AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

APPLICATION OF LASER TECHNIQUE IN THE MEASUREMENTS

by

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A Thesis

submitted in partial fulfillment for the

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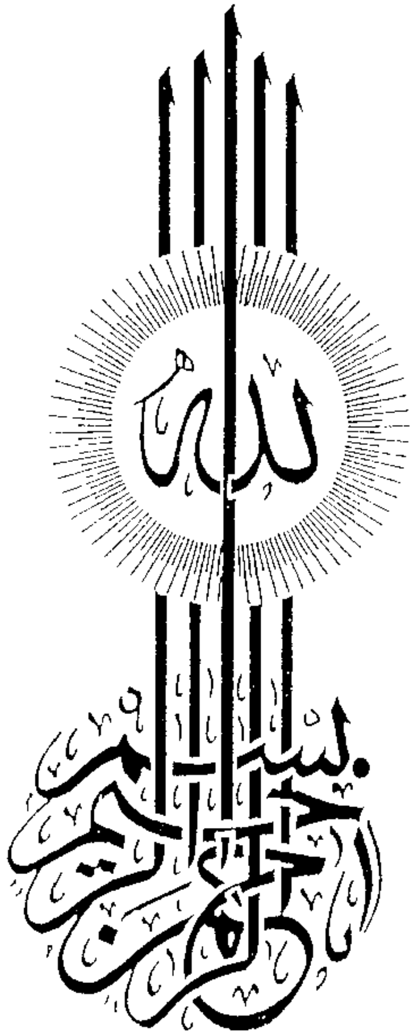
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STATEMENT

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

This work, included in the thesis, was carried out by the author in the National Institute for standards from Oct. 1988 to Feb. 1993 .

No part of this thesis has been submitted for degree or qualification at any other university or institute.

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ABSTRACT

The shadow optical method (caustic) is a method suitable for stress analysis at stress concentrated areas. The principle of this method was firstly proposed in 1964. Since this time it has been proved that the shadow optical method is one of the most simple experimental optical methods.

In the present work the method of caustics in the case of transmitted light was introduced on Poly (methyl methacrylate), PMMA, specimens. Experiments were carried out to verify the theory of caustics with three cases of stress risers, namely sharp crack, v-notch and close proximity to drilled holes, taking into account all involved parameters and their influence on the accuracy of the method. The involved parameters are those included in the equations of caustics to determine the stress concentrated state. These parameters are: the radius of the initial curve of the caustic (r_o), the distance between the point light source and the specimen (Z_i), the distance between the screen and the specimen (Z_o) and the thickness of the specimen (d).

A comparison between the stress intensification values calculated by the method of caustics and calculated by the fracture mechanics equations were made at various caustic parameters values. Limits and limitations within which the shadow optical method may be used were set to get the best accuracy.

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LIST OF MAIN SYMBOLS

a	crack length (mm)
c	stress-optical constant (mm^2/N)
D	caustic diameter (mm)
D_l	longitudinal caustic diameter (mm)
D_t	transverse caustic diameter (mm)
d	specimen thickness (mm)
E	Young's modulus (N/mm^2)
F	applied force (N)
K_I	stress intensity factor, mode I (opening mode) ($N/mm^{1.5}$)
$K_I(C)$	stress intensity factor obtained by the caustic method ($N/mm^{1.5}$)
$K_I(F)$	stress intensity factor obtained by the linear fracture mechanics theory ($N/mm^{1.5}$)
K_{Ic}	critical stress intensity factor ($N/mm^{1.5}$)
m	magnification ratio ($m=Z_i+Z_o\ /Z_i$)
n	subscript and exponent used in the complex potential function $\emptyset(z)$ and $\Psi(z)$
R	hole radius (mm)
r	polar radius of points on specimen (mm)
r_o	radius of the initial caustic curve (mm)
S	tensile stress (N/mm^2)
x', y'	cartesian co-ordinates of points on screen (mm)

z	complex expression for a point on specimen
Z_i	distance between point light source and specimen plane (mm)
Z_o	distance between specimen plane and image plane (mm)

Greek symbols

α^*	stress-optical coefficient (mm/N)
γ	eigen value
λ	singularity order
λ	wave length (mm)
ρ	notch radius (mm)
σ	applied stress (N/mm^2)
$\phi(z)$	complex potential function
ϕ	polar angle of points on specimen (deg.)
Ψ	apex angle (deg.)
$\Psi(z)$	complex potential function

CHAPTER 1

INTRODUCTION AND THE AIM OF THE WORK

1.1 Introduction

In the development of the basic stress relations it is assumed that cross sections remain constant and that there are no irregularities. However, most of mechanical parts do have holes, grooves, notches, or other kinds of discontinuities present which are called stress risers. Such stress risers alter the stress distribution so that the basic stress relations no longer describe the stress state. In this case the actual stress distribution is not uniform and the maximum stress may be multiple times as large as the uniform stress. Since the occurrence of failure by fast fracture is necessarily associated with the presence of high local stresses (stress concentration) near stress risers, any realistic measurement of such stresses becomes very important to avoid a catastrophic failure in mechanical parts.

Since the danger of the stress concentration on the mechanical parts has been realized, several analytical methods were established to analyze the stress intensification very near to the stress risers. These analytical methods are classified into theoretical solutions presented by the science of fracture mechanics and experimental solutions such as Photoelasticity, Laser holography, X-Ray diffraction and the Shadow Optical method thereafter referred to as the Caustic method.