Data Mining Approach With IEC Based Dissolved Gas Analysis For Fault Diagnosis Of Power Transformer

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Abstract

Dissolved gas analysis (DGA) is a powerful diagnostic technique foe monitoring the internal condition of transformer as it is capable of detecting faults in the incipient stage, before they develop into major faults and result in outage of transformer. In this paper we evaluate different transformer condition on different cases. This paper uses dissolved gas analysis to study the history of different transformer in service, from which dissolved combustible gases (DCG) in oil are used as a diagnostic tool for evaluating the condition of the transformer. In this paper we present data mining approach and IEC ratio method. By using data mining concepts we can categorize faults and also map the percentage of fault. This is an efficient approach for fault diagnosis of power transformer where we can find the fault in all obvious conditions. We use java for programming.

Keywords
DGA, IEC method, data mining, fault diagnose (FD)

I. INTRODUCTION

THE WORKING state of a power transformer is a vital element in assessing the safety and reliability of a power system. A failure of a power transformer may cause a serious outage of an electrical network. Therefore, many efforts have been dedicated to the incipient fault detection of power transformers, out of which dissolved gas analysis (DGA) is a widely used one. DGA is based on the fact that transformer faults, mainly in the form of thermal, arcing, and partial discharge (PD), can be detected by analyzing dissolved gases in the insulation oil of a transformer. The ratios of specific dissolved gas concentrations are processed using predefined criteria [1]. This analysis can indicate one or more possible fault states of a transformer and thus allows taking necessary preventive measures. In the past, various criteria for DGA have been developed, such as the Rogers, Dornenburg, key gas methods, etc[1].In these methods ,the fault diagnosis (FD) criteria are mainly established based upon the key gas (e.g. hydrogen (H2), methane (CH4), ethane (C2H6), ethylene (C2H4), acetylene (C2H2), carbon monoxide (CO), carbon dioxide (CO2), etc.) concentrations or their mutual comparison ratios, with which the working state of a transformer can then be evaluated against preset thresholds [1].

The main limitation of the earlier conventional methods is that the predefined criteria are established upon empirical studies. In some cases, measured gas concentrations or ratios may be incomplete and thus do not fit within the predefined criteria. As a result, faults that occur inside transformers may not be identifiable. On the other hand, in practice, different DGA methods often produce different judgments when processing the same dissolved gas record [2]. Hence, power engineers are often forced to use several DGA methods and other related information about a transformer ,e.g. previous operation history of the transformer, results of the latest inspection, states of no-load tap changer, and so on [3] to assess the working state of the transformer, which obviously is not a convenient way.

Insulating oils suffer from deterioration, which can become fatal for transformers. Also, discharge in oil can cause serious damage to the other insulating materials, making the monitoring of power transformers insulation an important task. When insulating oils and cellulose materials in reactive equipment are subjected to higher than normal electrical or thermal stresses, they decompose to produce certain combustible gases referred to as fault gases. For incipient fault conditions (i.e. slowly evolving fault), the gases generated will be dissolved into the oil long before any free gas is accumulated in the gas relay. Thus by analyzing oil sample for dissolved gas content it is possible to assess the condition of the equipment and detecting faults at an early stage. If a fault is indicated, the type of fault can be predicted using various analysis methods.

A large number of techniques are available for transformer health monitoring. However, a focused approach is required for diagnostics. Considering the long service life of a power transformer and prevalent use of human judgment (expert), there is a need to structure a knowledge base around expert knowledge while continuing to create new diagnostic capabilities which can be plugged in. This paper gives an overview about how fusion of data mining based techniques can be used in diagnostics of power transformers.

The remaining of this paper is organized as follows. We discuss DGA in Section 2. In Section 3 we discuss about IEC. The Evolution and recent scenario in section 4.In section 5 we discuss about proposed approach. The conclusions and future directions are given in Section 6. Finally references are given.

II. DGA

Dissolved gas analysis (DGA) is the study of dissolved gases in insulating fluid such as transformer oil. Insulating materials within transformers and electrical equipment break down to liberate gases within the unit. The distribution of these gases can be related to the type of electrical fault, and the rate of gas generation can indicate the severity of the fault. The identity of the gases being generated by a particular unit can be very useful information in any preventative maintenance program. The collection and analysis of gases in an oil-insulated transformer was discussed as early as 1928. Many years of empirical and theoretical study have gone into the analysis of transformer fault gases.

DGA usually consists of three steps: Sampling, extraction, analysis. Modern technology is changing this process with innovation of DGA units that can be transported and used on site as well as some that come directly connected to the transformer its self. Online monitoring of electrical equipment is an integral part of the smart grid. Though this new technology is promising often oil quality labs are still utilized as third party verification. Also upgrading all equipment to meet the goals of the smart grid can be cost prohibitive.

