FUZZY LOGIC BASED RISK ASSESSMENT IN A TOOL ROOM

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Abstract:

Safety and reliability are essential issues in modern sciences. Modern equipment and systems should meet technical, safety and environmental protection requirements. The risk can appear as personal injury or death, mission degradation, property technical damage or destruction. The risk is a measure of harm or loss associated with the human activity. It is the combination of the likelihood and the consequence of a specified hazard being realized. To manage the risk of human activities and to make reliable decision, the risk of the given system or process should be known correctly. Fuzzy logic is a new mathematical tool to model inaccuracy and uncertainty of the real world and human thinking. This paper will show the possibility of use of the fuzzy logic to assess the risk.

Keywords- Hazard analysis, implementaion of fuzzy logic , fuzzy assessment.....

1.INTRODUCTION

The study done in a tooling centre of a leading connector manufacturing company. Spares for high speed, high precision toolings are manufactured in the regional tooling centre at Cochin. Regional tooling centre is a world class facility with a controlled atmosphere and high tech machine tools and auxiliary equipment's, to meet global quality standards in tooling.

2.ABOUT RISK, RISK ASSESSMENT AND RISK MANAGEMENT

Risk

All human activity involves any risk. The risk is the combination of the likelihood and the consequence of a specified hazard being realized.

Risk analysis

There are a lot of approaches for conducting risk analysis. Since there are of

a lot of different kinds of systems, many techniques have been developed to struggle with the most common issues of risk analysis.

Risk assessment

Risk assessment is an important element of risk management. The goal of risk assessment or risk characterization is to determine risk context and acceptability, often by comparison to similar risk. There are many qualitative and quantitative methods to assess risk. In the last case the risk is determined by multiplication of severity and probability measures.

It is determination of the severity of the hazard in terms of its potential impact on the people and equipment.

Severity assessment should be based upon the worst possible outcome that can reasonably be expected.

Using quantitative risk assessment method, the risk is product of probabilities and calculated “crisp” severity of investigated hazard.

3.IDENTIFICATION OF THE PROBLEM

` As a commitment to the environment and safety , the management had decided to implement the environment management system in line with ISO 14001 standard requirements and occupational health and safety management system in line with BS OSHAS 18001 management system requirements.

The HIRA assessment done in October 2017 and the identified unacceptable risks in the production floors are the falling of jobs on humans and the hit with sharp objects.

4.IMPLEMENTATION OF FUZZY LOGIC

Fuzzy Logic is a form of logic used in some expert systems and other artificial intelligence applications in which variables can have degrees of truthfulness or falsehood represented by a range of values between 1 (true) and 0 (false). With fuzzy logic, the outcome of an operation can be expressed as a probability rather than as a certainty. For example, in addition to being either true or false, an outcome might have such meanings as probably true, possibly true, possibly false, and probably false.

Methods of fuzzy logic can provide a convenient way to conduct risk analyses. The article describes an application of fuzzy logic and fuzzy approach into risk analyses and into risk management process.

The main advantage of using fuzzy approach is limitation of subjectivity in risk assessment. That can provide basis for regular repeating of risk analyses so

efficient control system can be created instead of formal occasional risk analyses. Fuzzy logic is a convenient way to map an input space to an output space. Comprehensive understanding of some processes in the system is required and is critical for conducting risk analysis based on fuzzy logic:

• Correct and consistent identification of sources of risk,

• Understanding the process of risk activation,

• Correct identification of input data that determines significance of risk.

Benefits of Fuzzy Approach for Risk Management

There are some important benefits of fuzzy approach for risk management process that are not possible to achieve with fully qualitative methods. The fuzzy risk assessment, no matter of used methods and input data, leads to a specific numerical output. Any further changes of input data also change this output, so regular repeating of analysis is meaningful.

Regular repeating of fuzzy risk analysis is important for achieving the optimal results. That is a reason why there are good results of using fuzzy approach for assessing the highly dynamic systems where there are regular changes in values of input data.

5.FUZZY ASSESSMENT SYSTEM DEVELOPMENT

During risk assessment based upon experiences uncertain categories (see Tables 1 and 2) should be used, which can be investigated by only fuzzy tools.

Firstly the fuzzy membership functions of all input and output parameters and logical rules should be determined.

