A Study into the Use of the Dysfunction Mode and Effects Critical Analysis (DMECA) in a Power Plant

by

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Declaration

This is to certify that the thesis work entitled "A Study into the Use of the Dysfunction Mode and Effects Critical Analysis (DMECA) in a Power Plant" has been carried out by Azizur Rahman in the Department of Industrial Engineering & Management, Khulna University of Engineering & Technology, Khulna, Bangladesh. The above research work or any part of the work has not been submitted anywhere for the award of any degree or diploma.

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ABSTRACT

Dysfunction Mode and Effect Critical Analysis (DMECA) is a well-established tool for assessing dysfunctions regarding the quality of maintenance and production processes. It is conceptually same as the Total Quality Management (TQM) tool of Failure Mode and Effect Critical Analysis (FMECA). It helps to focus on core challenges while still including a wide range of dysfunctions. Since the nature of dysfunctions and quality issues are very similar, the general idea and framework of a DMECA may be adapted successfully to remove dysfunctions in management process. The DMECA approach, to determine and analyze possible dysfunctions in complex management processes, was developed by Massimo Bertolini, et.al. [2]. They recommended that this method can be applied to various fields such as manufacturing industry, power plant, gas generating plant even where the measure of management process efficiency is more difficult. The analytical tool DMECA works according to the new ISO 9000:2000 standards and the Total Quality Management (TQM) principle concerning the 'process approach'. In this study, DMECA method is applied to determine and analyze the possible dysfunctions in complex management process of a power plant. According to the literature reviewed, probably this is the first to use the DMECA in a large power plant. DMECA is used to analyze each potential dysfunction mode for each elementary activity constituting the plant processes, to identify the subsequent effects. A list of priority interventions of the dysfunction modes then decided. The evaluation of the priorities are utilized to create a classification of the potential dysfunction modes according to a criticality parameter obtained by the combination of severity of the consequences, probability that the dysfunction occurs and chances that it can be detected.

The process break-down structure defined during the process identification phase (reported in Figure 4.4 for the firms' processes) 09 sub-processes and 57 activities of job management process were identified. For each activity, possible dysfunctions had established and 175 potential causes have been identified for the whole process of 'job management'. A code number was assigned to each dysfunction with the same criteria as used to map the processes. In order to conduct a criticality analysis of dysfunction, the judgment criteria is defined, by which the unwanted event was

assessed. The conversion tables (Table 4.2, 4.3, 4.4 & 4.5) were suggested to translate linguistic judgments into numerical values to obtain a Risk Priority Number (RPN). Thus, it will be possible to judge and evaluate the criticality of the dysfunction causes.

Data for this study were collected from the respondents of the study area by using the questionnaire prepared (Appendix A). The interviews were made group wise in the power plant during their work and leisure time with the permission of interviewee as well as management. Each personnel completed the questionnaire independently, with the support of Table 4.5. Mean values (from all questionnaires) of the three parameters; occurrence dysfunctions (O_D), Detectability dysfunctions (D_D) and severity dysfunctions (S_D) for each dysfunction were calculated. Finally, the respective RPNs were obtained as $RPN = O_D \times D_D \times S_D$. The calculated RPN values are provided in table 4.6. These products may be viewed as a relative measure of the management dysfunctions. The RPN values can range from 1 to 1000, with 1 being the smallest management dysfunction possible and 1000 being the biggest management dysfunction possible. These values were then used to rank the various causes in the dysfunctions. In case of process with a relatively high RPN, the engineering team must make efforts to take corrective action to reduce the RPN. Likewise, because of a certain dysfunction has a relatively low RPN, the engineering teams should not overlook the causes and should not neglect an effort to reduce the RPN. This is especially true, when the severity of a cause is high. In this case, a low RPN may be extremely misleading, not placing enough importance on a cause where the level of severity may be disastrous. In general, the purpose of the RPN was to rank the various causes documented. The smaller the RPN the better – and – the larger the worse. Dysfunction causes and their relative weights were investigated for each activity in order to determine the most critical and to decide improvement actions. There are only 25 causes of dysfunctions those are critical amongst 175 cusses. The beauty of DMECA method is that it permits to identify and eliminate particular dysfunctions and simultaneously it will correct or eliminate other problems or inefficiencies indirectly. Therefore, at the end of the DMECA structured process analysis, we obtained schemes where relatively few corrective actions can solve multiple dysfunctions (Table 5.2). This was possible because there were a strong interrelationship between management processes and activities.

The main advantage of the methodology is its applicability to the managerial processes of each organization (i.e., firms, public services, local agency or government). In particular, DMECA is a valid technique to evaluate processes efficiency and effectiveness in the field of service sector where measuring, monitoring and correcting the possible dysfunctions in managerial processes are critical to improve the performances of production and maintenance. To analyze the managerial dysfunctions in any organization the DMECA approach is very effective and it involves low cost as it is found in this research work. So, it is a cost effective and can be applied to identify management personnel deficiencies which in turn will be helpful for uninterrupted production and/or maintenance. It identifies, access and ranks dysfunctions that are challenging to eliminate. Thus, the method prevents the consumption of time and cost of production and/or maintenance. In this study an application of the DMECA technique applied in an important power plant (maintenance and production for electricity) to analyze, to evaluate and to improve job management process efficiency. Finally a number of recommendations are made to the management to implement the research findings to the plants. At last but not least some recommendations are also made for further study.

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Nomenclature

AE	Assistant Engineer
BPDB	Bangladesh Power Development Board
CA	Criticality Analysis
CE	Chief Engineer
D_D	Detectability of dysfunction
DMECA	Dysfunction Mode and Effect Critical Analysis
ETO	Engineering-to-Order
Ex-En	Executive Engineer
FMEA	Failure Mode and Effect Analysis
FMECA	Failure Mode and Effect Critical Analysis
ICAM	Integrated Computer Aided Manufacturing
IDEF	Integrated DEFinition
MTBD	Mean Time Between Failure
O_D	Occurrence Dysfunction
PBS	Process Break down Structure
S_D	Severity Dysfunction
SADT	Structured Analysis and Design Technique
SDE	Sub-Divisional Engineer
TQM	Total Quality Management
NDT	Non Destructive Testing

CHAPTER 1

INTRODUCTION

1.1 Motivation Behind The Thesis

Traditionally, the trade-off between time, cost and quality has been considered as a dilemma in production and maintenance of a plant. The fact was that no optimal results regarding all three dimensions could be achieved at a time. The tension between time and quality was seen, in simple terms, as the following: the more time spent, the better maintenance quality can be achieved. However, a conflicting goal is to perform maintenance within small time in order to minimize the time of production. And, of course, to minimize costs. The third dimension cost adds a further tension to this trade-off. Adding resources (e.g. financial means or manpower) to the management process may reduce the maintenance time and may help to achieve better quality, but as a consequence, maintenance costs increase. The interdependence between these three dimensions has become a known dilemma in production and maintenance. In the past, companies sought to achieve the right tradeoff in order to maximize their profits [1].

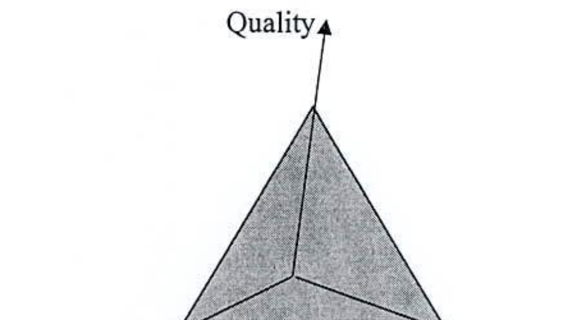


Figure 1.1: Dilemma in Production Development

The tool, Dysfunction Mode and Effects Critical Analysis (DMECA) applied in this thesis is a new approach to manage the conflict between time, cost, and quality by determining and analyzing the possible dysfunctions in the complex management process. It's easy to achieve high quality no longer implicates the need of large funds.

DMECA seeks to address all three dimensions of the dilemma stated above. Quality can be improved by eliminating dysfunctions in all relevant managerial activities. Furthermore, DMECA seeks to achieve the objectives within little time. The challenge of developing a production and maintenance functions at low costs and within small time can be achieved by concentrating on value creation and minimizing non-value adding activities to the possible extent.

Risk or uncertainty in production and maintenance adds a fourth dimension that is difficult to understand and address. Good management is a qualifier of schedule (time), cost, and performance (quality). Effectively managing the management process and maintenance significantly reduces the likelihood of cost, schedule, and performance deviations during execution. Production and maintenance management, therefore, is tightly connected to the success of management process and addresses all three dimensions.

Maintenance management and the time dimension are tightly connected. Of course, its execution takes up some time. Maintenance management seeks to identify potential threats and time-consuming loops. It also may prevent redesign. Additionally, maintenance management achieves similar benefits regarding the objectives of costs. Although funds are needed for the implementation and execution of maintenance management, significant savings may be achieved by early identification of fault and prevention of potential late changes in the process. Finally, maintenance management also addresses the third dimension quality. Those two areas are probably the most similar ones and should have some significant parallels. Both focus on potential errors and seek to minimize the dysfunctions of them [1].

Many dysfunctions inherent in management are defined with its process. In this study, the process of management is elaborated in the activities of production and maintenance. For this purpose, a survey is conducted in the Khulna Power Station to point out the various states of production. It was determined how successfully the requirements can be incorporated into a management process. The survey also showed that a perfect requirement does not guarantee a perfect production and maintenance, and these requirements are often not fulfilled through a conventional management process.

Management processes thus requires a reliable method for assessing the risks and challenges of the production and maintenance. Unfortunately, only a very limited number of work methods exist which facilitate this and perhaps are not followed by most of the government power plant in Bangladesh. This leads to uncertainty in evaluating different concepts in assigning resources to the development of management process, and in assessing the future power generation potential of the plant. Thus, a practical method is needed that manages dysfunctions regarding management process, and addresses all dimensions of production and maintenance.

A well-established tool for assessing dysfunctions regarding the quality of maintenance and production processes is the Dysfunction Mode and Effect Critical Analysis (DMECA). DMECA is conceptually same as the Total Quality Management (TQM) tool of Failure Mode and Effect Critical Analysis (FMECA). It helps to focus on core challenges while still including a wide range of dysfunctions. Since the nature of dysfunctions and quality issues are very similar, the general idea and framework of a DMECA may possibly be adapted successfully to remove dysfunctions in management process. This new methodological approach named 'Dysfunction Mode and Effects Critical Analysis' (DMECA) to determine and analyze possible dysfunctions in complex management processes was developed by Massimo Bertolini, et.al. [2]. They recommended that this method can be applied to various fields such as manufacturing industry, power plant, gas generating plant even where the measure of management process efficiency is more difficult. The DMECA represents an analytical tool to work according to the new ISO 9000:2000 standards and the Total Quality Management (TQM) principle concerning the 'process approach'. According to the literature reviewed probably this is the first to use the DMECA in a large power plant to determine and analyze possible dysfunctions in complex management processes [2].

1.2: Objectives of the Research Work:

Power plant is a large organization. There are various fields to implement the DMECA method individually. This study involves the dysfunctions of the management process about operation and maintenance of the plant. The specific objective of this study is as follows:

- To analyze all possible dysfunctions of management processes in the power plant with DMECA method.
- To identify the subsequent effects of each potential dysfunction mode.
- To make a list of priority interventions for all the dysfunctions.
- To prioritize and classify the dysfunctions by the Risk Priority Number (RPN) which represents the severity of the consequences.
- To investigate potential causes of dysfunctions and determine the improvement actions.

CHAPTER 2

LITERATURE REVIEW

2.1 Related Works

Following the principles of the Total Quality Management (TQM) philosophy, the ISO 9000:2000[1] standard emphasizes the process approach to manage an organization's quality system. 'Process approach' means that all the activities must be identified, managed and controlled. In particular, the organization must:

(i) define the interrelations between processes, and
(ii) monitor how a dysfunction in a process (or activity) influences the results of other processes (or activities).

Another TQM concept emphasized by ISO 9000 norms is related to continuous improvement of processes, and involves applying Deming's Plan-Do-Check-Act (PDCA) paradigm [2].

