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Original Research Article

STATOR INTERTURN SHORT CIRCUIT FAULT DIAGNOSIS BY CURRENT CONCORDIA PATTERN USING FUZZY FOR DECISION EVALUATION

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Abstract: An early detection and diagnosis of induction motor stator short circuit inter turn fault prevents greater damage to nearby coils, core, and insulation and eventually to the motor. The presence of stator inter turn short circuit fault can be detected by analysis of parks transformed stator current Concordia patterns. Further in this paper to increase accuracy and extract features, wavelet transformation is used and for decision making fuzzy system is been trained. The proposed fuzzy approach is dependent on detailed level coefficient Concordia pattern, obtained from wavelet transformation. Experimental results integrate the aim of paper.

Keywords: Concordia pattern, fault diagnosis of induction motor, fuzzy logic, wavelet.

Introduction: Three phase squirrel cage induction motor plays a vital role in industries due to their high power-weight ratio, low price and easy maintenance [1]. To increase reliability early fault detection is of prime importance. The methods of fault detection and diagnosis can be classified in to two ways [1]. First method based on modeling of IM [1]. Second one based on signal measurement [1]. First one deal with certain assumptions under which uncertainties are difficult to model and numbers of equations required are more and complex to model and moreover disturbances are unable to be modeled without assumptions. Whereas signal based method measure signals compare draw features which differentiate between faults using various techniques such as time domain analysis, frequency domain, wavelet, signal processing tools etc. further many more systems are used to diagnose inter turn fault such as negative sequence impedance[1], winding function based system[3], transient analysis of IM model[4]. Among these, wavelet is more advantageous as it can deal with non-stationary signals[5].The proposed system uses signal based method and basically for feature extraction wavelet is used and for decision evaluation fuzzy system is trained on the basis of detail level coefficient

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(fifth level) of parks transformed current (Id and Iq).

Concordia Transformationtheory: Defines a new set of variables, the new quantities are obtained from the projection of the actual variables on three axes one along d-axis, second along q-axis and third on stationary axis[2]. The stator current of phase „a" considered as reference now these variables are transformed in to new one as d, q and o and the two phase equations obtained in terms of three phase are as follows.

The equations (1) & (2) are simulated in lab view. and under various faulty and healthy conditions as shown in Fig.1. The evaluated results are used as input to wavelet for feature extraction.

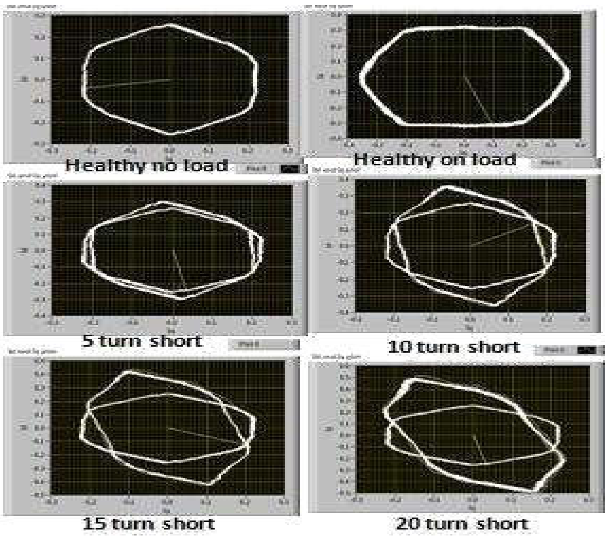

Figure 1: plots of Id and Iq for various condition under load and no load condition

Wavelet transform works on basic principle of breaking signal in to shift and scaled version of mother wavelet [5]. Wavelet is more advantageous as it has inherent capability toreveal hidden features of waveform and perform multi-resolution analysis.

