An Associative Binary Particle Swarm Optimization for the Diagnosis of Transformer Failure

Anurag Tamrakar, V. B. Reddy

***Abstract*: In this paper an associative binary particle swarms optimization (BPSO) for the diagnosis of transformer failure. In this approach transformer oil gas have been considered for the fault diagnosis so that proper functionality of transformer can be enhanced and the efficiency of transformer can be improved. For this dissolve gas analysis (DGA) and IEC standards have been used for weight assignment of different gas ratios. Rule mining have been applied where these standards fails in the weight assignments. Finally based on the rules associates with different gas ratios have been analyzed separately for each clusters. Finally based on BPSO faults have been diagnosed in several iterations. The results clearly indicate that our approach has better fault diagnosis and individual gas associations.**

***Index Terms*: BPSO, Associations Rules, DGA and IEC Standards.**

I. INTRODUCTION

Gases dissolve in the transformer oil is the current tends to address the issues of transformer. Dissolved gas analysis (DGA) is the one of the technique for the transformer oil analysis. The use shows the type and fault category to analyse the way of finding the transformer faults in different category. It also provides the way of diagnosis different types of faults. It is also necessary in finding the required dissolve gas analysis and the techniques for the moderation of the approaches. The usages and their impact are shown in different literatures [1−3].

Different data mining techniques can be helpful in the fault diagnosis. This paper aim is to explore the possibility of different data mining and evolutionary techniques to explore the possibility of controlling and provide the proper diagnosis. Different data mining techniques like association rule mining, k-means, fuzzy c-means, support vector machine; artificial neural network etc. can be beneficial as it is efficient in pattern discovery, classification and clustering [4−10]. Different gas analysis methods have been discussed previously and the impacts are analysed with their pros and cons. But discussing different research areas, it is found that there are several gaps in the direction of the previous approaches and it can be discussed and analysed in the further research work to help categorize the data in the way it can be found to be useful in different aspects of transformer oil categorization and the proper diagnosis of the approach.

II. LITERATURE REVIEW

In 2009, Lin et al. [11] proposed a grey clustering analysis (GCA) method for fault diagnosis. They have suggested that the hydrocarbon molecules and carbon oxides are produced due to the insulation. They have suggested that the abnormal conditions can be detected based on the DGA method. Their GCA method outperforms based on the other approach presented.

In 2012, Da et al. [12] presented a DGA system for transformer failure diagnosis. They have used kohonen self-organizing map for the rule generations. For the transformation Zero-order Takagi–Sugeno fuzzy rules have been used. Their results shows good indication by their approach in terms of the previous approaches compared and analyzed.

In 2012, Sun et al. [13] discussed and reviewed the computational intelligence (CI) approaches for transformer oil. They have also discussed the DGA approach data for diagnosing power transformer faults. They have discussed different methodological aspects with the pros and cons and the usability in the direction of transformer fault diagnosis.

In 2016, Yu et al. [14] suggested that the dissolved gas analysis (DGA) can be helpful in transformer fault diagnosis. They have suggested that the use of artificial neural network can improve the diagnosis possibility. These have the advantages of parallel processing, self-adaptation, association memory and non-linear mapping and other features. They have predicted the internal faults based on the probabilistic neural network.

In 2017, DoostanandChowdhury [15] suggested the need of fault diagnosis in case of power system. It ensures the proper reliability and regulations of the power system. According to the authors, there is the need of proper understanding of different faults. They have proposed a systematic procedure and establish association rule mining on the fault data sets. They have also included the case study.

In 2017, Bandara et al. [16] suggested different oil as an insulation for the transformer in previous research work. They have investigated different combinations so that the improvements can be identified and applied. Their results indicate that the main property which affects the performance is conductivity. So they have suggested that controlling it in the way to handle it in proper manner is beneficial.

In 2017, KalathiripiandKarmakar [17]suggested the need of condition monitoring of transformers. They have suggested that the ageing status can help in the monitoring the condition. They have suggested that DGA has widely used for this purpose but this approach have carrier gas need and regular calibration drawbacks. So they have used ultra violet-visible (UVvis)spectroscopy and nuclear magnetic resonance (NMR). Their results indicate that this method is fast and reliable in discovering moisture content.