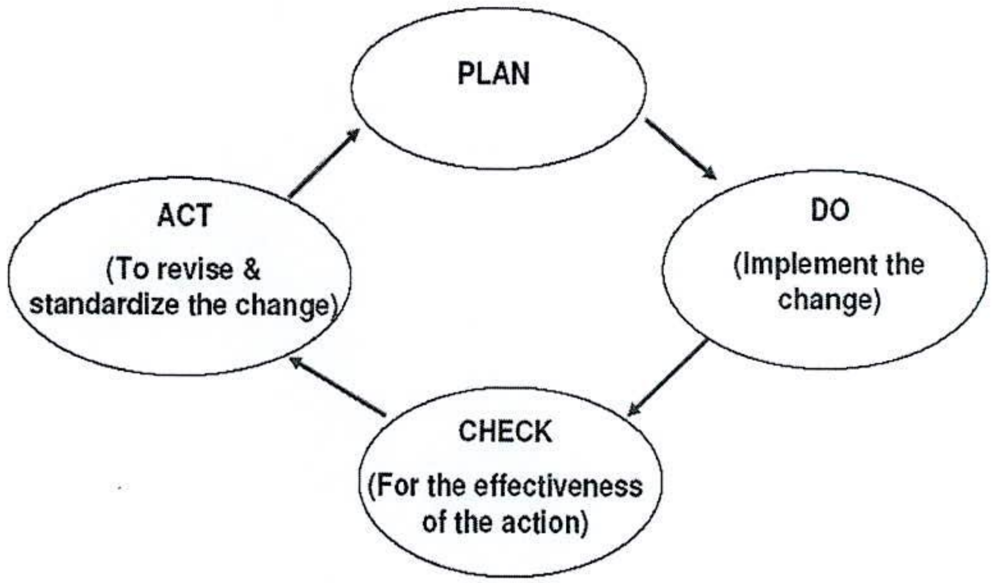


Figure 2.1: Deming's Plan-Do-Check-Act (PDCA) paradigm.

1. **Plan**

- Identify the problem
- Understand the current Situation by clarifying processes and causes of variations from the standards
- Set targets and decide on what situation should be if the problem was solved
- Identify indicators of improvement
- Collect relevant data
- Analyze the problem
- Analyze the root causes
- Create a plan for action

2. **Do**

- Develop and implement countermeasures
- Propose as many solutions to the vital few root causes
- Narrow down solutions to the most effective and practical countermeasures
- Implement countermeasures

3. **Check**

- Confirm effectiveness of countermeasure
- Monitor implementation of countermeasure
- Document the effectiveness of the countermeasure by collecting data
- Analyze data
- Determine if the problem has been solved; if targets have been achieved; if standards have been reached
- Reflect on the lessons learned

4. **Act**

- Standardize & institutionalize countermeasures
- Present the results to an organization-wide forum and get top management approval to adopt the solutions throughout the organization.

The organization must correctly select the most important and critical processes, which need improvement actions.

The literature to date does not provide a unique suitable technique that is able to represent a systematic and logical approach to

(i) describe and analyze management processes, and
(ii) Selection of improvement actions.

Two main classes of techniques are adopted to analyze processes. The first class constitutes methodologies to represent a process or more interrelated processes based on graphical methods. For example, IDEF methodology (IDEF is an acronym meaning ICAM definition, where ICAM, in turn, is an acronym for Integrated Computer Aided Manufacturing) is a group of methods used to perform modeling in support of enterprise integration [3]. IDEF's roots began to form when the Air Force, in response to the identification of the need to improve manufacturing operations, established the Integrated Computer-Aided Manufacturing (ICAM) program in the mid-1970s. The requirement to model functions (processes), data, and dynamic (behavioral) elements of the manufacturing operations resulted in the initial selection of the Structured Analysis and Design Technique (SADT) method (SADT is a registered trademark of SofTech). SADT was developed by SofTech's Doug Ross in the early 1970s. A subset of SADT was the basis for the Air Force's ICAM language notation [4].

SADT: Structured Analysis and Design Technique

Structured Analysis and Design Technique (SADT) is a diagrammatic notation for constructing a sketch for a software application. It offers building blocks to represent entities and activities, and a variety of arrows to relate boxes. These boxes and arrows have an associated informal semantics. SADT can be used as a functional analysis tool of a given process, using successive levels of details. The SADT method allows defining user needs for IT developments, which is very useful in the industrial Information Systems, but also to explain and to present an activity's manufacturing processes, procedures.

- Diagrammatic notation for constructing a sketch for an application.
- Offers boxes to represent entities and activities.
- Offers a variety of arrows to relate boxes.
- Boxes and arrows have an associated (informal) semantics; users are aided by box and arrow labels, other informal documentation.
- Has inspired many other commercial tools.
- Has been in use since the mid-seventies.
- SADT is available as a commercial CASE tool under the name IDEF0.

A major development from the ICAM program was the Integrated DEFinition methodology as it is now called IDEF [4]. This methodology was used as a regimented approach to analyzing an enterprise, capturing "as-is" process models, and for modeling activities (organizational units) within an enterprise. Thus, an enterprise could develop a basis for process improvement planning and have a foundation to define information requirements. The Integrated DEFinition (IDEF) methodology is a suite or family of methods that supports a paradigm capable of addressing the modeling needs of an enterprise and its business areas. IDEF technologies have grown over the past four to five years, the Department of Defense is a prime user of the technologies, and some of the largest U.S. corporations have adopted the IDEF technologies for competitive advantage. Although IDEF was originally intended for use in systems engineering, the suite of IDEF methods is evolving and contains the necessary notations to support software development. Several attempts have been made to apply these methods to software development. It was originally developed by the US Air Force Programmer for Integrated Computer Aided Manufacturing (ICAM). Unfortunately, although this technique can identify the correlation between activities and define the 'father-child' relationship between processes, it cannot define the criticalities of possible dysfunctions, nor does it permit the establishment of criteria or the definition of priorities of improvement actions. According to Goulden and Rawlins (1995) [5], by using this approach, activities could be mapped together to build an integrated picture, however this can be a time consuming task with visually confusing results and so can fail to engender a sense of ownership and widespread understanding of management processes. Similar conclusions regarding the limitations of the IDEF type models for process analysis have been reached by Dale and Plunkett (2000). The second type of approach is represented by problem solving techniques, which are generally able to define the priorities and criteria of improvement actions by adopting structured approaches composed of brainstorming sessions, decision-making support methods, correlation and pondering matrixes and flow diagrams for example. Unfortunately, they neither permit the correlation of the results obtained from improvement actions with other processes, or the evaluation of their impact. In summary, there are no methods suitable to support description and analysis of processes and, contemporaneously, able to investigate dysfunction consequences, their impact on whole process efficiency, and also the definition of improvement actions. To fill this gap in this research work a new approach called Dysfunction Mode and Effects Critical Analysis (DMECA) is implemented for the study.

2.2 Related theory

2.2.1 Failure Mode Effect and Criticality Analysis (FMECA)

It's a procedure for evaluating the various aspects of a system in order to "identify all catastrophic and critical failure possibilities so that they can be eliminated or minimized through design correction at the earliest possible time." [6]. Failure modes, effects, and criticality analysis (FMECA) is a methodology to identify and analyze:

- All potential failure modes of the various parts of a system
- The effects of these failures may have on the system
- How to avoid the failures, and/or mitigate the effects of the failures on the system

Continually measuring the reliability of a machine, product, or process is an essential part of Total Quality Management. When acquiring new machines, creating a new product, or even modifying an existing product, it is always necessary to determine the reliability of the product or process. One of the most powerful methods available for measuring the reliability of the process or product is FMEA. FMEA is an analytical technique that combines the technology and experience of people in identifying foreseeable failure modes of a product or process and planning for its elimination. This method can be implemented in both the design and the process areas and basically involves the identification of the potential failure modes and the effect of these on both the internal and the external customer.

FMEA attempts to detect the potential product-related failure modes. The technique is used to anticipate causes of failure and prevent them from happening. FMEA uses occurrence and detection probability criteria in conjunction with severity criteria to develop risk prioritization numbers for prioritization of corrective action considerations. This method is an important step in debugging and preventing problems that may occur in the manufacturing process. It should be noted that for FMEA to be successful, it is extremely important to treat the FMEA as a living document, continually changing as new problems are found and being updated to ensure that the most critical problems are identified and addressed quickly.

The FMEA evaluation should be conducted immediately following the design phase of product production and, definitely in most cases, before purchasing and setting up any machinery. One purpose of FMEA is to compare the design characteristics relative to the planned manufacturing or assembly methods to make certain that the product meets the customers' requirements. Corrective actions should begin as soon as a failure mode is identified. Another purpose of FMEA is to provide justification for setting up a process in a certain manner. FMEA may be viewed as the formal manner in which engineers will analyze all possible nonconformities and problems that may arise in a given process or with a certain product. This will, in a sense, encourage all the engineers to analyze and to find nonconformities in user-friendly format, within an organized. FMECA is a technique used to identify, prioritize, and eliminate potential failures from the system, design or process before they reach the customer.

The purpose of Failure Modes and Effects Critical Analysis (FMECA) is to determine the parts that are most likely to fail in an assembly. FMECA begins with the basic components of the system and determines how each may lead to a failure in the system. Every possible failure and every part is considered under FMECA. FMECA not only considers the possibility of failure for a given part but also its significance with regard to the entire system. Once all possible failures have been identified, they are ranked and given a Risk Priority Number (RPN) and a corrective action is suggested [7].

2.2.1.1 FMECA Procedure

A Failure Mode, Effects and Criticality Analysis is a procedure for identifying potential failure modes in a system and classifying them according to their severity values [8]. The following are the steps of FMEA procedure:

- Define the system and its performance requirements
- State all assumptions and ground rules that will be used in the analysis
- Develop block diagrams of the system and identify possible failure modes. [i.e., breaking, cracking, leaking, etc.]
- Identify causes of each failure mode
- Determine impact of every possible failure mode on the operation of affected items, items of subsequent assemblies, and the total system.
- List the possible symptoms of all failures and the means used to detect the failure.
- Assign a severity ranking to each failure mode.
- Assign an occurrence ranking to each failure mode [i.e., estimate of the probability of the failure cause actually happening].
- For each potential failure mode, perform a criticality analysis.
- Evaluate and recommend any corrective actions and improvements to the design.

2.2.1.2 Preparation of FMECA worksheets

A suitable FMECA worksheet for any analysis will be decided. In many cases the client (customer) will have requirements to the worksheet format - for example to fit into his maintenance management system. A sample FMECA worksheet covering the most relevant column is given below [9].

Table 2.1: A sample FMECA worksheet.

<table>
<tr><td colspan="5">System:</td><td colspan="7">Performed by:</td></tr>
<tr><td colspan="5">Ref Drawing No.:</td><td colspan="3">Date:</td><td colspan="4">Page No</td></tr>
<tr><td colspan="3">Description of unit</td><td colspan="3">Description of failure</td><td colspan="2">Effect of failure</td><td rowspan="2">Failure rate</td><td rowspan="2">Severity ranking</td><td rowspan="2">Risk reducing measures</td><td rowspan="2">Comments</td></tr>
<tr><td>Ref no.</td><td>Function</td><td>Operational mode</td><td>Failure mode</td><td>Failure cause or mechanism</td><td>Detection or failure</td><td>On the sub system</td><td>On the system function</td></tr>
<tr><td>(1)</td><td>(2)</td><td>(3)</td><td>(4)</td><td>(5)</td><td>(6)</td><td>(7)</td><td>(8)</td><td>(9)</td><td>(10)</td><td>(11)</td><td>(12)</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

For each system element (subsystem, component) the analyst must consider all the functions of the elements in all its operational modes, and ask if any failure of the element may result in any unacceptable system effect. If the answer is no, then no further analysis of that element is necessary. If the answer is yes, then the element must be examined further. The various columns in the FMECA worksheet are given below [9].

1. In the first column a unique reference to an element (subsystem or component) is given. It may be a reference to an id. in a specific drawing, so-called tag number, or the name of the element.
2. The functions of the element are listed. It is important to list all functions. A checklist may be useful to secure that all functions are covered.
3. The various operational modes for the element are listed. Examples of operational modes are: idle, standby, and running. Operational modes for an airplane include, for example, taxi, take-off, climb, cruise, descent, approach, flare-out, and roll. In applications where it is not relevant to distinguish between operational modes, this column may be omitted.
4. For each function and operational mode of an element the potential failure modes have to be identified and listed. Note that a failure mode should be defined as a non fulfillment of the functional requirements of the functions specified in column 2.

