MODELING AND CONTROL OF V-GROOVE ROTARY IMPACT DRIVER

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MODELING AND CONTROL OF V-GROOVE ROTARY IMPACT DRIVER

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LIST OF ABBREVIATIONS

DC	Direct Current
e.m.f	electromagnetic force
FET	Field Effect Transistor
HAV	Hand Arm Vibration
HIL	Hardware-in-the-Loop
HiL	Human-in-the-Loop
LED	Light Emitting Diode
MBD	Model Based Design
MCU	Micro Controller Unit
MIL	Model-in-the-Loop
PCBA	Printed Circuit Board Assembly
PMDC	Permanent Magnet Direct Current
PWM	Pulse Width Modulation
RPM	Rotation per minute
RTM	Real-Time Target Machine
SIL	Software-in-the-Loop
TET	Task Execution Time
TTI	Techtronic Industries

LIST OF SYMBOLS

Δs_{JB}	Axial displacement of jackshaft referring to steel ball, (mm)
Δs_{SB}	Axial displacement of striker referring to steel ball, (mm)
Δs_{SO}	Axial displacement of striker, (mm)
α_A	Assembly uncertainty factor
α_{SJ}	Relative rotational acceleration of striker to jackshaft, (Rad/s^2)
δ	Diameter ratio
$\boldsymbol{\gamma_S}$	V-profiled angle of striker, (rad)
$\boldsymbol{\gamma_J}$	V-profiled angle of jackshaft, (rad)
λ	Motor damping, (N*m/(rad/s))
μ	Coefficient of friction
μ	Poisson's ratio
$\boldsymbol{\mu_{dynamic}}$	Dynamic coefficient of friction
$\boldsymbol{\mu_K}$	Coefficient of friction in the head bearing area of bolt
μ_G	Coefficient of friction in the thread of bolt
μ_{static}	Static coefficient of friction
$\boldsymbol{\pi}$	Pi = 3.142
θ	Angle of rotation or shaft's angle of twist, (rad)
$\dot{\boldsymbol{\theta}}$	Speed of rotation or shaft's speed of twist, (rad)
$\ddot{\boldsymbol{\theta}}$	Acceleration of rotation or shaft's acceleration of twist, (rad)
$\boldsymbol{\theta_{SB}}$	Relative rotational angle of striker to steel ball, (rad)
θ_{JB}	Relative rotational angle of jackshaft to steel ball, (rad)
$\boldsymbol{\theta_{SJ}}$	Relative rotational angle of striker to jackshaft, (rad)
ω	Rotational velocity, (rad/s)

ω_n	Frequency of vibration (Hz)
ω_o	Motor no-load rotational velocity, (rad/s)
$\boldsymbol{\omega_{SJ}}$	Relative rotational velocity of striker to jackshaft, (rad/s)
$\boldsymbol{\omega_{th}}$	Linear region rotational velocity threshold (rad/s)
$\boldsymbol{a_{SO}}$	Axial acceleration of striker, (mm/s)
b	Damping constant (Ns/mm)
$\boldsymbol{c_v}$	Transition approximate coefficient, (rad/s)
$\boldsymbol{d}$	Diameter of shaft, (mm)
$\boldsymbol{d_2}$	Pitch diameter of the bolt thread (mm)
d_W	Outside diameter of the plane head bearing surface of the bolt (mm)
$\boldsymbol{f}$	Load joint damping (Viscous friction coefficient) (Nm/(rad/s))
$\boldsymbol{h_0}$	Cone height of an unloaded single spring (mm)
$\boldsymbol{i}$	Number of springs in serial
$\boldsymbol{i_o}$	No-load current, (A)
$\boldsymbol{i_{rotor}}$	Rotor current, (A)
$\boldsymbol{i_s}$	Rotor start current, (A)
$\boldsymbol{k}$	Spring stiffness (N/mm)
$\boldsymbol{l_0}$	Height of unloaded single spring washer (mm)
$\boldsymbol{k_t}$	Motor torque constant, (Nmm/A)
$\boldsymbol{k_v}$	Motor back e.m.f. constant, (Vs/rad)
$\boldsymbol{l}$	Length of shaft, (mm)
$\boldsymbol{n}$	Number of springs in parallel
$\boldsymbol{r_S}$	Radius of V-profiled on striker, (mm)
$\boldsymbol{r_J}$	Radius of V-profiled on jackshaft, (mm)
$\boldsymbol{s}$	Deflection of single spring (mm)
$\boldsymbol{t}$	Time, (s)
$\boldsymbol{t_s}$	Thickness of individual spring washer (mm)

