

AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING



A COMPUTERIZED
MACHINING INFORMATION CENTRE
FOR TURNING



By

HASSAN AHMED HASSAN AHMED HASSAN

A Thesis

Submitted in Fulfillment of The
Requirements of the Degree of Ph. D.
In Mechanical Engineering

Supervised By

Prof. Dr. M. A. EL-HAKIM


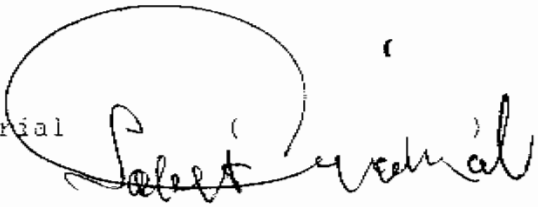

1990

Central Library - Ain Shams University

33757

621-34
H. A

Examiners Committee

<u>Name, Title, and Affiliation</u>	<u>Signature</u>
1. Prof. Dr. M. A. El-Hakim Prof. of Production Engineering Faculty of Engineering, Ain Shams University.	
2. Prof. Dr. Sabet Rizkallah Gabriel Prof. of Machine Design, Faculty of Engineering, Ain Shams University.	
3. Prof. Dr. M. Sadek Eid, Prof of Industrial Engineering, Moncton University, Canada.	



STATEMENT

This dissertation is submitted to Ain Shams University for the degree of Ph. D. in Mechanical Engineering.

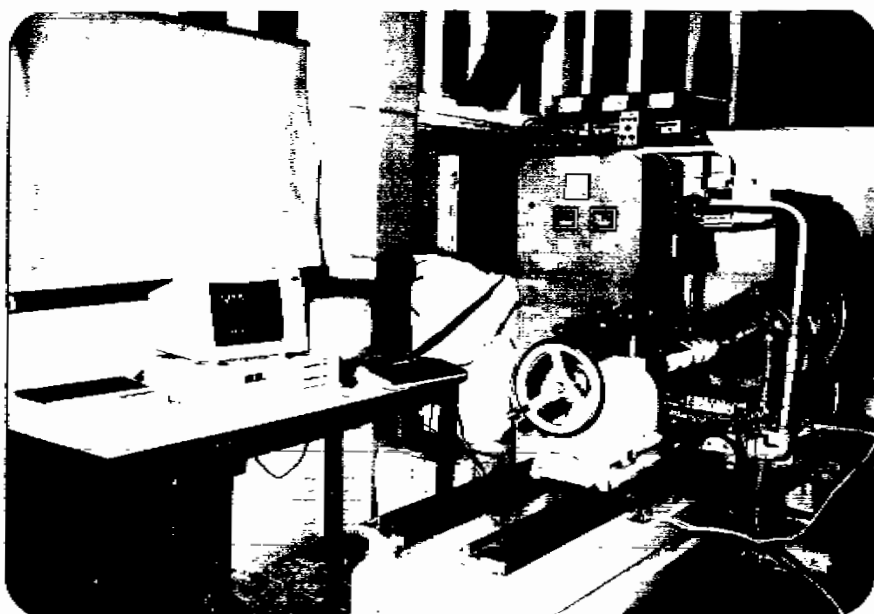
The work included in this thesis was carried out by the author in the department of Production Engineering, Ain Shams University, from 10-11-1986 to 11-10-1990.

No part of this thesis has been submitted for a degree or a qualification at any other University or Institute.

