iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 1 **Issue:** IV **Month of publication:** November 2013

DOI:

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

Evaluating Failure of a Refrigeration cycle using Triangular Intuitionstic Fuzzy Approach

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Abstract: In real life systems, the information may be inaccurate or might have linguistic representation. In such cases the estimation of precise values of probability becomes very difficult. In order to handle this situation, triangular fuzzy approach is used to evaluate the failure rate status. In this paper we introduced triangular fuzzy fault tree analysis for evaluating failure range of the refrigeration cycle system.

Key Words: triangular Intuitionstic fuzzy approach, fuzzy fault tree, failure rate, refrigeration cycle etc.

1. INTRODUCTION

The theory of fuzzy sets (FSs), proposed by Zadeh (1965) [6] has gained successful applications in various fields. However, the membership function of the fuzzy set is a single value between zero and one, which combines the favouring evidence and the opposing evidence. Due to fuzzy boundaries, this single value for the membership grade is the result of the combined effect of evidences in favour and against the inclusion of the element in the set the utility of the application of fuzzy sets depends on the capability of the user to construct appropriate membership functions, which are often very precise. In many contexts it is difficult to assign a particular real number as a membership grade and in such cases it may be useful to identify meaningful lower and upper bounds for the membership grade. In 1986, Atanassov [7] introduced

Intuitionistic fuzzy sets (IFSs) which have been found to be very useful to deal with uncertainty information.

The concept of the IFSs is a generalization of that of the FSs. IFS's are being studied and used in different fields of science. Among the research works on these sets we can mention Atanassov [2,3,4]; Atanassov and Gargov [1]; Szmidt and Kacprzk (2001) [7] proposed the definition of Intuitionistic Fuzzy numbers (IFN) and studied the perturbation of IFN.

Vol. 1 Issue IV, Nov ember 2013
ISSN: 2321-9653

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2. FUZZY SETS

A set is a well-defined collection of objects. It has a sharp boundary to distinguish which element of the universe of discourse belongs to the set. In real life applications situations, it is not possible to distinct these elements by such a sharp layer due to the uncertainty involved. A fuzzy set is a set that consists of the elements having varying degrees of belongingness in the sets. So these situations may be better explained by the fuzzy sets, the set which contains all the elements of the universe but with different degrees of membership.

A crisp set A may be defined over a universe X and may be characterized by its characteristic function χ_A as

$$A = \{(x, \chi_A(x))\}$$

Where $\chi_A : X \rightarrow \{0,1\}$ is defined by

$$\chi_A(x) = \begin{cases} 1 & if\ x \in A \\ 0 & if\ x \notin A \end{cases}$$

In analogy to the characteristic function, we can define a function called membership function $\mu_{\tilde{A}} : X \rightarrow [0, 1]$ to characterize a fuzzy set defined over the universe X as follows.

$$\tilde{A} = \{(x_i, \mu_A(x_i)) : x_i \in X\}$$

Where $\mu_{\tilde{A}}(x) \in [0, 1]$

2.1 Definition of Intuitionistic Fuzzy Sets (IFS_s):-

Fuzzy set theory was first introduced by Zadeh in 1965 [6]. Let X be universe of discourse defined by $X = \{x_1, x_2, ..., x_n\}$. The grade of membership of an element $x_i \in X$ in a fuzzy set is represented by real value between 0 and 1. It does indicate the evidence for $x_i \in X$, but does not indicate the evidence against $x_i \in X$. Atanassov in 1984 [4] presented the concept of IFS, and pointed out that this single value combines the evidence for $x_i \in X$ and the evidence against $x_i \in X$. An IFS $\bar{A}$ in X is characterized by a membership function $\mu_{\bar{A}}(x)$ and a non membership function $\nu_{\bar{A}}(x)$.

2.2 Intuitionistic Fuzzy Set: - Let E be a fixed set. An Intuitionistic fuzzy set $\bar{A}$ of E is an object having the form $\bar{A} = \{< x, \mu_{\bar{A}}(x), \nu_{\bar{A}}(x) >: x \in E\}$

Where the functions $\mu_A : E \rightarrow [0, 1]$ and $\nu_A : E \rightarrow [0, 1]$ define respectively, the degree of membership and the degree of non-membership of the element $x \in E$ to the set A, which is a subset of E and for every $x \in E$, $0 \leq \mu_A(x) + \nu_A(x) \leq 1$.

