# Predicting Failure in the Hydraulic Lift Structures with Monitoring and Fuzzy Logic

**Morteza Jamshidian[1*], Sayed Ali Mousavi[2]**
M.Sc. Student, Mechanical Manufacturing ,Najafabad Branch, Islamic Azad University, Najafabad, Iran
*Email of Corresponding Author: jmoreza@yahoo.com
Assistant Professor, Department of Mechanical Engineering, Najafabad Branch, Islamic Azad University, Najafabad, Iran
*Received: December 21, 2014; Accepted: April 1, 2015*

**Abstract**
There are several strategies for maintenance and repairing of devices in industry. However, they are still confronted with many uncertainties. A hydraulic lifting device after ten years of working in a technical center in Isfahan is faced with uncertainty in terms of reliability. Being able to know the reliability of pieces means predicting failure occurrences, which is accomplished by condition monitoring of the pieces by measurement of errors and ambiguous boundaries. Using condition monitoring and expert groups and multiple membership functions by creating a fuzzy system in MATLAB software uncertainties important components and the structure status are obtained in the fuzzy form. Moreover, between the healthy and damaged conditions a percentage of health is obtained and the health of system is shown.

**Keywords**
Fuzzy logic, Condition monitoring, Hydraulic lift, Expert group

## 1. Introduction

The expected downtime and guessing the reliability of the machines are the main concerns of users of industrial machinery and equipment and administrative organizations. So far, a strategy such as preventive maintenance (PM) has been used to great cost [1]. Method condition monitoring (CM) has been used to predict failure for about twenty years. In this way, uncertainties such as measurement error and the inability to determine the limits still exist. This uncertainty can be resolved with the express sentences of quality, and to establish a fuzzy system. Fuzzy logic methods in the human brain can be used to replace the now classical logic. Monitoring using fuzzy logic can be used as a method to detect the ability of devices to be used. Between absolute good and absolute spoiled can also be found an option to be used in the planning [2].In this paper, fuzzy logic method has been discussed for monitoring the mechanical structure of a lift in training aircraft maintenance center.

### *1.1 Condition monitoring*

Condition monitoring is the measurement and monitoring of parameters that indicate the status of the device as working and repeatable and comparable information is useful for troubleshooting. Full use of surveillance techniques, using the five senses, vibration analysis, sound analysis, ultrasonic analysis, thermography and efficiency are analyzed. Early warning of potential damage to the device with your show. And the more time that passes, the risk warnings and the more costly it will become. Using the five senses is still important to take care of the equipment. Touch can also help

to give us an understanding of vibrating equipment. Also, the temperature measurement can be done with touching. However, it is not possible in some cases to measure temperature in this way if the temperature is too high. Visual inspection and non-destructive testing is one of the most important tools for many types of defects such as leaks and breakages, and so the observed deformations are recognizable. Some drawbacks lead to the release of a particular odor that is detectable by the human nose. For example, some oil failures, electrical circuits and equipment failure and so the smell is knowable.Listening is one of the best tools for sound analysis of both quantitative and qualitative terms. Sometimes, the human ear works best to detect the sound source and the failure of the analyzer system, because the human ear is able to differentiate between different patterns of sound and linking the various failures.By referring to the table it will be realized that most of these standards are standards for monitoring and evaluation experts are available with the five senses in the early warnings of potential failures in the diagram (pf) (Figure 1) can be diagnosed by experts. Monitoring concept was born in the Seventies and is widely used to control mechanical systems [3].