Power transformers, being key components in any electrical network, require mindful operation and maintenance, in order to obtain safe and optimum working life. As transformers age, monitoring of their condition becomes more vital, with surveillance and diagnostic techniques being needed to prevent the possibility of surprise failures. Dissolved Gas Analysis (DGA) is a fundamental technique in establishing fault mechanisms in oil-filled power transformers. In its simplest form, DGA analyzes the relative amount of three gasses in transformer oil: CH_4, C_2H_4 and C_2H_2

(methane, ethylene and acetylene) these gases are discharged from the insulation system (paper, wire) to the oil under detrimental conditions. Empirical measurements of the relative percentage of these gasses in the oil have been mapped to specific problems in the transformer.

According to Richard Green [4] the dissolved gas analysis (DGA) technique is an important tool for monitoring and troubleshooting a transformer's operational condition. There are four basic transformer fault types, categorized by severity. [5] Arching, the most severe transformer fault, produces significant amounts of hydrogen and acetylene as the mineral oil breaks down from the electrical discharge. If cellulose insulating paper is exposed to the arching, then CO2 and CO will be generated.

Next in severity is localized heating or sparking due to intermittent high voltage flash without current. The symptomatic gases produced are increased levels of methane and ethane. Third in severity is localized overheating. Overheating, as an example, may be caused by electrical contact failure, which produces ethylene and methane gases. If severe overheating occurs, then trace amounts of acetylene may be present.

Transformer oil sample analysis is a useful, predictive, maintenance tool for determining transformer health. Along with the oil sample quality tests, performing a dissolved gas analysis (DGA) of the insulating oil is useful in evaluating transformer health. The breakdown of electrical insulating materials and related components inside a transformer generates gases within the transformer. The identity of the gases being generated can be very useful information in any preventive maintenance program. There are several techniques for detecting those gases and DGA is recognized as the most informative method.

The two principal causes of gas formation within an operating transformer are electrical disturbances and thermal decomposition. All transformers generate gases to some extent at normal operating temperatures. Insulating mineral oils for transformers are mixtures of many different hydrocarbon molecules, and the decomposition processes for these hydrocarbons in thermal or electrical faults are complex. The fundamental chemical reactions involve the breaking of carbon hydrogen and carbon- carbon bonds. During this process, active hydrogen atoms and hydrocarbon fragments are formed. These fragments can combine with each other to form gases: hydrogen (H2), methane (CH4), acetylene (C2H2), ethylene (C2H4), and ethane (C2H6).

III. IEC Ratio Method

Like a doctor perform different test for the disease, DGA can warn about the problem or fault in oil. It diagnosis and increases the chances of finding the appropriate cure. The detection of incipient faults in oil immersed transformers by examination of gases dissolved in oil, developed from original Buchholz relay application. According to N. A. Muhamad et al. [7] Gas Chromatograph (GC) is the most practical method available to identify combustible gases. GC involves both a qualitative and quantitative analysis of gases dissolved in transformer oil [8].

According to N. A. Muhamad et al. [7] there are several approaches which are used for DGA. Some among them are Norms Method, Gas Ratio Method and Key Gas method. In condition monitoring, the advantage of using ratio method is that, they overcome the issue of volume of oil in the transformer by looking into the ratio of gas pairs rather than absolute values.

This method originated from the Roger's Ratio method, except that the ratio C2H6/CH4 was dropped since it only indicated a limited temperature range of decomposition [3].

Although Roger's Ratio and IEC Ratio are useful, the drawback of these ratio methods is that there can be some combinations of gases that do not fit into the specified range

Here, the remaining three gas ratios have different ranges of code as compared to the

Roger's ratio method and they are shown in table 5. The faults are divided into nine different types as listed in table

Table 1: IEC Ratio Codes

Ranges of the Gas Ratio	**Codes of Different Gas Ratio**		
	$C_2H_2\backslash C_2H_4$	**$CH_4\backslash H_2$**	**$C_2H_4\backslash C_2H_6$**
<0.1	0	1	0
0.1-1	1	0	0
1-3	1	2	1
>3	2	2	2

Table 2 : Fault types according to the IEC Gas Ratio Codes

Fault Type Number	**Fault Type**	**C_2H_2/ C_2H_4**	**CH_4 /H_2**	**C_2H_4/ C_2H_6**
1	No Fault	0	0	0
2	<150 ^{0}C Thermal Fault	0	0	1
3	150^{0}C-300^{0}C Thermal Fault	0	2	0
4	300^{0}C -700^{0}C Thermal Fault	0	2	1
5	>700 ^{0}C Thermal Fault	0	2	2
6	Low Energy PD	0	1	0
7	High Energy PD	1	1	0
8	Low Energy Discharge	1 or 2	0	1 or 2
9	High Energy Discharge	1	0	2

But, the drawback of these ratio methods is that it fails to cover all range of data and quite fall outside the scope of tables. To overcome this problem, in this paper we use data mining with IEC ratio is used to overcome the drawback and combine both codes.