DWT is defined as

$$DWT\ f(m, n) = \sum f(t)\, \psi_{m,n}(t) \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

In dwt filter band structure is used in which the approximate level coefficient of lower level are passed through a high pass and low pass filter followed by a down sampling by 2 to compute both the detail and approximate level coefficient at higher level[5]. In this paper five level decomposition is used, chosen arbitrarily as shown in fig.2.

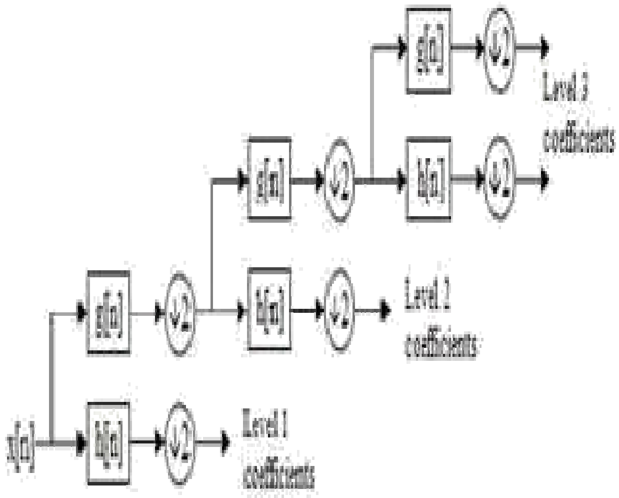

Figure 2: Wavelet decomposition

Detailed and approximate level coefficients level of Id and Iq for healthy system obtained using wavelet are as shown in fig.3. and fig.4.

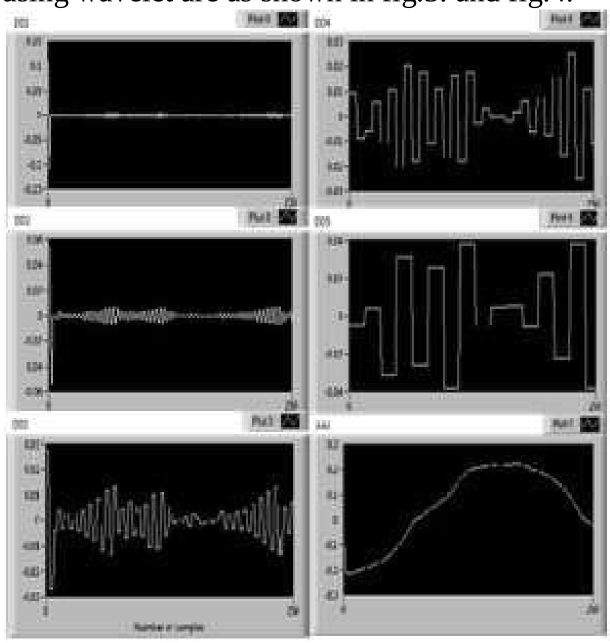

Figure 3: Detailed and approximate level coefficients level of Id for healthy system

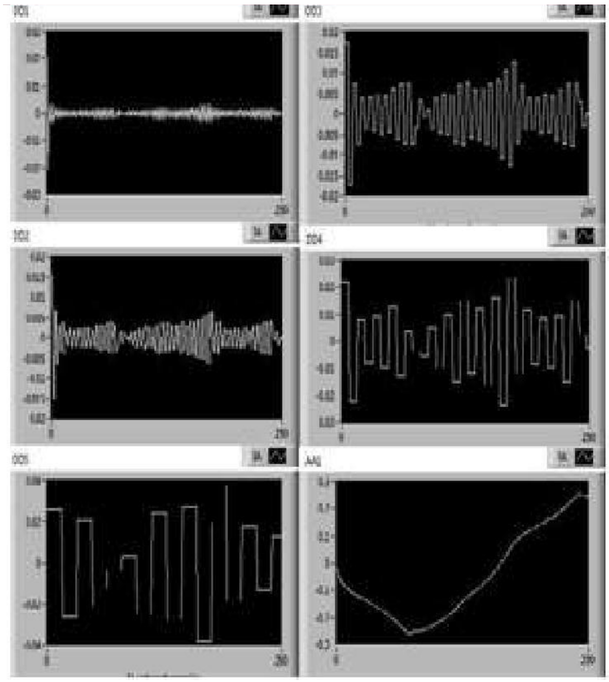

Figure 4: Detailed and approximate level coefficients level of Iq for healthy system.

