DESIGN, DEVELOPMENT AND CALIBRATION OF TORQUE STANDARD MACHINE

By

Khaled Abdelaziz Mohamed Abdelrhem

A Thesis Submitted to the

Faculty of Engineering at Cairo University

As Partial Fulfillment of the Requirements for the Degree of

DOCTOR OF PHILOSOPHY

in

MECHANICAL DESIGN AND PRODUCTION ENGINEERING

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Title of Thesis:

Design, development and calibration of torque standard machine

Key Words:
Torque, Calibration, Temperature, Humidity

Summary:

A NIS 1 kN·m secondary standard torque calibration machine designed earlier [1] is further developed to be a primary standard torque calibration machine. Design and construction of a lever-mass system with ends to be coaxial with the transducer axis are implemented. FEM analysis is used to check the mechanical stresses occurring in the critical components affecting the deflection in the designed lever arm. Procedures for accurate measurements torque arm are described. Expected relative expanded uncertainty is worked out to be $2 \cdot 10^{-4}$.

A study on the effect of relative humidity and temperature on the DMP40 measuring amplifier and the BN100A bridge calibration unit as one of the main sources of torque machine uncertainty is reported. Furthermore, the effect of relative humidity on the zero signal of torque transducers is investigated. Finally a study of the influence of temperature and relative humidity on the sensitivity and the characteristics of torque transducers such as residual zero torque, reversibility and creep, is presented. Equations are presented to predict the effect of temperature/relative humidity changes on the sensitivity of torque transducers.

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Nomenclature

A	Torque transducer characteristic constant for zero signal, mV/V.
A_H	Torque transducer's humidity characteristic constant for sensitivity, mV/V.
A_T	Torque transducer's temperature characteristic constant for sensitivity, mV/V.
w	Width, m.
b	Inverse τ , s^{-1}.
b_H	Inverse τ_H, s^{-1}
b_T	Inverse τ_T, s^{-1}.
C	Viscoelastic humidity constant of torque transducer's zero signal, (%·s%mV/V).
C_H	Viscoelastic humidity constant of the sensitivity of torque transducer, (%.s)/(mV/V).
C_T	Viscoelastic temperature constant of the sensitivity of torque transducer, (°C.s)/(mV/V).
d_c	Core diameter of the screw, m.
E	Young's Modulus, Pa.
e_{cg}	Maximum change of torque transducer signal due to lever inclination, N·m
e_{st}	Relative air pressure stability error, %.
F	Force, N.
$\vec{F}$	Resultant force vector.
F_1, F_2	Two forces applied at both lever sides, N.
$\vec{F_1}$	Vector of the first force.
$\vec{F_2}$	Vector of the second force.
f	Factor of safety
g_{local}	local gravity acceleration at the place of NIS, m/s^2.
H_1	Starting relative humidity, %.
H_2	Final relative humidity, %.
h	Height , m.
K	Elastic humidity constant of torque transducer's zero signal, (% % mV/V).
K_H	Elastic humidity constant of the sensitivity of torque transducer, %/(mV/V).
$K_{H,v}$	DMP40 humidity coefficient at input voltage ratio, mV/V/%.
K_T	Elastic temperature constant of the sensitivity of torque transducer, °C/(mV/V).
$K_{T,v}$	DMP40 temperature coefficient at input voltage ratio, mV/V/°C.