In 2018, SekarandMohanty [18] suggested the importance of high impedance fault (HIF) detection. They have suggested that due to low current magnitudes, it is less discoverable.

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They have used mathematical morphology (MM) and a decisiontree (DT) model for HIF protection. They have also used the MM filter. They have discussed the results in different variations of systems.

In 2018, Ayalew et al. [19] discussed about the insulating and cooling of transformers. They have suggested the biodegradable ester oils. They have examined the dissolve gases through DGA methods. They have used acrylic tube for the testing. The results indicate the faults through H_2 and$C_2H_2$and other small proportions found are CH_4, $C_2H_4$and C_2H_6. They have found that the C_2H_2 is combustible highly. They have proved that ester oil has the diagnosis capability.

III. MATERIAL AND METHODS

In this paper an efficient associative binary particle swarm optimization for the diagnosis of transformer failure has been proposed. The transformer oil gas proportions have been used as the dataset for the experimentation and evaluation. The gas proportions have been analyzed based on DGA and IEC standards. The gas ratios considered here are $C_2H_2\backslash C_2H_4$ (G1), $CH_4\backslash H_2$ (G2) and $C_2H_4\backslash C_2H_6$ (G3). The ranges considered for the experimentation are <0.1, 0.1−1, 1−3 and >3. There are 9 different faults have been considered for the experimentation. These are no fault category, thermal fault (<150 ^{0}C), thermal fault (150^{0}C−300^{0}C), thermal fault (300^{0}C−700^{0}C), thermal fault (>700^{0}C), low energy, high energy, low energy discharge and high energy discharge. Figure 1 shows the complete process flowchart of our approach. In the first phase the gas ranges have been selected from the G1-G3 ratios for finding the appropriate ratios. Then acceptable gas ratio codes have been sending for the input. Then DGA and IEC based analysis have been performed for the analysis. Then rule based discovery through associated items and BPSO have been applied. It is useful in finding the association in the individual gas ratios. So it is useful in finding the associated maps between the dissolve gas and the faults. Then BPSO is applied to find the threshold of the faults which can be controlled through different parametric variations and the aspects ratios can be analyzed and categorized. Frequency associations have been performed to achieve the ratios presented in G1, G2 and G3. It will profound the ratios and their mapped data can be helpful in the formation of the aggregate components. The aggregate components show the category wise division. This division input will send to the optimization process. It process the input and find the highest thresholds in different iterations so that the iterations can show the fault categorization in different ranges and the ranges have been determined by the best values obtained from the DGA and IEC standard method applied on the gas ratios. So in our approach proper individual gas components ratio determination as well as the aggregation has been performed.

