MONITORING AND PREDICTION OF BEARING FAILURE BY ACOUSTIC EMISSION AND NEURAL NETWORK

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ABSTRACT

The purpose of this research is to develop an appropriate ANN model of bearing failure prediction. Acoustic emission (AE) represented the technique of collecting the data that was collected from the bearing and this data were measured in term of decibel (dB) and Distress level. The data was then used to develop the model using ANN for bearing fault prediction model. An experimental rig was setup to collect data on bearing by using Machine Health Checker (MHC) Memo assist with MHC Analysis software. In the development of ANN modeling, the result obtained shows that the optimum model was Elman network with training algorithm, Levenberg-Marquardt Back-propagation and the suitable transfer function for hidden node and output node was logsig/purelin combination. Four models were built in this research for multiple step ahead prediction, that were one day ahead model (Model 1), seven days ahead model (Model 2), fourteen days ahead (Model 3) and thirty days ahead model (Model 4). In the application part, a computer program was written on bearing failure prediction. This program was implemented using graphical user interface (GUI) features that can be implemented by using a MATLAB GUI. In the end, the user was able to use this program as a tool to operate or simulate bearing failure prediction.

ABSTRAK

Tujuan penyelidikan ini adalah untuk membangunkan model ANN yang bersesuaian bagi meramal kegagalan galas. Pancaran akustik mewakili teknik pengambilan data yang diambil daripada galas dan data tersebut diukur dalam ukuran paras desibel (dB) and paras Cemas. Data tersebut kemudiannya digunakan dalam pembangunan model menggunakan rangkaian neural tiruan untuk pemodelan peramalan kegagalan galas. Rig ujikaji dibina untuk mengumpul data pada galas dengan menggunakan Machine Health Checker (MHC) Memo dengan perisian MHC Analysis. Dalam pembangunan pemodelan ANN, keputusan yang diperolehi menunjukkan pemodelan optima ialah menggunakan rangkaian Elman dengan algoritma pembelajaran Perambatan-balik Levenberg- Marquardt dan fungsi pindahan yang sesuai untuk nod terselindung dan nod keluaran adalah kombinasi logsig/purelin. Empat model telah dibina dalam penyelidikan ini bagi ramalan pelbagai langkah kehadapan, iaitu pemodelan satu hari kehadapan (Model 1), tujuh hari kehadapan (Model 2), empat belas hari kehadapan (Model 3) dan tiga puluh hari kehadapan (Model 4). Dalam bahagian aplikasi satu aturcara komputer untuk meramal kegagalan galas telah dibangunkan. Aturcara ini dilaksanakan dengan antaramuka pengguna grafik (GUI) yang menggunakan MATLAB GUI. Pada akhirnya pengguna boleh menggunakan aturcara ini sebagai perkakasan untuk membuat atau menyelaku ramalan kegagalan galas.

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LIST OF SYMBOLS

%	-	Percentage
φ	-	Transfer function
α	-	Contact angle
$\sum$	-	Summation
a_i	-	Actual value
a_1	-	Reliability adjustment factor.
a_2	-	Material/construction adjustment factor.
a_3	-	Operating condition adjustment factor.
B	-	Connection matrix from the input layer to the hidden layer
b_h, b_o	-	Bias vector
C	-	Connection matrix (matrix of weight) from the hidden layer to the output layer
C_r	-	Basic dynamic radial rated load (Newtons).
C_T	-	Dynamic load rating
D	-	Ball diameter
d_i	-	Bore diameter
d_m	-	Pitch diameter
d_o	-	Outside diameter
e_i	-	Error
$f(\cdot)$	-	Nonlinear mapping
f_i	-	Ball Pass Frequency, Inner race
f_o	-	Ball Pass Frequency, Outer race
f_r	-	Ball Spin Frequency

h	-	Function argument
kHz	-	Kilo Hertz
L_{10}	-	Basic rated life in 10^6 revolutions.
L_{10h}	-	Basic rated life in hours.
L_{na}	-	adjusted life rating in hours; adjusted for reliability, material and operating condition
MHz	-	Mega Hertz
N	-	Number of data
N_r	-	Rotational speed (rpm).
p	-	3 (constant value for ball bearing).
P_r	-	Equivalent radial load (Newtons).
r_i	-	Inner groove radius
r_o	-	Outer groove radius
S	-	Shaft rotation rate in hertz
$s(k)$	-	Intermediate variable
T	-	Time
t_i	-	Desired value
$u_{i,}$	-	Input vector
u(t)	-	dB value of day t
V	-	Voltage
V_c	-	Velocity of cage bearing
V_i	-	Velocity of inner race
V_N	-	Noise level
V_o	-	Velocity of outer race
Vs	-	Signal level
$w_{i,j}$	-	Weight
X	-	Actual input
$X_{\max}$	-	Actual inputs at their maximum
$X_{\min}$	-	Actual inputs at their minimum
X_s	-	Scaled input
y_i	-	Output vector
y(t)	-	Distress value of day t

z^{-1}	-	Time delay
Z	-	Number of ball

LIST OF ABBREVIATIONS

AE	-	Acoustic emission
ALE	-	Adaptive line enhancer
ANN	-	Artificial neural network
BSF	-	Ball spin frequency
C	-	Coupling
dB	-	Decibel
DWPA	-	Discrete wavelet packet analysis
DWT	-	Discrete wavelet transform
ERN	-	Externally Recurrent Networks
FFNN	-	Multilayer feedforward neural network
FFT	-	Fast Fourier Transform
GUI	-	Graphical user interface
HFRT	-	High frequency resonance technique
IRN	-	Internally Recurrent Network
kgf	-	Kilo gram force
lbs	-	Pounds
M	-	Three phase motor
m	-	Meter
MHC	-	Machine Health Checker
MLP	-	Multilayer Perceptron.
MSE	-	Mean square error
NDT	-	Non-destructive testing
NN	-	Neural Network
NNPCA	-	Neural Network PCA
OSA	-	One Step Ahead

P	-	Applied load
PC	-	Personal computer
PCA	-	Principal component analysis
RMS	-	Root mean squared
RNN	-	Recurrent Neural Networks
rpm	-	Rotation per minute
RUL	-	Remaining useful life
S1, S3	-	Support bearings and housing
S2	-	Tested bearing
SNR	-	Signal to noise ratio
SVM	-	Support vector machines

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