UNIVERSITY OF STRATHCLYDE

DEPARTMENT OF MECHANICAL ENGINEERING

DYNAMIC CUTTING AND VIBRATION TESTS

ON NIMONIC BARS

by

Nimal R. Arthenayake

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

December, 1970
Glasgow.

CONTENTS

CONTENTS

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, a_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 logarithims

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 ($lbf.sec^2 / ft$)

MV - Milli Volts

P - Force (lbf)

P_u - Maximum load (lbf)

P_y - Load at yield point (lbf)

R - Viscons damping coefficient ($lbf.sec / ft$)

S_u - Ultimate tensile strength ($tonf / in^2$)

S_{yp} - Yield stress ($tonf / in^2$)

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