DGA Sample Data with IEC Method

S.NO	H_2	CH_4	C_2H_4	C_2H_6	C_2H_2	FAULT CODE	FAULT TYPE
1	4.5925	24.797	13.8563	14.707	.003033	3	150^0C-300^0C Thermal Fault
2	5.3862	.4166	.028271	.04776	.000408	6	Low Energy PD
3	1.6427	1.4899	.5277	7.4315	.00452	1	No fault
4	4.1159	.8980	2.5779	.9623	.03779	2	<150 ^{0}C Thermal Fault
5	1.7011	1.1971	.8177	.117	.1293	9	High Energy Discharge
6	1.8589	3.108	3.212	2.148	.00807	4	300^0C -700^0C Thermal Fault
7	.3985	5.5257	4.442	.8250	.00277	5	>700 ^{0}C Thermal Fault
8	.5585	.1546	.0041	.000846	.01696	8	Low Energy Discharge
9	30.991	2.8591	.6192	.6374	.06910	7	High Energy PD
10	4.4171	.3517	.1288	.0297	.005011	-	Null
11	4.3368	1.0566	.9231	.2002	.002501	-	Null
12	6.0646	12.025	15.713	.6513	.001383	5	>700 ^{0}C Thermal Fault
13	2.7011	1.1871	.7167	.217	.2293	9	High Energy Discharge
14	.1487	.9906	.1008	.0745	.00965	4	300^0C -700^0C Thermal Fault
15	6.8729	2.2421	.1700	.4064	.00599	1	No Fault
16	30.991	2.8591	.6192	.6374	.06910	7	High Energy PD
17	2.6080	18.9712	2.7400	39.848	.00415	3	150^0C-300^0C Thermal Fault
18	1.7020	.2414	.2545	.2089	.00405	2	<150 ^{0}C Thermal Fault
19	5.7787	.5458	.07298	.1546	.00692	6	Low Energy PD
20	.7683	.7255	.00873	.1139	.00994	-	Null
21	7.9165	4.3174	5.211	3.284	1.8652	-	Null

IV. Evolution and Recent Scenario

In 2008, Dr. D.V.S.S. Siva Sarma et al. [12] discuss Non-Destructive Evaluation of Power transformer by monitoring various parameters, to predict its in- service behavior, is very much necessary for operating engineer to avoid catastrophic failures and costly outages. Dissolved Gas Analysis (DGA) is an important tool for transformer fault diagnosis. The ratio methods used in the DGA have an advantage that they are independent of volume of gases involved. But the main drawback of the ratio methods is that they fail to cover all ranges of data and ambiguity about the boundaries of gas ratios in diagnosing the fault. Artificial Intelligence techniques like Artificial Neural Network (ANN), Fuzzy Logic (FL) and Extension Neural Network (ENN) are used to overcome the above drawbacks, and the results of various methods are compared in their research.

In 2008, Zhang Wei-zheng et al. [13] about the Fisher rule to evaluate the results of the two pretreatment methods is also introduced.

The evaluation of the results indicates that both of the two data pretreatment methods can achieve the purpose of big difference in the value of mean between classes and small difference in dispersion of a class. The DGA data of the failure transformers are treated by different normalization methods as the training samples, and then the samples are trained in the compound neural networks which use the CP algorithm. The diagnosis results of the test samples indicate that the new methods may help to improve the precision of network diagnosis.

In 2009, C.K. Diwedi et al. [14] discusses from the test results, it is observed that the transformer which has very good result. Winding cellulose paper may be aged to such an extent (assessed from DP) that may sudden force or transient may result in failure. DP cannot be conducted regularly to ascertain mechanical integrity of the winding paper. FURAN analysis is a substitute for DP. But most of time, Furans are not detected and there is no universal correlation available for DP and Furan.. Both, the moisture content and ageing of paper influences furan. Frequency response analysis gives the information regarding the movement of winding but does not give much, information above mechanical integrity of winding which is essential for transformer reliability. They proposed, an approach has been made to compare the moisture content in the winding from RVM and estimated from oil ppm (using Norris diagram) and estimated from winding DLA.

In 2009, Z. Yang et al. [10] present a novel association rule mining (ARM)-based dissolved gas analysis (DGA) approach to fault diagnosis (FD) of power transformers. In the development of the ARM- based DGA approach, an attribute selection method and a continuous datum attribute discretization method are used for choosing user-interested ARM attributes from a DGA data set, i.e. the items that are employed to extract association rules. The given DGA data set is composed of two parts, i.e. training and tests DGA data sets. An ARM algorithm namely Apriori-Total from Partial is proposed for generating an association rule set (ARS) from the training DGA data set. Afterwards, an ARS simplification method and a rule fitness evaluation method are utilized to select useful rules from the ARS and assign a fitness value to each of the useful rules, respectively. Based upon the useful association rules, a transformer FD classifier is developed, in which an optimal rule selection method is employed for selecting the most accurate rule from the classifier for diagnosing a test DGA record. For comparison purposes, five widely used FD methods are also tested with the same training and test data sets in experiments. Results show that the proposed ARM-based DGA approach is capable of generating a number of meaningful association rules, which can also cover the empirical rules defined in industry standards.