5. The failure modes identified in column 4 are studied one-by-one. The failure mechanisms (e.g., corrosion, erosion, fatigue) that may produce or contribute to a failure mode are identified and listed. Other possible causes of the failure mode should also be listed. If may be beneficial to use a checklist to secure that all relevant causes are considered.
6. The various possibilities for detection of the identified failure modes are listed. These may involve diagnostic testing, different alarms, proof testing, human perception, and the like. Some failure modes are evident, other are hidden. The failure mode "fail to start" of a pump with operational mode "standby" is an example of a hidden failure. In some applications an extra column is added to rank the likelihood that the failure will be detected before the system reaches the end-user/customer. The following detection ranking are generaly used:

Table 2.2: Detection ranking procedure in FMECA

Rank	Description
1-2	Very high probability that the defect will be detected. Verification and/or controls will almost certainly detect the existence of a deficiency or defect.
3-4	High probability that the defect will be detected. Verification and/or controls have a good chance of detecting the existence of a deficiency/defect.
5-7	Moderate probability that the defect will be detected. Verification and/or controls are likely to detect the existence of a deficiency or defect.
8-9	Low probability that the defect will be detected. Verification and/or control not likely to detect the existence of a deficiency or defect.
10	Very low (or zero) probability that the defect will be detected. Verification and/or controls will not or cannot detect the existence of a deficiency/defect.

7. The effects each failure mode may have on other components in the same subsystem and on the subsystem as such (local effects) are listed.

8. The effects, each failure mode may have on the system (global effects) are listed. The resulting operational status of the system after the failure may also be recorded, that is, whether the system is functioning or not, or is switched over to another operational mode. In some applications it may be beneficial to consider each category of effects separately, like: safety effects, environmental effects, production availability effects, economic effects, and so on.
9. Failure rates for each failure mode are to be listed. In many cases it is more suitable to classify the failure rate in rather broad classes. An example of such a classification is:

Table 2.3: Failure rate ranking in FMECA

1	Very unlikely	Once per 100 years or more seldom
2	Remote	Once per 100 years
3	Occasional	Once per 10 years
4	Probable	Once per years
5	Frequent	Once per month or more often

10. The severity of a failure mode is the worst potential (but realistic) effect of the failure considered on the system level (the global effects). The following severity classes for health and safety effects are sometimes adopted:

Table 2.4: Ranking (Procedure 1) about severity of a failure in FMECA

Rank	Severity class	Description
10	Catastrophic	Failure results in major injury or death of personnel.
7-9	Critical	Failure results in minor injury to personnel, personnel exposure to harmful chemicals or radiation, or fire or a release of chemical to the environment.
4-6	Major	Failure results in a low level of exposure to personnel, or activates facility alarm system.
1-3	Minor	Failure results in minor system damage but does not cause injury to personnel, allow any kind of exposure to operational or service personnel or allow any release of chemicals into the environment

In some application the following severity classes are used

Table 2.5: Ranking (Procedure 2) about severity of a failure in FMECA

Rank	Description
10	Failure will result in major customer dissatisfaction and cause non-system operation or non-compliance with government regulations.
8-9	Failure will result in high degree of customer dissatisfaction and cause non-functionality of system.
6-7	Failure will result in customer dissatisfaction and annoyance and/or deterioration of part of system performance.
3-5	Failure will result in slight customer annoyance and/or slight deterioration of part of system performance.
1-2	Failure is of such minor nature that the customer (internal or external) will probably not detect the failure.

11. Possible actions to correct the failure and restore the function or prevent serious consequences are listed. Actions that are likely to reduce the frequency of the failure modes should also be recorded.
12. The last column may be used to record pertinent information not included in the other columns [7].

2.2.1.3 Risk priority number

An alternative to the risk matrix is to use the ranking of:

O = the rank of the occurrence of the failure mode

S = the rank of the severity of the failure mode

D = the rank of the likelihood that the failure will be detected before the system reaches the end-user/customer.

All the ranks are given on a scale from 1 to 10. The risk priority number (RPN) is defined as $RPN = S \times O \times D$

The smaller the RPN the better – and – the larger the worse [7].

2.2.1.4 Outputs of FMEA

- Identification of any design weaknesses.
- Identification of failure modes those are most likely to cause failure of the product during operation.
- Identification of failure modes that could lead to hazardous conditions.
- Identification of the product those are most likely to fail.

2.2.1.5 RPN reduction

The risk reduction related to a corrective action may be comparing the RPN for the initial and revised concept, respectively. A simple example is given in the following table.

Table 2.6: Example of RPN reduction

	Occurrences **O**	**Severity** **S**	**Detection** **D**	**RPN**
Initial	7	8	5	280
Revised	5	8	4	160
% Reduction in RPN				43%

2.2.1.6 Summing up

The FMECA process comprises three main phases:

Table 2.7: The main phases of FMECA

Phase	Question	Output
Identification	What can go wrong?	Failure descriptions Causes - Failure modes - Effects
Analysis	How likely is a failure? What are the consequences?	Failure rates RPN = Risk priority number
Action	What can be done? How can we eliminate the causes? How can we reduce, the severity?	Design solutions, Test plans, manufacturing changes, Error proofing etc.

Today, the FMECA approach can offer interesting prospects of development and applications in the process analysis of organisations, such as traceability systems in the food industry [9] or integration with the HACCP system for food safety tool control [12]. The FMECA methodology permits the development of suitable techniques to:

- define a functional structure of the organisation's processes and activities (with a father-child relationship)
- investigate potential causes of dysfunctions and errors in company processes
- evaluate criticalities and impacts of single dysfunctions on the whole process analyzed
- manage a planned and structured improvement action and its effect.

FMECA is a very structured and reliable method for evaluating hardware and systems. The concept and application are easy to learn, even by a novice. The approach makes evaluating even complex systems easy to do. DMECA method was developed according to the concept of FMECA to eliminate the critical management process dysfunctions [7].

2.2.2 Dysfunction Mode and Effects Critical Analysis (DMECA)

The DMECA method proposed is conceptually derived from the Failure Mode Effect and Criticality Analysis (FMECA) approach [6], [10] which was originally developed and used in reliability and maintenance activities [11]. The FMECA technique is a very effective, user-friendly tool to identify and assess how potential failures can affect the performance of a process or product [11]. Similar to FMECA, the DMECA methodology is fundamentally the result of two sequential phases:

1. Dysfunction Mode and Effects Analysis (DMEA) – analysis each potential dysfunction mode for each elementary activity constituting the company processes, to identify the subsequent effects. A list of priority interventions of the dysfunction modes can then be decided.
2. Criticality Analysis (CA) – the evaluation of the priorities create a classification of the potential dysfunction modes according to a criticality parameter obtained by the combination of severity of the consequences, probability

that the dysfunction occurs and chances that it can be detected. In particular, the two phases are based on the following steps (Figure 2.2):

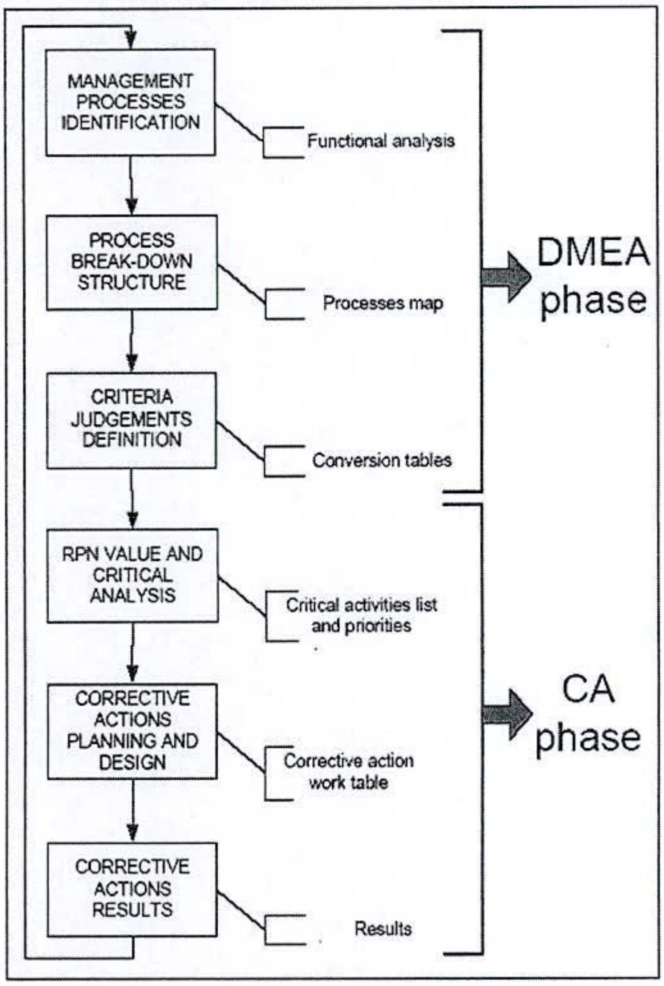


Figure 2.2: Structured processes for the application of DMECA methodology

1 DMEA phase:

A dysfunction modes and effects analysis (DMEA) is a procedure for analysis of potential failure modes within a system for classification by severity or determination of the effect of failures on the system. Failure causes are any errors in management process, especially those that affect to production and maintenance. Effects analysis refers to studying the consequences of those failures.

- Management processes identification – the result is a list of the main processes in relation to the firm's organizational chart (functional department and their activities)

- Process Breakdown Structure (PBS) definition, where the functional structure of the processes consists of:

  a. System → macro-processes identification
  b. For each macro-process → processes identification
  c. For each process → sub-processes identification
  d. For each sub-process → activities identification.

  In this study, The organization must build a tree-shaped process map exploiting the father-child relationship between processes and activities.

- Criteria judgments definition – by applying DMECA, a new correlation matrix between value of probability, severity and detection parameters, and their relative evaluation criteria, has been determined in place of the value reported in product FMECA applications. The result is to obtain tables to convert qualitative and linguistic judgments to quantitative data for probability, detection and gravity of possible dysfunctions [13].

1. Criticality Analysis phase:

Criticality analysis is another component of Dysfunction Mode, Effects, and Criticality Analysis (DMECA). It is an extension of Dysfunction Mode and Effects Analysis (DMEA). In addition to the basic DMEA, it includes a criticality analysis, which is used to make the probability of failure modes against the severity of their consequences. They are as follows:

- Risk Priority Number (RPN) evaluation – dysfunction causes (instead of failure) and their relative weight can be defined for each activity in order to determine the most critical and decide improvement actions. The result is a list of critical activities and priorities.
- Corrective actions planning and design – DMECA method provides a structured approach to investigate, plan and apply improvement actions by using a corrective action worktable.

- Corrective action results evaluation – on the basis of the results, the DMECA process can restart to implement new or reengineered activities.

The used technique is conceptually derived from the Failure Mode Effect and Criticality Analysis (FMECA) technique. The DMECA represents an analytical tool to work according to the new ISO 9000:2000 standard and the Total Quality Management (TQM) principle concerning the 'process approach'. DMECA enables users to:

• build a systematic structure (map) of a management process

• evaluate potential dysfunctions of the elementary activities comprising the process

• evaluate a Risk Priority Number (RPN) for each cause of dysfunction

• support the definition and evaluation of the possible improvement actions in a structured way.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 General

A study was accomplished in a systematic manner on some management personnel of Khulna Power Station (KPS) in Khulna, Bangladesh. In this descriptive type of study different variables such as skill, job type of the personnel, different activity of the management process, dysfunctional cause of the activity as well as its modes and effects, frequency to occur the dysfunctions, detect ability of the dysfunction, severity of the dysfunctions and the corrective action of critical dysfunctions are taken into consideration. Several management personnel are requested for interview to collect information/data associated with dysfunction mode and effect of the management processes. Some group discussions also arranged to cross-check the information as well as to avoid confusion.

3.2 Research Methodology

Importance of methodology in conducting any research can hardly be over looked. It needs a very careful and sincere consideration. The methodology, which was used in this study, enables to collect valid and reliable information/data and to analyze those data to arrive at correct decision. Keeping this in mind, utmost care has been taken for using proper methods in all aspect of this study. The details steps of the methodology to accomplish the objectives of the study are stated in the followings:

3.2.1 Selection of Sample: A reasonable sample size, which can at least satisfy the objectives set for the study, was taken into account. During the research period, number of active management personnel was 57 and they have different job responsibility. They change their work place according to their transfer order but they always work in a power station under Bangladesh Power Development Board (BPDB) in Bangladesh. It was surveyed that about 95% officers have been working in KPS more than 6 years. There are several departments such as operation, maintenance (mechanical, electrical, instrument and control), administration, accounts and security. All of these departments are guided by chief engineer and also most of the personnel related to operation and maintenance have vast knowledge to accelerate their jobs. There are 28 first class officers are directly involved in the operation and maintenance of 110 MW Khulna Power Station. As this study was mainly limited to the dysfunctions about the operation and maintenance (O&M), so interviewed personnel were chosen from the O&M department. To avoid confusion and to make cross check two groups were made, each group contained 7 personnel from different departments. It was tried to cover all the activity about O&M management dysfunctions. However, due to availability of the different types of employee at a time in the plant, 5 personnel were interviewed in each group. For each group at least one from each department has been taken into consideration. In total 5-7 management personnel were interviewed.

