DISSOLVED-GAS-ANALYSIS-BASED INTELLIGENT EXPERT SYSTEM FOR POWER TRANSFORMERS FAULTS DIAGNOSIS AND INSULATION OIL QUALITY ASSESSMENT

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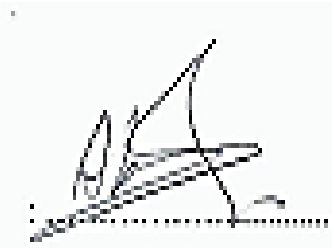
Signature : 

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ABSTRACT

Accurate diagnoses of faults and assessment of insulation oil quality in electrical power transformers for life-long maintenance are ever demanding. Transformers insulation excellence is known to deteriorate over time because of temperature fluctuations and moisture contents, which significantly affects its durability and functionality. Developing an intelligent programme for precise and efficient determination of transformers faults types and oil quality evaluation in the early stages are key challenges in protecting transformers from potential failures that occur during operation to avoiding economic losses. Dissolved gas analysis (DGA) being a reliable method is used to develop an intelligent expert system for faults diagnoses and insulation oil quality assessment in power transformers. Implementation of artificial intelligence (AI) including fuzzy logic, expert system (ES), and artificial neural network (ANN) made the DGA analysis confirms to the standards. This comprehensive DGA based intelligent expert system is demonstrated to be capable of diagnosing all types of potential faults accurately and assessing the quality of insulation oil efficiently via the ratio methods of Rogers, IEC and Doernenburg. The developed algorithm used three approaches, namely traditional C++ programming language, ES based adaptive neuro-fuzzy inference system (ANFIS) and ES based on ANN as per the standards of IEEE, C57-104 and IEC 60599 specifications. These approaches were compared and the optimum one was determined. The proposed algorithm is trained via back propagation and matched with IEC standard to identify the faults type. Single filtering and degassing, double filtering and degassing and reclamation processes are used in the absence of oil. Using the ANN expert system, the achieved accuracy is 96% for the faults diagnosis process and 98% for the evaluation of the quality of insulation oil compared to the actual results. Experimental results revealed that the proposed expert system based on ANN is highly accurate in terms of diagnosing the faults is oil insulation quality evaluation in high voltage power transformers. Results of the proposed method are statistically analyzed and compared with the existing techniques.

CONCLUSIONS AND FUTURE WORK

5.1 Conclusions

The purpose of the present thesis is to develop DGA based accurate intelligent expert system for power transformers faults diagnosis and insulation oil quality assessment. Based on the statistical analyses of the experimental data the following conclusions are made.

A DGA based intelligent expert system with ANN and ANFIS are succesfully developed for precise fault diagnosis and simultaneous assessment of the insulation oil quality in power transformers. A computer algorithm using visual C++ software based on the methods of Rogers's ratio, IEC ratio and Doernenburg's ratio is written and the transformers faults type as well as the insulaion oil quality is assessed. The proposed ES based proposed intelligent algorithm demonstrated to be accurate in determining the transformers fault types and insulation oil quality simultaneously. A comparison of the three developed approaches with the actual measurement revealed the superiority of the proposed methods in terms of accuracy and efficiency. Thus, the proposed intelligent expert system is more robust for implementation than the existing traditional techniques.

The authenticity of the developed intelligent ES is judged by examining their reliability and accuracy, where the experimental results are compared with the actual real results acquired from the Malaysia's National Electricity Company (TNB). The accuracy of the expert systems based on ANNs is determined to be more precise with tiny error and high matching percentage. The training process of the NNs is performed via back-propagation algorithm, which reduced the error rates significantly for the diagnosis of faults and assessing the insulating oil quality with appropriate treatment. The need for more than one DGA method is justified because a single method often cannot accurately diagnose the faults and access the oil qulity. Thus, more than one ratio method is used to enhance the accuracy of the results by reducing the error rate.

The advantages of the ANN technology are greatly exploited in building the proposed intelligent ESs so that they outperform the techniques based on traditional programming in terms of percentage of error and matching ratio. To achieve this goal, the expert systems are designed based on the standard specifications (IEE Standared C57-104 and IEC 60599). It is demonstrated that the present system obeys these standards (specification tables) and can recognize faults depending on the proportion of dissolved gases. The network trained the samples and reduced the error rates remarkably. The construction of the proposed expert systems relied on the knowledge base and inference engine, where the knowledge base is familiar with all the faults types that are expected to occur in DGA as well as assessing insulation oil quality by determining the deterioration of insulation coefficient. This is calculated through combustible gases dissolved in the oil and the appropriate treatment for the oil is emphasized.

The performance of the proposed approaches is compared with the traditional approach and other existing intelligent expert systems. The developed DGA based intelligent ES is discerned to be much superior for transformer faults type diagnosis and oil quality assessment than the traditional program. Furthermore, the intelligent expert systems based ANFIS revealed some variation in the diagnosis and evaluation process and failed to diagnose the malfunction of the transformer. Intelligent expert systems based on ANN produced the best results. The traditional approach is based on visual Studio in C++ program and the intelligent expert systems was designed via MATLAB code based on GUI technique. They are used to build the user interface and the expert technology (ANN and ANFIS) in the design of inference engine and knowledge base. The implementation of these intelligent expert systems is affirmed to be successful for precise diagnoses of transformers faults type and insulating oil quality assessment.

Because the using faults diagnostic and assessing the quality of insulation oil separately and also poor insulating oil in transformers because the dissolved gases and moisture lead to sudden faults, It was necessary to determine the objective to resolve the problem through develop a DGA based on intelligent expert system and traditional approch for fault diagnosis and simultaneous assessment of the insulation oil quality in power transformers. By using visual C++ software and intelligent expert system an applying the ANN and ANFIS technique based on the methods of Rogers's ratio, IEC ratio, Doernenburg ratio and TCG method, for faults diagnosis and assessing the insulation oil quality in the same time

The maintenance teams in the substations,Information needs to be attributed to the dissolved gases to avoid the emergence of sudden faults in transformers because lead to economic losses,so must determine the transformers fault and assess insulation oil quality simultaneously to avoid this losses.

Some of results in used traditional methods for the fault diagnosis in power transformers inaccurate,in this study, compared tothe accuracy and efficiency of the proposed intelligent expert system with traditional approaches, by using SPSS software toanalyze and compare the results to choose the best method.

5.2 Recommendations for Future Work

This thesis used intelligent techniques to diagnose faults and assessing quality of oil insulating simultaneously. In spite of the achievements of the objectives proposed several other aspects need to be cover for further improvement in the fault diagnosis and assessing of the insulating oil in power transformers. It is hoped that further improvements may significantly help to diagnose the occurred fault and oil contamination in all submerged transformer. Based on the results achieved and the limitations the following recommendations are made:

- It is worth to improve the work of the expert system through the use of sensors for the detection of dissolved gases in the transformer insulating oil. These sensors will be able to detect the gas rates without reference to the sampling of oil and sending to the laboratory for analysis to determining the values of gas ratios [108]. Sensor technology will remarkably improve the accuracy of fault diagnosis and oil quality evaluation.

- Future expert systems must work online after the data signal is transferred from the sensors and the values of the detected gas to the expert system, which in turn will make the diagnosis and evaluation more robust [109].

- It is important to explore the possibility of using other techniques such as genetic algorithm (GA) in building more accurate expert systems for fault diagnosis and oil quality assessment.

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