# Implementaton of 5S in a Plastic Manufacturing Company with Fuzzy Logic

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## Abstract:

*In this research work the 5S methodology is implemented in a workplace for the betterment of the working environment and the augmentation of production. The 5S philosophy focuses on effective workplace organization and standardized work procedures.Not only the employees feel better about where they work, but also the continuous improvement of 5S leads to less waste, better quality and faster lead times.Out of the available various lean manufacturing techniques, 5S offers good potential for required improvement.This paper deals with the implementation of 5S methodology in the HAMKO Corporation Ltd, Bangladesh. 4 week field work is carried out in this company to ensure better work performance and improved production rate.The results after the 5S implementations states that production system efficiency is improved from 61.64% to 78.40% in the successive week. This result shows that continuous improvement can be achieved by implementing the 5s philosophy properly and using Fuzzy Logic optimal efficiency has derived.*

## For Referring this Paper:

## Keywords:

## Introduction

Small scale industries play an vital role in enhancing economy in Bangladesh. 5S has emerged as powerful tool for increasing productivity and efficiency in these industries. Global markets are continuously changing and demanding product of high quality and low cost. Such products can be produced using lean manufacturing, a management philosophy that intended to reduce all types of wastes at all levels of product manufacturing so as to decrease product cost and to withstand in the competitive benchmarking. 5S is a basic lean manufacturing tool for cleaning, sorting, organizing and providing necessary groundwork for work place improvement.

The aim of this paper is introducing the tactic of implementing the 5S methodology for measuring the efficiency of productivity. On the basis of the individual research it can

be stated that introducing the 5S rules bring the great changes in the company, for instance: process development by cost's reduction, increasing of effectiveness and efficiency in the processes, upkeep and upgrading of the machine's productivity, safety increasing and reduction of the industry pollution, proceedings according to assessments [1].

Based on Japanese word that begin with "S", the 5S philosophy focuses on effective workplace organization and standardized work procedure. 5S simplifies work environment, reduces waste and non-value activity while improving quality, efficiency and safety. 5S is the Japanese concept for "House Keeping". Tradionally 5S is thought of as being just about tidying up or good housekeeping and on a simple level it is, but approached properly it can be much more than that [2].

### Fuzzy Logic

Fuzzy logic reflects how people think. It attempts to model our sense of words, our decision making and our common sense. As a result, it is leading to new, more human, intelligent systems.

*Fuzzy logic is a set of mathematical principlesfor knowledge representation based on degreesof membership.*

Fuzzy, or multi-valued logic was introduced in the 1930s by Jan Lukasiewicz , a Polish philosopher. While classical logic operates with only two values   1 (true) and 0 (false), Lukasiewicz introduced logic that extended the range of truth values to all real numbers in the interval between 0 and 1. He used a number in this interval to represent the *possibility*  that a given statement was true or false. For example, the possibility that a man 181 cm tall is really tall might be set to a value of 0.86. It is likelythat the man is tall. This work led to an inexact reasoning technique often called possibility theory [3].

Later, in 1937, Max Blackpublished a paper called "Vagueness: an exercise in logical analysis". In this paper, he argued that a continuum implies degrees. Imagine, he said, a line of countless   "chairs". At one end is a Chippendale. Next to it is a near-Chippendale, in fact indistinguishable from the first item. Succeeding "chairs" are less and less chair-like, until the line ends with a log. When does a *chair* become a *log*? Max Black stated that if a continuum is discrete, a number can be  allocated to each element. He accepted vagueness as a matter of probability [3].

In 1965 LotfiZadeh, published his famous paper "Fuzzy sets". Zadeh extended the work on possibility theory into a formal system of mathematical logic, and introduced a new concept for applying natural language terms. This new   logic for representing and manipulating fuzzy terms was called fuzzy logic, and Zadeh became the Master of *fuzzy logic*[3].

## Research Backgrond

Our research motive has come from studying the research paper of P. M. Rojasra et al. (2013) and in this research paper the impact of 5S on performance improvement has been experimentally shown [4]. On their work, the numerical calculation of 5S has been given comprehendly and their work effort have been accomplished according only the practical field value.

But in our research work we have tried to use Fuzzy logic for getting better result and accuracy of the work. A comparative analysis of experimental efficiency and fuzzy derived efficieny help to find out estimation accuracy, data or information redundancy and interpretation of efficieny level up-down.

