Design and Fabrication of Energy Harvester by Using Fluttering Phenomenon

By

Eng. Ahmed Fathy Shabaan Abd Allah

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
In
MECHANICAL DESIGN AND PRODUCTION ENGINEERING

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Under the Supervision of

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Title of Thesis:

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Key Words:

Energy harvesting; electromagnetic induction; windbelt, fluttering phenomnon.

Summary:

The objective of this study is to convert wind energy into electrical power. A mechanical vibrations generates due to fluid-structure interaction between airflow and belt. A Permanent magnet and copper coil are used to harvest electrical power from the mechanical vibrations of flexible belt which fixed on it magnet. A strong magnet is used to increase the power. A parametric analysis have been studied to analyze the effect of each design parameter on the harvester performance.

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NOMENCLATURE

B_r	Electro-magnetic flux
b	Width of fluttering belt
C	is the velocity of wave propagation
C_α	rotational damping coefficient
C_h	vertical damping coefficient
C_L	Lift coefficient
C(k)	derived function for the reduced frequency
D	Drag force
d_i	Coil inner diameter
d_o	Coil outer diameter
d_w	Coil wire diameter
D_{em}	coefficient of electromagnetic damping
E	Modulus of elasticity
f	structure flutter frequency
f_c	copper filling factor
F_{em}	electromagnetic force
h	Vertical displacement of belt
h_c	Coil height
H_i	flutter derivative coefficient
I	section polar moment per unit length
i	Electric current
K_α	rotational stiffness coefficient
K_h	vertical stiffness coefficient
L	vertical aerodynamic lift force
L_C	Coil inductance
L_w	Length of wire
L_b	Length of fluttering belt
M	aerodynamic pitching moment
m	mass of belt per unit length
N	Number of coil turns
R_C	Coil resistance
R_L	Load resistance
T	Belt tension
t_b	Thickness of belt
t_m	Thickness of magnet
U	Mean air velocity

V	Voltage drop across the load resistance
V_{r}	reduced wind velocity
V_T	Volume of coil
α	angular displacement
δ	gap distance between coil and magnet
ρ_{air}	Air density
ξ_h	critical damping ratio

ABBREVIATION

AFM	Atomic Force Microscope
WBEH	Wearable Biomechanical Energy Harvesting
PVDF	Polyvinylidenefluorid
CFD	Computational Fluid Dynamic
FEA	Finite Element Analysis
FSI	Fluid Structure Interaction
mf	Magnetic Field
IVP	Initial Value Problem

Table of Contents

LIST OF TABLES

LIST OF FIGURES