In 2010, Bálint Németh et al. [15] deal with an expert system that utilizes fuzzy logic implementation into dissolved gas in oil analysis technique. To improve the diagnosis accuracy of the conventional dissolved gas analysis (DGA) approaches, this part proposes a fuzzy system development technique based combined with neural networks (fuzzy-neural technique) to identify the incipient faults of transformers. Using the IEEE/IEC and National Standard DGA criteria as references, a preliminary framework of the fuzzy diagnosis system. Then they deals with artificial neural network (ANN) based fault diagnosis is presented, which overcomes the drawbacks of the previously applied fuzzy diagnostic system that is it cannot learn directly from the data samples. This expert system also considers other information of transformer such as type, voltage level, maintenance history, with or without tap changer etc. These proposed approaches provide the user a more accurate result and better condition awareness of the transformer.

V. Proposed Approach (IEC+Datamining)

1. Our approach is based on IEC ratio method where we can find the fault efficiently and accurately. Our proposed algorithm is shown below1. Insert the ratio of H2, CH4, C2H4, C2H6 and C2H2.[Figure 2]
2. Generate Gas Ratio Rule which is CH4/H2, C2H2/C2H4, and C2H4/C2H6. IEC Ratio Method Uses the Following Three Ratios: CH4/H2, C2H2/C2H4, and C2H4/C2H6. [Figure 3]
3. Find the Fault according to the condition given in table 1 and table 2
4. Apply association Rules:
5. Pattern is generated.
6. Rules are accepted with the help of support
7. Faults are found according to the the support

Our approach finds all most all type of faults according to the fault type which are in accordance of IEC table with the help of association rule mining. According to Sotiris Kotsiantis et al. [16] Association rule mining is one of the most important and well researched techniques of data mining, was first introduced in [17]. It aims to extract interesting correlations, frequent patterns, associations or casual structures among sets of items in the transaction databases or other data repositories. Association rules are widely used in various areas such as telecommunication networks, market and risk management, inventory control etc. Various association mining techniques and algorithms will be briefly introduced and compared later. Association rule mining is to find out association rules that satisfy the predefined minimum support and confidence from a given database.

Data mining is finding important information from raw data .it is knowledge minig from data. ARM is a kind of data mining technique . Basic idea of ARM in DGA is to generate association relationship between set of key gases and transformer working state i.e. various fault class or no fault .the derived association relationship are then interpreted as a set of association rule which can be used for transformer fault diagnose(FD) As a supplement of classification rules defined in the conventional method .

ARM is a kind of data mining techniques, which can discover significant association rules between items in a database [23]. In ARM, one item extracted from a database record, e.g. a gas ratio or a working state label from a DGA record, can be defined as an attribute. The main task of an ARM process is to discover potential relationships and correlations among user- interested attributes. The generated association relationships are then interpreted as a set of association rules. Briefly, the main procedures of ARM can be described as follows: let I =[i1,i2,...,in] be a set of selected items, i.e. at- tributes. Define T to be a set of training data, e.g. DGA records. Each record R
in T is composed of several attributes and as- signed with a unique identifier. Also, $R \subseteq I$.
LetA and B be two sets of attributes. A specific record Rt from T contains A if and only if $A \subseteq Rt$. An association rule is defined in the following form: $A \rightarrow B$ (1) where $A \subset I$, $B \subset I$, and $A \cap B = \emptyset$. In (1),A and B ar edefined as the antecedent and consequent of the rule respectively. The expression means that if A is presented in Rt, then B is likely presented in Rt as well. IEC + DM approach is work in the following manner.

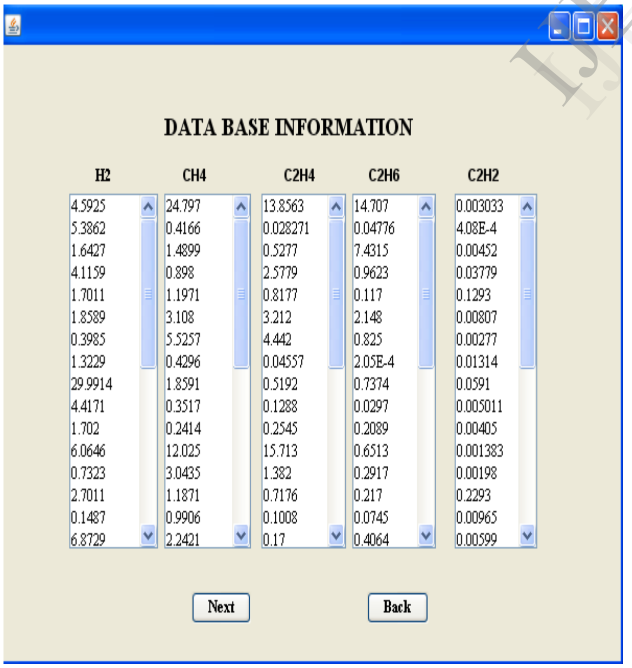
1) If the pattern is found from the IEC method the fault is returned according to the IEC method.
2) If the pattern is not found then we choose the minimum associated rule from the IEC Rule table.
3) Because we associate related Items , this approach provides a good and efficient way of finding faults.