# The 5S Methodology

Poor workplace conditions may lead to increasing of wastes such as time consumed in searching for required items or motion to avoid obstacles. It could also lead an accident or haphazard. 5S is lean manufacturing tool for work place organization and it is essential to the enactment of lean strategies. 5S is a reference to five Japanese works which described standardized clean up. The 5S are:
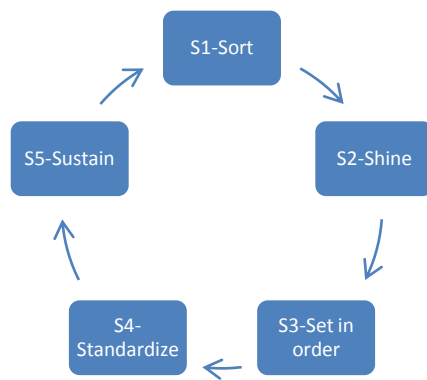


**Figure 1**.The 5S continuous cycle

In this paper the whole work was focused on 5S rating system, which make us able to comprehend the improvement criteria for particular S of 5S system. Here we have given total rating of 25 score, which is alienated in five equal parts for each specific S of 5S system. We give highest 5 marks to each S. After that we have made a graph which helped us able to understand the efficiency and better improvement. The detail and calculation of each S is given bellow.

## S1 Seiri (Sort)

Seiri is the first S in 5S system, which is basically deal with the availability of materials and process of product manufacturing. For calculation of Seiri rating, we allot 5 criterion regions for seiri arrangement, and decide that the sub system should achieve minimum 3 marks out of 5 because it tends us to define that the system will be in issue when it is above 50% active. Following are the Seiri rating criterion [4].

(1) Material availability: Giving 1 marks if material is entirely available or giving 0 marks if material is not fully available.

(2) Faulty goods: If there are A items which contains B items as defective Then the marks will be Fraction of fine goods = $[1- \{B/A\}]$

(3) Workingstate is an important aspect for the arrangement of material and tools, because without the comfort of operator the best process arrangement also has zero value. Giving 1 mark if operating condition is under control and giving 0 marks if operating condition is not under control.

(4) Relative information about working condition, process guidelines, tools information, material information etc., is also important for Seiri rating. Giving 1 mark for full information and giving 0 marks for partial information.

(5) Elimination of waste Elimination of waste is also an important aspect for Seiri rating. Let total N no of waste are listed but only M were eliminated the marks of elimination process will be Fraction of waste elimination = $[1- \{M/N\}]$ Now add all five marks and get total rating of Seiri out of 5. If the Seiri system will get less than 3 marks then do the arrangement again because if it is got below 3 marks it means it has very poor condition of analysis.

## S2 Seiton (Straigthen / Set in order)

Seiton is second S of 5S system which deals with the proper arrangement of equipment and tools on the shop floor. The main objectives of Seiton are forming a regular workplace, avoiding time loss while searching the material and mistake proofing

work. Following are the Seiton rating criterion [4].

(1) Sequence rating: Let there are X no. of tools are in proper sequence and Y no of tools are not in proper sequence. Then sequence rating will be Fraction of proper sequence = [1- {Y/X}]

(2) Material arrangement rating This criterion basically deals with the providing of raw material and accessories for the particular operation. Let D be the lack of material and C be the total material required, then Fraction of material available = [1-{D/C}]

(3) Instrumentpreparation rating: This criteria shows the consistency if the system about providing service for proper fulfilment of tooling requirement. Let P be the no. of irregular process and Q be the total no. of process. Fraction of consistency to tool arrangement: [1-{P/Q}]

(4) Material planning consistency: The aim of this consistency is "every time perfect arrangement". Let U be the fail arrangement and V be the total no. of arrangement. Fraction of consistency: [1-{U/V}]

(5) Working efficiency of Seiton system: Working efficiency = working time for process / Total time allotted for process Now do sum of all the above five criteria and note it as the rate of the Seiton system. This rate should have minimum value of 3 points, if not then system will set again or need analysis again.

### S3 Seiso(Shine / Clean)

In order to realize effective tasks, it is essential to create a clean and regular working and living environment. This is because dust, dirt and wastes are the source of untidiness, indiscipline, inefficiency, faulty production and work accidents. We can handle cleaning practices by two approaches: "general cleaning of workplace" and "machine, hardware and tool cleanliness". Seiso process indicates the "Renovation of the work place".

