan Industri Batu Caves 1/3
Taman Perindustrian Batu Caves
Batu Caves Centre Point
68100 Batu Caves
Selangor Darul Ehsan

CONTENTS

CHAPTER ONE: Mechatronics System Design and Applications

CHAPTER TWO: Modelling and Simulation

CHAPTER THREE: Intelligent Systems

CHAPTER FOUR: Instrumentation, Dynamics and Control

CHAPTER SIX: Speech and Image processing

CHAPTER SEVEN: Robotics and Automation

CHAPTER EIGHT: MEMS and Materials

CHAPTER NINE: MEMS and Materials

CHAPTER TEN: MEMS and Materials

CHAPTER ELEVEN: MEMS and Materials

Investigations of the Causes of Chatter in Computer Aided Manufacturing Process during End Milling Operation

Md. Anayet U Patwari[1*], A.K.M. Nurul Amin[1], Waleed Faris[2], S.Alam[1]

[1]Department of Manufacturing and Materials Engineering
[2] Department of Mechanical Engineering
Faculty of Engineering, International Islamic University Malaysia
Kuala Lumpur, Malaysia
[1*] Corresponding author e-mail: aupatwari@hotmail.com

ABSTRACT

Chatter is an unwanted but sometimes unavoidable phenomenon in computer aided machining. The term defines the self-excited violent relative dynamic motion between the cutting tool and work-piece. Experimental investigations have been conducted on the chips and common types of discreteness in the form of serrated saw teeth have been identified. It has been identified that the chip formation process has a discrete nature, associated with the periodic shearing process of the chip during machining of Ti6Al4V. Apart from the primary serrated teeth, a typical instability of periodic nature, in the form of secondary saw/serrated teeth, which appear at the free edge of the chip, has been identified. Mechanism of formation of these teeth has been studied and the frequency of their formation has been determined. The different modes of the vibrating components have been extracted by modal analysis and the vibration responses during cutting conditions have also been recorded using an online monitoring data acquisition system. The most vibrating components during computer aided milling machine operation have been identified. It has been found that chatter appears in the system as a resonance during cutting when the chip serration frequency is equal or any integer multiple of the prominent natural frequency of the system components like spindle, tool holder.

1.0 INTRODUCTION

Chatter is undesirable due to its adverse effects on the product quality, operation cost, machining accuracy, tool life, machine-tool bearings, and machine-tool life. It is also responsible for reducing output. Other forms of vibration apart from chatter in metal cutting include free vibration and forced vibration. These do not pose any fundamental problems to the machinist because when the sources of the problem are identified, they can be eliminated. The main characteristic of machine tool chatter is that it is a self-induced vibration, not caused by external periodic forces. Chatter draws the energy for its maintenance from the cutting operation. Although chatter has been extensively investigated in the past 40 years, it is still very difficult to suppress it in practice. Hypotheses developed over the years are mainly as follows: Taylor suggested that element chip formation is responsible for chatter [1], but this proposition was not acceptable since element chip formation occurs at extremely low cutting speed where chatter is almost absent. Kudinov [2] and Shteinberg [3] considered that the periodic effect of built-up-edge (BUE) formation can excite vibration. Kuznetsov [4] also considered that the vibration caused by the unstable and periodically broken BUE is responsible for chatter. However, no serious chatter is also observed in the cutting speed range of BUE formation, but chatter generally exists at relatively higher cutting speeds where BUE is absent. Eliasberg [5] considered that the cause of chatter is the formation of a crack in the chip above the tool point. This was observed by using a movie camera. However, Loladze [6] established that at higher cutting speeds, the chip fully adheres to the tool surface. As such, there cannot be any cracks formed at the tool point at those cutting speed ranges, so it cannot be accepted as the physical cause of chatter. Doi [7], Doi and Kato [8], and later Kato [9] concluded based on their experiments on orthogonal cutting on a reasonably flexible workpiece, that chatter was established primarily due to a phase lag of the cutting force with respect to the fluctuation of chip thickness. It was found that force fluctuations lagged the vibration movement. It was postulated that due to this lag effect, some energy is left available in each