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Identification and Prioritizing The Potential Failures In Sme Using Traditional And Fuzzy Based Fmea

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ABSTRACT

In the present work, various causes of potential failures in SME are identified and prioritized. The processes involved inmanufacturing a flange used byXYautomobile industry was studied under the expertise of the core team from the plant and data was collected. The collected data rated on a particular scale, used to calculate the risk priority number (RPN) and prioritize the potential failures. Further, the reasons for highly ranked failures identified using Cause and Effect diagrams. The RPN used to prioritize the risk was calculated using the traditional failure mode and effect analysis(FMEA) methodology. Further, to tackle the vagueness and uncertainty associated with it, fuzzy methodology has been suggested. The rpn is a product of severity of the failure, occurrence and detection of the failure.

Further Fuzzy RPN (FRPN) is the output using fuzzy methodology, which is obtained by making If-Then rules in fuzzy inference system (FIS). The RPN and FRPN attainedi.e. the yield of methodologies adopted, are compared to perform the assessment.So, average FRPN is calculated and five potential failures has been decided which needs immediate actions as these are participating maximum in the rejection and has ranked higher by traditional and Fuzzy based methodology both. Conclusively,the findings of the current methodologies have been used to reduce the risks associated and to enhance the competence of the currentapproach. The evaluated information after the analysis will help to reduce the cost by improving the quality of the system.

***Keywords**: FMEA, Fuzzy methodology, Fuzzy inference system, Potential Risk, RPN.*

1. INTRODUCTION

In the present mechanization-based situation, all ventures or associations like assembling, specialist co-ops are working under extraordinary strain to develop themselves consistently to stay focused in the market and conveying quality items to fulfil their clients. The dismissal and modify of the parts or administrations in the framework acquire significant expenses and cuts down the notoriety of the association. In spite of the fact that the structure facing any kind of the fails, may bring to working condition again subsequent to overhauling or fixes however some of the time trigger to recognize the reasons for the fails to maintain a strategic distance from the comparative fails to happen in future, prompted improve the performability

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of the framework, decreased item cost, improved quality, confidence of the client and guarantee nonstop improvement.After modifications of technical aspects, the issues go critical for the managers to predict the failures or their potential causes to develop the maintenance plan which may satisfactorily address the criticality technically and strategically.For the most part, Risk need number (RPN) is determined utilizing FMEA to organize the potential disappointment modes. Further extending from higher to bring down need, criticality is chosen, and support arrangement can be confined relying on the distinctive need. In the present case, it was seen that during assembling of spine, barely any issues happen during producing like Pitting (86 pcs), Billet length undersize (55 pcs), Scale during forging (46 pcs) prompting significant dismissal. An endeavour has been made to define a system for riskidentifiable proof and prioritizing it.FMEA is one of thetraditional methodsutilizedfor risk identification but results are imperilled to uncertainties as it involves the expertise of the individual or a team involved in risk identification [1]. The vagueness and uncertainties involved can be answered by adopting thefuzzy methodology[2–4]. In the current attempt, the applications ofunified FMEA and fuzzymethodology used for recognition and ranking of risk in manufacturing of the flange in XY industry of India.

2. LITERATURE REVIEW

FMEA is a procedure utilized by different specialists for chance investigation of intricate frameworks as it led to investigation of the risk in wind turbine department [5]. FMEA says hardly a few disadvantages that lessens opportunity of disposal of the threat that may happen. The method, which utilizes least & most extreme derivation, fuzzified, and afterward de-fuzzified of risks examination of disappointment approaches and afterward organizing it as per fuzzy RPNs' number is utilized for expelling vulnerability [6, 7]. Few reads have been utilized such methodology for chance appraisal. An incorporated FMEA and Fuzzy based approach were utilized for risks appraisal in an oil organization of Iran [8]. Such approach which involves the use of fuzzy FMEA has been employed for enhancing acquiring process in an open medical clinic [9]. Settnes introduced a proposition for decrease in the standards for diminishing the multifaceted nature of fuzzy rationale with FMEA technique [10]. It disposes of a portion of the principles, which are not important to deliver the yield.The fuzzy based way to deal with delineate imprecision and unclearness natural in etymological evaluation while estimating the seriousness of protection dangers [19]. The proposed system used to make sense of unwavering quality, accessibility and viability (RAM) parameters in a substance preparing plant [15]. Fuzzy deduction framework used to organize danger of Jerusalem artichoke preparing gear as data accessible for Failure modes and impacts examination (FMEA, for example, client necessities and assessments of master could be indistinct or uncertain while planning the item [17]. A paradigm dependent on fuzzy evidental way to deal with assess the risk utilizing fuzzy participation intensity and manage the breaking points of customary FMEA that assesses 21 prospectiverisk by registering risk need number [19]. A projected correlation among the conventional and fuzzy created FMEA to distinguish the landing framework of flying machine as one of the possible disappointments in airplane business [20]. An improved way to deal with recognize risk need numbers utilizing fuzzy essential where fuzzy gage gives the significance of specific marker and set of pointers [14 -16].There have been investigations of coordinating different