Catastrophic Complete mission failure, death, or loss of system

Critical Major mission degradation, severe injury, occupational illness or major system damage

Moderate Minor mission degradation, injury, minor occupational illness, or minor system damage

Negligible Less than minor mission degradation, injury, occupational illness, or minor system damage

Table 1. Severity categories	
Catastrophic	Complete mission failure, death, or loss of system
Critical	Harmful to the health and safety of the employees. The impact will result more than one shift time to rejoin for duty and also have impact on work related long time health issues. Work should not be started until the risk has been reduced and if the risk involves work in progress, urgent action to be taken/ Management program available to reduce the risk to acceptable level
Moderate	Harmful to the health and safety of the employees. The impact will result less than one shift time to rejoin for duty. Efforts should be made to reduce the risk, but cost of prevention should be carefully measured and limited
Negligible	No impact on health and safety of employees. No additional controls are required. Monitoring is required to ensure that the controls are maintained

Table 2. Probability categories		
Frequent	Continuously experienced	more than 0.1
Likely	Occurs regularly	0.01 ~0.25
Occasional	Occurs several times in the life of the system	0.001 ~0.01
Seldom	Can be expected to occur in the life of the system	0.0001~ 0.01
Unlikely	Unlikely but could occur in the life of the system	less than 0.0001

Table 3. Sample Risk Assessment Matrix					
	Frequent	Likely	Occasional	Seldom	Unlikely
Catastrophic	EH	EH	H	H	M
Critical	EH	H	H	M	L
Moderate	H	M	M	L	L
Negligible	M	L	L	L	L

EH – Extra High; **H** – High; **M** – Medium; **L** – Low.

Figure 1. Severity sets definition

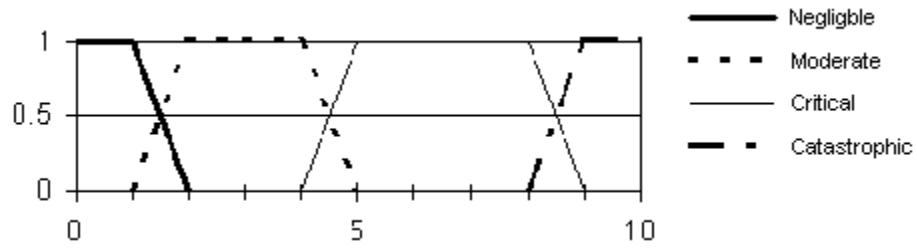


Figure 2. Probability sets definition

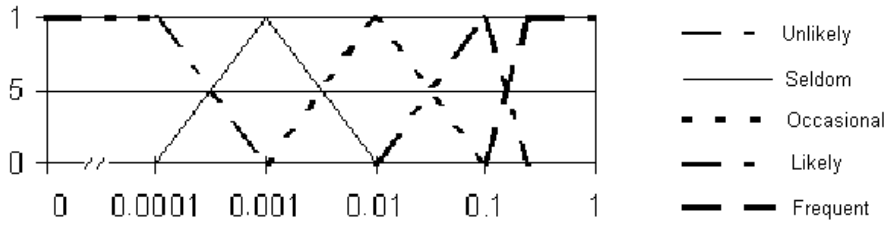
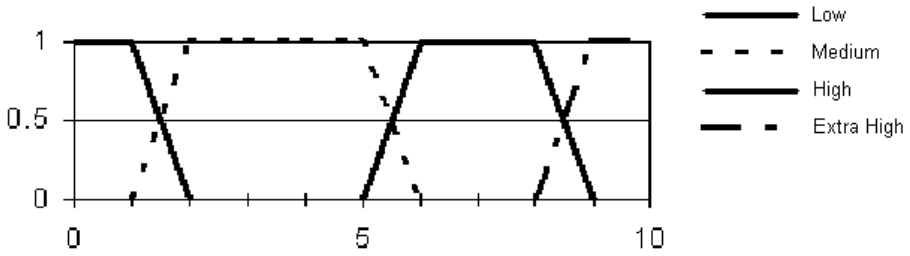


Figure 3. The risk sets definition



6. FUZZY ASSESSMENT PROCESS APPLICATION.

A fuzzy logic-based decision-making process realizes the following process. This process is a combination of four subprocesses: fuzzification, inference, composition, and defuzzification The company has assessed its risk using the fuzzy logic based risk assessment method. The severity and probability are determined by past six months incidents level (October 2017 to March 2018), result of which are the followings:

Falling of jobs on humans -

• degree of severity is 8.75 in a numeric scale from 0 to 10;

• probability of occurrence is 0.0075 in a numeric scale from 0 to 1;,

Hit with sharp objects

•degree of severity is 1.75 in a numeric scale from 0 to 10;

• probability of occurrence is 0.0023 in a numeric scale from 0 to 1.

