Improving the Safety in Factories Manufacturing Steel Products with a Fuzzy Approach and an Emphasis on Risk Management

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Abstract
Identifying areas and activities that could impose damages to the system, or puting personnel at risk, as well as threatening the survival of the organization is crucial. According to market needs and customer acquisition, managers of factories who are making structural components always try to define new projects and products with new capabilities. Thus, a bulk of activities in the steel components manufacturing plant of metal constructions is linked to new projects; therefore, project risk management is highly pivotal within these plants and demands serious attention. In this regard, we would examine risk management in factories manufacturing steel structures' fragments. This study is applied, discovering the cause or reasons of an incident. In this study, we sought to distinguish the impact of safety engineering and risk management in steel components factories, besides an emphasis on risk management with fuzzy approach.
Keywords:
Project risk - risk identification - structural parts factories - fuzzy approach

1. Introduction

Today, development and growth of technology and industry have increased the risk significantly in the industry and diversify risks. On the other hand, these advances, has faced us with a lot of dangers that cause damages to property and lives exposed. Damaging risk can be identified and controlled (HSE, 2008). In the new era with rapid development of industry and technology, concerns about adverse consequences threatening the human life are increasing. Damaging effects of these developments, including fusion (France), piper alpha (England) and Chernobyl (Russia) as humanitarian disasters and environmental pollutants emerged causing deep reflection on the human consequences such as health and the environment [1]. Comparing great events in different countries, regardless of their level of expansion, represent many similarities with each other.

Factors such as human error rely too much on the safety of facilities, lack of planning, lack of preparation in critical condition and in less developed countries, non-compliance with standards of safety, health, and environment in the technology transfer [2].

One of the strategies for the development of the construction industry is a serious approach to the implementation of industrial construction. The industrialization means the methods that the use of human resources, raw materials and capital to respond to the housing needs of society with economic efficiency by using new technologies in a structured and modular, organized and coherent manner. It is achievable by providing the necessary technical conditions for the expansion of production facilities in construction industry raise the level of skilled manpower and the use of new techniques and tools to run the building.

Project management means planning, organizing, resource allocation, control and appropriate leadership to meet the defined project goals successfully. In this regard, the correct use of knowledge, skills, tools and techniques necessary to facilitate in such a way that the project management process implies is very important. In the knowledge of project management any matter having an impact in any way on the anticipated objectives of the project is regarded as a challenge, either positive or negative in achieving the goals. So projects are either vulnerable to or will profit from the uncertainty. Uncertainties generally changes what occur in the future by changing various factors such as changes in the assumptions and objectives, human performance in the corporate and individual levels (skills, experience, accuracy, efficiency), and environmental performance (market, economy, politics, culture, nature) [3].

According to this definition, risk is expressed as the uncertainty that it is possible to measure its probability; in other words, uncertainty is unmeasurable, but the risk can be measured and the changes that are likely to occur can be traced. Since a project is always performed in an environment full of uncertainties, then it is faced with numerous risks and uncertainties. Synchronicity of uncertainties with the objectives of the project causes the risk. Social scientists have shown that people are more willing to averse the risk and a few people are able to tolerate the risks that would be imposed on them. They fear especially the risk of unknowns, and this fear can be strengthened as a result of environmental conditions such as exposure to an incident in the headlines of newspapers [4].

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In general, three global approaches in relation to the risk are:

1. The negative approach, where risk is expressed as a probability of occurrence and the results of a risky event, or occurrence chance of an inclement event. Some of the standards of Great Britain and Canada before the year 1990 had such an approach,

2-neutral approach, which considers risk as the chance of anything that affect project objectives. Standards in Australia and New Zealand have addressed this view;

3- A comprehensive approach to reduce the impact of potential negative events and using the opportunity to improve in desired goals. ISO standards and the PMBOK have used such an approach.

In all the above approaches, the principle of risk survival is inevitable: no risk is vanished, but transferred; and the transfer consists of some costs; therefore, it can be said that with the passage of time, attitude to risk has passed negative perception by crossing the neutral view and currently approaching comprehensive understanding [5]. Enterprise risk management is the heart of the safety system.