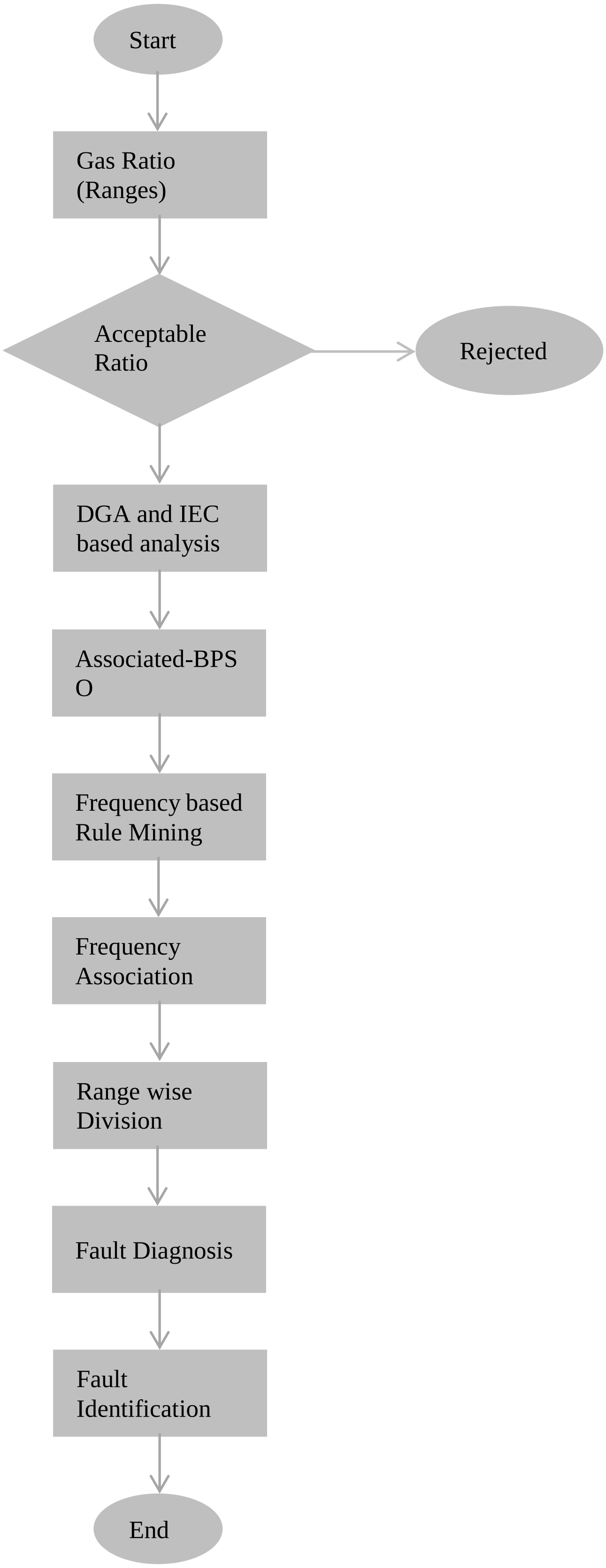

Figure 1: Flowchart of the Working Procedure

Algorithm

Step 1: Gas ratio from G1-G3 have been selected and it is check for the acceptable ration for data input.

Step 2: DGA and IEC standards have been considerd for the fault categorization.

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Step 3: The weights have been assigned according to the IEC standards and if not found appropriate then DGA standards have been applied.
Step 4: Rule mining helps in assigning the weight where the values are not found or the two values found o be similar.
Step 5: Similar ranking have been assigned for each iterations for the gas analysis.
Step 6: range wise clustering have been perormed for the data seperation and ranking.
Step 7: BPSO have been applied for the final dissolve fault threshold diagnosis.
Step 8: End.

IV. RESULTS

In this section results have been discussed and compared. First comparison shows the comparison based on different groups and rules achieved for the gas analysis. Figure 2 shows the rule based clustering for G1. Figure 3 shows the rule based clustering for G2. Figure 4 shows the rule based clustering for G3. The results clearly indicate that the dissolve gas prediction is successful in case of all the gases ratios. It also indicate that the results in all category the diagnosis percentage in terms of the percentage output. It shows the involvement of the gas ratios and the percentages which are dissolved. It clearly indicates that it is superior to the previous approaches in finding the gas ratio with different proportions. In the traditional approaches it is not identified and not discussed so the weight assignments are not clear. Figure 5 shows the result of BPSO based fault threshold in case of G1. Figure 6 shows the result of BPSO based fault threshold in case of G2. Figure 7 shows the result of BPSO based fault threshold in case of G3. The results in case of Figure 5-7 shows that the fault diagnosis in each iteration for different categories have been identified and successfully diagnosed. For this we have considered different iterations and G1-G3 gas ratios for checking it in all aspects ratios. The results depicted that the ratio variations are minor in all the cases which shows the effectiveness of our approach. It also shows that the weight assignment have been completed through the rule generation approach where traditional approaches fails. It is also clear from the results that it is depicted the case values in terms of G1 to G3 gases.