Fuzzification

In the fuzzification subprocess, the membership functions defined on the input variables are applied to their actual values, to determine the degree of truth P(*xi*) for each rule premise.

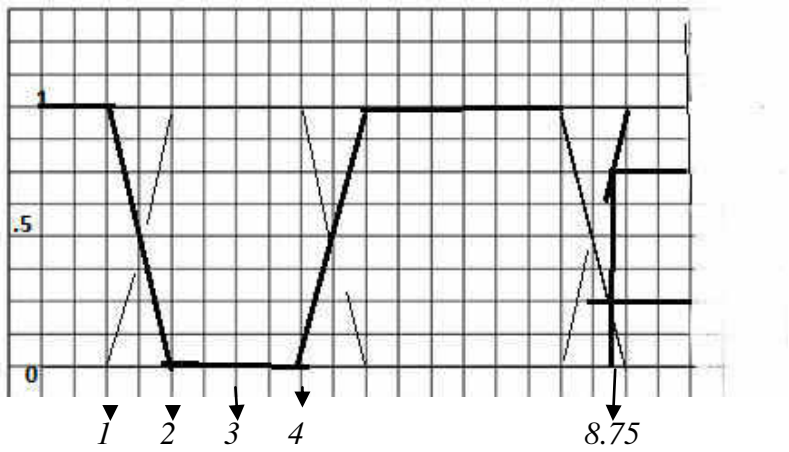
Graph number 1 –For the hazard of falling of jobs –Determination of the degree of truth of severity sets

Degree of severity is 8.75 in a numeric scale from 0 to 10;

In our case the degrees of truth of severity sets are

μ (*severity _ is _ critical*) 0.75 ;

μ (*severity _ is _moderate*) 0.25



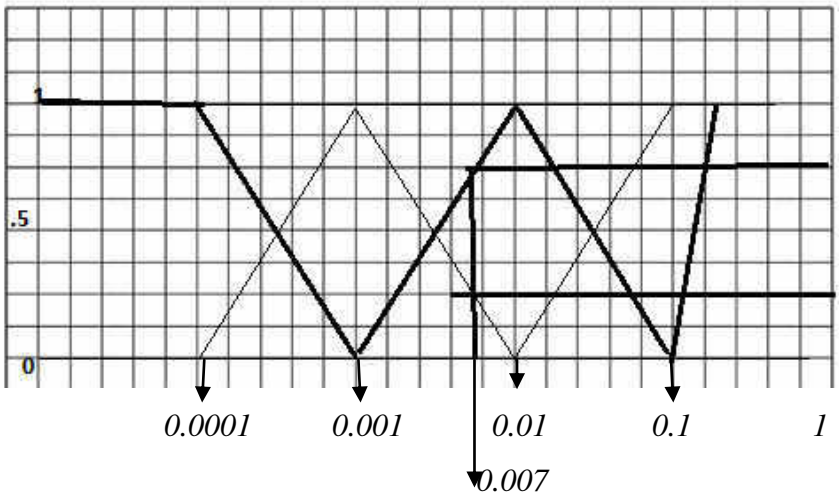
Graph number 2 –For the hazard of falling of jobs –Determination of the degreeof truth of probability sets

Probability of occurrence is 0.0075,

Degrees of truth of probability sets are

μ (*probability _ is _ occasional*) 0.75 ;