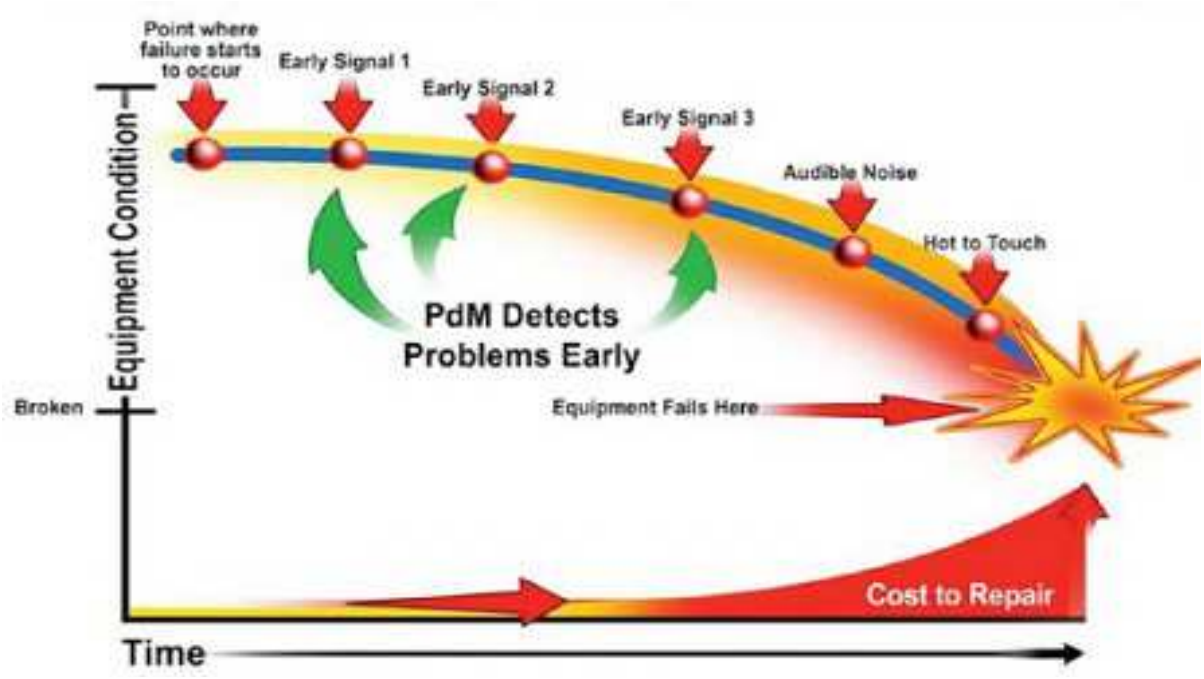


Fig. 1. Potential Failure (p-f) graph

*1.2 Fuzzy logic*

Fuzzy logic is a method that replaces the conclusion of the human brain. In fact, the way the human brain works is based on the fuzzy input and processing in the human brain. This method can also be applied in industry. Classical logic is based on a binary system (true or false, zero or one, black or white), but fuzzy logic with a number of values between zero and one can show anything. If black and white are shown with zero to number one, then the gray numbers will be close to zero. Fuzzy Logic believes that ambiguity is the nature of science. Unlike others who believe they should be more accurate approximations to increase productivity, Zadeh believes that it should seek to build models that introduce uncertainty as part of the system. Fuzzy logic is flexible and easy to understand. Tolerance of imprecise data can be built on top of the experience of experts. Since

fuzzy logic is based on the definitions of quality which are used daily, it is very simple to use[4]. The starting point for building a fuzzy system is to obtain a set of rules of if - then. In fuzzy logic membership functions are used for inference. The membership function of the fuzzy sets is important. Since all the information related to a fuzzy set are described by its membership function and fuzzy sets in all applications and issues than it used to be. The membership function of the fuzzy value specifies a set. In MATLAB software there are opportunities to create a fuzzy system. With if-then rules we can predict and use the membership functions of the system created [5].

*1.3 Fuzzy condition monitoring*

Condition Monitoring as a new method to predict equipment failures is considered, including the detection of defects such as geared turbines and parts of the Balkans [6].Transformers defect detection technique with measure vibrations in machine Condition Monitoring and also the use of fuzzy modeling [7].The amount of particular matter in the case of transformer oil can help by Condition Monitoring fuzzy errorsindiagnosis [8].The research was conducted using a combination of fuzzy model that shows this method can be converted into a maintenance strategy [9].

