DETECTION AND IDENTIFICATION OF STICTION IN CONTROL VALVES BASED ON FUZZY CLUSTERING METHOD

By

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LIST OF SYMBOLS

A_i	The antecedent fuzzy set
C	Number of clusters
C_v	Valve coefficient
$\mathrm{D}_{\mathrm{ik}}^2$	Squared inner-product distance norm
e	Error
F	Volumetric flow rate
F_a	Applied force
F_f	Applied external force
F_i	Fuzzy covariance matrix
f_d	Dynamic friction
F_r	Spring force
f_s	Static friction
F_v	Viscous friction
I_{stic}	Stiction performance index
J	Slip Jump
J_m	Cost function for clustering

K	Process gain
K_c	Controller gain
m	Amount of fuzziness
$\mathrm{MSE}_{\mathrm{sin}}$	Mean-squared error for sinusoidal fitting
MSE_{tri}	Mean-squared error for triangular fitting
N	Length of data (Number of samples)
OPhg	Upper bond of control signal
OPlw	Lower bond of control signal
R^2	Goodness-of-fit
r_{xy}	Correlation coefficient
S	Stick band plus dead band
sg	Specific gravity of the fluid
stp	Moving state of the valve
T_{d}	Time delay
$\mathrm{T}_{\mathrm{fin}}$	Time window
T_s	Sampling time
τ_l	Zero-crossing for negative lags of CCF
τ_r	Zero-crossing for positive lags of CCF

r_0	CCF at lag zero
U	Fuzzy partition matrix
$\mathrm{u_s}$	Control signal at resting state of the valve
V	Vector of cluster prototypes (centers)
x_{ss}	The value of the input signal when the valve gets stuck
$\mathrm{z_k}$	Data of the *k*-th sample
$\propto$	Valve design parameter
ΔP_v	Pressure drop across the valve
θ_{th}	Threshold
Ω_i	The degree of activation of the i-th rule