μ (*probability _ is _ seldom*) 0.25

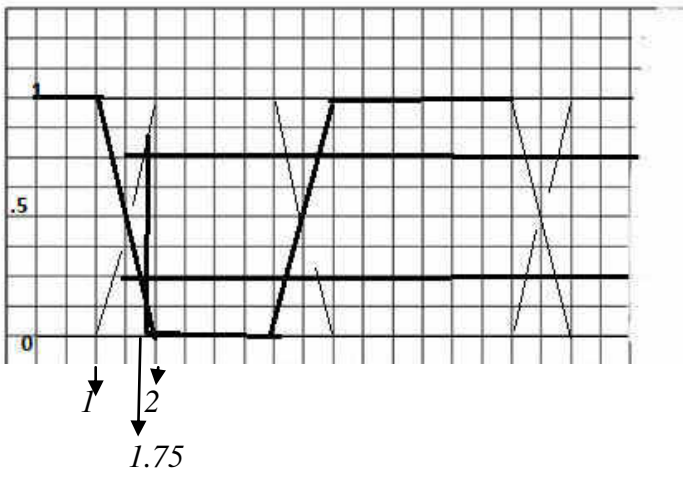


Graph number 3 –For the hazard of hit by objectives –Determination of the degreeof truth of severity sets

Degree of severity is 1.75 in a numeric scale from 0 to 10;

μ (*severity _ is _ critical*) 0.75 ;

μ (*severity _ is _moderate*)0.25 .

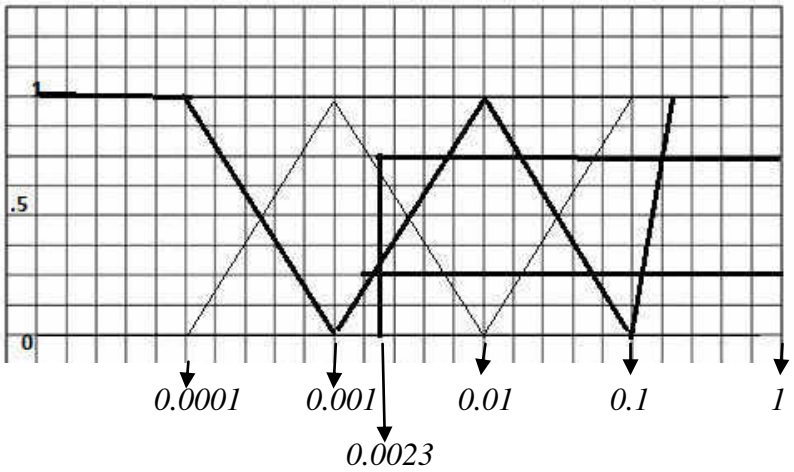


Graph number 4 –For the hazard of hit by objectives –Determination of the degree of truth of probability sets

Probability of occurrence is 0.0023.

μ (*probability _ is _ occasional*) 0.75 ;

μ (*probability _ is _ seldom*) 0.25



Namely, severity of the investigated event is in some degree critical and moderate.That is, probability of the event's occurrence mentioned above can be occasional and infrequent to some degree.

Inference

In the inference subprocess, the truth-value for the premise of each rule is computed, and applied to the conclusion part of each rule. This results in one fuzzy subset to be assigned to each output variable for each rule.

In our example only there is only four logical rules, which are practically used. on the basis of the Risk

Assessment Matrix (Table 3), they are the following ones:

Rule (A): If *severity is critical* and *probability is occasional* then *risk is high*;

Rule (B): If *severity is moderate* and *probability is occasional* then *risk is medium*;

Rule (C): If *severity is critical* and *probability is seldom* then *risk is medium*;

Rule (D): If *severity is moderate* and *probability is seldom* then *risk is low*.

Using the given rules, the risk – a result of a rule – can be high, medium and low. Only fuzzy logic tools can unwind this conflict. In the fuzzy logic, the minimum operator is used instead AND classical logic connection. Therefore:

In both the above risks as falling of jobs on humans and the hit with the sharp objects

Rule (A) – risk_is_high: μ(zA) _ min_0.75; 0.75 =0.75;

Rule (B) – risk_is_medium: μ(zB)_ min_0.25; 0.75= 0.25 ;

Rule (C) – risk_is_medium: μ(zC) _ min_0.75; 0.25= 0.25;

Rule (D) – risk_is_low: μ(zD) _ min_0.25; 0.25 = 0.25 ;

The truth-values of all other rules are zero, therefore there is no need to mind them during composition subprocess.