Seiso system contents the following criteria [4]:

(1) Is the machine clean or not: If the machine is clean then giving 1 point and if not then giving 0 point

(2) Process path clean: If the path of process is clean then allotting 1 point and if not giving 0 point.

(3) Proper environment for working condition: Working environment include the ergonomics of the worker like proper souse of light and air, which makes the worker continuously fresh and energetic and make him stay away from errors during operation. Working condition rating will be Let J will be total aspect for favorable condition and I be the no. of fail arrangement. Fraction of environment: [1-{I/J}].

(4) Cleaning consistency: Let E is the total no. of cleaning required and F is the cleaning not done say inconsistency. So consistency rate will be Fraction of consistency = [1-{F/E}].

(5) Safety from accident: Let K is the total no. of accident chances and L is the total no for accidents occurs. Then safety rate will be Fraction of safety: [1-{L/K}].

After adding all the above five criteria the rate of Seiso system can be recorded. This rate should have minimum value of 3 points, if not then system will set again or need analysis again

### S4 Seiketsu (Standardize)

Seiketsu is generally means for make a peak standard which should be achieve by the manufacturing process practice. Standard should be communicative and easy to understand. Seiketsu rating will be found by

calculating the average of previous three S, because standard of any system will rise and fall by mean rate depending factors [4].

### S5 Shitsuke (Sustain)

Shitsuke (Sustain) is the last S of the 5S system which is deal with the regularity of maintaining the standard of the organization for the particular process, which is only done by regular practices and by following the proper instruction of machine operating. By doing regular following of accurate of instruction we can maintain the machine condition at its peak level, which may help for better production and stay away from breakdown. Here following criteria are highlighted [4]:

(1) Removing small faults through the aid of cleaning.

(2) Providing the execution of visual control.

(3) Providing the performance of protective activities.

(4) Granting the responsibility of the machine to the operator.

(5) Formation of a disciplined company.

Shitsuke rating will be depending on the previous four S because without that the regularity will not maintain. Therefore Shitsuke rate will be the average of previous four S ratings.

After the calculation of this rating of 5S, efficiency is calculated at the end of every week and will so the performance improvement at the end of four week. The overall efficiency of the 5S system for the permitted or approved period will be average of the particular efficiencies for required week.

## Data Representation and Performance Results

A Plastic injection molding is a manufacturing process for producing thermoplastic and thermosetting polymer materials. Plastic product produced by injection molding process is widely used in today's world because of high cost of metallic materials and their lack of availability.

However, the experimental data of 4 week observation are plotted on the following tables and for 5S system, these tables are arranged consecutively.

**Table 1**.S1 SEIRI (Sort) RATING

| Week No. | Duration | Material Availability Rating | Faulty goods Rating | WorkingState Rating | Relative Information Rating | Elimination of Waste Rating | Total Rating |
|---|---|---|---|---|---|---|---|
| | | 0 or 1 | [1-{B/A}] | 0 or 1 | 0 or 1 | [1-{M/N}] | |
| Week 1 | 02\04\2014-08\04\2014 | 1 | 0.3 | 1 | 1 | 0.2 | 3.50 |
| Week 2 | 09\04\2014–15\04\2014 | 1 | 0.5 | 1 | 1 | 0.4 | 3.90 |
| Week 3 | 16\04\2014–22\04\2014 | 1 | 0.6 | 1 | 1 | 0.4 | 4.00 |
| Week 4 | 23\04\2014-29\04\2014 | 1 | 0.7 | 1 | 1 | 0.6 | 4.30 |

**Table 2.** S2 SEITON (Set in order) RATING

| Week No. | Duration | Sequence Rating | Material Planning Rating | Instrument Preparation Rating | Material Arrangement Consistency Rating | Working Efficiency Rating | Total Rating |
|---|---|---|---|---|---|---|---|
| | | [1-{Y/X}] | [1-{D/C}] | [1-{P/Q}] | [1-{U/V}] | w.t./ t.a.t. | |
| Week 1 | 02\04\2014 - 08\04\2014 | 0.3 | 0.3 | 0.4 | 0.6 | 1.15 | 2.75 |
| Week 2 | 09\04\2014 – 15\04\2014 | 0.3 | 0.5 | 0.4 | 0.5 | 1.23 | 2.93 |
| Week 3 | 16\04\2014 – 22\04\2014 | 0.2 | 0.6 | 0.5 | 0.6 | 1.25 | 3.15 |
| Week 4 | 23\04\2014 - 29\04\2014 | 0.3 | 0.7 | 0.6 | 0.6 | 1.36 | 3.56 |