3.2.2 Sampling Technique: Sample selected in such a way that collected data fulfill the objectives of the study. As the total number of sample were not large, but considering the limitations of time, efforts, availability of concurrence for providing information, purposive sampling technique were used in this study.

3.2.3 Period of Research: Power generation in Bangladesh is a continuous business like other countries. If Khulna Power Station (KPS) is considered smooth or trouble free generation depends on the lower saline availability in the river water. Beside the plant salinity is the main cause of corrosion of the boiler and condenser tube etc. Similarly during irrigation season, the inductive load increases. As a result generation efficiency affected and management personnel are more conscious about the machine maintenance. In the rainy season the salinity of the river is low and as well as less irrigation is required for the lands. So, machines run comparatively smoothly, and the maintenance personnel are more free than that of other season in the year. Therefore the research work was conducted in the plant from June-August, 2008 for data collection.

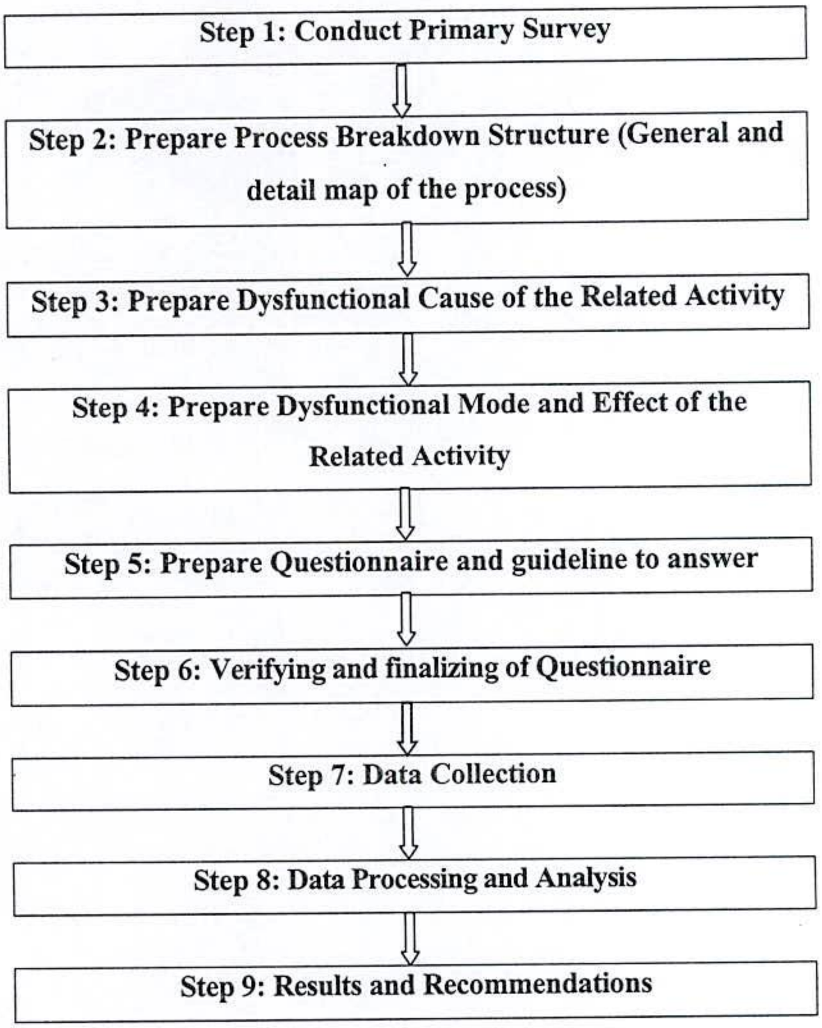
3.2.4 Research Instruments: In order to collect information, a set of interview schedules for the plant Management personnel were prepared. Keeping the objectives of the study in mind, a primary visit and informal discussion was made with some management staffs in order to develop a format with variables of interest. Based on the primary survey and knowledge gathered from the management people, a process break-down structure defined during the process identification phase (reported in Figure 4.5 for the firms' processes) there are 09 sub-processes and 57 activities of job management process. Figure 4.5 reported the detailed breakdown structure for the macro-process operations of the job management process. Now dysfunctional causes their modes and effects of the related activities were prepared by the group discussion. A set of preliminary questionnaire were prepared before preparing the final Questionnaires, to do pre-test on some management staffs. Most of questions were close ended, but few questions were kept open for the interest of the study. This pretest was helpful to find the gaps to locate faulty questions and statement in the draft questionnaires to fulfill the objectives of the study. Necessary additions, alterations and adjustments were made in the questions on the basis of the feed back from pre-test. The finalized version of questionnaires were photocopied and used for collecting information. The data for this thesis work were collected from the plant using the prescribed questionnaire as shown in appendix A.

3.2.5 Procedure of Data Collection: Data for this study were collected from the respondents of the study area by using the questionnaire prepared. The interviews were made group wise in the power plant during their work and leisure time with the permission of interviewee as well as management. Sometimes, managers hesitated to provide some information about matters relates to him or the information that would go against their management. Keeping this in mind, it was tried to explain the purpose of the study to each of the interviewee and established rapport before starting the interview with every respondent. Whenever any respondent faced difficulty in understanding any question, the researcher took utmost care to explain that particular question clearly to him.

In response to the question related to management process dysfunctions records and information, some respondent was reluctant to answer. But after being motivated they tried to give the information as they could remember or understand. Some information they provided on assumption basis as the plant management did not maintain any record. To overcome this problem, all possible efforts were made by the researcher himself to ensure that the collection of reasonably accurate data from the field. When each interview was over, each schedule was checked and verified to be sure that answers to all items had been properly recorded. The data collected from the two groups are now interchanged between these two groups for the better correction and/or suggestions. If there were any items which were overlooked or contradictory, the respondents were revisited to obtain the missing and/or correct information.

3.2.6 Techniques of Data Analysis: Based on the prepared questionnaire, data on the variables were considered and the information were summarized, complied to fit those into tables and finally analyzed in accordance with the objectives of the study. In this way overall picture of the study were identified to point out various dysfunctions of the managerial process.

3.2.7 Interpretation of the Results: On the basis of the results, necessary recommendations were made according to appendix B for the betterment of the plant management process in terms of corrective actions of the dysfunctions. The whole process of study work can be shortly explained by the following flowchart:



CHAPTER 4

PROCESS ANALYSIS AND DATA COLLECTION

4.1 Organogram of Khulna Power Station (KPS)

Similar to the FMECA model, the first step of DMECA is the development of the functional map to identify the management processes. To analyze the management process of Khulna Power Station (KPS), it was necessary to know about the organogram of the organization. Figure 4.1 shows the Organogram of KPS from Chief Engineer to staff; Figure 4.2 shows the Organogram of KPS from Manager-1 to staff and Figure 4.3 shows the Organogram of KPS from Manager-2 to staff. This functional decomposition of organogram is made up to show the successive detailed levels. The bottom level depends on factors such as the objectives of the analysis, time and cost dedicated to the study.

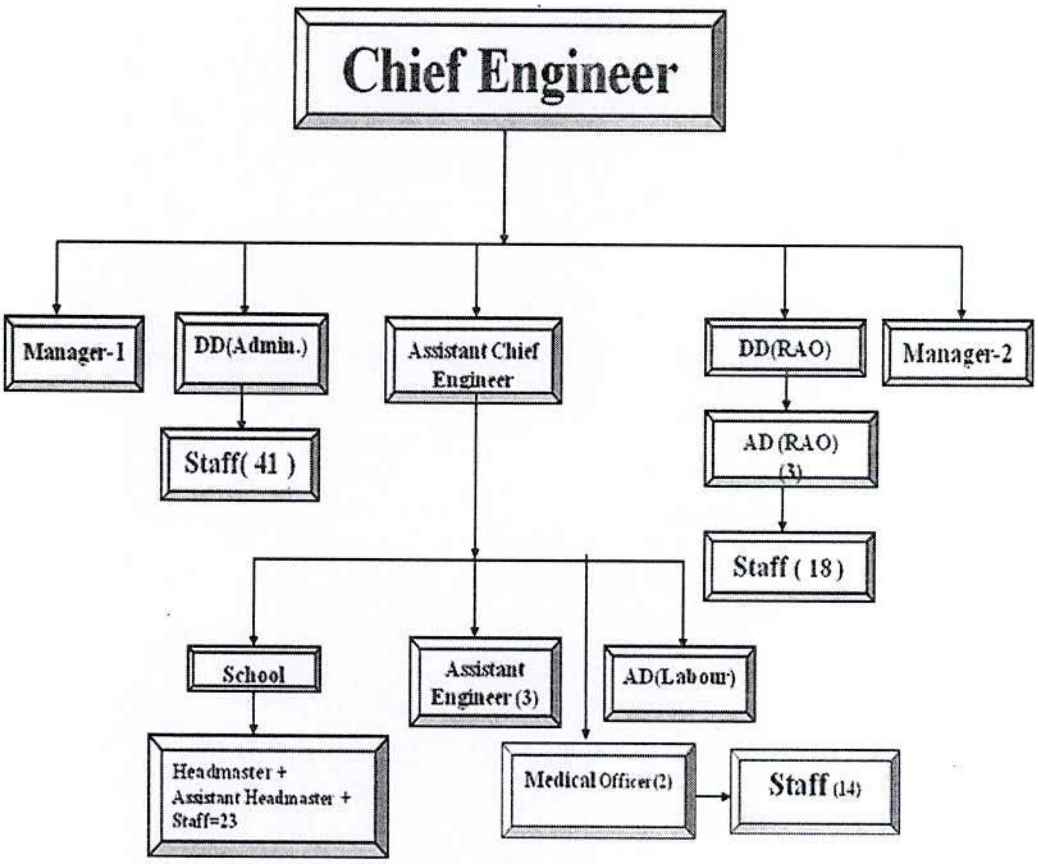


Figure 4.1: Organogram of Khulna Power Station (from CE)

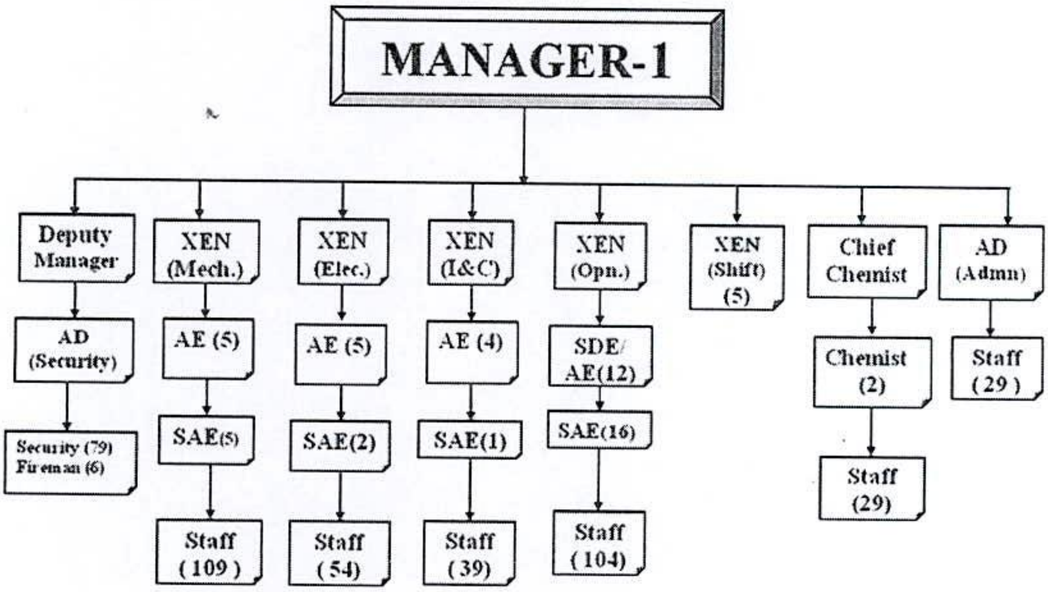


Figure 4.2: Organogram of Khulna Power Station (from Manager-1)

