DEVELOPMENT OF REGENERATIVE PIEZOELECTRIC LINEAR GENERATOR FOR ALTERNATIVE POWER GENERATION

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Engineering in Automotive.

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

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LIST OF SYMBOLS

Capital letters

C_1	Capacitance in Farads with variable ranges
D_i	Electric displacement
E	Electric field
F_{out}	Output force
I_{out}	Current output in amperes
L	Displacement
ΔL	Displacement change
P	Polarization
P_{ave}	Average power
P_o	Peak power
R	Resistance
T	Cycle time in seconds
T_m	Mark Time in seconds
T_s	Space Time in seconds
V_{in}	Input voltage
$V_{p\text{-}p}$	Rated voltage
T	Pulse length

Lower case letters

d_{ij}	Piezoelectric Modulus
d_{31}	Piezoelectric strain constant in the 1-axis induced due to a unit applied field in the 3-axis

d_{33}	Piezoelectric strain constant in the 3-axis induced due to a unit applied field in 3-axis
k_x	Stiffness value at various operating range
pF	Electrostatic capacity
s	Non-zero piezoelectric effect

Greek symbols

σ_j	Applied mechanical stress
ε	Dielectric constant
ε_{ij}	Dielectric constant Modulus
ε_{pulse}	Energy pulse strain, Bandwidth parameter
λ_j	Applied mechanical strain

LIST OF ABBREVIATIONS

ABS	American Bureau of Shipping
AISI	American Iron and Steel Institute
$BaTiO_3$	Ceramic Barium Titanate
CAD	Computer Added Design
DC	Direct Current
FET	Field-Effect Transistor
HB	Hard Black
IC	Integrated Circuit
LED	Light Emitting Diode
MAX	Maximum
MEMS	Micro Electro Mechanicals
MFC	Multi Fibre Composites
PC	Personal Computer
PVDF	Polyvinyl Fluoride
PZT	Piezo Zirconate Titinate
RPM	Regulations Per Minute
SiO2	Quartz
SiTHy	Static Inductance Thyristor
SCRs	Silicon Controlled Rectifier
UL	Ultra Light
2D	Two Dimensions
3D	Three Dimensions

ABSTRACT

The unique ability of piezoelectric materials shows their potential in harvesting power for the application of micro to miniature power source range of devices in the industry. Focus on the suspension operating system which produces waste vibrating energy as a source of power, a conceptual design of a regenerative piezoelectric linear generator was developed by considering some factors including the dimensions, shapes, maintenance convenience and material behaviour. In this project, piezoelectric plate used in a buzzer was modified to be a multilayer stack as an actuation element for the regenerative piezoelectric linear generator which able to supply power for certain applications. The performance of the fabricated prototype had been tested on a specific testing rig within some inputs variables in terms of different force magnitude, speed and load duration. The preliminary testing on the real system of the generator also performed where two loadings from 50kg's and 80kg's person bouncing had been considered. The experimental testing had agreed the hypothesis made where the model configurations and the mechanism of power harvesting implemented could influence the power output achieved by the system. The proposed design is proved able to achieve more power within more smart material thickness and layers. It also able to works within different frequencies and load duration that refer to variety of road conditions we have in our country. The average output power achieved was reached until 1.33mW and the value could be enhanced within the addition of piezoelectric plate thickness and layers. This thesis elaborated the whole process of designing the generator from the first brainstorming of conceptual design until the recommendation of the designed model.

ABSTRAK

Kelebihan unik yang terdapat pada bahan pizoelektrik menunjukkan potensinya dalam penghasilan kuasa untuk aplikasi sumber kuasa mikro kepada miliwatts pada alat-alat yang dihasilkan dalam industri. Dengan memfokuskan kepada operasi sistem suspensi yang menghasilkan lebihan tenaga getaran sebagai sumber kuasa, satu rekaan konsep penjanakuasa pizoelektrik telah dicadangkan dengan mengambil kira beberapa faktor termasuklah ukuran, bentuk, kesesuaian penyelenggaraan dan sifat bahan. Dalam projek ini, kepingan pizoelektrik yang digunakan dalam penggera telah diubahsuai untuk dijadikan satu tingkatan lapisan sebagai elemen penggiat untuk penjanakuasa pizoelektrik yang berupaya untuk menghasilkan kuasa untuk aplikasi tertentu. Keupayaan rekaan model contoh telah diuji pada satu radas ujikaji yang spesifik dengan beberapa pembolehubah berdasarkan perbezaan daya, kelajuan, dan tempoh masa. Beberapa ujian percubaan awal pada sistem generator sebenar juga telah dilakukan di mana dua beban daripada henjutan individu 50 kilogram dan 80 kilogram telah diambilkira. Ujian percubaan tersebut telah mengesahkan hipotesis yang dibuat iaitu penyelarasan model dan mekanisme penghasilan kuasa yang dibuat boleh mempengaruhi hasil kuasa yang diperolehi oleh sistem. Cadangan rekaan tersebut telah disahkan berupaya untuk memperolehi lebih kuasa dengan lebih banyak ketebalan dan lapisan bahan yang berkualiti. Ia juga berupaya untuk beroperasi dengan perbezaan frekuensi dan tempoh masa beban yang merujuk kepada kepelbagaian keadaan jalan di negara ini. Hasil kuasa tertinggi yang diperolehi adalah sehingga $1.33mW$ dan nilai tersebut boleh ditingkatkan dengan penambahan ketebalan dan lapisan kepingan pizoelektrik. Tesis ini menghuraikan keseluruhan proses rekaan generator bermula daripada idea awal rekaan konsep sehingga cadangan penambahbaikan model rekaan tersebut.

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