When the universe of discourse E is discrete, an IFS $\bar{A}$ can be written as

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$$\bar{A} = \sum_{i=1}^{n} [\mu_A(x),\ 1 - \nu_A(x)]/x, \forall x_i \in E$$

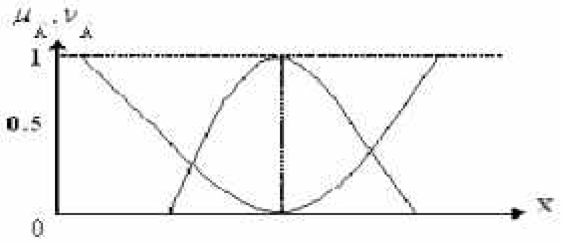

Fig.1 Membership and non-membership functions of $\bar{A}$

2.3 Triangular Intuitionistic Fuzzy Numbers (TIFN):-

The TIFN $\bar{A}$ is an Intuitionistic Fuzzy number $(\bar{A})$ is an Intuitionistic Fuzzy set in R with five real numbers (a_1, a_2, a_3, a', a'') $with\ (a' \le a_1 \le a_2 \le a_3 \le a'')$ and two triangular functions

$$\mu_{\bar{A}}(x) = \begin{cases} \frac{x-a_1}{a_2-a_1}, & for\ a_1 \le x \le a_2 \\ \frac{a_3-x}{a_3-a_2}, & for\ a_2 \le x \le a_3 \\ 0, & otherwise \end{cases}$$

$$\nu_{\bar{A}}(x) = \begin{cases} \frac{a_2-x}{a_2-a'}, & for\ a' \le x \le a_2 \\ \frac{x-a_2}{a''-a_2}, & for\ a_2 \le x \le a'' \\ 1, & otherwise \end{cases}$$

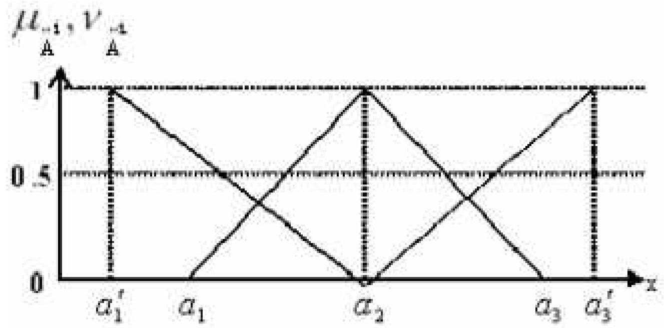

Fig.2 Membership and non-membership functions of TIFN

2.4 Arithmetic operations on IFNs:-

The arithmetic operations denoted generally by *, of two IFNs is a mapping of an input subset of R x R (with elements $x = (x_1, x_2)$) onto an output subset of R (with elements denoted by y). Let $A_1\, and\ A_2$ be two IFNs, and $(A_1 * A_2)$ the resultant of operations then:

$$A_1 * A_2(y)$$

$$= \left\{ \begin{pmatrix} y, \\ \mathrm{V}_y = x_1 * x_2[A_1(x_1) \wedge A_2(x_2)], \\ \wedge_y = x_1 * x_2[A_1(x_1) \vee A_2(x_2)] \end{pmatrix} T, \forall x_1, x_2, y \in R \right\}$$

With $\mu_{(A_1 * A_2)}(y) = \square_y = x_1 * x_2[A_1(x_1) \wedge$

$A2x2$

$and\ \ \nu_{(A_1 * A_2)}(y) = \square_y = x_1 * x_2[A_1(x_1) \vee$

$A2x2$

3. NUMERICAL COMPUTATIONS

Here we have a simple fault tree structure of failure of refrigeration cycle system. The failure of the system depends on different factors like –electric supply ,hot cooling factor ,condenser failure , compressor failure etc .There are two major factors one is failure power supply and the second one be heat capacity exceeds. For both of these there are two sub factors .The following notation has been used to get failures

A_F = Represents the failure of refrigeration system

B_F = Represents the failure of electric supply

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$\tilde{C}_f$ = Represents the failure of cooling system.

$\tilde{D}_f$ = Represents the failure of the condenser

$\tilde{E}_f$ = Represents the failure of the compressor

$\tilde{F}_f$ = Represents the excess of commodity

$\tilde{G}_f$ = Represents the failure of refrigerant.