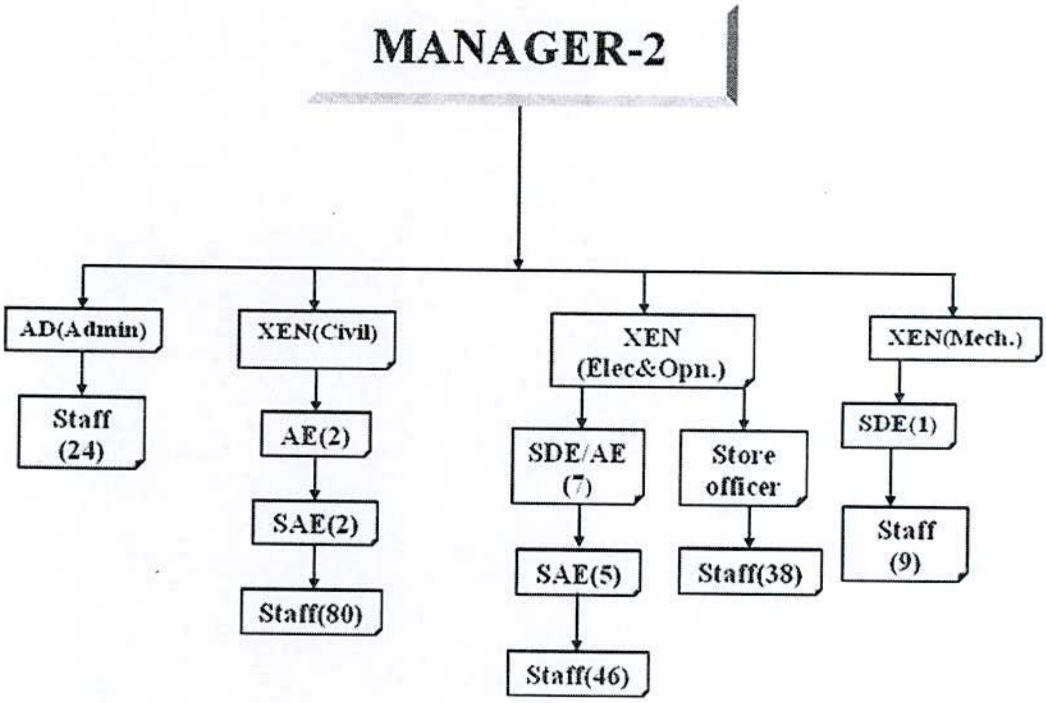


Figure 4.3: Organogram of Khulna Power Station (from Manager-2)

The DMECA methodology is a team effort where the responsible engineer involves from assembly, manufacturing, materials, quality, service, supplier, and the next customer (whether internal or external). A team has certain responsibilities, which include communicating with the rest of the team, coordinating corrective action assignments and follow-up, keeping files and records of DMECA forms, keeping the process moving, and finally, analyzing the effects of corrective action. Continual measuring the management process to manage a machine, production or process is an essential part of DMECA. There are 60 management personnel who are directly involved in management process but currently working 40 personnel, 28 of which are directly involved in operation and maintenance. Table 4.1 shows the manpower position of Khulna Power Station.

Table 4.1: Manpower Position of Khulna Power Station

Sl. No.	Name of Position	As per set up
1.	First Class Officer	60
2.	Second Class Officer	31
3.	Staff (Technical & Non Technical)	604
4.	School Personnel	21
5.	Security Personnel	93
6.	Regional Accounts Personnel	25
	Total	**834**

4.2 Management Process Identification and Process Breakdown Structure

For this study, the input to management process mapping was the five–level organization chart reported in Figure 4.4 (processes breakdown structure) where Level-1 represents Khulna Power Station which is managed by Chief Engineer. Level-2 includes the activities about general management, job management, purchasing and financial activities these are managed by manager unit 1 and manager 2. In this study, the dysfunction about job management was investigated thoroughly. In the job management process - the executive engineers are responsible about operation and maintenance, another level of managers (Sub-Divisional Engineers (SDE) and assistant Engineers (AE)) are responsible about job planning, production/maintenance and job closing, rest of the works are managed by Sub-Assistant Engineer (SAE)

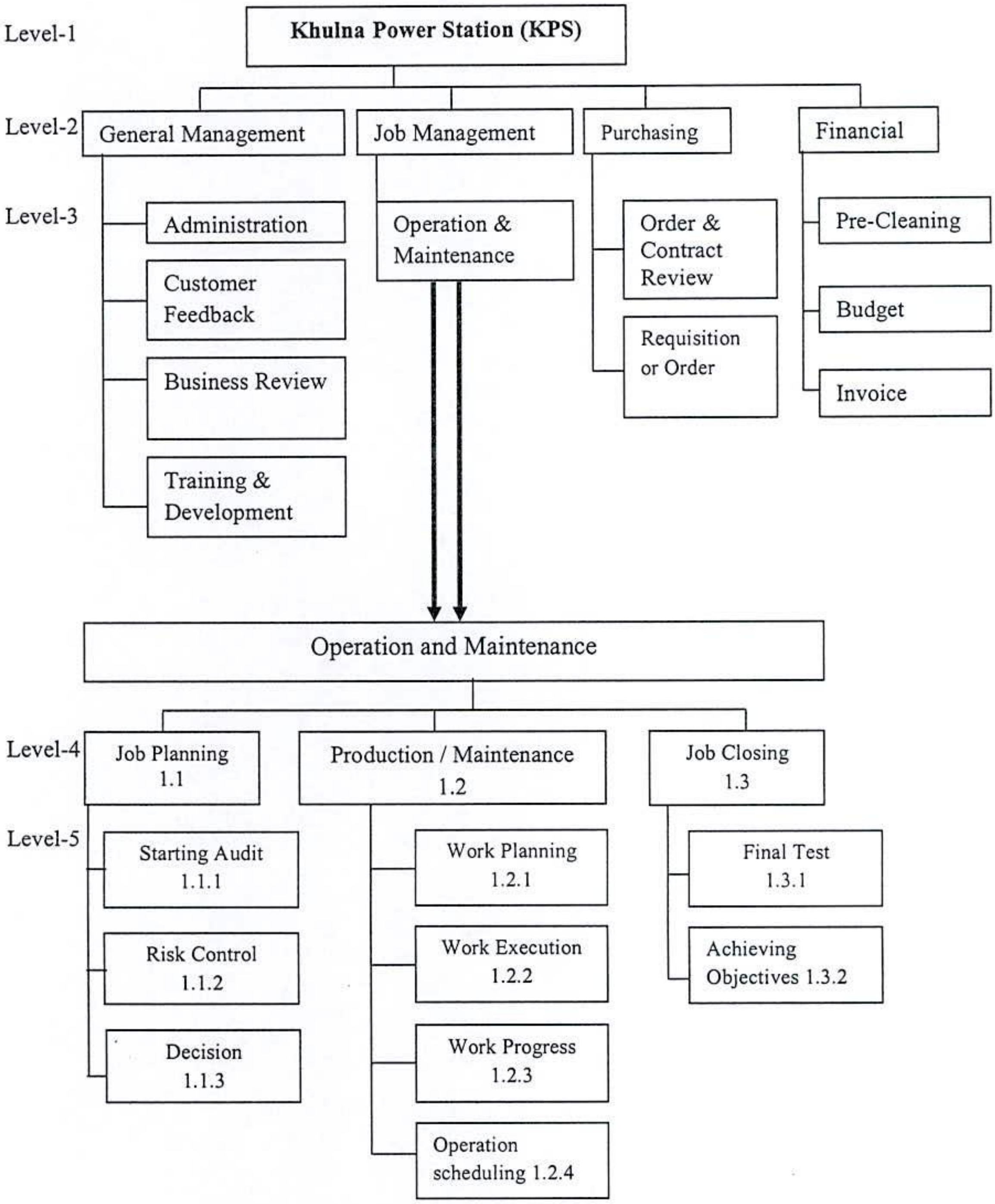


Figure 4.4: Process (Maintenance and/or Production) breakdown structure (General map of the process)

1. 1st level – the firm
2. 2nd level – function
3. 3rd level – macro-process
4. 4th level – process
5. 5th level – Sub-process

In Figure 4.4, the 4th and 5th levels of the operations macro-process were more detailed because this is the objective of the DMECA analysis.

The second step consists of breaking down the sub-processes of Figure 4.4 to the level of detail needed for the analysis – that is, down to elementary activities as shown in Figure 4.5. Each activity was distinguished by an alphanumerical identification symbol, which labels each decomposition level.

In the process break-down structure defined during the process identification phase (reported in Figure 4.4 for the firms' processes) 09 sub-processes and 57 activities of job management process were identified. Figure 4.5 reported the detailed breakdown structure for the macro-process 'operations and maintenance' of the process 'job management' located at Level 2 of firm-process as reported in Figure 4.4.

ID	MACRO PROCESS	ID	PROCESS	ID	SUB PROCESS	ID	ACTIVITY
1	Operation and maintenance	1.1	Job planning	1.1.1	Starting audit	1.1.1.1	Integrated stock check
						1.1.1.2	Correspondence inventory and transport document
						1.1.1.3	Disassembly
						1.1.1.4	Cleaning components
						1.1.1.5	Visual and dimensional control
						1.1.1.6	Chemical composition analysis
						1.1.1.7	Certification data emission
				1.1.2	Risk control	1.1.2.1	Control of the customer
						1.1.2.2	Requirements review
						1.1.2.3	Data review
						1.1.2.4	Know-how availability check
						1.1.2.5	Resources availability review
						1.1.2.6	Economical value review
						1.1.2.7	Time respecting check
				1.1.3	Design	1.1.3.1	Work cycle
						1.1.3.2	Quality control plan
						1.1.3.3	Waiting for drawing
						1.1.3.4	Technical data
						1.1.3.5	Contractual conformities review
						1.1.3.6	Waiting for contract modification
						1.1.3.7	Material
						1.1.3.8	Spare parts
						1.1.3.9	Purchasing
		1.2	Production / Maintenance	1.2.1	Work planning	1.2.1.1	GANTT Diagram
						1.2.1.2	Spare parts availability check1
						1.2.1.3	3Work loads check
						1.2.1.4	Job assignment
				1.2.2	Work execution	1.2.2.1	Mechanical works
						1.2.2.2	Welding
						1.2.2.3	Thermal processing
						1.2.2.4	NDT and check

ID	MACRO PROCESS	ID	PROCESS	ID	SUB PROCESS	ID	ACTIVITY
1	Operation and maintenance	1.2	Production / Maintenance	1.2.2	Work execution	1.2.2.5	Waiting for job engineer master
						1.2.2.6	Other waiting
						1.2.2.7	Transport between job shops
						1.2.2.8	Spare parts taking
						1.2.2.9	Assembly
						1.2.2.10	Balancing
						1.2.2.11	Final checks
						1.2.2.12	Machine operation
						1.2.2.13	Generation
				1.2.3	Work progress control	1.2.3.1	Activity progress audit
						1.2.3.2	Audit of the checks
						1.2.3.3	Purchasing activities audit
						1.2.3.4	Data check
						1.2.3.5	Delay control
						1.2.3.6	Corrective action proposal
						1.2.3.7	Update GANTT
						1.2.3.8	Delay info to customer
				1.2.4	Operation scheduling	1.2.4.1	Man Machine control
						1.2.4.2	Machine hour control
		1.3	Job closing	1.3.1	Final test	1.3.1.1	Documentation review
						1.3.1.2	Dimensional review
						1.3.1.3	Interface review
				1.3.2	Achieving objectives review	1.3.2.1	Customer satisfaction data
						1.3.2.2	Time respect data
						1.3.2.3	Cost respect data
						1.3.2.4	Quality respect data

Figure 4.5: Process breakdown structure (detailed map of the process)

4.3 Judgment Criteria, Dysfunction Definition and Criticality Analysis of DMECA

In order to conduct a criticality analysis of dysfunction, it was necessary to define the judgment criteria, by which the unwanted event was assessed. Proponents of the well-known conversion tables (Table 4.2, 4.3, 4.4 & 4.5) suggested to translate linguistic judgments into numerical values used to obtain a Risk Priority Number (RPN) which should not be applied in second because they are appropriate and defined for maintenance activities, rather than management processes.