Risk management is a systematic planning process to identify, analyze, respond and monitoring project risk. The process of risk management involves risk identification, analysis, and risk analysis, responding to risk and controlling the risk. Risk management process is based on the Deming cycle. The objective of risk management is to maximize the positive effects and also to minimize the negative effects of opportunities and threats, respectively.

Effective management of risk is one of the principles that ensure success in achieving organizational goals. In this type of risk management, financial risk is also included in the assessment. It provides conditions that can reduce costs; issues associated with safety and health is also adjusted. In the past, temporary efforts to manage the risks were performed, for example, paid only to control a certain risk. However, different recent ideas for risk control such as HSWA2 focuses on managerial processes, an approach which is recently approved by the UK Health and Safety Commission. Risk management necessarily includes the following sub-processes:

1. Identification

2. Evaluation

3. Control (elimination or mitigation of risk)

In business environments, operations managers at all levels have the responsibility to identify, evaluate and control the risks that can cause injury, damage or loss [4].

Frequently, risk management process includes:

• Risk identification: includes a list of events that may occur and the possible causes of these events. There are many techniques for risk identification such as brainstorming, checklists, questionnaires, interviews, Delphi, SWOT matrix, causal diagram.

• Risk Analysis: The risks identified in the previous step are analyzed in this stage. It will be determined at this stage how the event is likely to occur and what are its consequences. The risk analysis tools include, but not limited to: Pareto plot, FMEA, and probability-impact matrix.

• Response to risk: it means finding an appropriate reaction against the risks which are possible to occur. The approaches used in this phase include risk avoidance, risk transfer, e.g. delegation of work to contractors, risk distribution, for example, using multi-providers instead of buying only from a supplier, risk mitigation, risk acceptance, and financial protection.

• Risk control involves considering, reporting, following-up and tracking the risk.

Risk control is to answer these questions:

- Does the strategy set for risks is implemented according to the plan?

- Do responses have been effective?

- What new responses are needed?

- What is the correct policy to track?

The risk control tools such as checklists and earned value analysis are used in this process. Effective risk management can be very complex. Risk management does not simply understand the risks, their consequences, probability and risk perception. In fact, risk management includes reforms in management processes in both the overall and detailed levels to ensure continuous and effective risk controls [4].

Despite this, in assessing the success of projects, the most of objectivity is about technical engineering, while there may be other factors that seem invisible playing a determinant role [6]. According to the discussion above, it seems risk management affect performance of factories manufacturing the main parts of metal structures. In general, it should be stated that

numerous failures, faults and injuries have strengthened the need for safety and health care programs. Sometime, damages and injuries were the result of inadequate operation. Later, the technology is largely making disasters. But in the current era, defects and deficiencies in the management have caused it [4].

Often in projects, risks are underestimated and delegated to the departments with low level of knowledge, resources and capacity to manage them effectively, resulting in increased costs and delays in the project. Identifying risks in the system and assessing these risks by focusing on how these risks occur, and also regarding the consequences, help organizations and factories to make efficient use of resources and avoid resources wastages. Also, following this evaluation, personnel will become familiar with the dangers of system and learn how to deal with risks [7]. Hence, risk identification and allocation are powerful factors in risk management decisions. Before carrying out the risk assessment, risk identification issue, and then control of risks will be important in the programs of organizations. It is obvious that when the number of threats detected is more than one, a question arises to address the issue of control. So, study and research in the field of risk management has a high value in projects which is often overlooked or some of its details are not accurate. Hence, it is essential to identify risks and provide appropriate solutions. This requires a lot of research as well as a detailed look at the research done in other countries; so it can be helpful in order to achieve the desired objectives. Hence, the present study examines the risk management in factories making one of the main pieces of metal structures.

2. Basic Concepts in Risk Management

Risk is a situation that could lead to an accident. The purpose of identifying risks is providing the opportunity to assess, reduce and, at best, eliminate risk.

Risk: the chance (probability) of a danger. In fact, it is a combination of probability and severity of the consequences of the incident.