The sample for this study and analysis is taken from Office of The Executive Engineer, Testing Divison II, MPPTCL Nayagaon Jabalpur , Oil Testing Laboratory.

VI. **Conclusion and Future Directions & Results**

The main procedures of our approach are developed, including data preprocessing, rule discovery with Association Rule Mining (ARM). Then, with the useful rules extracted from a generated ARM, a fault is found. For comparison purposes, we can input set of ratio using IEC approach. Drawback of the ratio method is that there can be some combinations of gases that do not fit into the specified range is overcome with the help of data mining. With the help of data mining fault is found where the method failed to cover range and with based on association individual proportion of the particular range of particular ratio is found which will help to find the general pattern of the IEC method according to table1 and 2

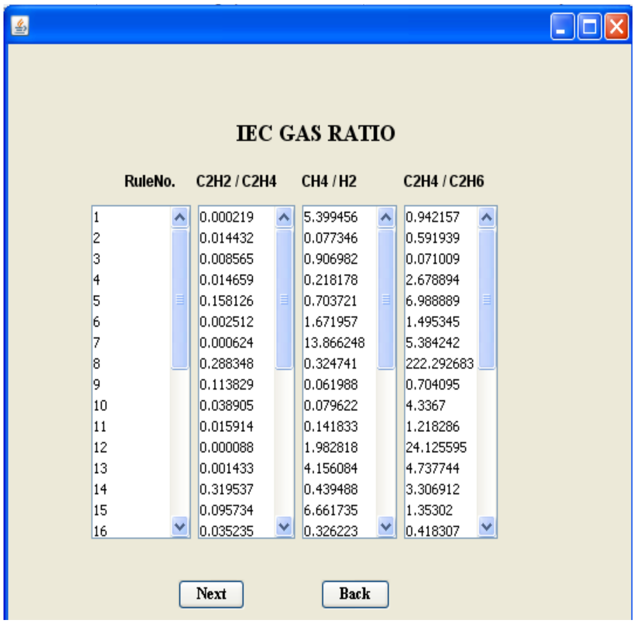
Multiple faults can also be find with the help of data mining.



DATA BASE INFORMATION

H2	CH4	C2H4	C2H6	C2H2
4.5925	24.797	13.8563	14.707	0.003033
5.3862	0.4166	0.028271	0.04776	4.08E-4
1.6427	1.4899	0.5277	7.4315	0.00452
4.1159	0.898	2.5779	0.9623	0.03779
1.7011	1.1971	0.8177	0.117	0.1293
1.8589	3.108	3.212	2.148	0.00807
0.3985	5.5257	4.442	0.825	0.00277
1.3229	0.4296	0.04557	2.05E-4	0.01314
29.9914	1.8591	0.5192	0.7374	0.0591
4.4171	0.3517	0.1288	0.0297	0.005011
1.702	0.2414	0.2545	0.2089	0.00405
6.0646	12.025	15.713	0.6513	0.001383
0.7323	3.0435	1.382	0.2917	0.00198
2.7011	1.1871	0.7176	0.217	0.2293
0.1487	0.9906	0.1008	0.0745	0.00965
6.8729	2.2421	0.17	0.4064	0.00599