## 2. Material and method

The upper structure of a lift has been investigated for a period of ten years since making. To work with the device, safety is very important. The manufacturer of the machine instruction that was written during one of the sectors which parts must be replaced after ten years of the vertical structure. To do this, the basket, vertical canvas and balance tube, triangular to replace brass pins and bushes should be disassembled and new parts installed and because it is only ten years working. By monitoring the brass pins and bushes should be monitored. One of the tools to do so is reliance on the five senses, i.e. seeing crush, cracks, corrosion and rusting of the health and canvas liners, screws. Bush also represents noise and wear and dilate the hinges. Here canvas and tubes for balance and health of the undefined and despite the extent of discoloration or cracks in welds and joints and is defective warning also just to say that this part of the surface is damaged, or is healthy and can continue to work. Using fuzzy logic in monitoring can help the ambiguities to be resolved. To do this in MATLAB software a fuzzy logic toolbox was created that includes a number of membership functions of a fuzzy system. With the exposure of membership functions for each of these parameters, experts were chosen. The toolbox fuzzy (Figure 2) to the input membership functions zmf, smf, gauss mf Figure 3 and for outputs of tri mf membership function was used.

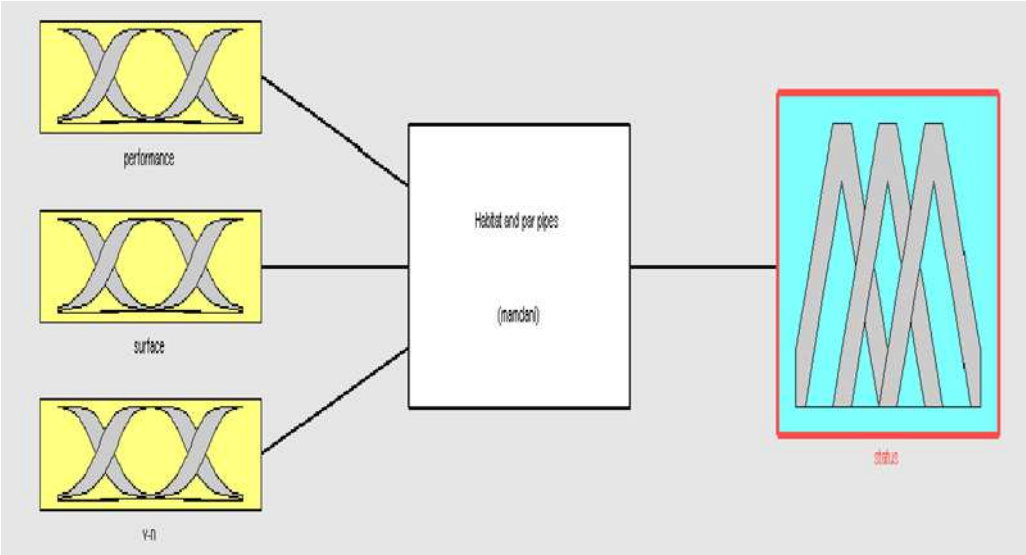


Fig. 2. Fuzzy logic toolbox in MATLAB software

Then a set of rules (if -then) was written by the experts of the rules stated in terms of quality. (Figure 4) Membership functions for different states of inputs and outputs were named and the membership functions for the performance of three modes (SLOW, PROPER VALID) and the appearance of modes( GOOD AVERAGE, BAD) and the vibration and noise (LOW, MEDIUM, HIGH) and the output of the three (CRITICAL, MEDIUM, NORMAL )considered according to the rules and membership functions of these structures are likely to be adjusted. (Table 1)

Table1. Table Rules monitoring

| lift structures | | | |
|---|---|---|---|
| PERFORMANCE-SURFACE | V-N | | |
| | L | M | H |
| S-G | M | C | C |
| S-A | C | C | C |
| S-B | C | C | C |
| P-G | M | M | C |
| P-A | M | M | C |
| P-B | C | M | C |
| V-G | N | M | M |
| V-A | N | M | C |
| V-B | M | M | C |

The first law was written for first home table. If the performance was SLOW (S) and the appearance was GOOD (G), and vibration and noise was LOW (L) then the balance of ecosystems and pipe fittings is MEDIUM. The structural components of lift tables are set up and the views of the expert group, including maintenance workers and professionals are recorded to make the construct. In these tables, the structure was divided into three parts and monitoring the results of the expert group on selection medium ( M) natural (N) and good (G) and bad (B) and critical (C ) low (L) and (H) were high. For options in Tables 1 to 3, a number between 0 and 10 was considered.
C = 0, (B, H) = 2.5, M = 5, (L, G) = 7.5, N = 10, C = 0, (B, H) = 2.5, M = 5, (L, G) = 7.5, N = 10