**Table 3.** S3 SEISO (Shine/ Clean) RATING

| Week No. | Duration | Machine Cleanliness Rating | Process Path Cleanliness Rating | Working Environment Rating | Cleaning Consistency Rating | Safety Rating | Total Rating |
|---|---|---|---|---|---|---|---|
| | | 0 or 1 | 0 or 1 | [1-{I/J}] | [1-{F/E}] | [1-{L/K}] | |
| Week 1 | 02\04\2014 - 08\04\2014 | 1 | 1 | 0.4 | 0.3 | 0.3 | 3.00 |
| Week 2 | 09\04\2014 – 15\04\2014 | 1 | 1 | 0.4 | 0.5 | 0.4 | 3.30 |
| Week 3 | 16\04\2014 – 22\04\2014 | 1 | 1 | 0.5 | 0.6 | 0.4 | 3.50 |
| Week 4 | 23\04\2014 - 29\04\2014 | 1 | 1 | 0.6 | 0.7 | 0.6 | 3.90 |

**Table 4.** S4SEIKETSU (Standardize) RATING

| Week No. | Duration | Total Rating = (S1+S2+S3) /3 |
|---|---|---|
| Week 1 | 02\04\2014 - 08\04\2014 | 3.08 |
| Week 2 | 09\04\2014 – 15\04\2014 | 3.38 |
| Week 3 | 16\04\2014 – 22\04\2014 | 3.55 |
| Week 4 | 23\04\2014 - 29\04\2014 | 3.92 |

**Table5.** S5SHITSUKE (Sustain) RATING

| Week No. | Duration | Total Rating = (S1+S2+S3+S4) /4 |
|---|---|---|
| Week 1 | 02\04\2014 - 08\04\2014 | 3.08 |
| Week 2 | 09\04\2014 – 15\04\2014 | 3.38 |
| Week 3 | 16\04\2014 – 22\04\2014 | 3.55 |
| Week 4 | 23\04\2014 - 29\04\2014 | 3.92 |

**Table6.** EFFICIENCY OF 5S SYSTEM

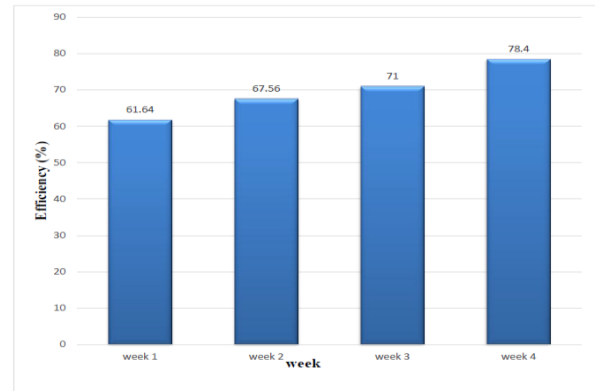| Week No. | Duration | (S1+S2+S3+S4)*100 / 25 | Efficiency |
|---|---|---|---|
| Week 1 | 02\04\2014 - 08\04\2014 | (3.5+2.75+3.0+3.08+3.08)*100 / 25 | 61.64% |
| Week 2 | 09\04\2014– 15\04\2014 | (3.9+2.93+3.3+3.38+3.38)*100 / 25 | 67.56% |
| Week 3 | 16\04\2014 – 22\04\2014 | (4.0+3.15+3.5+3.55+3.55)*100 / 25 | 71.00% |
| Week 4 | 23\04\2014 - 29\04\2014 | (4.3+3.56+3.9+3.92+3.92)*100 / 25 | 78.40% |