It is, therefore, necessary to redefine evaluation factors, acceptability limits and conversion criteria for the parameters utilized in order to determine RPNs context of the management process. By means of brainstorming sessions it was possible to:

- define objective and general judgment criteria.
- determine judgment categories as a function of the criteria
- verify that, combining judgments, there are no insignificant cases attribute a range of values to each category (ensuring each range is comparable with other ranges).

Each dysfunction had thus been judged according to the following three factors: (i) Occurrence Dysfunction (O_D), (ii) Detectability of Dysfunction (D_D) and (iii) Severity Dysfunction (S_D). For Occurrence Dysfunction (O_D), six levels (reported in Table 4.2) was identified, ranging from 'irrelevant' to 'very high' and described through Arabic numerals 1 to 10 [2]. The Mean Time Between Dysfunction (MTBD) factor was introduced which is similar to the Mean Time Between Failure (MTBF) in FMECA and represents the mean time between two same dysfunctions [9]. The values in the third column of Table 4.2 were obtained by interviewing personnel. Generally, the MTBD values in days can change for different companies and depends on the annual number of jobs. A suitable way of calculating the MTBD value is as follows:

$MTBD=36500/(N_c * D_{100\,i})$ in days

where:

N_c = mean number of jobs per year (historical data)

$D_{100\,i}$ = number of dysfunctions of type i per 100 jobs.

Table 4.2 Conversion table for dysfunction occurrence factor

Qualitative/linguistic evaluation of the dysfunction occurrence	MTBD value	Percentage happen (%)	O_D
Irrelevant	> 1 year (> 365 days)	< = 1	1
Remote	4, 5–11 months (132–331 days)	2 to 5	2–3
Low	2–4 months (66–121 days)	6 to 10	4–5
Moderate	1–2 months (27–60 days)	11 to 24	6–7
High	2 weeks–1 month (14–26 days)	25 to 49	8–9
Very high	< 2 weeks (< 13 days)	> = 50	10

For the Detectability of Dysfunction (D_D) judgment, a qualitative linguistic evaluation table was proposed as reported in Table 4.3. Based on these judgments, the detectability of dysfunction was divided into five classes, defined by Arabic numerals 10 to 1 and ranging from 'very low' to 'very high' [12].

Table 4.3: Conversion table for detectability of dysfunction factor

Qualitative/linguistic evaluation of the dysfunction detection	Description	D_D
Very low	Customers detects dysfunction after commissioning	9–10
Low	Dysfunction detected at final test	7–8
Moderate	Dysfunction detected by inspection or after control	4–6
High	Dysfunction detected after work operation where born	2–3
Very high	Dysfunction detected during work	1

Finally, in traditional FMECA, when studying product reliability, the gravity factor was based on parameters such as security and safety [13]. For DMECA, on the other hand, we must consider other parameters related to management methods and process functioning. In general, taking into consideration the objectives and the mission of a firm, the gravity factor can be based on productivity loss, high cost, delay in responding to customer needs and quality loss. This list is not meant to be exhaustive. For this case-study, the mission was suggested considering time and quality results (Table 4.4) as critical variables [2].

Table 4.4 Conversion table for the dysfunction severity factor (Time and quality parameter)

Qualitative/linguistic evaluation of the dysfunction severity	Description	S_D
Critical	Job delivery delay > 1 month OR Unacceptable quality level: significant risk to ship inadequate material to the customer	10
Very important	Job delivery delay from 15 days to 1 month OR Unacceptable quality level: unacceptable defect detected during final test	7–9
Important	Job delivery delay from 1 to 2 weeks OR Unacceptable quality level: unacceptable defect detected at its first occurrence	4–6
Unimportant	Job delivery delay from 2 to 6 days OR Acceptable quality but at the standard limit	2–3
Trivial	Job delivery delay < = 1 day OR Dysfunction mode does not influence quality	1

The next step was the evaluation of possible dysfunctions and the identification of the related causes, attributing a value to the three factors: probability, detection and gravity. In the process break-down structure defined during the process identification phase (reported in Figure 4.4 for the firms' processes), there are 09 sub-processes and 57 activities of job management process have been identified. Figure 4.5 reported the detailed breakdown structure for the macro-process 'operations' of the process 'job management' located at Level 2 of firm-process as reported in Figure 4.4. For each activity, possible dysfunctions had established and 175 potential causes have been identified for the whole process of 'job management'. A code number was assigned to each dysfunction with the same criteria used to map the processes. Thus, it is possible to judge and evaluate the criticality of the dysfunction causes.

4.4 Data Collection

To reduce the variability of the answer and the subjective judgment, each personnel completed a questionnaire (Appendix A) independently, with the support of Table 4.5.

Based on the DMEA phase described above, a Criticality Analysis (CA) phase was conducted for every dysfunction identified. As reported in Table 4.6, for each detailed activity, the following are determined:

- all possible and potential causes or problems that can cause dysfunction on activities
- modes of dysfunctions
- the effects of the dysfunction on the whole process or part of it, and the associated personnel.

Table 4.5 Indications to complete questionnaire

Column	Indications to complete questionnaire
a	How many times does this kind of cause (reported in the row) of dysfunction happen in every 100 jobs? Write your number.
b	What is the value of gravity of this kind of dysfunction as described in Table 4.4? Write your S_D value.
c	What is the value of detection of this kind of dysfunction as described in Table 4.3? Write your D_D value.

Mean values (from all questionnaires) of the three parameters (O_D, D_D and S_D) for each dysfunction then be calculated. Finally, the respective RPNs was obtained as follows: $RPN = O_D \times D_D \times S_D$. The calculated RPN value is given in table 4.6.

This product may be viewed as a relative measure of the management dysfunctions. Values for the RPN can range from 1 to 1000, with 1 being the smallest management dysfunction possible. This value was then used to rank the various causes in the dysfunctions. In case of process with a relatively high RPN, the engineering team must make efforts to take corrective action to reduce the RPN. Likewise, because of a certain concern has a relatively low RPN, the engineering teams not overlook the causes and not neglect an effort to reduce the RPN. This is especially true when the severity of a cause is high. In this case, a low RPN may be extremely misleading, not placing enough importance on a cause where the level of severity may be disastrous. In general, the purpose of the RPN was to rank the various cause on the document [7].The smaller the RPN the better – and – the larger the worse.

Table 4.6: Detailed activities, dysfunction causes, modes and effects

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	Mean O	Mean D	Mean S	RPN
1.1.1.1	Integrated stock check	1.1.1.1.1	Wrong evaluation of integrity	Work interruption	Money penalty	8	5	8	320
		1.1.1.1.2	Wrong personnel involved			9	4	9	324
		1.1.1.1.3	Absence of advanced technology			9	6	7	378
1.1.1.2	Correspondence inventory and transport document	1.1.1.2.1	Less knowledge/involvement of the work force to the inventory control	Delay to completing work	Increasing man month	6	5	4	120
		1.1.1.2.2	Less knowledge/involvement of the warehouse personnel to the practical task			7	3	6	126
		1.1.1.2.3	Wrong/absence of software for document preservation and/or transportation			4	4	6	96
1.1.1.3	Disassembly	1.1.1.3.1	Less tendency to documentation when disassembling	Wrong procedure to disassembly	It interrupts when assembling	5	5	6	150
		1.1.1.3.2	Less secured preservation of the machines manual			9	5	8	360
		1.1.1.3.3	Wrong personnel involvement			4	5	4	80
1.1.1.4	Cleaning components	1.1.1.4.1	Absence of suitable machineries	Less cleaning	More time required when assembling	7	5	5	175
		1.1.1.4.2	Wrong personnel			6	4	5	120
		1.1.1.4.3	Application of wrong procedure			4	3	4	48
1.1.1.5	Visual and dimensional control	1.1.1.5.1	Less involvement of the skilled personnel	Failure for minor causes	Increases break down time	4	4	7	112
		1.1.1.5.2	No standard inspection procedure			9	5	8	360
		1.1.1.5.3	Less visual inspection tendency			6	3	4	72

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	Mean O	Mean D	Mean S	RPN
1.1.1.6	Chemical composition analysis	1.1.1.6.1	Absence of right personnel	Quick metallurgical damage	Increases conductivity and corrosion	9	5	7	315
		1.1.1.6.2	No machineries present			5	5	7	175
		1.1.1.6.3	Shortage of document about standard chemical composition			6	5	6	180
1.1.1.7	Certification of collected data	1.1.1.7.1	Wrong data analyzing	Right data is not in right time	Difficult to identify the causes of failure	7	5	5	175
		1.1.1.7.2	Less involvement of the skilled personnel			4	5	5	100
		1.1.1.7.3	Redundancy and the information noise present			9	6	7	378
1.1.2.1	Control of the customer	1.1.2.1.1	No improvement over previous solution	Miss understanding between departments	Takes more time	6	4	5	120
		1.1.2.1.2	No preferences as its importance			6	5	6	180
		1.1.2.1.3	Slow improvement of resources for customer satisfaction			4	6	7	168
1.1.2.2	Requirements review	1.1.2.2.1	Requirement varied with time rapidly	Less idea generating capacity	Require exparts	5	6	6	180
		1.1.2.2.2	Redundancy and/or shortage of required resources			6	7	5	210
		1.1.2.2.3	Absence of previous data			8	5	9	360
1.1.2.3	Data review	1.1.2.3.1	Less physical practice for recording data	Proper data is not available	Work becomes relatively difficult	9	6	7	378
		1.1.2.3.2	Wrong data acquisition procedure			4	5	4	80
		1.1.2.3.3	Tendency to manipulate data by recorder			5	6	6	180

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	Mean O	Mean D	Mean S	RPN
1.1.2.4	Know-how availability check	1.1.2.4.1	Motivation by certain/some groups	No right man in the right place	Less efficiency in the work	5	4	5	100
		1.1.2.4.2	Influences of trade unions			9	5	7	315
		1.1.2.4.3	No/too small reward for availability of best knowledge			7	4	7	196
1.1.2.5	Resource availability review	1.1.2.5.1	Wrong/no sufficient data	Difference between documentation and physical requirement of resources	More money involvement	6	5	6	180
		1.1.2.5.2	Wrong/time consuming procedure to represent data			4	5	5	100
		1.1.2.5.3	Difference between documentary and practical information			4	7	4	112
1.1.2.6	Economical value review	1.1.2.6.1	Wrong personnel	Wrong decision to replacement	Economical loss	6	6	5	180
		1.1.2.6.2	Wrong way to calculate			6	6	4	144
		1.1.2.6.3	Less factor involvement			5	5	7	175
1.1.2.7	Check of respective time	1.1.2.7.1	Less tendency to preserve data	More time to maintenance	Money penalty	5	4	6	120
		1.1.2.7.2	Tendency to using of the thumb rule			9	5	8	360
		1.1.2.7.3	No software present			7	5	4	140
1.1.3.1	Work cycle	1.1.3.1.1	Impractical due to the pressure of the government	Fault increasing	More breakdown time	8	6	7	336
		1.1.3.1.2	Too short/too long to execute the specific work			4	4	5	80
		1.1.3.1.3	Interferance of the third party			6	6	5	180

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	Mean O	Mean D	Mean S	RPN
1.1.3.2	Quality control	1.1.3.2.1	No body is responsible	More frequency to breakdown	Money penalty	7	4	7	196
		1.1.3.2.2	Shortage of high tech machinery			7	6	4	168
		1.1.3.2.3	Shortage of know-how about hi tech			6	4	6	144
1.1.3.3	Waiting for drawing	1.1.3.3.1	It consumes long time	Work supervision is critical	Require more time	4	7	6	168
		1.1.3.3.2	No detailed drawing of a project			5	5	7	175
		1.1.3.3.3	Immature drawing and language problem			8	5	8	320
1.1.3.4	Technical data	1.1.3.4.1	Insufficient data	Redundancy of the data	Data screening is difficult	7	5	4	140
		1.1.3.4.2	Error in preparing data			6	6	5	180
		1.1.3.4.3	Redundancy of the data			4	4	5	80
1.1.3.5	Contractual conformities review	1.1.3.5.1	Less concentration about review	Difficult to supervise maintenance	Interest of the higher authority	5	5	7	175
		1.1.3.5.2	Absence of skillness			6	5	6	180
		1.1.3.5.3	Overlooking tendency			9	5	7	315
1.1.3.6	Waiting for contract modification	1.1.3.6.1	Wrong coordination	Takes more time	Overall financial condition becomes critical	6	7	4	168
		1.1.3.6.2	Present rules about the time frame			4	4	7	112
		1.1.3.6.3	Contractor/supplier get more flexibility			5	5	6	150
1.1.3.7	Material	1.1.3.7.1	Wrong material selection	Less longevity	Frequent maintenance required	5	5	5	125
		1.1.3.7.2	No metallurgical expert			9	5	7	315
		1.1.3.7.3	No previous data about certain material			4	7	5	140