Damage: casualties resulting from the accident resulting direct or indirect financial losses and environmental damages or loss [8].

Consequence: conditions that arise as a result of actual risk.

By increasing complexity of the systems, the dangers and risks are both significantly increased. Therefore, laws and regulations related to safety in most developed countries are applied to proactively management, control and prediction of risk.

In most countries the balance between risk and related costs and benefits of risk reduction is established; but since safety of the lives is so important in most developed countries, enormous budgets are allocated for this purpose. For example, in England every solution that can save one life from death wins a reward up to 1200000 pounds. This number is 140,000 pounds for prevention from a major and 11,000 pounds for a minor injury. These figures reflect the importance of the safety and lives of people in developed countries [8].

Risk Managing and controlling from a systematic perspective is fulfilled through two procedures:

A) Risk evaluation

B) Risk management

The specifications about the acceptable risk limits and the techniques applied in the evaluation of risk are not the same in in many countries. Both risk evaluating and risk managing procedures are explained in the following paragraphs.

The factors that affect the risk levels in construction projects. Researches show that the basic risks of projects can be divided in to several categories:

1-The less important factor of uncertainty can cause financial risk and delay. The extent of work domain increases types of work which finally leads to the increased risk that is harder to be controlled in comparison with small and short term contracts.

2-More complex the technology, higher qualifications would be needed and as a result another uncertainty and risk factor would be found among workforces who can finish the job with minimum problems. The complexity of job can lead to the increase of mistakes which in turn causes delay and extra costs to the executor. Through anticipating and well managing the risks, one can minimize the mistakes.

3-Modernity and innovation: The executer's first projects would arise more dark points, ambiguities and doubts, so more experienced the executer, less doubts would be arose and the contractor can somehow estimate the executor's qualifications. In repeated projects some parts of the job which had been done before can help to reduce the cost and save the time. In other words more repeated the project, more mitigated the risks.

4-Sensitivity: National, cultural and historical projects are much important projects so they need more attention and scrutiny. Some projects need quick planning and performing. In these cases intensify risks and extra expenses are expected.

5- Geographical location: Although lack of good transportation, weather changes etc. can make the implementation of the project more difficult and add to its expenses, but unpredicted conditions such as unavailability of material and workforce as well as unexpected ups and downs in the work site etc. can increase risk coefficient. These types of projects confront with problems that can be predicted and prevented.

Risk management is one of the important factors of project management. Managing the risks by appropriate tools and methods can provide the project with time saving and cost reduction as well as quality improvement. In many standards such as "Project Management Body of Knowledge (P.M.B.O.K.)" and "Project Risk Analysis and Management (P.R.A.M.)" the processes of an effective risk are classified as below:

1-Definition of goals and limitations of risks

2-Comprehensive identification of risks

3-Purposeful assessment of their importance

4-Designing appropriate responses

5-Managing responses in order to obtain expected results [9].

The process of risk assessment for safety considerations

In the first step of risk management process, it is necessary to completely identify and define the scope and the condition of the system, its components and the relationship between the components. Then risk assessment is fulfilled within the defined scope. This process contains 3 basic phases:

1-Risk identification

2-Risk analyzing (identifying the results of risk, loss assessment and risk level determination)

3-Risk control (finding different solutions, choosing the best options, review and control)

These 3 phases are divided in to 8 procedures which are described in the following part:

- Risk identification

-Cause analyzing

-Result analyzing

-Loss analyzing

-determining risk level

-Suggesting solutions

-Choosing appropriate solutions

-System review and control [9].

According to Khandan and Farzaneh's [10] research on "the structure of risk management in industrial safety", development of sensitive and complicated methods for assessing system safety prevents from accidents. So accident analyzing methods identifies the potential of risk occurrence before system operation and the system safety will be organized based on a planned design and preforms in a "before accident" framework. The plan is based on analyzing-controlling method. Risk management enables the company to manage the current routine risks better and without worrying about accidental losses and continues its daily activities more completely and effectively. This research studies risk management process, risk analyzing, procedures after risk identification which includes risk elimination, risk mitigation, choosing and implementing solutions. It also investigates risk monitoring and makes the checklist of performing risk management in order to create a safe workplace.