Table2**.** Expert1

| **VIBRATION- NOISE** | | | | | **SURFACE** | | | | | **PERFORMANCE** | | | | | **Structural lift** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N | L | M | H | C | N | G | M | B | C | N | G | M | B | C | | |
| | * | | | | * | | | | | | * | | | | Habitat and par pipes | Piece name |
| | | * | | | * | | | | | | | * | | | Cabin and retentive | |
| | * | | | | * | | | | | | * | | | | Winch shaft and turret | |

Table3. Expert2

| **VIBRATION- NOISE** | | | | | **SURFACE** | | | | | **PERFORMANCE** | | | | | **Structural lift** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N | L | M | H | C | N | G | M | B | C | N | G | M | B | C | | |
| | * | | | | | * | | | | * | | | | | Habitat and par pipes | Piece name |
| | * | | | | * | | | | | | * | | | | Cabin and retentive | |
| * | | | | | * | | | | | | * | | | | Winch shaft and turret | |

Table 4. Expert3

| **VIBRATION- NOISE** | | | | | **SURFACE** | | | | | **PERFORMANCE** | | | | | **Structural lift** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N | L | M | H | C | N | G | M | B | C | N | G | M | B | C | | |
| | * | | | | | * | | | | * | | | | | Habitat and par pipes | Piece name |
| | | * | | | | | * | | | | | * | | | Cabin and retentive | |
| | | * | | | | * | | | | | * | | | | Winch shaft and turret | |

The fuzzy system input parameters were defined for the effect PERFORMANCE, SURFACE, VIBRATION, and NOISE. The results of Tables 1 to 3 were inserted at the output as well as a number between 0 to 10. Each segment was obtained (Table 5).After obtaining the health of each item and the overall health the device in a fuzzy system was obtained (Figure 2 and Figure 3) and the effect of health on the overall health structures lift three structures were investigated. These choices were made with the expert group. If -then law was written for inputs and outputs. For three

critical state structures (C) and medium (M) and normal (N) and The outputs insecure (I) and average (T) and safety (S) in the first table of the law is intended to house. It was written that if the normal part 1 (N), 2 and 3 critical (C), then the insecure structures (I) is. (Table 6)

Table5. Numerical results obtained from the monitoring

| Component NAME | PERFORMANCE | SURFACE | VIBRATION-NOISE | STATUS |
|---|---|---|---|---|
| Habitat and par pipes | 9.2 | 8.3 | 7.5 | 8.18 |
| Cabin and retentive | 5.7 | 8.3 | 5.8 | 5.09 |
| Winch shaft and turret | 7.5 | 9.1 | 7.5 | 8.13 |