**Figure 2**. The graph of weekly efficiency

# Fuzzy logic model for 5S:( Efficiency as response)

The modeling of the process has been done using fuzzy interference system (FIS). In this study four angular membership functions are selected for fuzzy model (fig. 1)
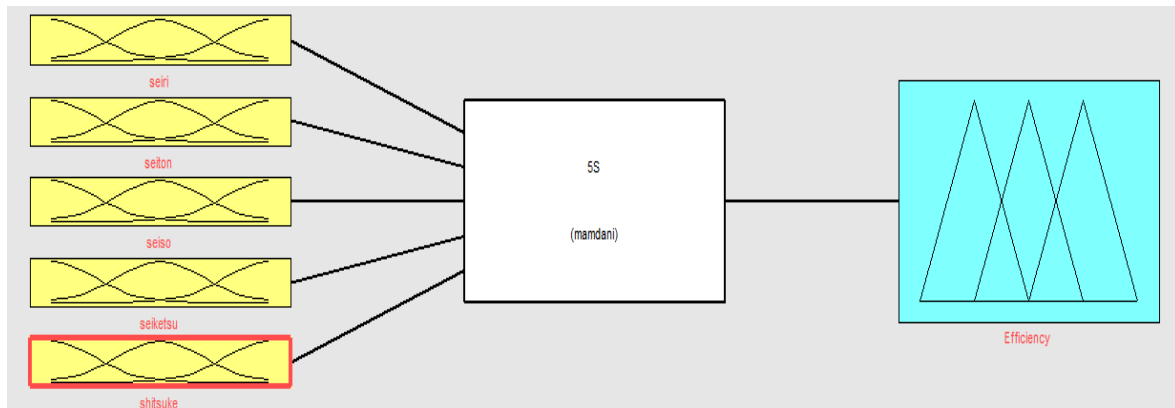