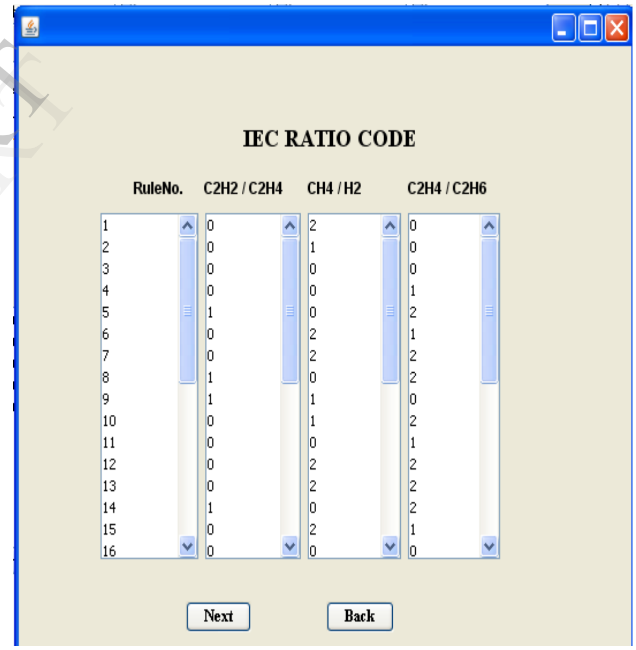
Figure 1 sample database



IEC GAS RATIO

RuleNo.	C2H2 / C2H4	CH4 / H2	C2H4 / C2H6
1	0.000219	5.399456	0.942157
2	0.014432	0.077346	0.591939
3	0.008565	0.906982	0.071009
4	0.014659	0.218178	2.678894
5	0.158126	0.703721	6.988889
6	0.002512	1.671957	1.495345
7	0.000624	13.866248	5.384242
8	0.288348	0.324741	222.292683
9	0.113829	0.061988	0.704095
10	0.038905	0.079622	4.3367
11	0.015914	0.141833	1.218286
12	0.000088	1.982818	24.125595
13	0.001433	4.156084	4.737744
14	0.319537	0.439488	3.306912
15	0.095734	6.661735	1.35302
16	0.035235	0.326223	0.418307

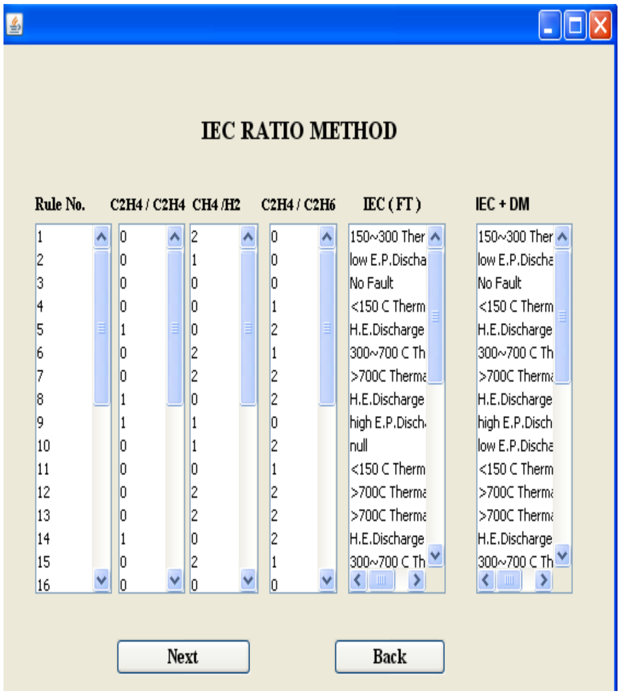
Figure 2 IEC Gas Ratio



IEC RATIO CODE

RuleNo.	C2H2 / C2H4	CH4 / H2	C2H4 / C2H6
1	0	2	0
2	0	1	0
3	0	0	0
4	0	0	1
5	1	0	2
6	0	2	1
7	0	2	2
8	1	0	2
9	1	1	0
10	0	1	2
11	0	0	1
12	0	2	2
13	0	2	2
14	1	0	2
15	0	2	1
16	0	0	0