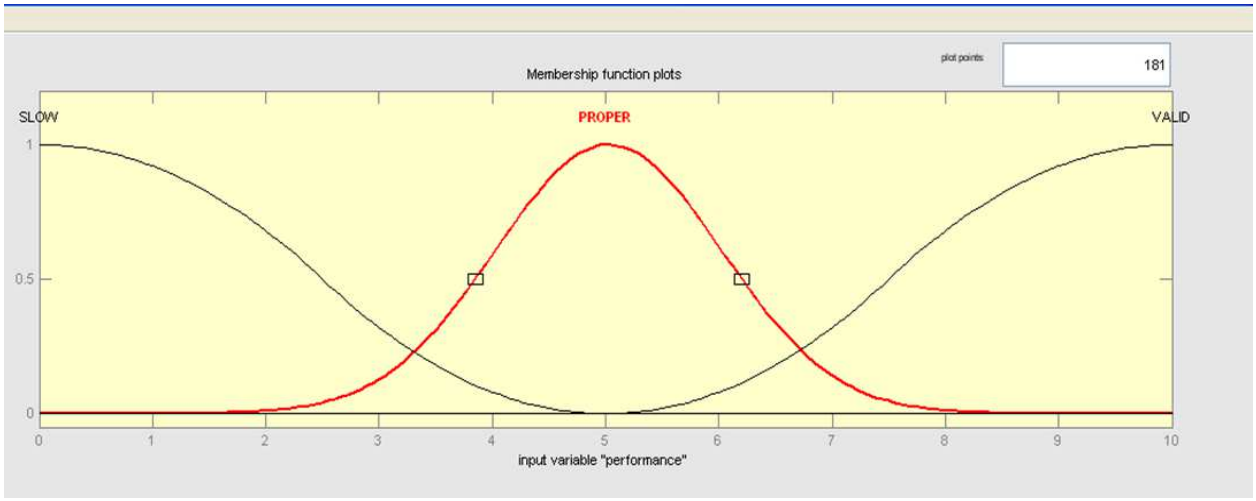


Fig. 3. Membership functions for inputs zmf, smf, gauss mf

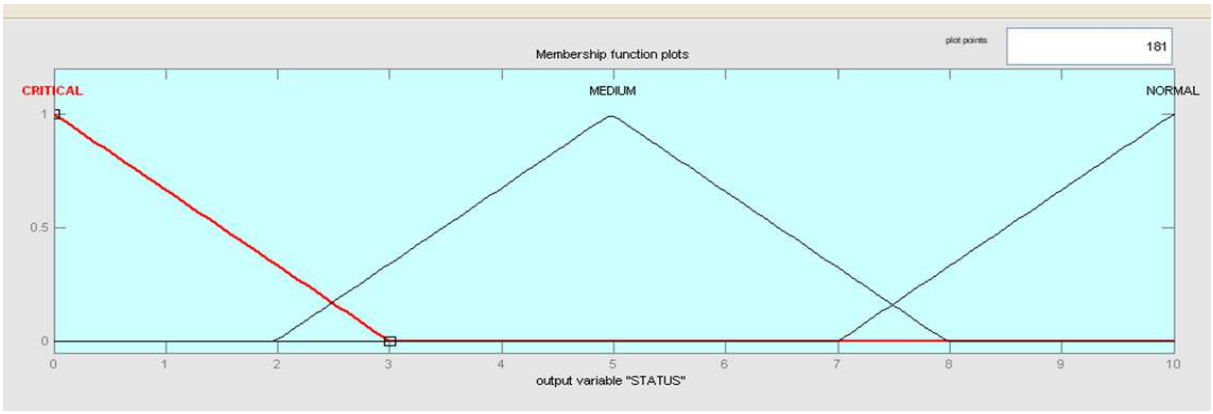


Fig. 4. Output membership functions trimf

Table 6. Rules on the health effects of structural health

| **(A)**Complex structures and lift cabin | | | |
|---|---|---|---|
| | **1** | | |
| **2-3** | **N** | **M** | **C** |
| **C-C** | I | I | I |
| **C-M** | I | I | I |
| **C-N** | I | I | I |
| **M-C** | I | I | I |
| **M-M** | T | T | I |
| **M-N** | T | T | I |
| **N-M** | T | T | I |
| **N-C** | I | I | I |
| **N-N** | S | S | I |

## 3. Results

Based on the results in Table 5 and the fuzzy system, the overall health of the device number 98.4 in output was achieved (Figure5) and a three-dimensional plot in MATLAB fuzzy toolbox fuzzy system was established. (Figure 6)