Nordlöf et al. [11] in a study on "safety culture and reasons for risk taking at a large steel manufacturing company: investigating the worker perspective" says that steel manufacturing workers face a lot of safety risks due to the nature of their job. The dominant culture of an organization affects the observation of safety methods and the related standards. The aim of this research is to study and describe the safety culture and risk taking at a large Swedish steel manufacturing company in order to investigate the workers' safety and risk taking experiences. In this research ten Focus group interviewed 66 workers and the safety work conditions were assessed through semi-structured interviews. Then through content quality analysis, the results were inductively compared. Using this analysis the safety culture and risk taking of the company were defined and classified in to these five categories:

1- Risk taking: The individuals should take the risks of work place.

2- The individuals' responsibility to safety: The individuals are highly responsible for safety.

3- Make a balance between efficiency and safety: These have opposite nature i.e. production and safety work have opposite natures.

4- The importance of relationship: Safety measures should be efficient.

5- Modernity and external conditions: The interaction between these factors has an effect on risk taking.

In social technical systems there is an interaction between social and technical factors of the organization. The findings of this study make social and technical aspects of safety culture and risk taking understandable.

In 2011 Nieto-Morote and Ruz-Vila in an article on "A fuzzy approach to construction project risk assessment" present a risk assessment methodology based on fuzzy theories which is an effective tool for analytic hierarchy process. They identified the risks and recognized judging parameters to assess the overall risk factors such as the effect of the risk, the probabilities (likelihood) of the risk and discrimination for predicting the risk. All these factors are described through qualitative scale in a way that the trapezoidal fuzzy numbers are defined to detect variable ambiguity. The major difference between this method and other fuzzy risk assessment methods is the use of algorithm to investigate the irregularities in fuzzy relations.

3. Research methodology

After collecting information, the results were analyzed using a fuzzy approach. Fuzzy logic as a newer concept in comparison with current methods was used for designing and modeling mathematical systems and developed and sophisticated possibilities. In designing fuzzy systems, values and regulations based on language variables or an expert's knowledge were used. Control systems based on fuzzy logic are regarded as extension of Boolean logic. Because in traditional logic everything is expressed as the binary (0 or 10), so in fuzzy logic Boolean, true proposition is expressed with a degree of truth. Membership function of a fuzzy set determines the mapping of each point in space to the degree of fuzzy membership which transforms input data to a 0 to 1 scale. In fuzzy systems the process of mapping is called inference engine which acts as IF-Then based on a set of fuzzy rules. For inference there are two main modelings as Mamdani fuzzy inference model and Takagi-Sugeno Fuzzy Inference. These two methods are the same in input fuzzing and the fuzzy set operations but they have different output functions. In Mamdani fuzzy inference the fuzzy set membership functions as an output.

Mamdani-type inference, expects the output membership functions to be fuzzy sets but in Takagi-Sugeno Fuzzy Inference the output membership functions are either linear or constant.

4. Simulation

• In this part an integrated fuzzy system is used and risk management is determined based on a fuzzy system. To use risk factors such as risk levels, the age of individuals, their processing power and financial resources, the inputs were studied in a fuzzy system and the data were processed and the processing procedures were optimized. Here a Mamdani-type inference is suggested:

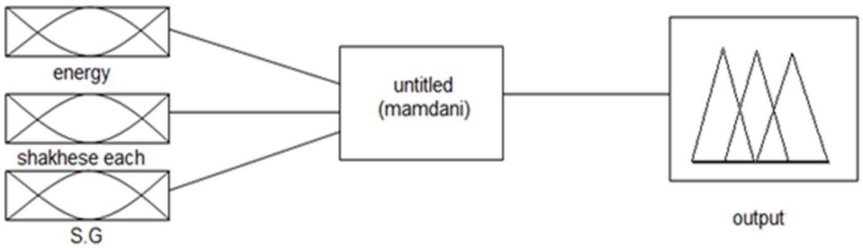


Figure 1: A Mamdani-type inference

The Inputs of a Fuzzy System

The first fuzzy system input is the risk levels.