Composition

In the composition subprocess, all of the fuzzy subsets assigned to each output variable are combined together to form a single fuzzy subset for each output variable.

Results of two rules are same (namely medium), the degree of membership:

μ(risk is medium) =max (μ(zB); μ (zC)) = max. (0.25;0.25) = 0.25

Using the above results:

μ risk is high =0.75

μ risk is medium=0.25

μ risk is low =0.25

Defuzzification

The defuzzification subprocess creates a crisp ranking from fuzzy conclusion set.

There are more defuzzification methods.

The Weighted Mean of Maximum (WMoM) method is one of commonly used procedure. This method gives the average, weighted by their degree of truth, of the support values at which all the membership functions that apply reach their maximum value. In case of trapezoidal membership function it is taken as center of the maximal range.

Formally, the Weighted Mean of Maximum conclusion *Z*:

$z = \sum \mu i \, xi / \sum \mu i$

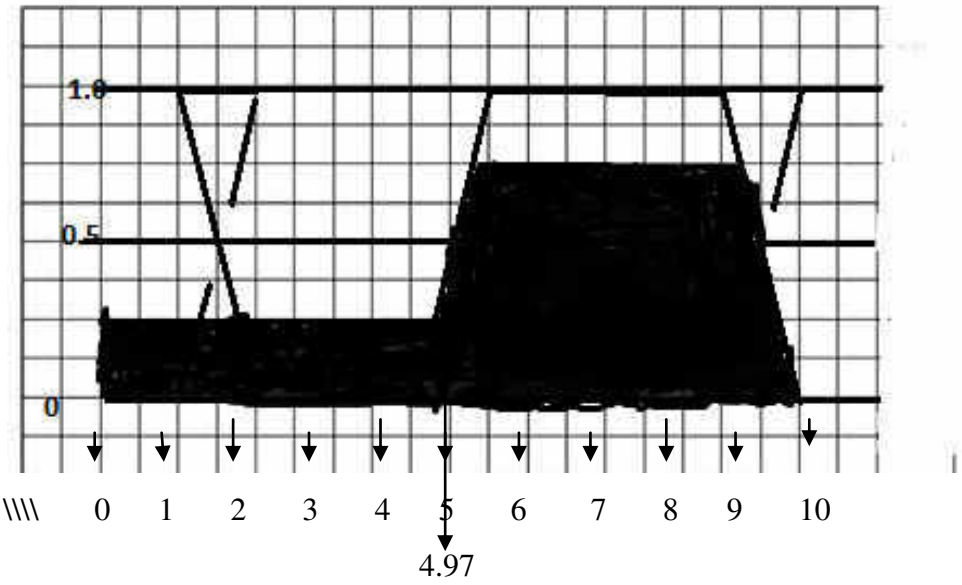
where:

n – number of quantized output conclusions;

xi – the support value of the *i*-th membership function;

μi – degree of truth of the *i*-th membership function.

Attachment ;Graph 5



In our example:

$$Z = \frac{0.25X0.85 + 0.25X3 + 0.75X7}{0.25 + 0.25 + 0.75} = 4.97$$

That is, the degree of risk of investigated undesired event is: 4.97.

On the basis of risk sets definitions the investigated sortie had high level risk..

Management could use this result to accept the risk during the next step of risk management process..

7. CONCLUSION:

We can conclude that there are several reasons why to use fuzzy logic in the process of risk analysis:

• Fuzzy approach creates flexible framework that can built on top of the experience of experts

• Fuzzy logic is tolerant to imprecise data.

• Regular risk analysis based on fuzzy logic can create an effective control system.

Various risks that endanger complex systems have very difficult mechanisms of activation so precise mathematical modelling the system is usually too complex for practical application. Fuzzy

logic with built-in toleration to imprecise data is an ideal tool for enhancing the effectiveness of risk analysis.

Certainly, fuzzy approach requires real experiences of experts and competent personnel to identify and collect needed data and to build a fuzzy system. However, subjective evaluation is limited especially compared to other methods.

This papers shown a fuzzy logic-based risk-assessment method. During prospective scientific research related to this field of mathematics, the fuzzy logic can be applied to all the performance indicators associated with health , safety and environment.

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