Experimental Setup: Setup consist of 3 H.P, 415 V, 4 pole, 50HZ 3 phase Induction motor with a special arrangement of stator turn available outside the motor structure for shorting them intentionally with the help of switch. Number of turns per phase is 180 with each set of tapping consisting of 5 turn and has capacity to bear 30-40 turns short circuit fault with mechanical loading arrangement as shown in Fig.5.

To measure data and make available for analysis to computer tools "NI USB-6212" with 16 inputs, 16bit,

400KS/s multifunction input output device is used as shown Fig.6. Known as data acquisition card (DAQ). The current and voltage signals are captured at sampling frequency of 16.89 KHz with the help of NATIONAL INSTRUMENT DAQ Which is shown in Figure.6. The Different experiments are carried out on laboratory test bench in healthy condition and inter-turn short circuit with 5, 10, 15, and 20 turns short circuited.

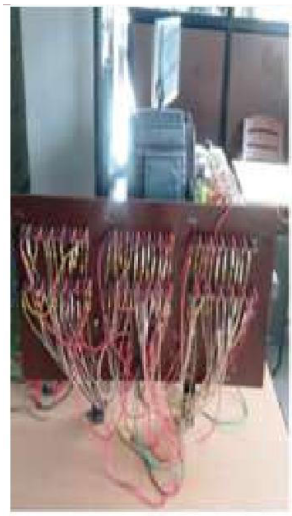

Figure 5: Experimental set up.

Figure 6:DAQ System.

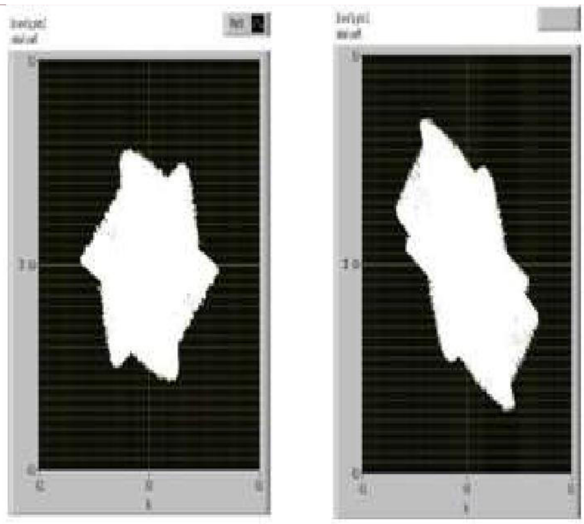

Figure 7: Plot of Id & Iq of dd5 (no load).

The stator currents (Id & Iq) at different turns short circuited are measured and analyzed by NI DSO and wavelet respectively such as 5turn, 10turn, 20turn, 25turn at the sampling frequency rate of 16.89khz.

Feature Extraction Using dwt: The data measured by NI is given as input to wavelet (db) for extracting features for various fault conditions .5th level detailed coefficients of both Id and Iq are plotted as shown in fig. And are analyzed for no load as well as for 50% load on IM as shown in fig.7. In this paper features extracted are PVM of dd5, Id/Iq, Inclination Angle as shown in Table.1. and Table .2.