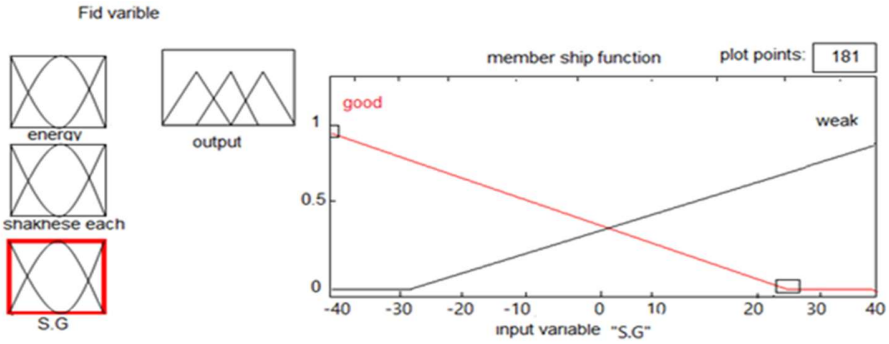


Figure 2: traffic in server, the first fuzzy system input

The first fuzzy system input is traffic in server. The second fuzzy system input is financial resources. In this case study the maximum distance considered 1000 and the range of zero to thousands is determined using fuzzy concepts. Maximum value of fuzzy system is expressed with human quantities.

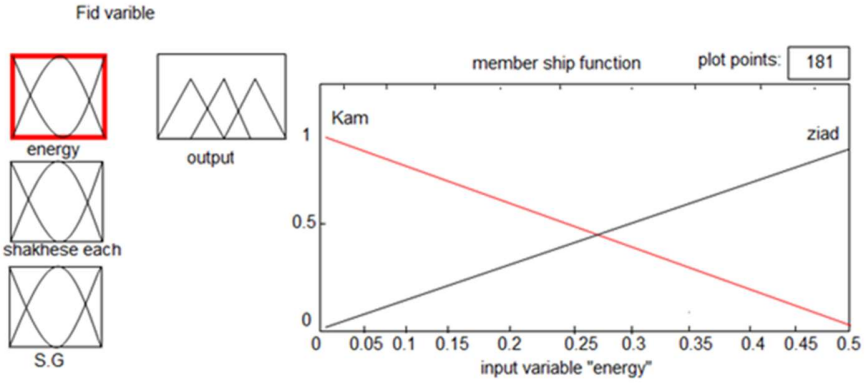


Figure 3: High, medium and low financial resources

Financial resources are the second fuzzy system input

The next fuzzy system input is the power of risk taking which was calculated. In studying the risk taking environment, the maximum power of risk taking is assumed to be one unit.