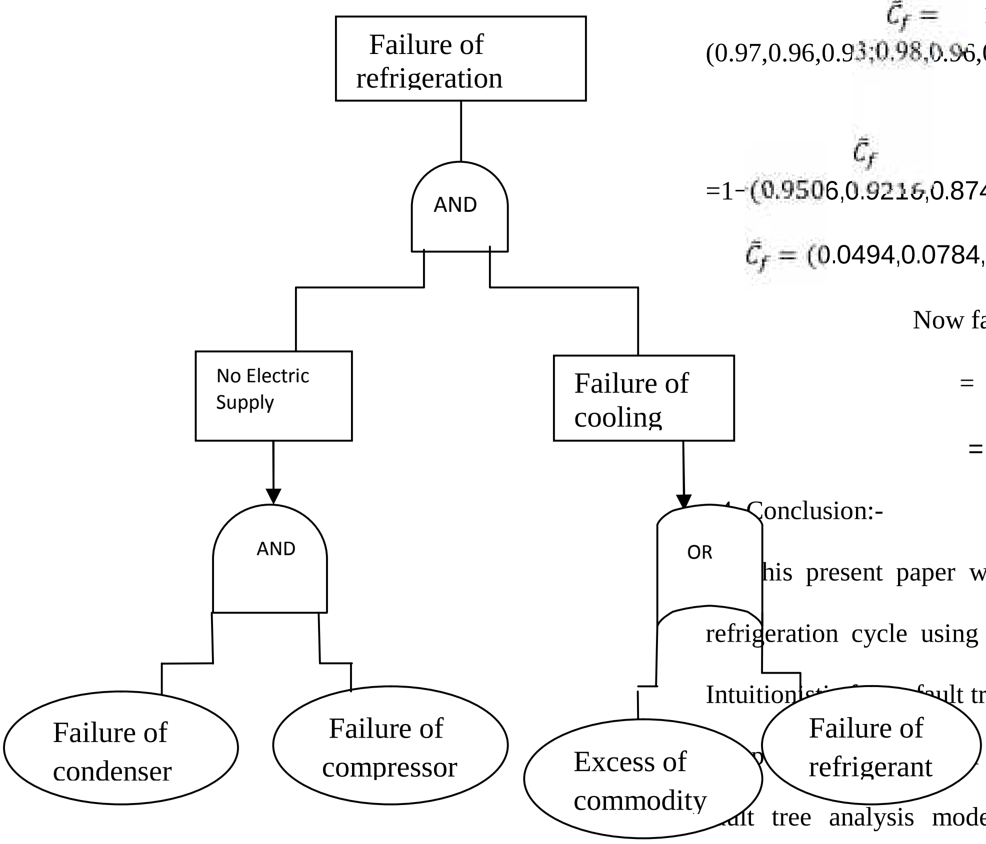

Fig.3 Fuzzy fault tree of refrigerant system

Let the reliability of events are

$\tilde{D}_f = (0.02,0.03,0.04; 0.01,0.03,0.05)$

$\tilde{E}_f = (0.03,0.03,0.05; 0.010.03,0.07)$

$\tilde{F}_f = (0.02,0.04,0.06; 0.03,0.04,0.05)$

$\tilde{G}_f = (0.03,0.04,0.07; 0.02,0.04,0.05)$

Step 1 Failure of electric supply = $\tilde{D}_f \times \tilde{E}_f$

$\tilde{B}_f = (0.0006,0.0009,0.002; 0.0001,0.0009,0.0035)$

Step 2 failure of cooling system=1− (1−$\tilde{E}_f$)(1−$\tilde{G}_f$)

$\tilde{C}_f =$ 1−(0.98,0.96,0.94, ; 0.97,0.96,0.95)(0.97,0.96,0.93;0.98,0.96,0.95)

$\tilde{C}_f$ =1−(0.9506,0.9216,0.8742; 0.9506,0.9216,0.9025)

$\tilde{C}_f = (0.0494,0.0784,0.1258; 0.0494,0.0784,0.0975)$

Now failure of the refrigeration system

= 1− (1− $\tilde{E}_f$)(1−$\tilde{G}_f$)

= (0.05,0.08,0.12; 0.04,0.08,0.10)

Conclusion:-

his present paper we have discussed failure rate of a refrigeration cycle using triangular Intuitionistic fuzzy sets. Intuitionistic fault tree analysis is efficient and simple to system of all fields. A new TIFN fault tree analysis model is proposed in this paper that modifies the fuzzy set arithmetic operations for implementing fault tree analysis. Results of TIFN fault tree are more flexible than the fuzzy fault tree analysis because it have more sharp boundary.

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