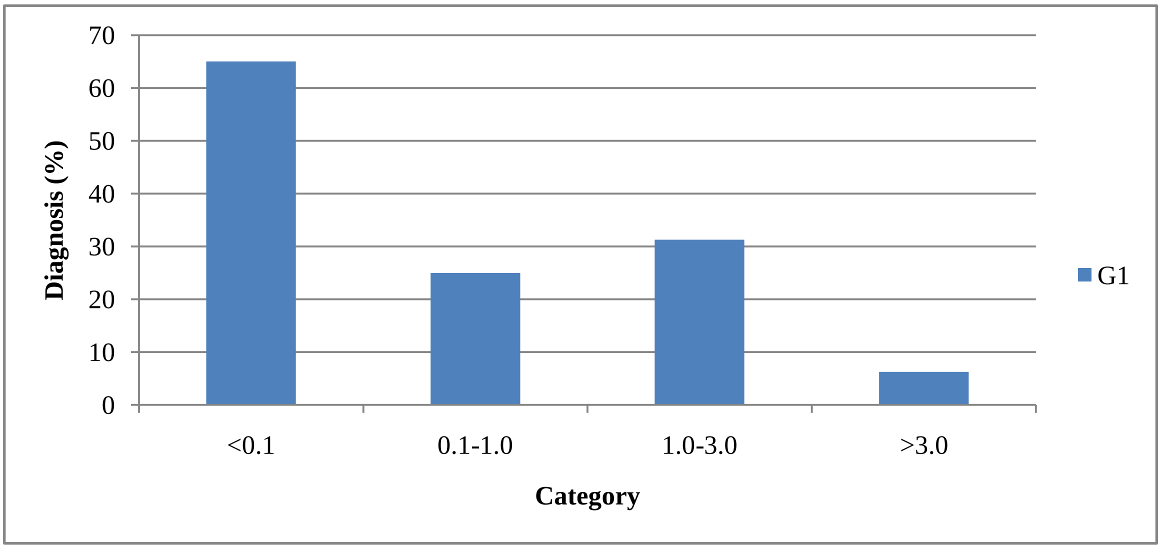

Figure 2: Rule based clustering for G1

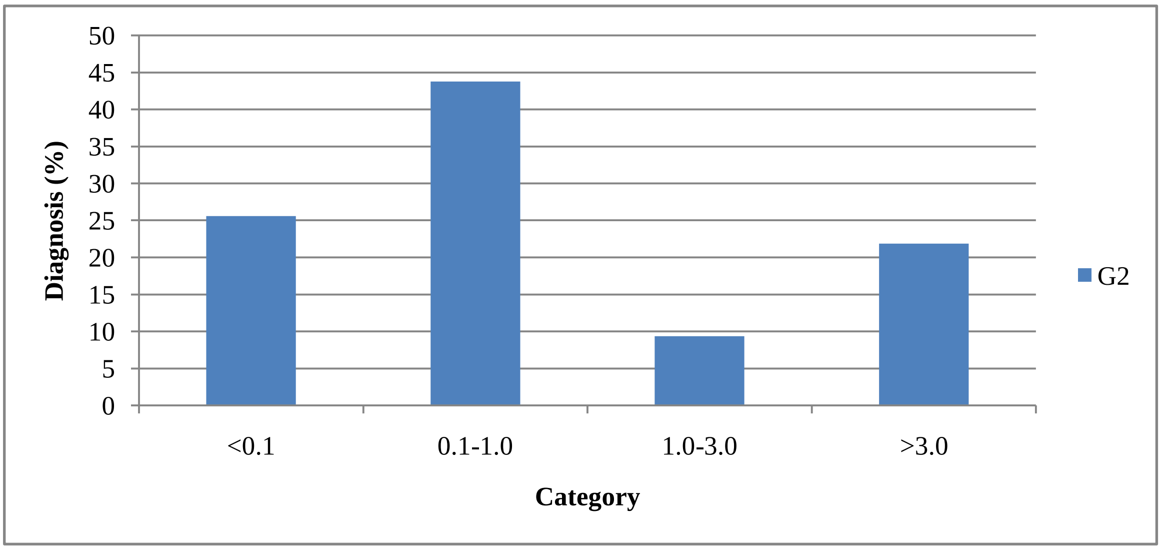

Figure 3: Rule based clustering for G2

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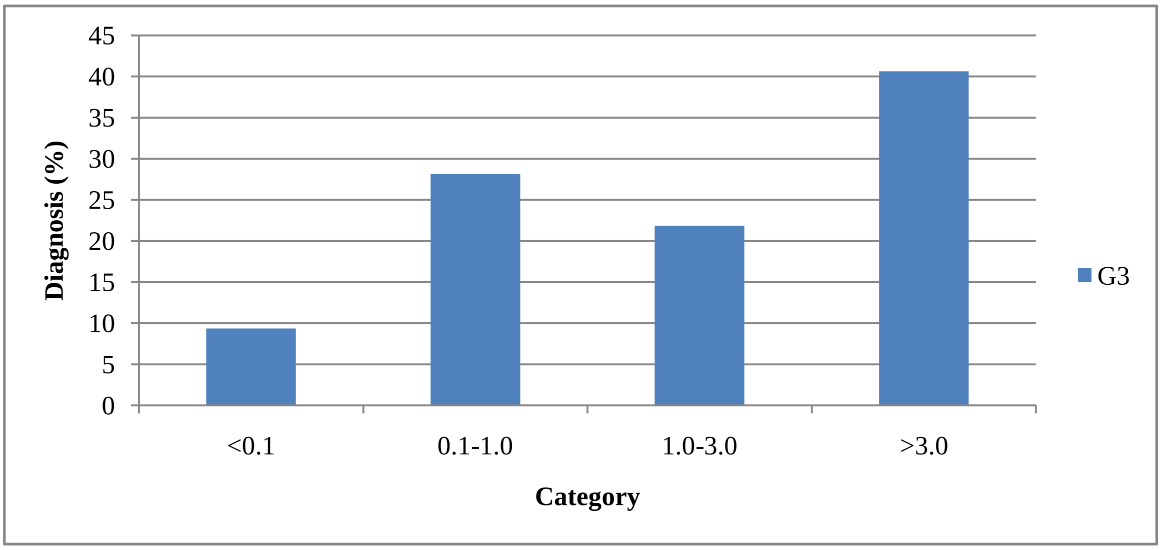