Date :

Signature :

Name : Hassan Ahmed Hassan Ahmed



THE MACHINING INFORMATION CENTRE (MIC)

A B S T R A C T

The application of computer automated manufacturing systems is rapidly increasing to follow the needs of industry. The speed of information flow in highly automated systems is extremely important as they are critically dependent on the amount of fresh information supplied to them. In the present work, a complete design, implementation, and testing of a computerized *Machining Information Center (MIC)* is carried out to meet the needs for automatic machinability testing that would overcome the difficulties and expenses of conventional machinability testing methods. MIC consists mainly of a master computer that controls a slave computer, which, in turn, controls an *Automated Machinability Testing Unit (AMTU)*. The system is protected against unintended events by including a closed loop emergency-detection system. The MIC remarkably decreases the testing time, cost and effort, material and tooling cost, as well as the experimental errors resulting from the unpredicted variation of machining conditions and from human interference. The MIC is recommended for the solution of machining problems, comparative evaluation of different workpiece and tool materials, machine tools, cutting fluids, ... etc. Moreover, it can be used as an experimental test rig for advanced machinability testing research.

C O N T E N T S

* ABSTRACT	i
* NOMENCLATURE	vi
* INTRODUCTION	1
 CHAPTER 1. .	
REVIEW OF LITERATURE	3
Statement of the Problem	12
Objective of the Present Work	12
 CHAPTER 2.	
MACHINABILITY CONCEPTS AND CRITERIA.	
2.1 Basic Concepts and Definitions	14
2.2 Machinability Criteria	18
Cutting Force	18
Power Consumption	20
Cutting Temperature	21
Tool Life	23
Chatter	25
Surface Integrity	27
Economics of Machining	29
2.3 Optimum Cutting Conditions	31
2.4 Machinability Reassessment	39

CHAPTER 3.
DEVELOPMENT OF THE MACHINING INFORMATION CENTER [MIC].

3.1	Definition and Basic Functions	40
3.2	Architecture of the MIC	43
3.3	Information Flow Through The MIC	46

CHAPTER 4.
COMPUTER-AUTOMATED MACHINABILITY TESTING UNIT [AMTU].

4.1	Automation Hardware	53
4.1.1	Mechanical Arrangements	53
4.1.2	Electrical Installations	56
4.1.3	Electronic Circuits	59
4.1.3.1	Speed control of D.C. Motor	59
4.1.3.2	Computer Interfaceing Circuits	68
4.1.4	Transducers	73
4.2	Computer Control of The Machinability Testing System	75
4.2.1	Cutting Speed Control	75
4.2.2	Feed Control	76
4.2.3	Position Control of Cutting Tool Along Workpiece axis	77
4.2.4	Setting the Depth of Cut	78
4.3	Automation Software	79
4.3.1	Main AMTU Control Program	79
4.3.2	Computer Network Program	81
4.3.3	Master Computer Automatic Testing Software	82

CHAPTER 5.
MACHINABILITY INFORMATION CENTER PROCESSOR [MICP].

5.1	Machinability Data Bank	90
5.1.1	Workpiece Material Data base	90
5.1.2	Cutting Tool Material Data base	92
5.1.3	Machine Tool Specifications Data base ..	93
5.1.4	Data Base Management System Commands ...	96
5.2	Computer-Aided Determination of Optimum Cutting Conditions	100
5.2.1	Software Logics	102
5.2.2	Workpiece Shape Data Entry	102
5.3	Testing of New Workpiece Materials	104
5.4	Quitting the MICP	106

CHAPTER 6.
EXPERIMENTAL TECHNIQUES.

6.1	AMTU Specifications	108
6.2	Cutting Tools	110
6.3	Test Specimens	111
6.4	Plan of Experiments	113
6.4.1	Chatter Testing	115
6.4.2	Cutting Force and Cutting temperature Testing	117
6.4.3	Tool Life Testing	119
6.4.4	Data Processing	121

CHAPTER 7.
MACHINABILITY TESTING USING THE DEVELOPED SYSTEM.
(A CASE STUDY).