**Figure 3.** Fuzzy logic model for 5S
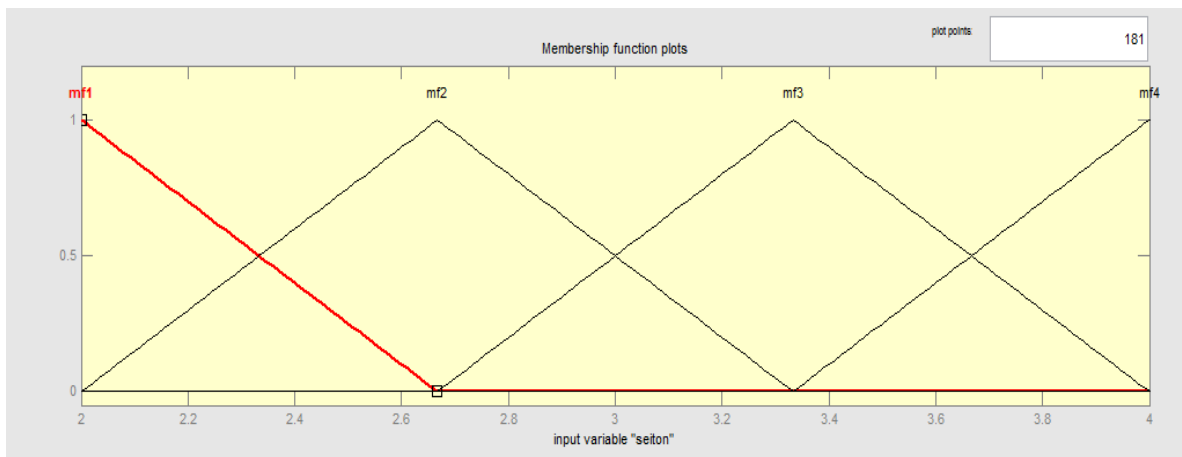
**Membership function for parameters**
This step is to define linguistic values assigned to the variables by the fuzzy subsets and their associated membership functions which may be zero or one called the grades of membership. Zero membership value indicated that it is not a member of the fuzzy set & one represe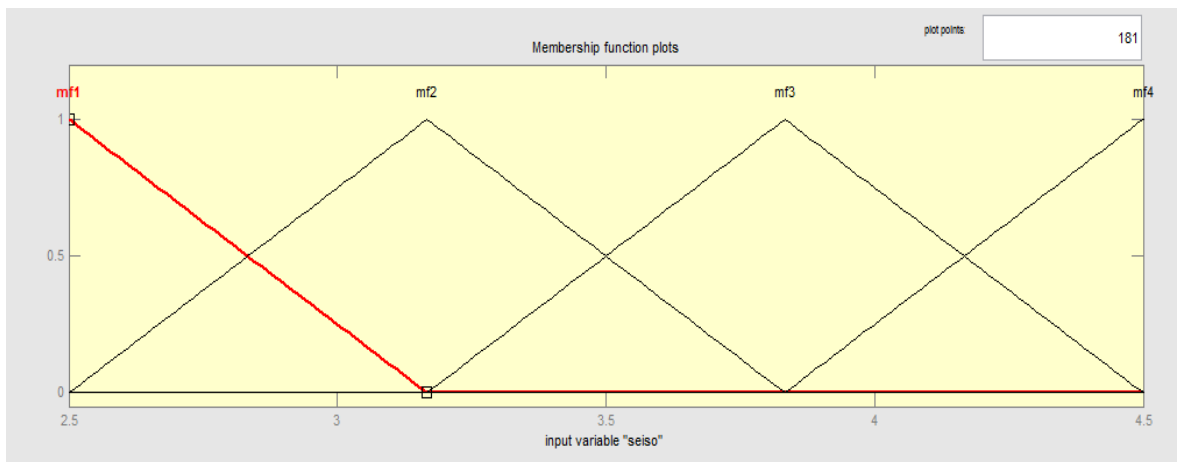nts a complete member. A membership function can have any shape but preferably should be symmetric which includes trapezoidal, triangular & bell shaped. Four membership function were generated for each input variable (SEIRI, SEITON, SEISO, SHITSUKE, SEIKETSU) as shown in fig 2(a, b, c, d, e)
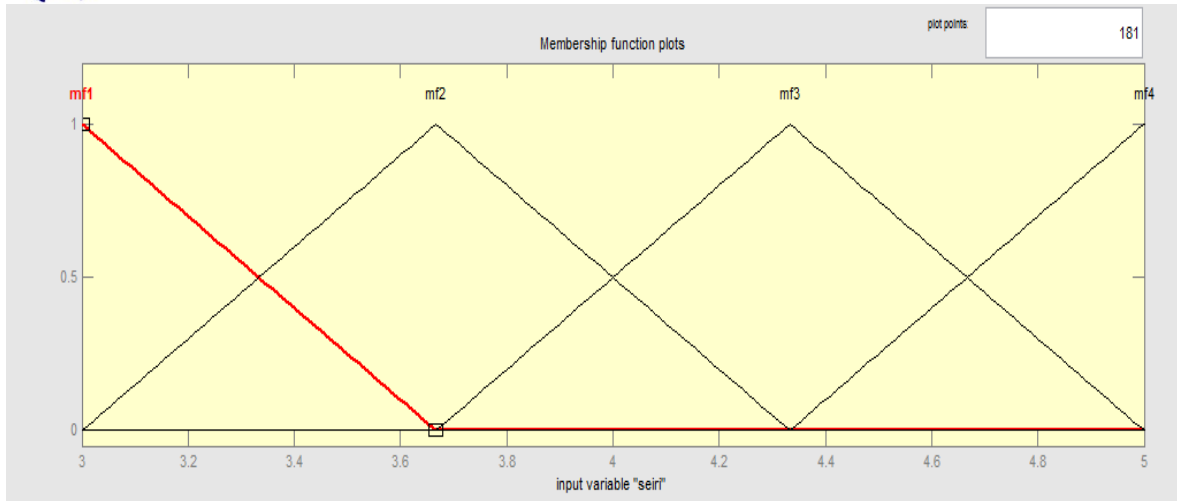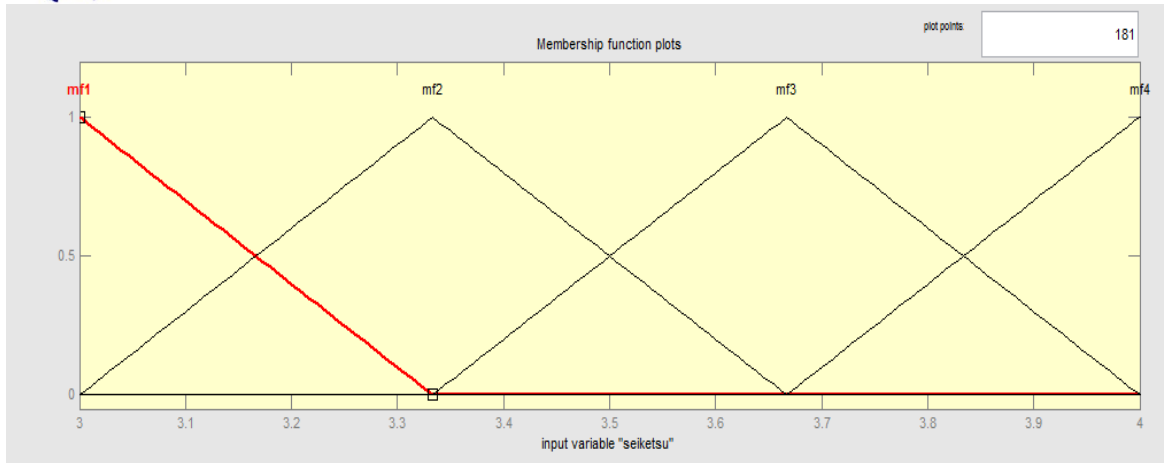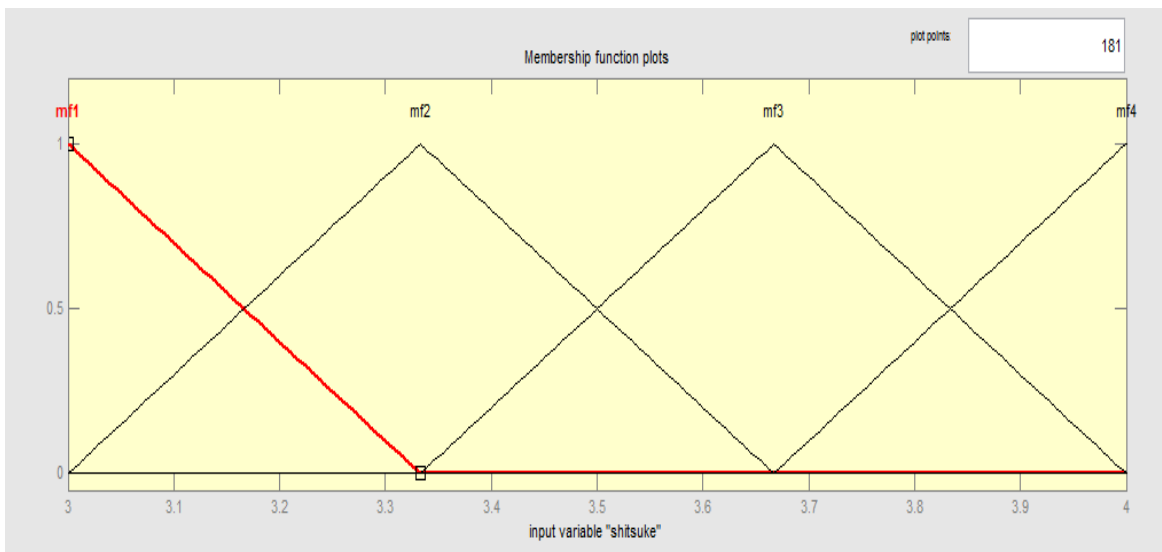
(a)