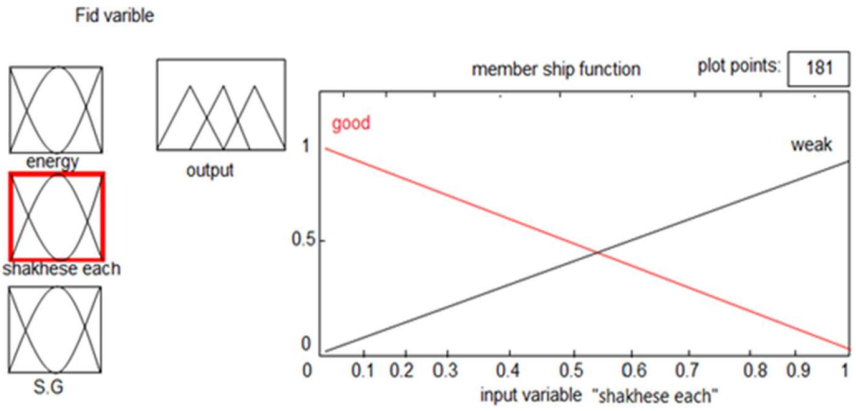
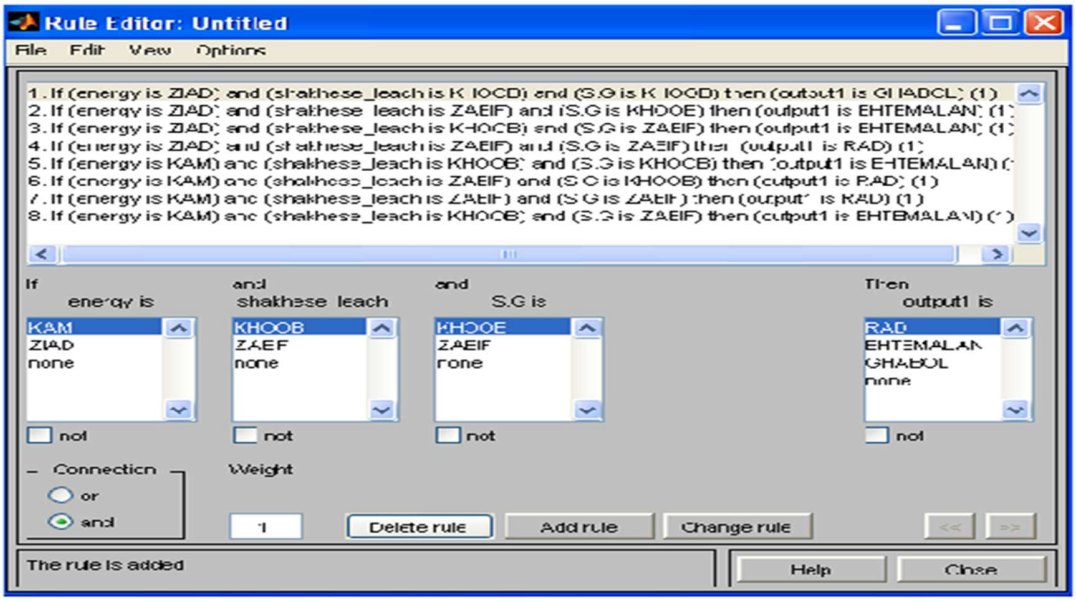


Figure 4: Financial resources are the second fuzzy system input

The third fuzzy system input is the power of risk taking

The third criterion which is chosen for fuzzy system input is age dispersion. Here we obtain the rules of fuzzy system:



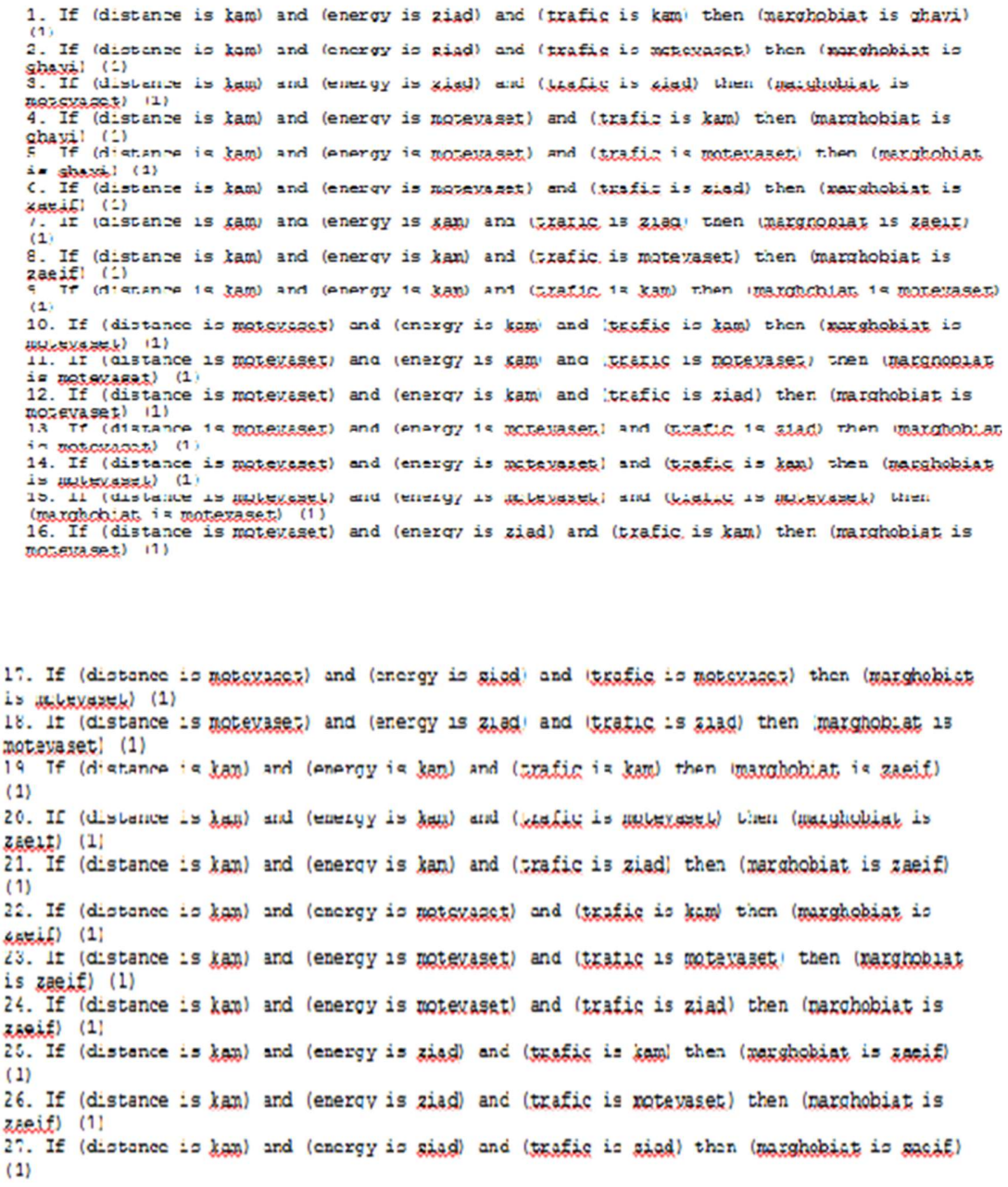


Figure 5: the rules of fuzzy system

Here we study the output membership function:

Based on inputs procedure, the fuzzy system is going to choose a number for any risky process in order to fulfill the project. We consider 5 as the threshold value.

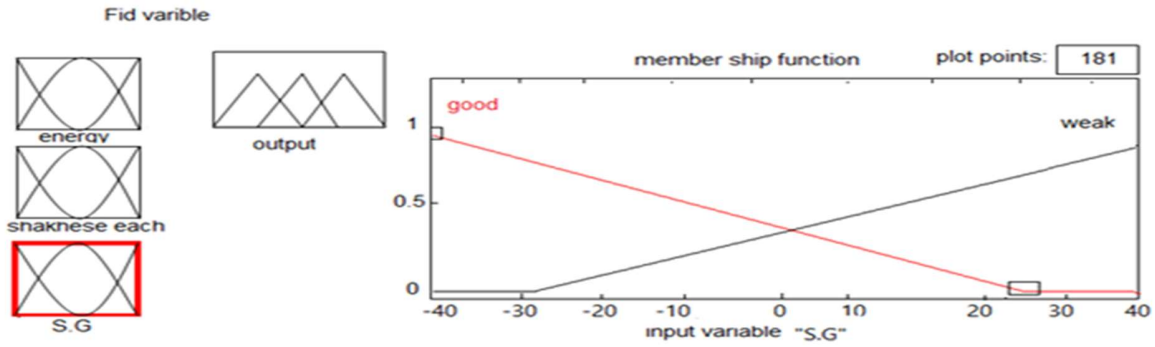


Figure 6: the output membership function

Here we compare the algorithms. The overall algorithm is shown as below:

If the output value is near 1, it is more appropriate in terms of quality index and it was in higher priority than the other options.

