

UNIVERSITY OF STRATHCLYDE

DEPARTMENT OF MECHANICAL ENGINEERING

පුස්තකාලය,
ශ්‍රී ලංකා විශ්ව විද්‍යාලය,
කටුබැද්ද මණ්ඩපය,
මොරටුව.

DYNAMIC CUTTING AND VIBRATION TESTS

ON NIMONIC BARS



University of Moratuwa, Sri Lanka
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

621.9 - 752

117

by

118

Nimal R. Arthenayake

19776

PERMANENT
REFERENCE
NOT TO BE
REMOVED FROM
THE LIBRARY.

A Thesis presented for the Degree of Master of Science
of the University of Strathclyde.

December, 1970

Glasgow.

19776


CONTENTS



University of Moratuwa, Sri Lanka
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

CONTENTS

	Page
ACKNOWLEDGEMENTS	1
ABSTRACT	2
NOMENCLATURE	3
1. INTRODUCTION	5
1.1 Introduction	6
1.2 Review of Literature	8
2. THEORY	12
2.1 Vibratory System	13
2.2 Tool Wear	18
2.3 Surface Finish	22
3. DESCRIPTION OF TEST EQUIPMENT	24
3.1 Machine tool	25
3.2 Material	27
3.3 Vibration tests	29
3.4 Machining tests	32
3.5 Analysis of tool point vibration	39
4. TEST PROCEDURE	41
4.1 Vibration tests	42
4.2 Machining tests	50
4.3 Analysis of tool point vibration	51
5. CALCULATIONS	52
5.1 Natural frequency of workpiece	53
5.2 Natural frequency of cutting tool	56
5.3 Damping ratio	57
5.4 Stiffness coefficient	59
6. RESULTS/	

	Page
6. RESULTS	61
6.1 Vibration tests	62
6.2 Machining tests	77
6.3 Analysis of tool point vibration	84
7. DISCUSSION, CONCLUSIONS AND SUGGESTIONS	105
7.1 Discussion	106
a) Vibration tests	106
b) Machining tests and tool point vibration	110
7.2 Conclusions	114
7.3 Suggestions	116
BIBLIOGRAPHY	118
APPENDIX I Forced Vibration of Workpiece	122
APPENDIX II  Plastic properties of Material	128
APPENDIX III Tables of Results	132
a) Vibration Tests	133
b) Machining Tests	148
c) Analysis of Vibration Recordings	156

ACKNOWLEDGEMENTS

The author would like to express his appreciation to Professor D. S. Ross, the head of the Production Engineering Department and to Professor W. B. McHutchison, the head of the Dynamics and Control Department for allowing him the laboratory facilities.

Special acknowledgement is due to the staff and technicians of Production Engineering, Dynamics and Control laboratories and Electronic workshop where the tests were carried out.

The author would like to express his deep gratitude to the supervisors of the thesis, Mr. R. Barron of the Dynamics and Control Department and Mr. N. R. Christie of the Production Engineering Department for their guidance and invaluable advice received at all times.



ABSTRACT

The use of Nimonic alloys in industry to meet more stringent specifications has resulted in an increasing number of machine tool vibration problems. Production engineers are aware that vibration during machining leads to shorter tool life and poorer surface finish.

Experimental work to investigate the tool wear, surface finish and dynamic characteristics of Nimonic bars has been carried out. The work was comprised of vibration tests, machining tests and analysis of tool point vibration recordings.

Results show that crater wear on the cutting tool is predominant and that surface finish and tool life are affected by a change in workpiece stiffness. Tool point vibrations occur at a frequency well below the natural frequencies of the workpiece and cutting tool.



NOMENCLATURE

A, α_n and B	-	Constants
A_f	-	Cross-sectional area of specimen at fracture (in^2)
A_o	-	Original cross-sectional area of specimen (in^2)
D_e	-	Percentage of elongation of material
D_o	-	Percentage reduction in area of material
E	-	Young's modulus (lbf/in^2)
e	-	Base of natural logarithms
f	-	Frequency variable (c/sec)
f_A	-	Frequency at point A on response plot (c/sec)
f_B	-	Frequency at point B on response plot (c/sec)
f_n	-	Natural frequency (c/sec)
I	-	Moment of inertia (in^4)
K	-	Stiffness coefficient (lbf/ft)
l	-	Length of workpiece (in)
L_f	-	Gage length of specimen at fracture (in)
L_o	-	Initial gage length of specimen (in)
M	-	Mass ($\text{lbf}\cdot\text{sec}^2 / \text{ft}$)
MV	-	Milli Volts
P	-	Force (lbf)
P_u	-	Maximum load (lbf)
P_y	-	Load at yield point (lbf)
R	-	Viscons damping coefficient ($\text{lbf}\cdot\text{sec} / \text{ft}$)
S_u	-	Ultimate tensile strength ($\text{tonf} / \text{in}^2$)
S_{yp}	-	Yield stress ($\text{tonf} / \text{in}^2$)

T	-	Toughness index number
t	-	Time variable
x	-	Displacement in x direction (ft)
\dot{x}	-	Velocity in x direction (ft/sec)
\ddot{x}	-	Acceleration in x direction (ft/sec ²)
y	-	Displacement in y direction (ft)
\dot{y}	-	Velocity in y direction (ft/sec)
\ddot{y}	-	Acceleration in y direction (ft/sec ²)
ξ	-	Non-dimensional damping ratio
ω	-	Angular frequency (Rad/sec)
ω_n	-	Natural angular frequency (Rad/sec)
μ	-	Mass per unit length (lbf.sec ² / in ²)
π	-	Circular constant