(b)



(c)

(d)



(e)

**Figure 4.** Membership function plots for input parameters (a)SEIRI,(b) SEITON, (c)SEISO, (d)SEIKETSU,(e)SHITSUKE

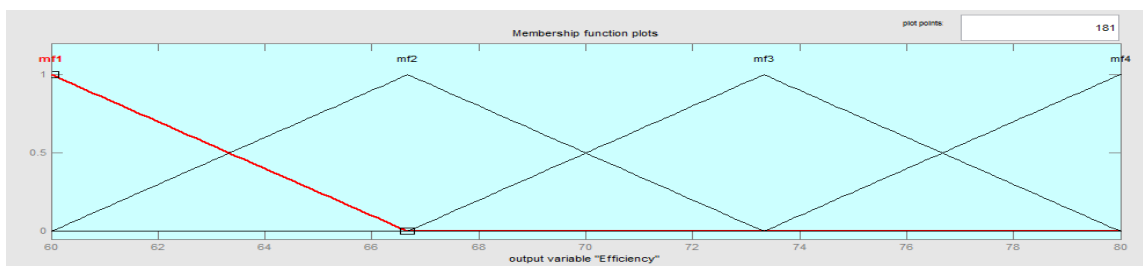Membership functions for 5S as output variable of the efficiency is shown in **Figure 5.**



**Figure 5.** Membership functions for output parameters (Efficiency)

# FIS rules employed in model (Efficiency as response)

For obtaining optimized solution, the rules at the base have been defined correctly & these rules were written based upon the experimental results. While preparing the rules, fuzzy method was used. Some selected rules are reported in **Figure 6.** fuzzy using MATLAB R2014a using Mamdani type of fuzzy interference system in fuzzy logic toolbox.