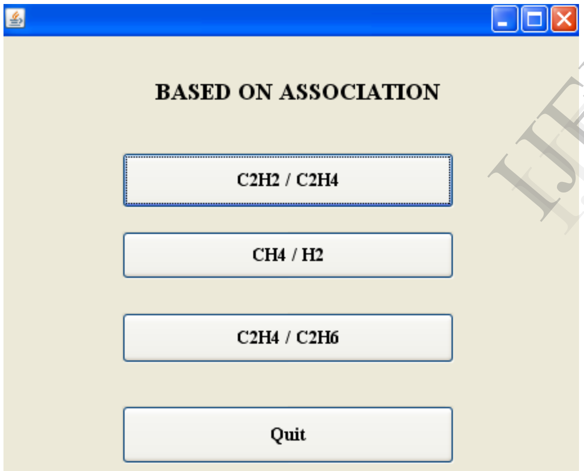
Figure 3 IEC Ratio Code



IEC RATIO METHOD

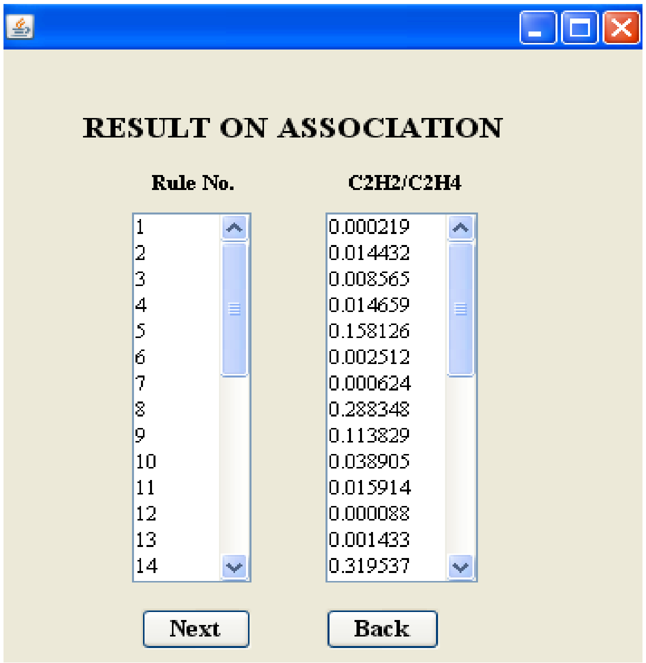
Rule No.	C2H4 / C2H4	CH4 /H2	C2H4 / C2H6	IEC (FT)	IEC + DM
1	0	2	0	150~300 Ther	150~300 Ther
2	0	1	0	low E.P.Discha	low E.P.Discha
3	0	0	0	No Fault	No Fault
4	0	0	1	<150 C Therm	<150 C Therm
5	1	0	2	H.E.Discharge	H.E.Discharge
6	0	2	1	300~700 C Th	300~700 C Th
7	0	2	2	>700C Therma	>700C Therma
8	1	0	2	H.E.Discharge	H.E.Discharge
9	1	1	0	high E.P.Disch	high E.P.Disch
10	0	1	2	null	low E.P.Discha
11	0	0	1	<150 C Therm	<150 C Therm
12	0	2	2	>700C Therma	>700C Therma
13	0	2	2	>700C Therma	>700C Therma
14	1	0	2	H.E.Discharge	H.E.Discharge
15	0	2	1	300~700 C Th	300~700 C Th
16	0	0	0		

Figure 4 Fault Type



BASED ON ASSOCIATION

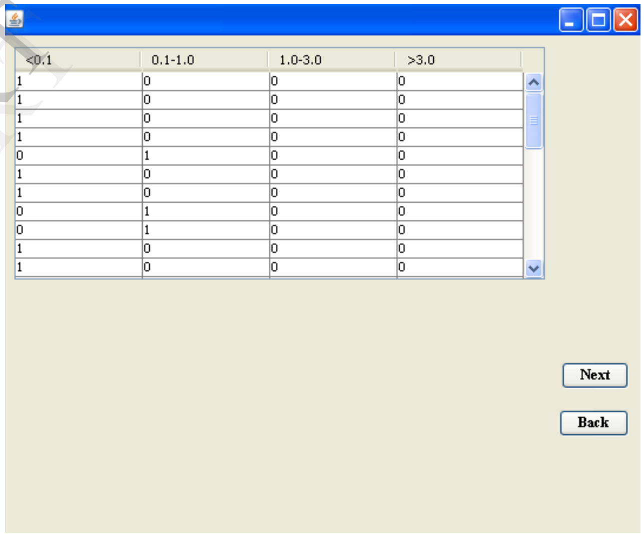
Figure 5 Based On Association



RESULT ON ASSOCIATION

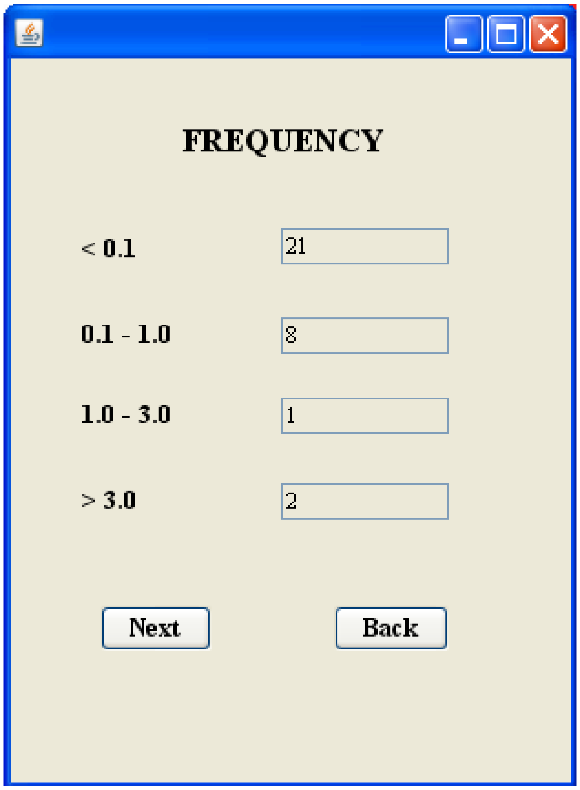
Rule No.	C2H2/C2H4
1	0.000219
2	0.014432
3	0.008565
4	0.014659
5	0.158126
6	0.002512
7	0.000624
8	0.288348
9	0.113829
10	0.038905
11	0.015914
12	0.000088
13	0.001433
14	0.319537

