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Condition Monitoring of Power Transformer using Fuzzy Logic in Matlab Software

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***Abstract:** This work did focuses on problem identification due to faults in power transformers during operation by using dissolved gas analysis such as key gas, IEC ratio, Duval triangle techniques, and fuzzy logic approaches. Then, the condition of the power transformer is evaluated in terms of the percentage of failure index and internal fault determination. Fuzzy logic with the key gas approach was used to calculate the failure index and identify problems inside the power transformer.*

I. INTRODUCTION

The Power Transformer is static device and one of the most important equipment in the electrical system are used for the step up or step down of electrical energy for transmission and distribution purpose. Power Transformer are the integral component of almost every transmission and distribution system. Power transformer might be subjected to several electrical and mechanical faults during operation. The continuity of service with high level of reliability is an important characteristics of an transmission system that requires continuous monitoring of system and its components.

There are several gases separated from the transformer oil in case of incipient fault. These gases are hydrogen (H2), methane (CH4), ethane (C2H6), ethylene (C2H4), acetylene (C2H2), carbon dioxide (CO2) and carbon monoxide (CO). In each type of fault, certain gases emerge at a higher rate,and the type of fault can be determined by looking at which gases emerge from it. In general, H2 and CH4 gases are formed in partial discharge fault, C2H4 and C2H6 gases occur in thermal faults and H2 and C2H2 gases occur in arc fault. The type and severity of the fault is determined by evaluating these gases with the oil dissolved gas analysis (DGA) method. There are many methods such as IEC ratio codes based on DGA, Rogers and Dornenburg.

II. CAUSES OF FAULTS

A transformer can be subjected to electrical and thermal stresses, which can damage the insulation materials and cause gas dissolution in the insulation oil. The causes of these faults are three main reasons: overheating, partial discharge and arc. Accurate detection of new faults is vital to the safety and reliability of a transformer.

III. NEED FOR CONDITION MONITORING

The equipments used in power transmission are very costly and the protection of all equipments are the considered primarily . The Power Transformer is the most important equipment in power transmission. If any is considered under faulty condition then the whole system is not realiable and convinient. So the necessity of Condition and Monitoring of Power Transformer.

MATLAB is a digital computing environment built on top of a simple scripting language, which make MATLAB perfect for rapid data analysis and testing. Here are the basic features of MATLAB. It is a high-level language for numerical computation, display and application development. It also provides an interactive environment iterative discovery, design, and problem solving. The MATLAB programming interface provides development tools to improve code quality maintainability and maximize performance.

IV. OPERATION WITH FUZZY LOGIC

Fuzzy Logic approach is a computerized calculation tool generally used to stimulate expert knowledge experience and automatic judgement without human action.

IEC ratio method applies three gas ratios R1, R2, and R3.

The ranges of each ratio are specified taking into account different types of faults, including Partial Discharge, Low Energy Discharge, High Energy Discharge, Thermal Fault Temperature lower than 300 ◦C, Thermal Fault between 300 to 700◦C, and Thermal Fault temperature greater 700 ◦C.

$R1 = \frac{C2H2}{C2H4}$, $R2 = \frac{CH4}{H2}$, $R3 = \frac{C2H4}{C2H6}$

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No	R1	R2	R3	Fault Type
1	NS	<0.1 (R21)	<0.2(R31)	KD(Partial Discharge)
2	>0.1 (R11)	0.1-0.5 (R22)	>1(R32)	D1 (Low Energy Arc)
3	0.6-2.5 (R12)	0.1-1 (R23)	>2(R33)	D2 (High Energy Arc)
4	NS	NS	<1(R34)	T1 (300˚<Thermal Fault)
5	< 0.1 (R13)	>1 (R24)	1-4(R35)	T2 (300˚<Thermal Fault<700˚)
6	<0.2(R14)	>1 (R24)	>4(R36)	T3 (Thermal Fault> 700˚)