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	Mean O	Mean D	Mean S	RPN
1.1.3.8	Spare parts	1.1.3.8.1	Wrong spare parts selection	Redundancy of the spare	Money involvement	6	5	6	180
		1.1.3.8.2	Redundancy of the spare parts			6	4	7	168
		1.1.3.8.3	Specification of the spare parts			6	4	4	96
1.1.3.9	purchasing	1.1.3.9.1	No individual purchasing rules	Works goes slowly	Takes more time	7	7	4	196
		1.1.3.9.2	Uncertainty about time			4	6	6	144
		1.1.3.9.3	Fairness about purchasing			9	5	8	360
1.2.1.1	GANT diagram	1.2.1.1.1	Work sheet incomplete	Contractual delivery time not respected and activities overlaping	Work sheet revision	4	5	4	80
		1.2.1.1.2	Incomprehensible work sheet			4	6	4	96
		1.2.1.1.3	Wrong work sheet			5	6	6	180
		1.2.1.1.4	Wrong/partial use of Project Software			5	4	6	120
1.2.1.2	Spare parts availability check	1.2.1.2.1	Missing/wrong evaluation of spare parts conformity	Delay with possibility of work interruptions	Efficiency loss and money penalties	3	4	5	60
		1.2.1.2.2	Missing/wrong evaluation of spare parts shortage			4	6	7	168
		1.2.1.2.3	Missing/wrong evaluation of spare parts quantity			5	7	5	175
1.2.1.3	Works loads check	1.2.1.3.1	Missing/wrong finding of resources saturation	Delay with possibility of work interruptions	Efficiency loss and money penalties	5	5	6	150
		1.2.1.3.2	Missing/wrong finding overlapping use of machineries			5	4	7	140
		1.2.1.3.3	Missing/wrong scheduling with GANTT chart			6	5	4	120

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	Mean O	Mean D	Mean S	RPN
1.2.1.4	Job assignment	1.2.1.4.1	Missing/wrong suitable personnel allocation	Work interruption or slow down; possibility of non conformity	More costs for re-work or external work	4	6	4	96
		1.2.1.4.2	Missing/wrong finding of suitable machineries			3	7	6	126
		1.2.1.4.3	Missing/wrong suitable space allocation for work			4	7	4	112
		1.2.1.4.4	Missing/wrong scheduling with GANTT chart			4	5	4	80
1.2.2.1	Mechanical works	1.2.2.1.1	Impractical time sanction	Tendency to finish maintenance quickly	Proper work done is not possible	9	5	8	360
		1.2.2.1.2	Wrong expectation of the higher authority			5	6	6	180
		1.2.2.1.3	Wrong/no use of the maintenance software			4	4	4	64
1.2.2.2	Welding	1.2.2.2.1	Shortage of manpower	Frequent breaks of the joints	Time and money penalty	6	4	5	120
		1.2.2.2.2	No checking of welders capability			8	6	7	336
		1.2.2.2.3	Welders know-how too small about welding defects			5	5	4	100
1.2.2.3	Thermal processing	1.2.2.3.1	Little know-how	Less tendency to follow the standard rule	Reduces life of the machine	4	7	5	140
		1.2.2.3.2	Dependency on third party			6	5	6	180
		1.2.2.3.3	Wrong use of thermal equipment			6	5	6	180
1.2.2.4	NDT and check	1.2.2.4.1	Dependency on third party	Breaks through imperfection	Increasing maintenance cost	6	5	5	150
		1.2.2.4.2	Little know-how			4	4	4	64
		1.2.2.4.3	Limited/no use of the NDT			8	5	8	320

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	Mean O	Mean D	Mean S	RPN
1.2.2.5	Waiting for the job engineer master	1.2.2.5.1	Less involvement of the in-house engineer	Waiting for experts	Takes long time	4	5	3	60
		1.2.2.5.2	More dependency on the foreign engineer			4	4	6	96
		1.2.2.5.3	It takes long time			6	5	5	150
1.2.2.6	Other waiting	1.2.2.6.1	Wrong coordination	Waiting for spare and machinery	Money penalty	5	6	4	120
		1.2.2.6.2	Apathy for the time binding of the out sources			7	5	5	175
		1.2.2.6.3	Weak procuring procedure			7	4	7	196
1.2.2.7	Material handle between job shops	1.2.2.7.1	Miss coordination	Wrong coordination	Takes more maintenance	6	7	4	168
		1.2.2.7.2	Wrong management about time			5	5	6	150
		1.2.2.7.3	Wrong communication with each other			4	5	2	40
1.2.2.8	Spare parts requirement	1.2.2.8.1	Wrong use of bin card	Miss allocation of spare parts	Production loss	4	7	6	168
		1.2.2.8.2	Wrong storage procedure			8	5	9	360
		1.2.2.8.3	Salty weather reduces the parts quality			4	6	5	120
1.2.2.9	Assembly	1.2.2.9.1	Wrong documentation when disassembling	Data missing	Requiring experts	4	6	6	144
		1.2.2.9.2	Training of the associated personnel			6	5	5	150
		1.2.2.9.3	Dependency of the workers know-how			7	4	5	140
1.2.2.10	Balancing	1.2.2.10.1	Wrong tool allocation for work	Increase vibration and temperature	Increasing frequency of the same break downs	5	5	6	150
		1.2.2.10.2	Wrong findings of suitable equipment			4	5	7	140
		1.2.2.10.3	Wrong suitable person allocation			5	7	4	140

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	Mean O	Mean D	Mean S	RPN
1.2.2.11	Final checks	1.2.2.11.1	Only visual check that is insufficient	Less concentration to final checking	Frequent breakdown	6	6	4	144
		1.2.2.11.2	Wrong/less factors are considered			7	4	6	168
		1.2.2.11.3	Skill of the personal			7	4	7	196
1.2.2.12	Machine operation	1.2.2.12.1	Miss allocation of the operator	No right man for the right machine	Wrong operation	5	7	4	140
		1.2.2.12.2	Wrong suitable machine allocation to the operator			9	5	8	360
		1.2.2.12.3	Apathy to study previous document			7	6	4	168
1.2.2.13	Generation	1.2.2.13.1	Frequency problem	No smooth generation	Machine fluctuating	4	5	4	80
		1.2.2.13.2	Blackout start problem			5	5	6	150
		1.2.2.13.3	Wrong coordination with the grid substation			8	6	7	336
1.2.3.1	Activity progress audit	1.2.3.1.1	Depends on contractor	Miss communication local and higher authority	Takes more time of a project	4	7	5	140
		1.2.3.1.2	Irresponsible tendency of the contractor			4	4	5	80
		1.2.3.1.3	Local authority does not give reports to the higher authority			6	4	4	96
1.2.3.2	Audit of the checks	1.2.3.2.1	Fairness on contractor	Difficult to check	Require extension of the project time	5	6	6	180
		1.2.3.2.2	High level of linkage of the contractor to the higher authority			6	5	6	180
		1.2.3.2.3	Skill of the personnel			7	5	4	140

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	Mean O	Mean D	Mean S	RPN
1.2.3.3	Purchasing activities to be audited	1.2.3.3.1	Shortage of knowledge of the government rule	Fairness about audit	Less tendency to purchase	6	4	6	144
		1.2.3.3.2	More complex rules of the government			9	5	7	315
		1.2.3.3.3	No individual rules present for the technical work			4	6	4	96
1.2.3.4	Data check	1.2.3.4.1	Wrong data access procedure	All type of data are not available	Takes more resources	5	7	5	175
		1.2.3.4.2	Wrong storage of data			6	6	5	180
		1.2.3.4.3	Less dependency on data			7	5	4	140
		1.2.3.4.4	No action taken by the study of the previous data			4	6	7	168
1.2.3.5	Delay control	1.2.3.5.1	No power for controlling delay on the local authority	Unethical relation between higher authority and the contractor	Third party gets more time	4	4	6	96
		1.2.3.5.2	Contractors are pioneer so delay in most of the cases			6	4	4	96
		1.2.3.5.3	Apathy of the higher authority			7	6	4	168
		1.2.3.5.4	Own interest of the higher authority or the contractor			5	5	7	175
1.2.3.6	Corrective action proposal	1.2.3.6.1	Lack of know-how of the personnel	Shortage of knowledge	No correct proposal	4	7	6	168
		1.2.3.6.2	Wrong proposal			5	7	5	175
		1.2.3.6.3	incomplete proposal			6	6	5	180
1.2.3.7	Update GANTT chart	1.2.3.7.1	Complex procedure	Less know-how about the time value of money	Money penalty	6	5	6	180
		1.2.3.7.2	More effort involved for their own interest			7	4	7	196
		1.2.3.7.3	Absence of all level awareness about GANTT chart			5	5	4	100

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	Mean O	Mean D	Mean S	RPN
1.2.3.8	Delay information to the customer	1.2.3.8.1	Wrong/miss information reaches to the customers	No pressure from customer end for completing the work	Takes more time	4	4	4	64
		1.2.3.8.2	Customer are not aware			6	5	6	180
		1.2.3.8.3	Little knowledge of the customer			4	6	4	96
1.2.4.1	Man machine control	1.2.4.1.1	Man vary with time	Particular man not involved for the particular machine	Wrong operation	4	6	5	120
		1.2.4.1.2	Apathy to collect data			9	5	8	360
		1.2.4.1.3	Wrong/Faulty work places			8	5	8	320
1.2.4.2	Machine hour control	1.2.4.2.1	Manual system	Control problem due to human error	Critical to calculate the operating hour of a machine	8	6	8	384
		1.2.4.2.2	Missing information			5	4	4	80
		1.2.4.2.3	Wrong selection of hour per machine			6	5	6	180
1.3.1.1	Documentation review	1.3.1.1.1	Wrong documentation	No right documentation	Data missing	6	5	6	180
		1.3.1.1.2	language problem			4	5	6	120
		1.3.1.1.3	Standard format is not present			4	7	7	196
1.3.1.2	Dimensional review	1.3.1.2.1	Dependency on contractor or third party	Dependency on the manufacturer	Maintaining dimension locally is a problem	6	4	4	96
		1.3.1.2.2	Shortage of skilled personnel			6	6	5	180
		1.3.1.2.3	Wrong/no knowledge of thermal impact on dimension			5	6	5	150

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	Mean O	Mean D	Mean S	RPN
1.3.1.3	Interface review	1.3.1.3.1	Skill of the personnel	Wrong review	Wrong interface	4	7	4	112
		1.3.1.3.2	No right man in right places			5	4	7	140
		1.3.1.3.3	Dependency on the experienced workers			6	5	6	180
1.3.2.1	Customer satisfaction data	1.3.2.1.1	No survey about customer satisfaction	No data about customers' complains	Less tendency to production development	7	5	4	140
		1.3.2.1.2	Apathy to preserve customer complains			8	5	8	320
1.3.2.2	Time respect	1.3.2.2.1	Wrong expectation of time by the third party	Third party does not obey the time bindings	Increases time value of money	5	6	6	180
		1.3.2.2.2	Less involvement of the local authority			4	6	6	144
		1.3.2.2.3	National requirement is not considered			6	4	5	120
1.3.2.3	Cost respect	1.3.2.3.1	Less involvement of the local authority	Frequency of breakdown increases	Total break down time increases	4	4	5	80
		1.3.2.3.2	Direct supervision of the higher/head office			4	7	6	168
		1.3.2.3.3	Overlook tendency of the national profit			4	6	7	168
1.3.2.4	Quality respect	1.3.2.4.1	No headache on the long durability	Wrong supervision procedure	Cost increases	5	5	4	100
		1.3.2.4.2	Complex government purchasing rules			5	5	4	100
		1.3.2.4.3	Wrong financial auditing procedure			4	6	6	144
		1.3.2.4.4	Less emphasis on the national demand			5	4	6	120

CHAPTER 5

ANALYSIS AND RESULTS

5.1 Identification of Critical Activities

The plant strategy is to keep machines in operation as much time as possible. The DMECA is a proactive tool, technique and quality method that enables the identification and prevention of management personnel errors. Defect, rework, and miss-management mean loss on material, loss in production time and cost as well. With the help of the DMECA method, it's easy to know what potentially may go wrong with the management personnel-management approach. DMECA can assist to improving overall efficiency of the management personnel. There are various types of jobs related to operation and maintenance in the Khulna Power Station (KPS). Management personnel are committed to smooth operation of the plant. So, preventive maintenance or condition based maintenance is very important. These can be achieved easily by eliminating the dysfunctions of the management personnel activities. This study investigated a lot of activities with the dysfunctions related to the activities of management process. For this reason a set of questioner was developed (Appendix-A) related to the management personnel activities. Management personnel are then interviewed with these questioners. Dysfunctional cause, mode and its effects are also investigated. All the dysfunctions are not Sevier. So it was important to identify what are the dysfunctions in the management process that are mainly involved for the loss of material, loss in production time and cost as well. At this point in the structured DMECA process, criticality analysis according to the procedure described in article 2.2.2 was carried out and the critical activities (high RPN) where improvement actions are necessary were found. Dysfunction causes and their relative weights were investigated for each activity in order to determine the most critical and decide improvement actions. The result is shown in a list of critical activities and priorities (Table-5.1). On the basis of these results, the DMECA process can restart to implement on new activities. This will be helpful to run the power plant more effectively and efficiently. For example, Table 5.1 shows the activities that receive higher RPNs on its dysfunction causes, these are the critical activities. Table 5.2 shows the corrective actions for these critical activities.