Figure 6 Results on Association



<0.1	0.1-1.0	1.0-3.0	>3.0
1	0	0	0
1	0	0	0
1	0	0	0
1	0	0	0
0	1	0	0
1	0	0	0
1	0	0	0
0	1	0	0
0	1	0	0
1	0	0	0
1	0	0	0

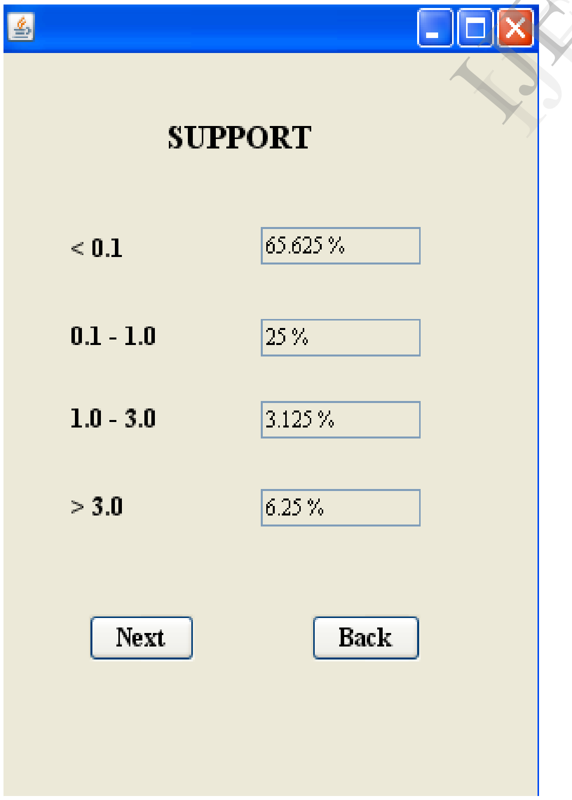
Figure 7 Fault Ranges



FREQUENCY

< 0.1	21
0.1 - 1.0	8
1.0 - 3.0	1
> 3.0	2

Figure 8 Frequency



SUPPORT

< 0.1	65.625 %
0.1 - 1.0	25 %
1.0 - 3.0	3.125 %
> 3.0	6.25 %

Figure 9 Support

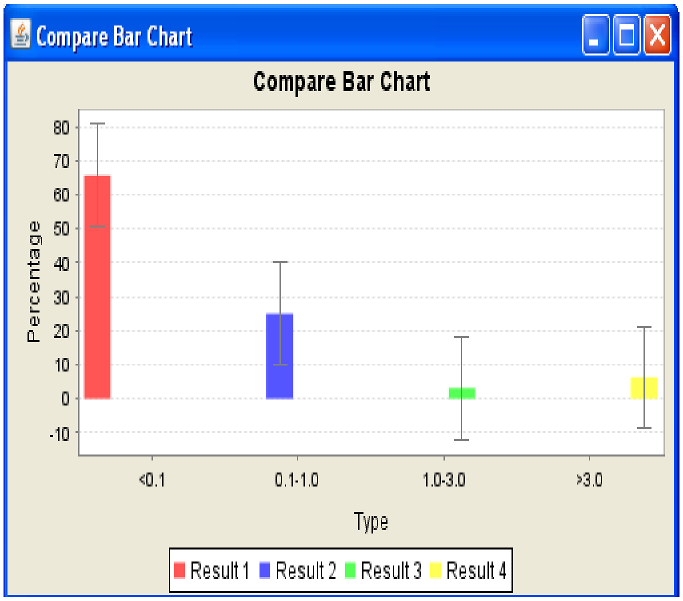


Figure10 comparision

S.NO	FAULT TYPE	IEC+DM
1	150^{0}C-300^{0}C Thermal Fault	150^{0}C-300^{0}C Thermal Fault
2	Low Energy PD	Low Energy PD
3	No fault	No fault
4	<150 ^{0}C Thermal Fault	<150 ^{0}C Thermal Fault
5	High Energy Discharge	High Energy Discharge
6	300^{0}C -700^{0}C Thermal Fault	300^{0}C -700^{0}C Thermal Fault
7	>700 ^{0}C Thermal Fault	>700 ^{0}C Thermal Fault
8	Low Energy Discharge	Low Energy Discharge
9	High Energy PD	High Energy PD
10	Null	Low Energy PD
11	Null	No fault
12	>700 ^{0}C Thermal Fault	>700 ^{0}C Thermal Fault
13	High Energy Discharge	High Energy Discharge
14	300^{0}C -700^{0}C Thermal Fault	300^{0}C -700^{0}C Thermal Fault
15	No Fault	No Fault
16	High Energy PD	High Energy PD
17	150^{0}C-300^{0}C Thermal Fault	150^{0}C-300^{0}C Thermal Fault
18	<150 ^{0}C Thermal Fault	<150 ^{0}C Thermal Fault
19	Low Energy PD	Low Energy PD
20	Null	High Energy Discharge
21	Null	High Energy Discharge

Fault According To Data Mining Result

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