Table 1: Fault Identification Using IEC Ratio (60599) Standard Method

V. SIMULATION DIAGRAM

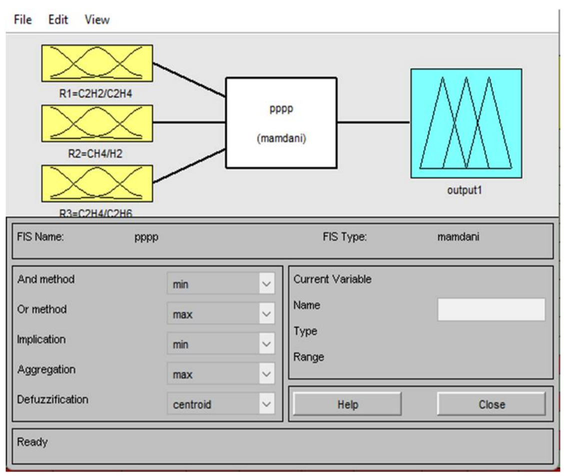


Fig.1.Fuzzy Toolbox

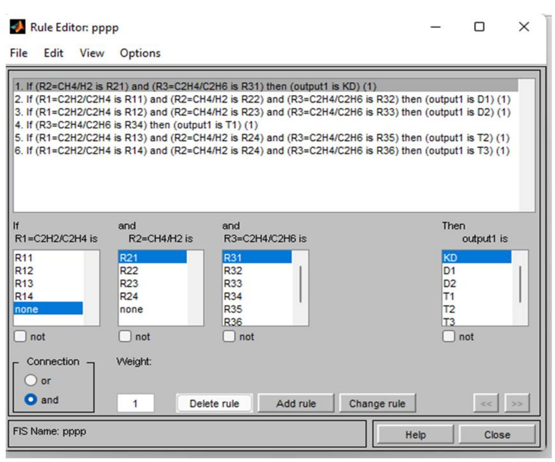


Fig.2.Fuzzy IEC Ratio Method Rules

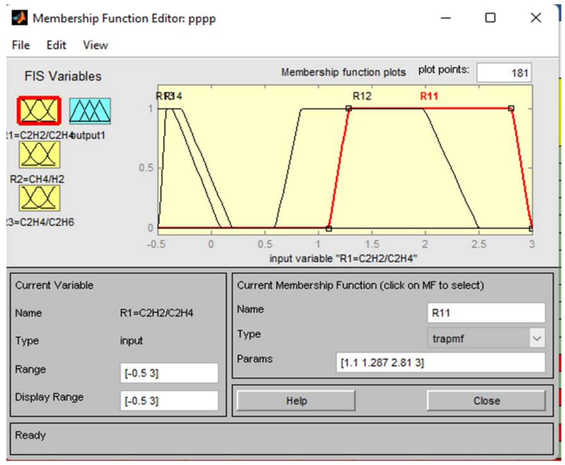
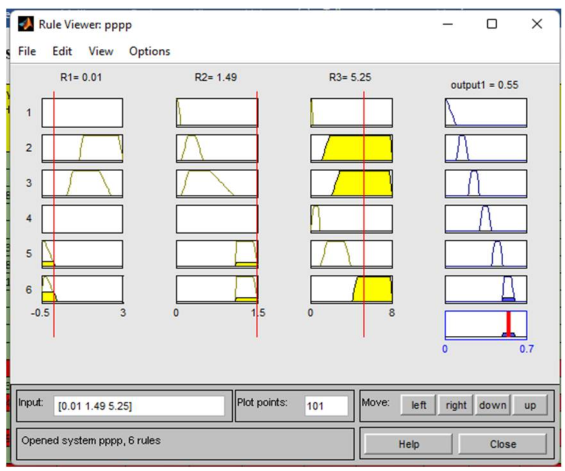