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apparatuses and techniques to improve the procedure of risk examination. A coordinated fuzzy philosophy with FMEA and dim social investigation utilized for chance appraisal of blower in warm power plant [11]. An incorporated FMEA with fuzzy AHP approach was figured for risk examination utilizing some model [12-13]. The comprehensive literature studies revealed that the analysis of risk is a futuristic approach used to assess the probable failures of the future and find a wide scope of applications in various types of the manufacturing organisations.

3. RESEARCH METHODOLOGY

Figure 1 shows the methodology proposed to carry out the FMEA and Fuzzy FMEA analysis in present case.

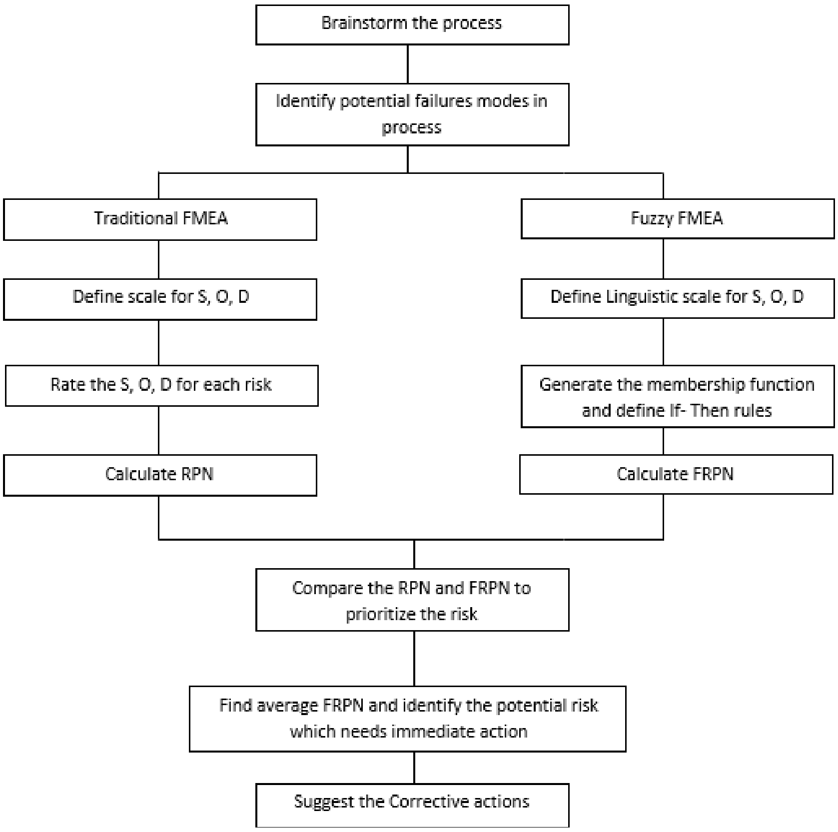

Figure 1: Research Methodology Proposed

The following steps are followed to perform the analysis:

1. Brainstorm all the processes of flange manufacturing, starting from forging followed by the machining and finishing.
2. Perform the FMEA and Fuzzy FMEA study to identify the risk involved. The steps involved to conduct FMEA and Fuzzy FMEA are as follows:
    a. Steps involved in for traditional FMEA:
        i. Outline the scale for Severity, Occurrence and detection using the expertise of the team. (Table 1)
        ii. Rate the severity, occurrence and detection for each failure or risk involved in process.
        iii. Evaluate the Risk priority number using the equation: RPN= S x O x D
    b. Steps involved in for Fuzzy FMEA:

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    i. Outline the linguistic scale for Severity, Occurrence and detection using the expertise of the team. (Table 2)
    ii. Membership functions generated for risk involved generally using triangular or trapezoidal membership function as it involved simplicity.
    iii. Define the If-Then rules in fuzzy inference system.
    iv. Identify FRPN using linguistic variable as input in fuzzy inference system and getting output as fuzzy RPN after de-fuzzification.
3. The RPN and Fuzzy RPN are compared to prioritize the risk.
4. Find average FRPN and identify the potential risk which needs immediate action and suggest the corrective actions.

Table 1: Severity, Occurrence and Detection rating for traditional FMEA

Rating	Severity	Occurrence	Detection
10	Harmful to worker or machine	Very high: Insistent fails	Almost impossible
9	Harmful to worker or machine with caution board		Very remote
8	100% of component rejected or reworked	High: Everyday fails	Remote
7	Segregation of component (less than 100%)		Very low
6	A part (less than 100%) rejected without segregation	Moderate: Irregular fails	Low
5	100% of part reworked outside the premises.		Moderate
4	Reworked less than 100% after segregation		Moderately high
3	Reworked less than 100% outside	Low: Moderately rare fails	High
2	Reworked less than 100% inside		Very high
1	Minor inconvenience to operation or operator or no effect.	Remote: Fails are improbable	Very high

Table 2: Severity, Occurrence and Detection rating along with Linguistic variables for Fuzzy FMEA.

Rating	Linguistic variable	Severity (S)	Occurrence (O)	Detection (D)
1,2	VL - Very Low	No component fails	Probable failure	Noticed 1-2 times
3,4	L - Low	Slight disruption, corrected easily	very infrequent fail	Noticed 3-4 times
5,6	M - Moderate	Minor Breakdown of parts of machine	moderately common failure	Noticed 5-6 times
7,8	H - High	Part unsafe to machine not humans	common failures	Noticed 7-8 times
9,10	VH - Very High	Part unsafe to machine or humans.	Utmost occur failures	Noticed 9-10 times

4. CASE DESCRIPTION

The goal of the assembling associations is to expand benefit, stay aggressive and produce great yields. FMEA is perceived quality administration instrument recognizes and organize potential risk in a procedure by figuring particular RPN. There are scarcely any weaknesses

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related with FMEA, are handled utilizing the fuzzy approach. In present case, the industry at Ludhiana, producing various components and they are facing challenges in few products as large number of components are rejected. So, process of flange manufacturing has considered for the present study. The process flow is shown in figure 2. Few problems like pitting (86 pcs), Undersize length of billet (55pcs), Scale (46 pcs) were observed during the study of the forging process while producing the flange.

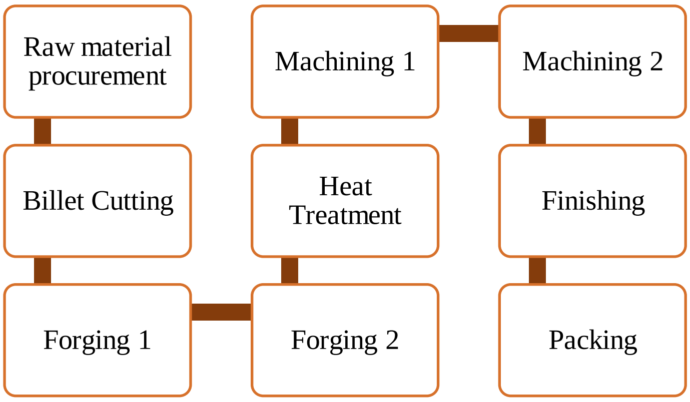

Figure 2: Process Flow of Flange

In the present study, to perform Traditional FMEA, the suggested rating for Severity, Occurrence and detection shown in Table 1. The various potential failures are named differently to handle the data easily, the operation names given as Fi (i = 1,2, 3……. n). The RPN values are calculated by suggesting appropriate rankings of severity, occurrence and detection concerned with the process. In spite of the fact that FMEA is an extremely helpful instrument to distinguish the hazard related with various procedure utilized in numerous ventures yet at the same time contains hardly any inadequacies like FMEA relies on the human expertise, Possibility of identical value of RPN as it is based on methodology of multiplication, Change in process may affect the risk associated, so it needs continuous updates and consumes times. In this way, fuzzy rationale based FMEA approach is fused to defeat the inadequacies.