Figure 4: Rule based clustering for G3

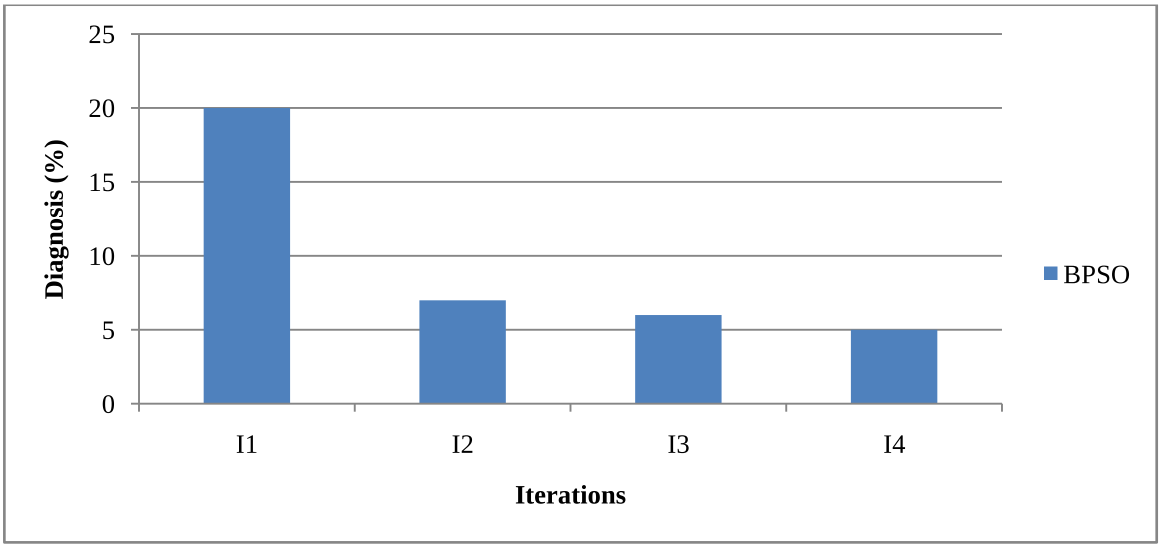

Figure 5: BPSO based fault threshold in case of G1

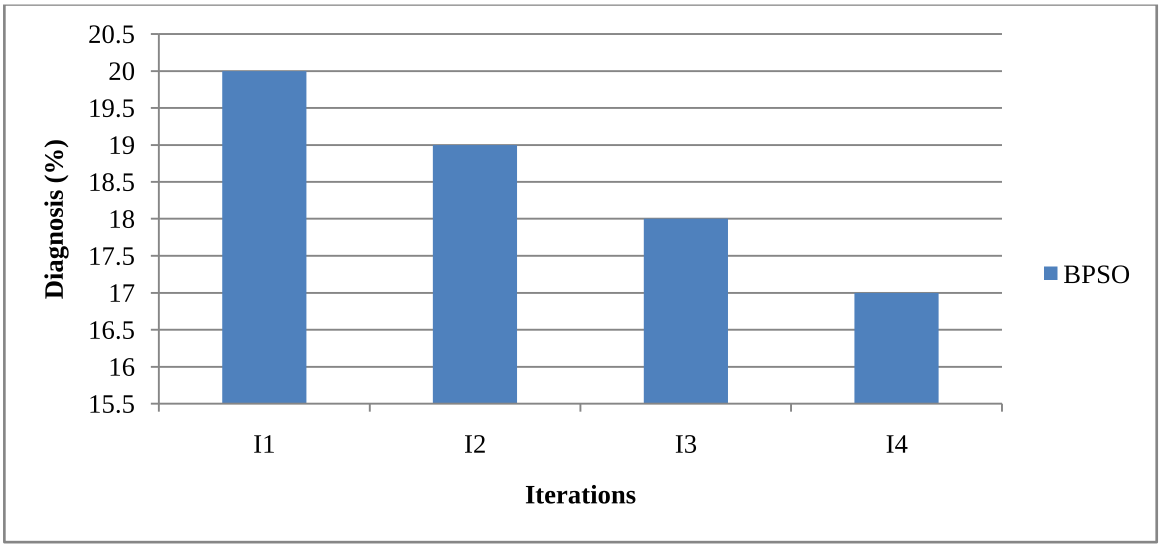

Figure 6: BPSO based fault threshold in case of G2

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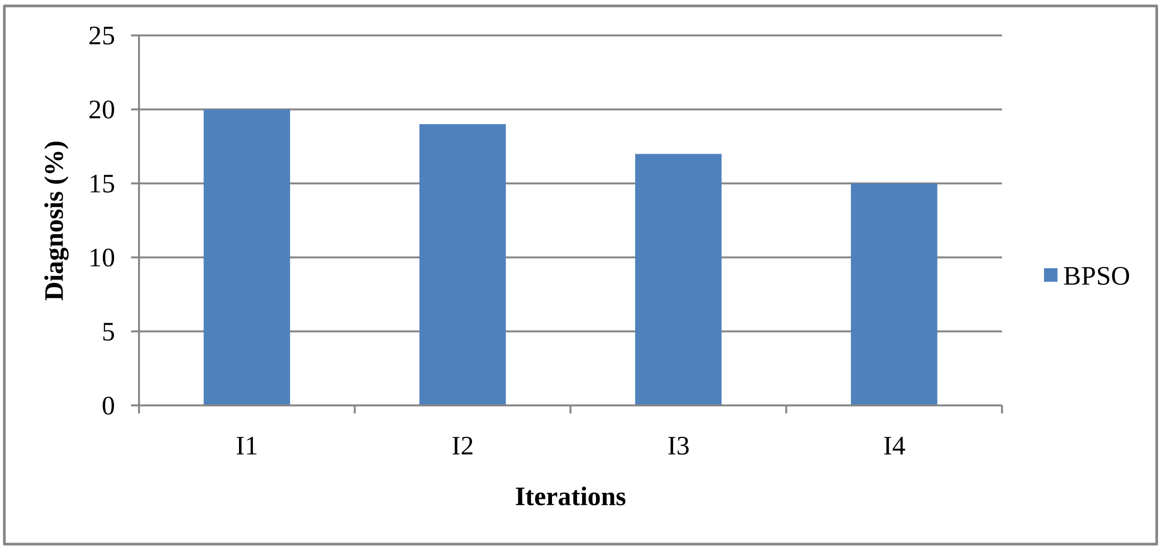

Figure 7: BPSO based fault threshold in case of G3

V. CONCLUSION

In this paper an efficient approach has been presented for the fault diagnosis and individual rule associations in different clusters. Our approach has divided in three parts. The first part is the process of weight assignments in different groups. In second part association rules have been applied for the individual association for the gas ratios (G1-G3). This input is used for the BPSO. The results proved that this approach is efficient in fault diagnosis and gas analysis individually and in aggregation.

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