Fig.3.Fuzzy IEC Ratio Method Input Membership Function



Fig,4.Fuzzy IEC Ratio Method Result View

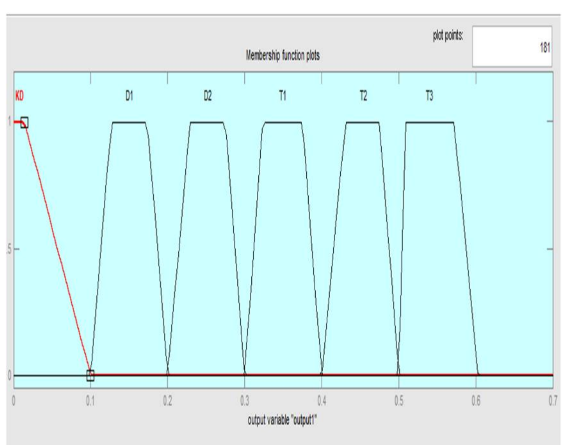


Fig.5.Fuzzy IEC Ratio Method Output Memurship Function

As the completion of collecting the data of power transformer from the sub-station it is very easy to simulate the monitoring of condition of power transformer . The Fig.1 shows the basic input and output structure of the project, it defines that three inputs are given to the MatLab Fuzzy Logic system which decides the single output in the form of either the transformer is under faulty condition or running under normal condition. Fig.2 indicate the rules defined in the Table3.1. In this Fig.2 the six rules are configured so that if the values of R1, R2, and R3 are match with the any of the condition then the respective fault is considered or the maintenance of the transformer is taken into consideration.

Fig.4 and Fig,5 are both images that appears before and after the input process. At time of input trapezoidal membership functions are used. In first image the inputs are set and the output is reflected in the form of the condition of Power Transformer, and in second image based on the value of the output the respective fault is derived. Also In Fig,4. The blue filled bar shows the severity or seriousness of the fault. As the bar is touches the bottom then the incipient fault is neglected for some time, As the bar is touches the top then the fault is not neglected and maintenance is required immediately, respectively severity of fault can be found out by the position of the bar in (%fi).

Sr.No.	Hydrogen ($H2$)	Carbon monoxide (CO)	Methane (CH4)	Carbon Di-oxide (CO2)	Ethylene (C2H4)	Ethane (C2H6)	Acetylene (C2H2)	R1	R2	R3	Fault Detect by fuzzy
1	0	276	8	1872	6	0	0	0	NS	NS	Normal
2	0	272	8	1804	6	0	0	0	NS	NS	Normal
3	581	141	31	899	49	2	0	0	0.08	24.5	Normal
4	0	123	21	796	42	20	0	0	NS	2.1	Normal
5	0	134	18	805	44	18	0	0	NS	2.44	Normal
6	63	205	15	862	0	0	0	NS	0.23	0	Normal
7	68	212	16	878	0	0	0	0	0.2352	0	Normal
8	616	171	30	976	33	2	343	10.91	0.0487	16.5	Normal
9	0	58	8	448	23	4	0	0	NS	5.75	Normal
10	0	54	9	432	25	5	0	0	NS	5	Normal
11	0	278	5	1872	5	0	0	0	NS	NS	Normal
12	0	270	4	1861	5	0	0	0	NS	NS	Normal
13	9	831	302	3936	651	124	9	0.01	33.55	5.25	T3
14	13	420	4	3041	37	1	0	0	0.3	37	Normal
15	149	112	117	1570	211	28	190	0.9	0.78	7.53	D2
16	2	2	0	56	0	0	0	0	0	0	Normal
17	690	14	284	131	494	50	525	1.06	0.41	9.88	D2
18	0	10	1	200	4	0	0	0	NS	NS	Normal
19	127	602	780	5038	1077	137	19	0.01	6.14	7.86	T3
20	82	397	359	2739	401	196	0	0	4.37	2.04	T2
21	2	7	2	335	3	0	0	0	1	NS	Normal
22	522	672	50	2294	23	8	27	1.17	0.095	2.87	Normal
23	5	708	5	5416	46	2	1	0.02	1	23	Normal
24	153	133	175	2216	202	72	4	0.019	1.143	2.805	T2
25	135	185	13	1100	7	8	0	0	0.096	0.875	Normal

VI. RESULT AND DISCUSSION

In this study, dissolved gas analysis was carried out by using the gas densities released as a result of failures in power transformers. IEC fuzzy logic systems have been applied to 25 samples gas concentration values for failure analysis.