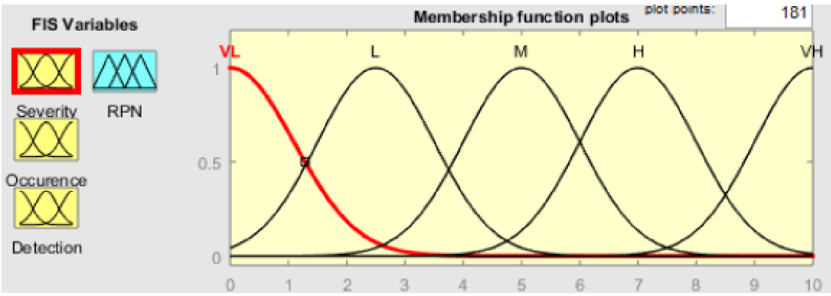

Figure 3: Membership function for input variables.

Further, Matlab software with student login is utilized to perform fuzzy FMEA. Utilizing the master information and experience, the If-Then rule information base has been developed by generating the membership function shown in figure 3. The linguistic scale defined for Severity, Occurrence and Detection are shown in Table 2, helps to convert input variable into linguistic variable VL, L, M, H, VH. An aggregate of 125 If-Then rules has been used.

5. RESULTS AND DISCUSSION

The RPN and FRPN calculated using the traditional FMEA and Fuzzy based FMEA methodology respectively along with the OP names are shown in the Table 3. Further the respective ranks of the OP's based on RPN and FRPN are also shown.

Table 3: RPN and FRPN along with the ranks of respective failure

S. No	OP Name	Severity	Occurrence	Detection	RPN	RPN Rank	Fuzzy RPN	FRPN Rank
1	F15	5	4	6	100	2	35.84	1
2	F12	7	3	6	126	1	33.96	2
3	F3	7	2	7	98	3	33.79	3
4	F2	7	2	7	98	3	32.94	4
5	F7	7	2	6	84	4	32.59	5
6	F10	7	2	6	84	4	32.57	5
7	F11	7	2	6	84	4	31.52	6
8	F13	6	2	7	84	4	31.38	7
9	F9	6	2	7	84	4	30.29	8
10	F32	4	3	6	72	6	30.23	9
11	F16	7	3	4	84	4	29.49	10
12	F8	5	3	5	75	5	28.11	10
13	F17	6	3	4	72	6	27.11	11
14	F21	6	2	6	72	6	26.60	12
15	F22	6	2	6	72	6	26.56	13
16	F23	6	2	6	72	6	26.48	13
17	F31	6	3	4	72	6	26.45	14
18	F4	4	3	6	72	6	26.37	15
19	F6	4	3	6	72	6	26.35	15
20	F5	7	2	5	70	7	26.30	16
21	F14	5	2	7	70	7	26.29	17
22	F25	6	2	5	60	8	26.22	18
23	F28	6	2	5	60	8	26.21	18
24	F29	6	2	5	60	8	26.12	19
25	F30	6	2	5	60	8	26.11	20
26	F19	5	3	4	60	8	26.10	21
27	F24	6	2	5	60	8	26.00	22
28	F27	6	2	5	60	8	25.90	22
29	F26	6	2	5	60	8	25.59	23
30	F18	7	2	4	56	9	25.39	24
31	F20	7	2	4	56	9	25.29	24
32	F1	7	2	4	56	9	25.05	25