7.1	Experimental Results and discussion	127
7.1.1	Cutting Force Relationships	127
7.1.2	Cutting Temperature Relationship	132
7.1.3	Tool Life Relationships	134
7.1.4	Chatter Relationships	135
7.2	Economic Evaluation of the MIC	137
* CONCLUSION	142
* REFERENCES	146
* APPENDICES	155
Appendix (1):		
Optimum Cutting Conditions Algorithm		155
Appendix (2):		
Technical Specifications of Interface III ..		159
Appendix (3):		
Time Response of		
The Speed and Feed Drives		161
Appendix (4):		
Hardware Specifications of		
The Master and Slave computers		162
Appendix (5):		
Correction of the Cross Sensitivity		
Errors of the Force Dynamometer		164
Appendix (6):		
Time Responses of The Cutting		
Force Components and Temperature		168
Appendix (7):		
Relationship Between The Tool		
Wear and The Axial Force Component		169

N O M E N C L A T U R E

<u>SYMBOL</u>	<u>UNITS</u>	<u>DEFINITION</u>
A	mm	machining allowance.
a	mm	depth of cut.
b	mm	width of cut.
b ₁	mm	limiting width of cut.
B	mm	flank wear land width.
C ₁	L.E.	machine cost constant.
C ₂	L.E.	tooling cost constant.
C _v	---	tool life coefficient.
C _e	---	cutting temperature coefficient.
D	mm	average workpiece diameter.
D ₁	mm	initial workpiece diameter.
D ₂	mm	final workpiece diameter.
D _c	mm	chucked workpiece diameter.
e	---	efficiency of the main drive.
e _f	---	efficiency of the feed drive.
F _a	N	axial cutting force component.
F _c	N	tangential cutting force component.
F _r	N	radial cutting force component.
G	---	operational amplifier gain.
I	Amp	electrical current.
K _{sa}	N/mm ²	specific cutting pressure due to F _a .
K _{sc}	N/mm ²	specific cutting pressure due to F _c .

K_{sr}	N/mm^2	specific cutting pressure due to Fr.
K_1	L.E./hr	labour hour rate.
K_m	L.E./hr	machine cost per hour.
K_{TP}	L.E.	tool capital cost.
K_{TC}	L.E.	tool change cost.
K_{TR}	L.E.	tool regrind cost.
L	mm	workpiece length.
m	---	tool life exponent.
m_a	---	axial force exponent.
m_c	---	tangential force exponent.
m_r	---	radial force exponent.
n	rpm	spindle rotational speed.
P	KW	power consumed.
P_m	KW	motor rated power.
r	mm	tool nose radius.
s	mm/rev	feed.
T	min	tool life.
v	m/min	cutting speed.
V_m	volt	mean voltage.
V_t	volt	tacho generator voltage.
V_s	volt	output servo voltage.
V_r	volt	computer reference voltage.
α	degree	clearance angle.
β	degree	tool wedge angle.
γ	degree	rake angle.
θ	degree	firing angle.
δ	---	system damping factor.

θ	$^{\circ}\text{C}$	cutting temperature.
ϕ	degree	plan approach angle.
μ	---	coefficient of friction.

INTRODUCTION

The introduction of the recent advances in machining technology necessitates the best utilization of machine tools through the use of the optimum cutting conditions, thus leading to maximum productivity and minimum manufacturing cost. The optimum values for the machining variables of a given workpiece material with different delivery conditions cannot be established without the provision of detailed machinability information about this specific workpiece material. This can be achieved only by performing a series of machinability tests on this material, processing the obtained data and converting them into useful cutting information. Using conventional methods of machinability testing requires considerable effort, time, and cost. Besides, considerable amount of workpiece and tool materials are consumed in the tests. Accordingly, conventional machinability testing is therefore reduced to one or two tests carried out on selected groups of workpiece and tool materials. This results in insufficient information about the given material which limits the effectiveness of the obtained results.

The present work presents a computerized Machining Information Center [MIC] comprising a computer automated machinability test equipment and a data bank which enables automated machinability testing, machinability data handling and interactive machining problem solving.

Several machining parameters such as the cutting force components, the cutting temperature, the tool life, vibrations, ... etc. are to be simultaneously measured by means of proper transducers which enable the on-line measurement of such parameters. They are then processed to obtain the related machinability data and saved into the machinability data bank. MIC results in considerable savings in the amount of time, effort and cost as compared with conventional machinability testing methods.