Taking into account the limit values of the gases formed as a result of the fault, IEC methods are applied to the fuzzy logic, which is one of the smart systems, and the fault is evaluated and the results are tabulated. In the fuzzy IEC method, it is seen that when the memberships of the input functions are used at different intervals, the results also change. When the results obtained from IEC fuzzy methods are examined, it is seen that better results are obtained in fuzzy

IEC method. At the same time, it was observed that more accurate fault analysis was performed with the fuzzy IEC method compared to the classical method.

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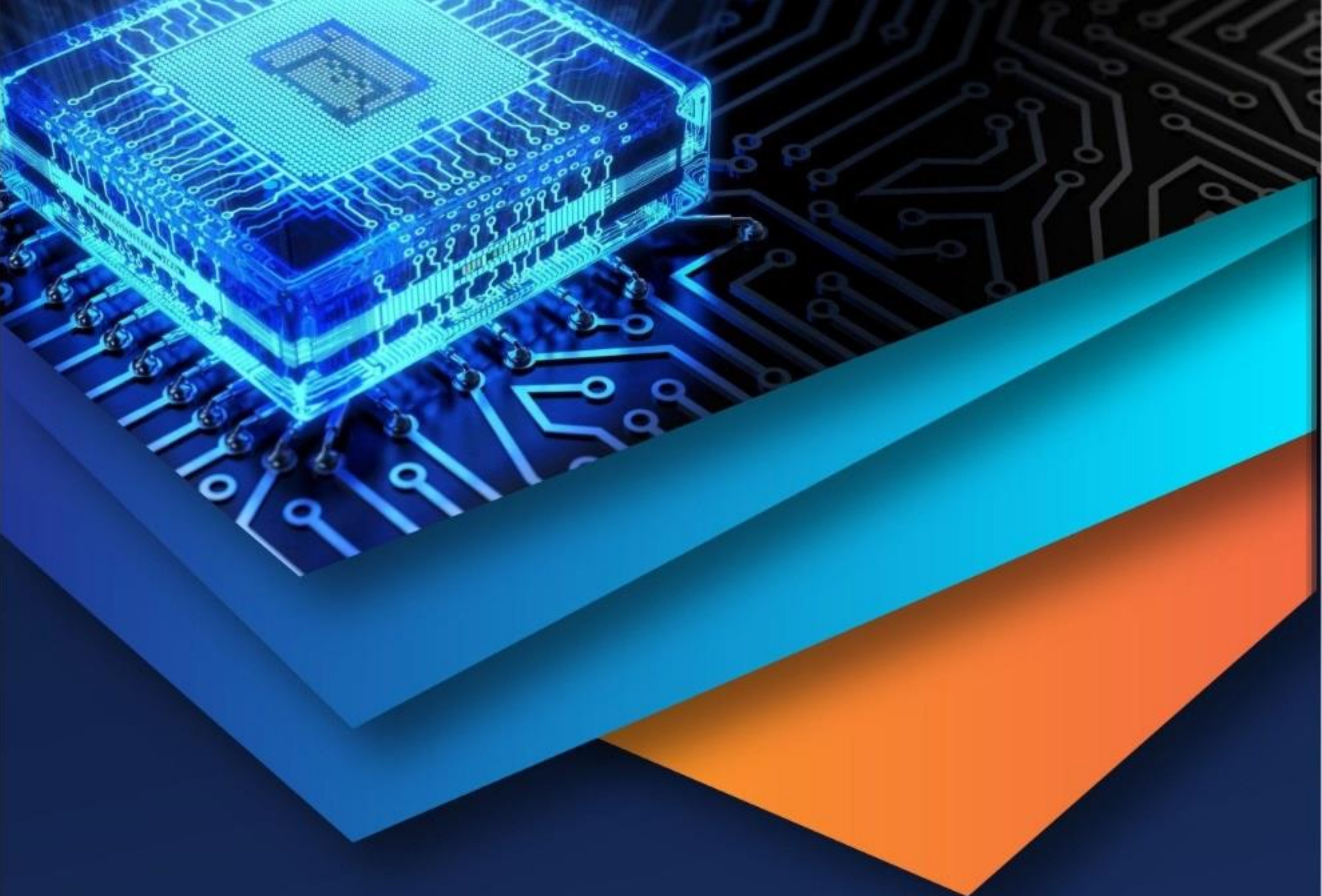

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