



A.K.M. Nurul Amin
Abdelgadir Mohamed Mahmoud

Chatter Control in Induction Heat Assisted End Milling

To Improve Machinability of Stainless Steel and
Medium Carbon Steels

LIBRARY
INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

**A.K.M. Nurul Amin
Abdelgadir Mohamed Mahmoud**

Chatter Control in Induction Heat Assisted End Milling

**To Improve Machinability of Stainless Steel and
Medium Carbon Steels**

LAP LAMBERT Academic Publishing

Copy no: 1295413
Initial: NABA
Date: 11/11/13
Location: MAT/PJ/INSTA/NTL A/R/K2A1RBF

Impressum / Imprint

Bibliografische Information der Deutschen Nationalbibliothek: Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über <http://dnb.d-nb.de> abrufbar.

Alle in diesem Buch genannten Marken und Produktnamen unterliegen warenzeichen-, marken- oder patentrechtlichem Schutz bzw. sind Warenzeichen oder eingetragene Warenzeichen der jeweiligen Inhaber. Die Wiedergabe von Marken, Produktnamen, Gebrauchsnamen, Handelsnamen, Warenbezeichnungen u.s.w. in diesem Werk berechtigt auch ohne besondere Kennzeichnung nicht zu der Annahme, dass solche Namen im Sinne der Warenzeichen- und Markenschutzgesetzgebung als frei zu betrachten wären und daher von jedermann benutzt werden dürften.

Bibliographic information published by the Deutsche Nationalbibliothek: The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at <http://dnb.d-nb.de>.

Any brand names and product names mentioned in this book are subject to trademark, brand or patent protection and are trademarks or registered trademarks of their respective holders. The use of brand names, product names, common names, trade names, product descriptions etc. even without a particular marking in this works is in no way to be construed to mean that such names may be regarded as unrestricted in respect of trademark and brand protection legislation and could thus be used by anyone.

Coverbild / Cover image: www.ingimage.com

Verlag / Publisher:

LAP LAMBERT Academic Publishing

ist ein Imprint der / is a trademark of

AV Akademikerverlag GmbH & Co. KG

Heinrich-Böcking-Str. 6-8, 66121 Saarbrücken, Deutschland / Germany

Email: info@lap-publishing.com

Herstellung: siehe letzte Seite /

Printed at: see last page

ISBN: 978-3-659-43654-3

Zugl. / Approved by: Kuala Lumpur, Malaysia, International Islamic University Malaysia,
Diss., 2001

Copyright © 2013 AV Akademikerverlag GmbH & Co. KG

Alle Rechte vorbehalten. / All rights reserved. Saarbrücken 2013

TABLE OF CONTENTS

Chapter 1 Introduction.....	1
Chapter 2 Existing Understanding on Subject	
Matter.....	6
2.1 Mechanics of Metal Removal.....	6
2.1.1 Introduction.....	6
2.1.2 Chip Formation.....	8
2.2 Dynamics of Machine Tool.....	11
2.2.1 Dynamic Characteristic of the Cutting Process.....	13
2.3 Material Properties at High Strain Rates.....	13
2.4 Influence of Increasing Speed on Chip Formation.....	16
2.4.1 Segmented Chip.....	16
2.4.2 Tool Forces at High Speeds.....	17
2.4.3 Tool Wear at High Speeds.....	18
2.4.4 Economics versus Chip Morphology.....	18
2.5 Machine Tool Chattering	19
2.5.1 The Dynamics of Cutting Process	20
2.5.2 Physical Causes of Chatter.....	21
2.5.3 General Theory of Machine-Tool Chatter	24
2.5.3.1 The Chip-Thickness Variation Effect (Regenerative Effect).....	24
2.5.4 Chatter Arising In Vertical Milling Machines.....	24
2.5.4.1 Chatter Theory Applied To Vertical Milling Machines.....	24

Chapter 3 Theoretical

Analysis.....	26
3.1 Thermal Models for Machining	26
3.2 Steady State Temperatures	27
3.3 Estimating Chip and Rake Temperatures in Orthogonl Machining	29
3.3.1 Heat Sources in Orthogonal Machining	29
3.3.2 Heat Flows in Orthogonal Machining	30
3.3.3 Estimating the Average Chip Temperature θ_c	31
3.3.4 Estimating the Average Rake Interface Temperature θ_r ..	32
3.4 Modeling Machining Vibration for Stability Analysis.....	34
3.4.1 Vibration Sources External to Chip Making.....	35
3.4.2 Vibration Sources Integral to Chip Making	36
3.4.3 Modeling the Machine Tool Structure	37
3.4.4 The Model for the Instantaneous Chip Thickness.....	39
3.4.5 Modelling Cutting and Instantaneous Chip thickness....	40
3.5 Time and Frequency Domain Equations of Motion.....	40

Chapter 4 Thermal Analysis.....42

4.1 Introduction.....	42
4.2 Materials Damping	43
4.3 High Frequency Induction Heating	44
4.3.1 Introduction	44
4.3.2 Main Elements of Induction Heating Machine	46
4.3.3 Merits of Induction Heating.....	47
4.4 Heat Distribution in the Workpiece.....	48

Chapter 5 Experimental Work.....	52
5.1 Equipment.....	52
5.1.1 Vertical Milling Machine Center (VMC).....	53
5.1.2 Portable Transistor Induction Heating	
Machine SP-25AB.....	53
5.1.3 Data Acquisition System.....	54
5.1.4 Surface Roughness Tester.....	56
5.1.5 Work Pieces.....	57
5.1.6 Specification of the Tool Holder and Cutting Tool.....	57
5.1.6.1 Tool Holder.....	57
5.1.6.2 Tool Insert.....	59
5.2 Experimental Setup.....	61
5.2.1 Experimental Preparation.....	61
5.2.1.1 Design of the Heating Coil.....	61
5.2.1.2 Design of the Heating Coil Fixture.....	63
5.2.2 Experiment Design.....	64
5.2.2.1 Experiment Layout.....	64
5.2.2.2 Experiment Procedure.....	65
Chapter 6 Result and Discussion.....	67
6.1 Experimental Results and Discussion.....	68
6.2 Medium Carbon Steel.....	69
6.2.1 Case I.....	69
6.2.2 Case II.....	73
6.2.3 Case III.....	77
6.2.4 Case IV.....	81
6.3 Stainless Steel.....	85
6.3.1 Case I.....	85

List of Contents

6.3.2 Case II.....	89
6.3.3 Case III.....	93
6.3.4 Case IV.....	97
6.4 Analysis of Data.....	100
6.5 Tool Wear Analysis.....	106
6.6 Tool Wear Intensity.....	108
6.7 Discussion	113
Chapter 7 Conclusions	115
7.1 Conclusions.....	115
Biography.....	117