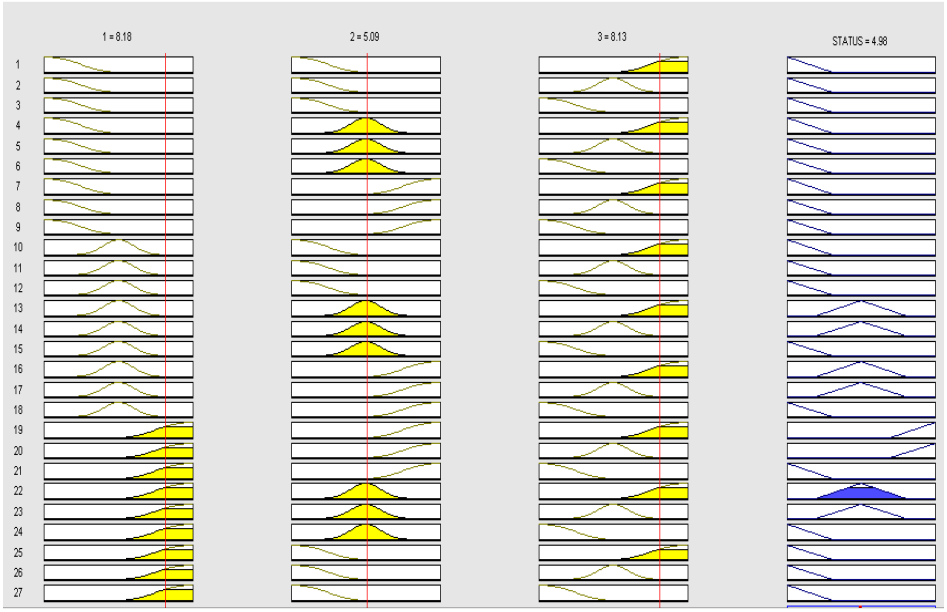


Fig. 5. Structural health rules elevator with input and output membership functions

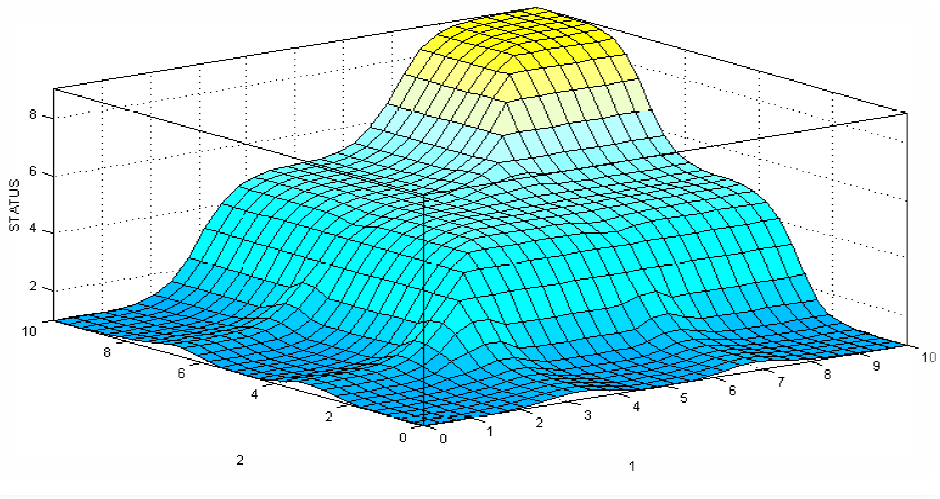


Fig. 6. Three-dimensional relationship between inputs (Part 1 and 2) and output (the overall health of the device)

Similarly, the relationship between parts 1, 3 and 2, 3 as well as the health of the entire the device is extractable from three-dimensional diagrams. According to Table 5, the numbers were obtained in the most critical part, basket, cabins and holder. Number 5.09 represents a decrease of 51 percent of its health. For this part of preventive maintenance the classic condition monitoring was that the basket should be opened and repaired or replaced. Monitoring by the implementation of fuzzy led to the conclusion that holder and the basket is still 49% reliable. The column rotating turret also has lost 19% of their health. In classic preventive maintenance and condition monitoring the solution was totally disassembling and replacing the bushes connection. Monitoring by the the implementation of fuzzy shows that 81% of this part is still safe and reliable and so is the need for disassembly and replacement of bushes. Part balance pipe and fitting canvas has lost 18% of its health. Classic preventive maintenance and monitoring suggested disassembling these parts. The experienced experts found that 82% are reliable. The implementation of fuzzy systems for the health effects of these three parts of the structure led to the conclusion that the device is 49%reliable. While the previous classical system indicated the complete disassembling and rebuilding and its costs had to be paid, If Table 5 is considered, early warnings of failure in all parts and repair or replace the cabin should be a priority because of faulty basket cabins and holder security risk and has overshadowed the whole structure and the whole structure is reached in the average alerts. If a 10% reduction of health considered an alert device and 30% of the critical point then there are two alerts to the critical point.