The value of the RPN predicted for all the processes or operations involved while manufacturing flange using Traditional FMEA approach. The possible causes, type of failure and their potential effects for all the operations performed while manufacturing. Various RPN's provided by the traditional FMEA for different failures and the higher RPN value has comes 126, F12 is the potential risk, then lowest RPN value comes as 14 for potential risk F77. The operation name is facing operation, where the facing of billet is done and risk involved is F12. The potential risk F15 comes second in the list with 100 as the predicted RPN and operation involved is the forging 1 operation. The third ranked potential risk is heavy pitting during forging (F3) and predicted RPN in 98 in both the cases. Thus, Traditional FMEA helps to prioritize the potential failures by identifying the RPN and using the predicted RPN, the suitable ranking has been given to potential failures. The predicted

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values have been used while reviewing the process in future. Be that as it may, not many of the activities have the indistinguishable RPN's independent of the size of seriousness or event or identification. It is scarcely to organize the hazard utilizing the indistinguishable RPNs as it relies on the earnestness, experience of the concerned included. Such vagueness can be answered using linguistic variables using fuzzy logic.

Table 4: Potential failures needs immediate actions

S. No	PF Name	Critical problems	RPN Rank	FRPN Rank
1	F15	Billet dia under size during step forging	2	1
2	F12	Length undersize during facing 1	1	2
3	F3	Heavy Pitting	3	3
4	F2	Cutting length under size (improper setting of machine)	3	4
5	F7	Scaling during annealing	4	5

Fuzzy based FMEA approach further employed to figure out the FRPN. The potential risk F15 has comes with FRPN as 35.84 which is highest among other FRPN values. The least FRPN value comes as 25.05 for F1 potential risk. Undersize length of the billet found as a defect while performing the step forging operations is F15 potential risk and the predicted FRPN is 35.84. The various values of FRPN predicted using fuzzy based methodology are non-identical as fuzzy methodology uses linguistic variables as the basis of the inference process to reduce the risk of ambiguity and vagueness.After comparison, it has been observed that total 32 potential risks are involved in the process and needs immediate addressal according to the respective rankings based on FRPN. But immediate response to such huge number is difficult to run simultaneously. So, average FRPN is calculated and five potential failures has been decided which needs immediate actions as these are participating maximum in the rejection and has ranked higher by traditional and Fuzzy based methodology both. The potential failures decided to addressed immediately are shown in Table 4.

Further Fish bone diagrams or cause and effect diagrams has been plotted for the potential risk to identify the root cause and suggesting the solutions for the same.

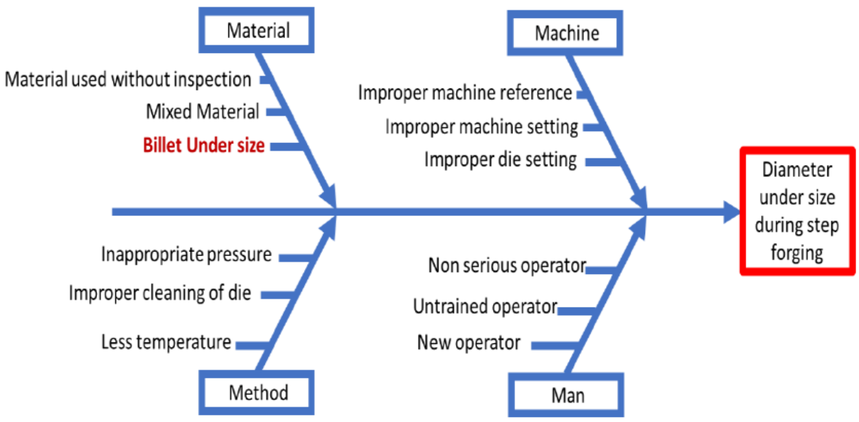

Figure 4:Cause and Effect diagram for F15 potential failure.

