A New Artificial Neural Network Based Failure Determination System For Electric Motors

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Abstract

A new measurement system was developed for determination of failures and defining the level of failure that may occur in bearings and rotor bearings or in foot of motor in single phase capacitor start motor. In system, the vibratory operation of the motor is provided by connecting different screws on the motor's rotor mounted flywheel or by gradually removing the nut bolts of motor foot. The VB3 vibration sensor outputs were recorded to the computer. The changing characteristics of sensor output for each experiment had more than one frequency component; therefore, FFT was performed for determining such components. It was observed that the frequency and amplitude values of first 5 harmonics could be used for determining the presence, type and level of failure but there was a nonlinear relation between each other. 2 different ANN customized separately were developed for determining the type and rate of the failure of motor. 80%, 10% and 10% of available data were reserved for training, testing and verification respectively and the ANN was trained. Accuracy degree for the ANN in the estimations following the training stage was calculated as $R = 0.97-0.98$. Furthermore, the results of ANN was compared with the results obtained using Sequential Minimal Optimization (SMO), Naive Bayes (NB) and J48 algorithms; and it was determined that the accuracy degree of ANN was higher.

Full Text

This preprint is available for [download as a PDF](#).

Declarations

The authors declare no competing interests

Figures

Figure 1

Failure types and their proportional distribution in asynchronous motors.

Figure 2

Block system of the failure determination and identification system developed.

Figure 3

Photos of stator and rotor of the motor tested.

Figure 4

Locations of VB83 vibration sensors on the motor.

Figure 5

Front panel and block diagram of LabVIEW program developed.

(a)

(b)

(c)

Figure 6

a) Representation of bearing damage, b) Representation of rotor bearing damages, c) Representation of foot damages of motor.

Figure 7

Photos of 1st Screw and 2nd Screw

Figure 8

Time domain signal of a) no failure b) rotor or bearing failure c) motor foot failure. Frequency domain signal of d) no failure e) rotor or bearing failure f) motor foot failure.

Figure 9

Close examination of FFT graphs based on the failure type of each harmonic fields between a) 0-0.4 Hz b) 49.4-50.4 c) 99.4-100.4 d) 149.4-150.4.

Figure 10

Close examination of FFT graphs based on the failure level of one harmonic field (50 Hz) for a) rotor or bearing failure b) motor foot failure.

Figure 11

Flow chart of the MATLAB program developed and the ANNs.

Figure 12

Result of 1st ANN.

Figure 13

Result of 2nd ANN.

```

1 - clear
2 - clc
3 - fprintf('Starting Program...\n\n');
4 - fprintf('Loading Experimental Datas...\n');
5 - load('Measurement_File.mat');
6 - fprintf('Experimental Datas are Loaded\n\n');
7 - fft_transformation;
8 - fprintf('Failure and Failure Type Detecting...\n');
9 - failure_class=round(net_class(Measurement_File));
10 - if (failure_class == [1;0;0])
11 -     fprintf('Result : No Failure\n');
12 - elseif (failure_class == [0;1;0])
13 -     fprintf('Result : Rotor or Bearing Failure\n\n');
14 -     fprintf('Failure Level Detecting...\n');
15 -     failure_level=100*net_hata(input_class_net(:,deney_no));
16 -     fprintf('Rotor or Bearing Failure Level = %%0.1f\n',failure_level);
17 - elseif (failure_class == [0;0;1])
18 -     fprintf('Result : Motor Foot Failure\n');
19 - else
20 -     fprintf('Error\n');
21 - end
22

```

Command Window

New to MATLAB? See resources for [Getting Started](#).

Starting Program...

Loading Experimental Datas...

Experimental Datas are Loaded

Calculating FFT for Measurement Datas...

Failure and Failure Type Detecting...

Result : Rotor or Bearing Failure

Failure Level Detecting...

Rotor or Bearing Failure Level = %50.2

fx >>

Figure 14

Program and output for rotor or bearing failure and level

```
Command Window
New to MATLAB? See resources for Getting Started.

Starting Program...

Loading Experimental Datas...
Experimental Datas are Loaded

Calculating FFT for Measurement Datas...

Failure and Failure Type Detecting...
Result : Motor Foot Failure
fx >>
```

Figure 15

Output of motor foot failure

Figure 16

Verification application with Raspberry Pi

Figure 17

Rate of usage for predictive maintenance approach in the determination of failures.