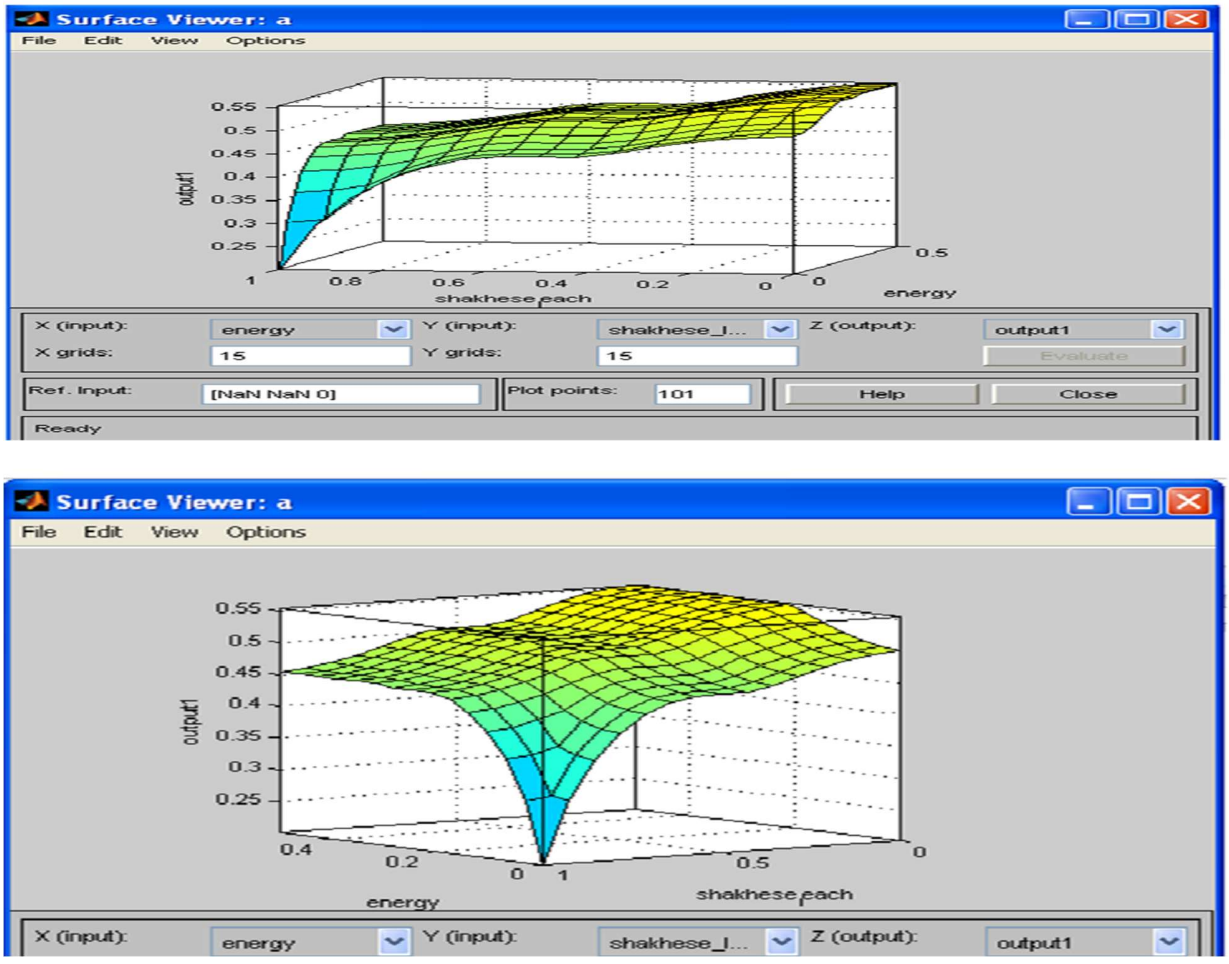


Figure 7: the application of the output value near 1

5. Conclusion

In this section in order to implement the proposed method, fuzzy systems for risk taking were instructed. In tests, when his data produce the best outcome, the accuracy and speed of algorithm is highly acceptable.

One of our challenges is collecting information and data. In future we can achieve better results through collecting larger amount of information.

Figure 8: the overall algorithm

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