$\boldsymbol{v_b}$	Electromagnetic force induction voltage (V)
$\boldsymbol{v_{pen}}$	Rate of distance change with time between two contact points is the penetration distance, (mm/s)
v_{poc}	Velocity at point of contact, (mm/s)
$\boldsymbol{v_{SO}}$	Axial velocity of striker, (mm/s)
$\boldsymbol{v_{th}}$	Threshold velocity, (mm/s)
x_{pen} or r_{pen}	Distance between two contact points is the penetration distance, (mm)
$\boldsymbol{x_{\dot{pen}}}$ **or** $\boldsymbol{r_{\dot{pen}}}$	Rate of distance change with time between two contact points is the penetration distance, (mm/s)
$\boldsymbol{D}$	V-profiled force variable (based on V-profiled angle $\boldsymbol{\gamma}$)
$\boldsymbol{D_{\varepsilon}}$	Spring washer outside diameter (mm)
$\boldsymbol{D_i}$	Spring washer inside diameter (mm)
$\boldsymbol{D_{Ki}}$	Inside diameter of the plane head bearing area of bolt (mm)
$\boldsymbol{D_{Km}}$	Effective diameter for the friction moment at the bolt head (mm)
E	Young's modulus (N/mm^2)
$\boldsymbol{F}$	Spring force of a single spring (N)
$\boldsymbol{F_f}$	Friction force, (N)
$\boldsymbol{F_H}$	Horizontal force acting on steel ball, (N)
$\boldsymbol{F_M}$	Assembly preload (N)
$\boldsymbol{F_M\ min}$	Minimum required assembly preload (N)
$\boldsymbol{F_M\ max}$	Maximum assembly preload (N)
F_N	Normal force, (N)
$\boldsymbol{F_V}$	Vertical force acting on steel ball, (N)
$\boldsymbol{F_S}$	Compression force from spring, (N)
$\boldsymbol{F_T}$	Combine springs force (N)
G	Modulus of rigidity for material or shear modulus (MPa)
J	Moment of inertia (kgm^2 or Nm/(Rad/s^2))

$\boldsymbol{K_1}$	Constant for spring force calculation in equation (2.11)
K_t	Torsional spring constant
$\boldsymbol{L}$	V-profiled motion variable (based on V-profiled angle $\boldsymbol{\gamma}$)
$\boldsymbol{L_{rotor}}$	Rotor winding inductance, (H)
$\boldsymbol{L_0}$	Initial assembly height of set springs (mm)
$\boldsymbol{M_A}$	Tightening torque (mNm)
$\boldsymbol{P}$	Pitch of the bolt thread (mm)
$\boldsymbol{R_{rotor}}$	Rotor/rotor winding resistant, (Ohm)
$\boldsymbol{T}$	Torque or Damping torque, (Nm)
$\boldsymbol{T_{brk}}$	Breakaway friction torque, (Nm)
$\boldsymbol{T_c}$	Coulomb friction torque, (Nm)
$\boldsymbol{T_E}$	Motor torque, (Nm)
T_V	Viscous friction torque (Nm)
T_W	Motor disturbance load torque (Nm)
T_S	Motor starting torque (Nm)
$\boldsymbol{V}$	DC Voltage source to motor, (V)

PEMODELAN DAN KAWALAN UNTUK PEMACU IMPAK BERPUTAR ALUR-V

ABSTRAK

Pemacu skru impak berputar yang dikategorikan sebagai alat kuasa tanpa kabel pegangan tangan memberikan peluang penggunaan dalam banyak aplikasi. Walau bagaimanapun, terdapat beberapa kekurangan dalam alat jenis ini seperti mekanisma impak yang tidak disegerakkan, kuasa yang terlalu banyak diperlukan untuk pekerjaan yang lebih tepat dan ia menghasilkan banyak getaran. Objektif kajian ini adalah untuk memodelkan sistem fizikal pemacu impak berputar alur-v dan aplikasi bebannya. Algoritma kawalan aliran keadaan dibangunkan terhadap model bagi menambahbaik kekurangan yang dinyatakan sebelum ini. Kelajuan dioptimumkan dengan menggunakan algoritma aliran keadaan dengan jenis data titik tetap yang mana ia dapat mengurangkan keperluan pengiraan perkakasan dengan ketepatan yang boleh diterima. Tinjauan kajian telah dilakukan bagi menilai kerumitan simulasi secara maya di antara model pemacu impak dan pemacu gerudi dalam melakukan penentusahan perkakasan masa nyata dalam simulasi maya. Tujuan ia dilakukan bagi menentusahkan algoritma yang dibangunkan supaya ia tidak terdedah kepada risiko melampau ketika penyudah tetap langkah masa ditetapkan. Akhir sekali, prototaip dibina berpandukan model perisian simulasi bagi ujian sebenar manusia dan pengesahan. Daripada keputusan, penambahbaikan sebanyak 10% terhadap segerakkan sistem, pengurangan impak laju sebanyak 33% bagi pengskruan kecil dan lembut, dan pengurangan sebanyak 19% dalam getaran hasil tork motor terhadap lengan pengguna dicapai. Pemahaman bernilai diperolehi daripada ujikaji dan pengoptimuman melalui simulasi.