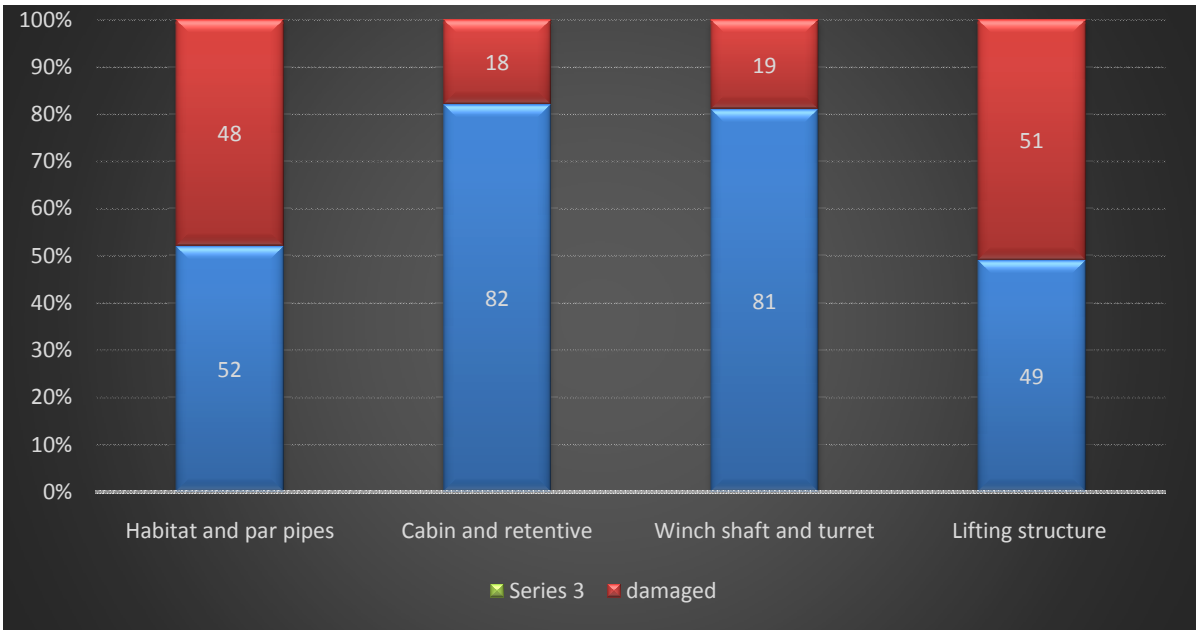


Fig. 7.

## 4. Discussion

There have been uncertainties in the structural integrity of the device. The monitoring fuzzy system using expert knowledge and fuzzy toolbox in MATLAB can help in choosing between absolute damage and absolute undamaged. Structural repairs need to be considered in planning and in some places where it was possible to predict the damage or the percentage of the undamaged. Because the fuzzy system is based on human knowledge and experience of experts, it is more reliable. it also reduces the cost of repairs.

In the future further investigations in the implementation of fuzzy systems of the monitoring devices need to be carried out. This method has become a strategy of maintenance and repair and maintenance of intelligent sensors installed on the device and optimized neural networks and genetic algorithms are also on the way.

## 5. References

[1] Hajshirmohamadi, A. 2002. Planning maintenance (technical management in the industry), ghazal: Esfahan.

[2] Masomi, G.H., Salehi, A., Meimandpur, B. 2009. Application of fuzzy logic in decision making and repairing machinery condition monitoring unit, Fourth Conference on Condition Monitoring and Fault Diagnosis of Machinery, Sharif University of Technology, February.

[3] Shahin, A. 2010. Prioritize strategies to increase the availability of equipment condition monitoring using the risk-taking preference score (RPN) and AHP approach with a case study in Steel Mobarakeh, Maintenance of research Rahavard, 2.

[4] Atai, M. 2010. Fuzzy multi-criteria decision, Shahrood University.

[5]Kia, S. 2010. fuzzy logic in MATLAB, publisher Qian green computing.

[6] Sachin, S. and Dalgobind, M. 2013. Condition Monitoring of Wind Turbines: A Review, International Journal of Scientific & Engineering Research, 4(8), 35.

[7] Po, C. and Jyh, C. 2011. Gu-Research on Transformer Condition-based Maintenance System using the Method of Fuzzy, Comprehensive Evaluation_World Academy of Science Engineering and Technology, 56.

[8] Alizadeh, D. and Ahmadi, H. 2010. monitoring diesel engine oil analysis using fuzzy logic, Quarterly Journal of Engine Research, 5(19).

[9] Faqih, N. 2010. The control fuzzy of planned maintenance and repairs, NavidShiraz.