1. If (input1 is mf1) and (input2 is mf2) and (input3 is mf1) and (input4 is mf1) and (input5 is mf1) then (output1 is mf1) (1)
2. If (input1 is mf2) and (input2 is mf2) and (input3 is mf2) and (input4 is mf2) and (input5 is mf2) then (output1 is mf2) (1)
3. If (input1 is mf2) and (input2 is mf2) and (input3 is mf2) and (input4 is mf2) and (input5 is mf2) then (output1 is mf2) (1)
4. If (input1 is mf3) and (input2 is mf3) and (input3 is mf3) and (input4 is mf4) and (input5 is mf4) then (output1 is mf4) (1)

**Figure 6.** Formulation of rules (Response Efficiency)

The set of rules along with membership function is shown in rule viewer of fuzzy model (**Figure 7.**) reveals that after the formulation of rules, the optimum value of efficiency at any setting between the low & high limits of the process parameter can be predicted.
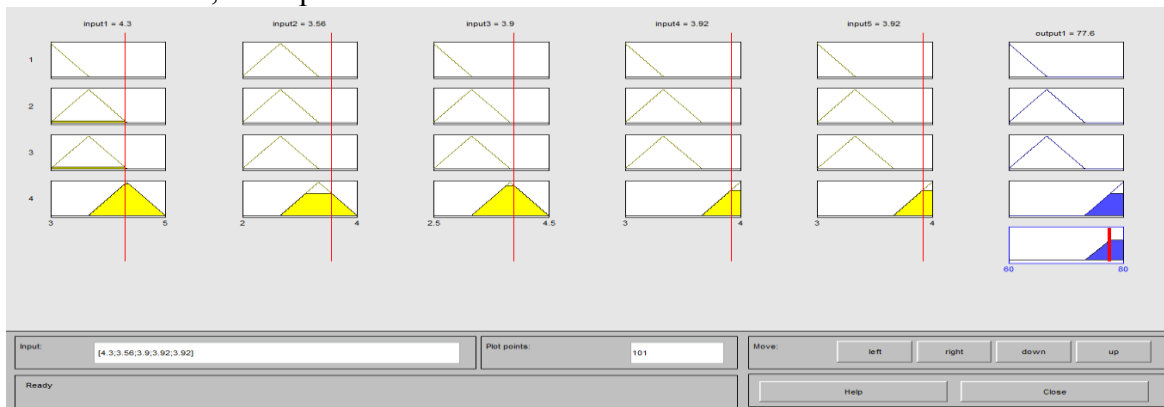


**Figure 7.** Rule viewer of fuzzy model

**Table 7.**

| Exp. no. | Experimental value of 5S Efficiency | Fuzzy value | % variation |
|---|---|---|---|
| 1. | 61.64% | 66.2% | 7.39% |
| 2. | 67.56% | 66.7% | 1.27% |
| 3. | 71.00% | 66.7% | 6.05% |
| 4. | 78.40% | 77.6% | 1.02% |

## Discussion

**Table 7.** gives the comparison of the predicted responses using fuzzy model & conducted experimental data. There seems to be a good agreement between fuzzy model & experimental values in all cases. In the present study the total data points involved were 4 & the average percentage error of various responses from fuzzy experimental model has found to be 3.93%. Thus the system has given an overall 96.07% accuracy from fuzzy model.

## Conclusion

This research work deals with performance measurement of work environment for increasing productivity and quality aspects of the organization. A complete illustration of 5S Philosophy has been sketched here for implementing it properly in the working field. Here a significant fluctuation in the efficiency measurement is shown which indicates the importance and originality of implementing 5S in first step. For research perspective, four week data may not sufficient to measure the performance rating accurately but for resource scarcity we have to accomplish the work focusing on gradual improvement. Implementing 5S in small companies in Bangladesh is really tough matter as the worker do not maintain so much rules & regulation and the worker always intend to do work easily and not maintaining proper instructions. To establish 5S in a company, it is crying need to teach the worker about 5S and train them to habituate with 5S implementation. Implementation of 5S is difficult in perspective of our country but proper implementation of 5S can make new era or revolution in our production management system as well as economy growth rate.

## Acknowledgement

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