ANALYSIS OF AN ELONGATED SPLIT-RING DYNAMOMETER

by

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NOMENCLATURE

A	area of cross-section of the ring
α	numerical factor used to obtain the shearing stress; = 1.5 for rectangular cross-section
b	width of the ring
β	dimensionless quantity, $= \frac{h}{r}$
χ	sensitivity ratio
δ_V, δ_H	vertical and horizontal deflections respectively of a quadrant of the ring
$\delta(y)$	increase in fiber length after application of load
Δ_V, Δ_H	vertical and horizontal deflections respectively of the whole ring
Δ_ψ, Δ_γ	angle between end sections of the curved beam before and after application of load respectively
e	distance of the neutral axis from the centroidal axis
E,G	modulus of elasticity and modulus of rigidity respectively
η	dimensionless quantity, $= \frac{\ell}{r}$
$\varepsilon(y)$	strain or unit elongation of the fiber
h	thickness of the ring
H	horizontal component of cutting force
I	area moment of Inertia about the centroidal axis in the plane of the width of the ring
ℓ	length of the straight beam
L	$= \dfrac{\left[\frac{\ell r}{I} + \frac{\ell^2}{2I} - \frac{r}{Ae} + \frac{1}{A} + \frac{\pi r}{2Ae}\right]}{\left[\frac{\ell}{I} + \frac{\pi}{2Ae}\right]}$

λ	function of β, $= 1 - \frac{\beta}{\ell n \left(\frac{2 + \beta}{2 - \beta}\right)}$
m	dimensionless parameter; $= \frac{e}{r - e}$
M_c, M_A, M_B	bending moments at the fixed end of the cross section
N, V, M	normal force, shear force, and bending moment respectively at any section
ω_1, ω_2	change in angle per unit of angle
ψ	stiffness ratio
P, Q, M_o	normal force, shear force, and bending moment respectively, at the section indicated in figure
r, ϕ	polar co-ordinates to refer points on the centroidal axis of the curved portion of the ring
r_2, r_1	outer and inner radius of the curved portion of the ring
R	radius of curvature after application of load
s	distance along the centroidal axis of the ring
σ_H	stress at the outer fiber of the ring subjected to the horizontal component of the cutting force
σ_{Vo}, σ_{Vi}	stress at the outer and inner fiber respectively of the ring subjected to the vertical component of the cutting force
θ_V, θ_{HR}	angular position of the cross-section in the curved portion of the ring
θ_{Vo}	angular position of the cross-section in the curved portion of the ring for $\sigma_{Vo} = 0$
U	total strain energy
U_1, U_2	strain energy of the straight and curved portions respectively of the ring
V	vertical component of cutting force
V_{max}, H_{max}	maximum vertical and horizontal component of cutting force

y normal distances of the stressed fiber from the centroidal axis

INTRODUCTION

Accurate measurement of the forces generated in cutting metals or refractories is needed for rational design of machine tools and cutting tools. Also, valuable information concerning machinability and tool wear may be obtained from the force data. The cutting forces are usually measured by means of a tool dynamometer.

Machine tool dynamometers typically contain an elastic member such as a metal column or beam, which deforms under applied force. The deformation is transmitted to strain gauges, located at suitable places on the elastic member. The strain gauges are usually connected in a four-arm wheatstone bridge to produce an output signal, which when calibrated, is an accurate indication of the applied force.

A particularly popular type of dynamometer used in practice is a split-ring dynamometer, which utilizes load rings as shown schematically in Figure 1. For analysis purposes, the circular ring is substituted for the octagonal ring as shown in Figure 2a. The active part of the dynamometer is shown schematically in Figure 2b. A split-ring dynamometer with strain gauge locations and four-arm wheatstone bridge wiring diagrams is shown schematically in Figures 3a and 3b. A three-dimensional version of the split-ring dynamometer using the type of load ring discussed, was used by B. King and R. O. Foschi [1]* to obtain the three orthogonal components of a cutting force.

As yet, a single dynamometer has not been designed which can be used for the measurement of desired forces on all machines (lathes, milling machines, drilling machines, grinding machines, etc.), as the forces to be

*Numbers in brackets designate references at the end of report.

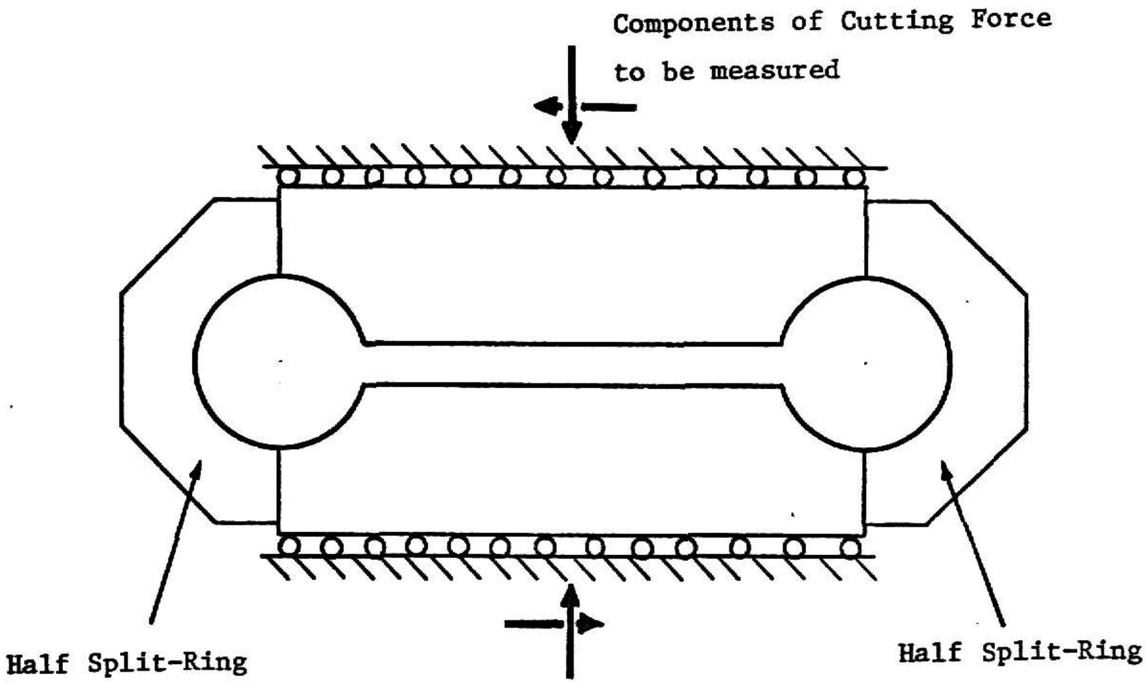
Components of Cutting Force
to be measured
Half Split-Ring
Half Split-Ring

Fig. 1