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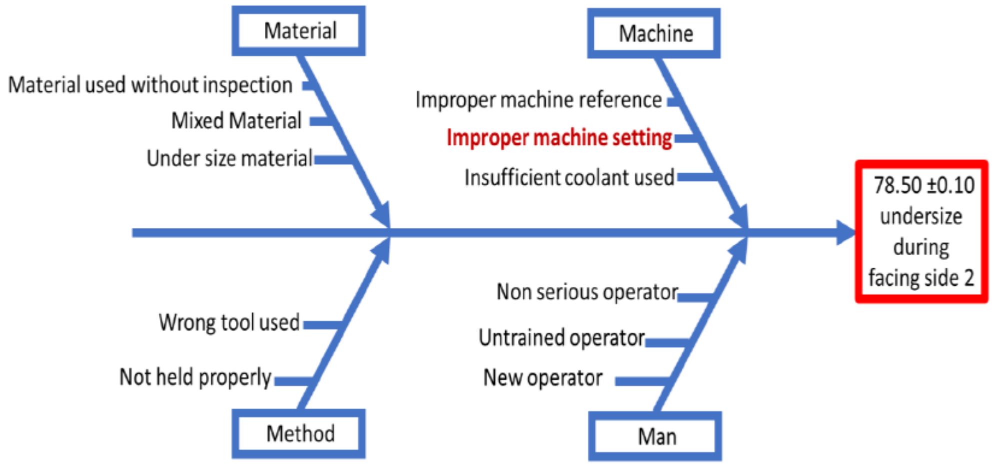

Figure 5:Cause and Effect diagram for F12 potential failure.

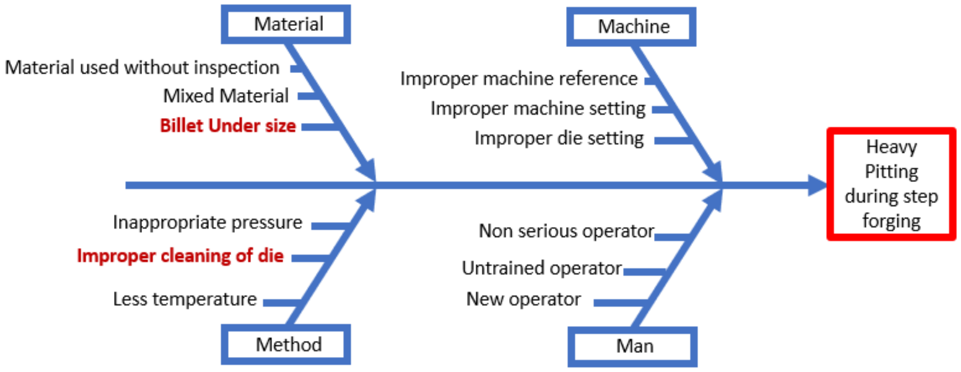

Figure 6:Cause and Effect diagram for F3 potential failure.

The cause and effect diagram plotted for F15 shown in Figure 4, for F12 potential risk, the cause and Effect diagram is shown in Figure 5 and cause and effect diagram for F3 potential failure ranked higher based on fuzzy methodology is shown in the Figure 6. A comprehensive brainstorming has been performed to identify the root causes for the highly ranked potential failures.

The critical potential failures identified based on comparing RPN and FRPN are shown in Table 4. For F15, during step forging, undersize billet length is one of the causes identified and it has been suggested to provide a C type snap gauge to the operator. It has been observed a drastic fall in the rejection after implementing the suggested idea. The other reason identified as the malfunctioning of the machine due to false setting of the machine for potential failure F12 which is ranked as 2nd. A particular procedure has been framed and implemented to set the machine accordingly, the users have been trained to perform the setting as per the procedure and only single piece identified after the implementation of suggested solution.

For the potential failures F3 and F7, it was identified that the die was not cleaned properly which leads to pitting and scaling during the forging, the flash being formed during the operation remain in the die and causes the said defect. So, it has been suggested to clean the

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die properly using the compressed air through a nozzle. Chemical cleaning of the dies also been suggested.

5.1 CONCLUSIONS

After performing the exhaustive study, few conclusions are drawn:

- The present study helps the maintenance department to decide the priority to address the problems as they are identified at the initial stage.
- The human errors involved in the traditional system has been answered using the fuzzy based methodology which involves the use of the linguistic variables.
- The identical RPN's has been easily ranked using FRPN's reduces the ambiguity in the system.
- The prior solutions suggested used to improve the productivity and reduced the cost of rejection and rework.

Further, the study performed contains limitations as the information used depends upon the expertise of the team involved, the participation and approach of the management and may varies from person to person and variation in the process are not covered in the study. It needs to be updated. Elsewise, the results or findings must be used for betterment of the industries or the organisations.

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