Table1: Extracted feature (NOLOAD)

PVM	Id/Iq	Inclination Angle	Turn Short
0.0634764	1.03019	45.85	0
0.0670289	0.922553	42.69	5
0.0728082	0.795811	38.51	10
0.0868795	0.620498	31.81	15
0.0950122	0.597069	30.84	20

Table2: Extracted feature (ONLO

PVM	Id/Iq	Inclination Angle	Turn Short
0.0849088	1.10462725	47.846	0
0.08100	0.9123	44.872	5
0.712154	0.84215	42.503	10
0.691254	0.79654	34.258	15
0.54789	0.658741	26.214	20

Fuzzylogic : Fuzzy depends on set of rules specified in its database and are used as input to make decision are also known as linguistic rules as approach of fuzzy based system works as human brain with respect to rules specified [7] .fuzzy based decision are accurate only if linguistic rules are build with greater analysis and also on number of member functions.

A. Design of Fuzzy Fault Detector: The extracted features are given to fuzzy as input to discriminate between stator inter turn fault severity ranging between 0-1.here „Inclination Angle" and „PVM" are used as inputs to fuzzy to decide FSI. Certain set of rules are derived with available data for both no load and 50% load condition which will act as look up table for fuzzy (mamdani). With the help of this data (set of rules) fuzzy is trained and able to evaluate fault severity index [7].FSI specified for number of turns short circuited is as given in the table.

Set of rules for no load and load conditions are valuated separately for the fuzzy. No load current drawn by IM is approximately 30% of full load which discriminate between load and no load condition.

Table3: Fault y Index for healthy, less, more fault

Sr. No	FSI	TYPE OF FAULT
1	0	HEALTHY
2	0.1-0.5	LESS FAULT (5,10,turn short)
3	0.5-1	MORE FAULT (20, 25 and above turn short)

Results: To define set of rules for fuzzy , under each fault (stator inter turn) condition 10set of readings were taken to decide range of member functions(IA and PVM) And also with healthy system as reference and all the data is fed as input to fuzzy and verified experimentally as shown in fig. With the increase in number turn short circuit fault FSI increases linearly which calibrates the aim of paper.

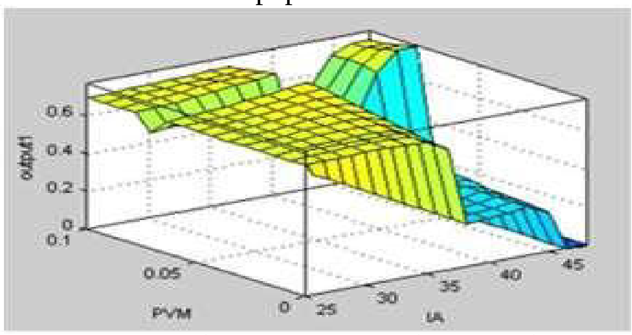

Fig 9. Graph of FIS, IA, PVM (fuzzy surface

viewer)

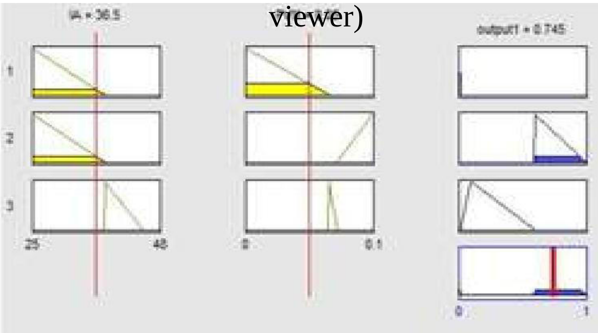

Fig 10. FSI indicator for major fault.

Fig. shows FSI for major fault i.e. in this paper 20 and above turn short circuited.

Conclusion: This paper has proposed a methodology by which IM stator inter turn fault severity can be diagnose. The proposed methodology was based on the parks transformation theory

Obtained Id and Iq spectrums were analyzed for feature extraction using wavelet transform and detailed level coefficient were plotted and the available data was as fed as input to fuzzy for decision evaluation. The results were verified both online and offline and the proposed system succeeded to calculate severity index of inter turn fault. Further the proposed algorithm with evaluated member functions with same technique can be implemented for different types of fault, and with the help of energy obtained for detailed level coefficients using parsvel‟s theorem too faults can be differentiated.

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