Table 5.1: Detailed critical activities, dysfunction causes, modes and effects									
ID	**Activity**	**ID**	**Dysfunctional cause**	**Dysfunctional mode**	**Dysfunctional effect**	**Mean O**	**Mean D**	**Mean S**	**RPN**
1.1.1.1	Integrated stock check	1.1.1.1.1	Wrong evaluation of integrity	Work interruption	Money penalty	8	5	8	320
		1.1.1.1.2	Wrong personnel involved			9	4	9	324
		1.1.1.1.3	Absence of advanced technology			9	6	7	378
1.1.1.3	Disassembly	1.1.1.3.2	Less secured preservation of the machines manual	Wrong procedure to disassembly	It interrupts when assembling	9	5	8	360
1.1.1.5	Visual and dimensional control	1.1.1.5.2	No standard inspection procedure	Failure for minor causes	Increases break down time	9	5	8	360
1.1.1.6	Chemical composition analysis	1.1.1.6.1	Absence of right personnel	Quick metallurgical damage	Increases conductivity and corrosion	9	5	7	315
1.1.1.7	Certification of collected data	1.1.1.7.3	Redundancy and the information noise present	Right data is not in right time	Difficult to identify the causes of failure	9	6	7	378
1.1.2.2	Requirements review	1.1.2.2.3	Absence of previous data	Less idea generating capacity	Require exparts	8	5	9	360
1.1.2.3	Data review	1.1.2.3.1	Less physical practice for recording data	Proper data is not available	Work becomes relatively difficult	9	6	7	378
1.1.2.4	Know-how availability check	1.1.2.4.2	Influences of trade unions	No right man in the right place	Less efficiency in the work	9	5	7	315
1.1.2.7	Check of respective time	1.1.2.7.2	Tendency to using of the thumb rule	More time to maintenance	Money penalty	9	5	8	360
1.1.3.1	Work cycle	1.1.3.1.1	Impractical due to the pressure of the government	Fault increasing	More breakdown time	8	6	7	336
1.1.3.3	Waiting for drawing	1.1.3.3.3	Immature drawing and language problem	Work supervision is critical	Require more time	8	5	8	320

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	Mean O	Mean D	Mean S	RPN
1.1.3.5	Contractual conformities review	1.1.3.5.3	Overlooking tendency	Difficult to supervise maintenance	Interest of the higher authority	9	5	7	315
1.1.3.7	Material	1.1.3.7.2	No metallurgical expert	Less longevity	Frequent maintenance required	9	5	7	315
1.1.3.9	purchasing	1.1.3.9.3	Fairness about purchasing	Works goes slowly	Takes more time	9	5	8	360
1.2.2.1	Mechanical works	1.2.2.1.1	Impractical time sanction	Tendency to finish maintenance quickly	Proper work done is not possible	9	5	8	360
1.2.2.2	Welding	1.2.2.2.2	No checking of welders capability	Frequent breaks of the joints	Time and money penalty	8	6	7	336
1.2.2.4	NDT and check	1.2.2.4.3	Limited/no use of the NDT	Breaks through imperfection	Increasing maintenance cost	8	5	8	320
1.2.2.8	Spare parts requirement	1.2.2.8.2	Wrong storage procedure	Miss allocation of spare parts	Production loss	8	5	9	360
1.2.2.12	Machine operation	1.2.2.12.2	Wrong suitable machine allocation to the operator	No right man for the right machine	Wrong operation	9	5	8	360
1.2.2.13	Generation	1.2.2.13.3	Wrong coordination with the grid substation	No smooth generation	Machine fluctuating	8	6	7	336
1.2.3.3	Purchasing activities to be audited	1.2.3.3.2	More complex rules of the government	Fairness about audit	Less tendency to purchase	9	5	7	315
1.2.4.1	Man machine control	1.2.4.1.2	Apathy to collect data	Particular man not involved for the particular machine	Wrong operation	9	5	8	360
1.2.4.1	Man machine control	1.2.4.1.3	Wrong/Faulty work places		Wrong operation	8	5	8	320
1.2.4.2	Machine hour control	1.2.4.2.1	Manual system	Control problem due to human error	Critical to calculate the	8	6	8	384
1.3.2.1	Customer satisfaction data	1.3.2.1.2	Apathy to preserve customer complains	No data about customer complain	Less tendency to production development	8	5	8	320

5.2 Identification of Corrective Action

Management of the Power Plant must focus on defining improvement actions to eliminate the dysfunctional causes of this activities described in table 5.1. A matrix similar to that presented in Appendix B, can be used to create, design, plan and control the corrective actions. In the matrix, the following are summarized:

- the critical activity
- the dysfunction cause
- the improvement action proposed
- the frequency of the improvement action
- time necessary to implement action
- a flag to indicate possible interruption of the action implementation
- the responsibility to implement action
- the executor
- the predicted cost
- the benefit

For the activity ID1.1.1.3 (Disassembly), related training course to develop skillness was suggested as corrective action to reduce relative RPNs factor as reported in Table 5.2. The benefits related to the proposed improvement action are O_D and D_D reductions.

The DMECA approach permits to identify how a corrective action can eliminate a particular dysfunction, also can be used to correct other problems or inefficiencies indirectly. Therefore, at the end of the DMECA structured process analysis, we obtained schemes where relatively few corrective actions can solve multiple dysfunctions (Table 5.2). This was because there is a strong interrelationship between management processes and activities.

This result is the most important of the DMECA method, as it permits the correction of a group of similar causes of dysfunctions through fewer corrective actions. Evidence of this is illustrated in Table 5.2, where the improvement actions (i) 'related training course' and (ii) 'action taken by the government' can eliminate twenty four dysfunctional causes related to twenty three different activities. Similarly, potentiality checking of welders and machine operators can eliminate two dysfunctional causes related to welding and machine operation activity, respectively.

For the activity 1.1.1.6 Chemical composition analysis, related training course to analyze chemical composition was proposed as corrective action to reduce relative RPNs factor as reported in Table 5.2. The benefits related to the proposed improvement action are O_D and D_D reductions.

Table 5.2: Corrective action planning and design scheme										
Critical activity				**Corrective action**						
ID	**Activity**	**ID**	**Dysfunctional cause**	**Improvement actioin**	**Frequency**	**Time**	**Responsible**	**Executor**	**Cost (Tk)**	**Benefit**
1.1.1.1	Integrated stock check	1.1.1.1.1	Wrong evaluation of integrity	Introducing advanced technology and related training	6 Months	4 to 5 days	Plant Manager	Executive Engineer	Approxim-ately 50000	Reduction of O_D
		1.1.1.1.2	Wrong personnel involved							
		1.1.1.1.3	Absence of advanced technology							
1.1.1.3	Disassembly	1.1.1.3.2	Less secured preservation of the machines manual	Related training courses for skillness						
1.1.1.5	Visual and dimensional control	1.1.1.5.2	No standard inspection procedure							
1.1.1.6	Chemical composition analysis	1.1.1.6.1	Absence of right personnel							
1.1.1.7	Certification of collected data	1.1.1.7.3	Redundancy and the information noise present							
1.1.2.2	Requirements review	1.1.2.2.3	Absence of previous data							
1.1.2.3	Data review	1.1.2.3.1	Less physical practice for recording data							
1.1.2.7	Check of respective time	1.1.2.7.2	Tendency to using of the thumb rule							
1.2.2.4	NDT and check	1.2.2.4.3	Limited/no use of the NDT							
1.2.2.8	Spare parts requirement	1.2.2.8.2	Wrong storage procedure							
1.2.4.2	Machine hour control	1.2.4.2.1	Manual system							

Critical activity				Corrective action						
ID	Activity	ID	Dysfunctional cause	Improvement actioin	Frequency	Time	Responsible	Executor	Cost (Tk)	Benefit
1.1.2.4	Know-how availability check	1.1.2.4.2	Influences of trade unions	Action by Government and higher authority	Annual	One month	Government and Bangladesh Power Development Board (BPDB) Authority	Plant manager	Approximately 20000	O_D, D_D, S_D Reduction
1.1.3.1	Work cycle	1.1.3.1.1	Impractical due to the pressure of the government							
1.1.3.3	Waiting for drawing	1.1.3.3.3	Immature drawing and language problem							
1.1.3.5	Contractual conformities review	1.1.3.5.3	Overlooking tendency							
1.1.3.7	Material	1.1.3.7.2	No metallurgical expert							
1.1.3.9	purchasing	1.1.3.9.3	Fairness about purchasing							
1.2.2.1	Mechanical works	1.2.2.1.1	Impractical time sanction							
1.2.2.13	Generation	1.2.2.13.3	Wrong coordination with the grid substation							
1.2.3.3	Purchasing activities to be audited	1.2.3.3.2	More complex rules of the government							
1.2.4.1	Man machine control	1.2.4.1.3	Wrong/Faulty work places							
1.2.2.2	Welding	1.2.2.2.2	No checking of welders capability	Check potentiality of welders and operators		4 to 5 days	Executive Engineer	Sub-Divitional Engineer	Approximately 20000	O_D, D_D Reduction
1.2.2.12	Machine operation	1.2.2.12.2	Wrong suitable machine allocation to the operator							
1.2.4.1	Man machine control	1.2.4.1.2	Apathy to collect data	Training on motivation						
1.3.2.1	Customer satisfaction data	1.3.2.1.2	Apathy to preserve customer complains							

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

In every organization (industrial, commercial, services), it is necessary to utilize a method to evaluate possible dysfunctions in managerial processes that can result trouble free operation. The Dysfunction Mode Effects and Criticality Analysis approach which represents an interesting and complete structured tool to find inefficiencies in the management process and consequently define suitable improvement actions. The method allows the user to analyze a process of a power plant in a detailed and structured way. In this thesis work, a case study of the application of DMECA is presented to illustrate the technique in a real business situation of 110 MW, Khulna Power Station (KPS), Bangladesh Power Development Board (BPDB), Goalpara, Khalishpur, Khulna, Bangladesh. The application of DMECA to the power plant helped us (i) to highlight potential criticalities in terms of elementary activities that form the processes and (ii) to define the improvement actions that must be implemented to complete the analysis and the improvement processes. In particular, it will allow the managers to plan, to schedule and to control proposed actions in terms of responsibility, cost and time. The method may also be useful for repeated applications and reiteration according to Deming's Plan-Do-Check-Act (PDCA) mentality to obtain an effective continuous improvement of the processes. In fact, organizations' needs changes rapidly and some activities can become more critical (i.e., greater RPN). Furthermore, the effects of improvement actions must be correctly evaluated continuously.

The main characteristic of the methodology is its applicability to the managerial processes of each organization (i.e., firms, public services, local agency or government). In particular, DMECA is a valid technique to evaluate processes efficiency and effectiveness in the field of services where the measuring, monitoring and correcting the possible dysfunctions in managerial processes are critical to improve the performance of production and maintenance.

To analyze the managerial dysfunction in any organization the DMECA approach is very effective and it involves low cost as found in the research work. So, it is cost effective and can be applied to identify management personnel deficiencies which will be helpful for uninterrupted production and/or maintenance. It identifies access and ranks of dysfunctions that are challenges to achieve. Thus, the method prevents the consumption of time and cost of production and/or maintenance. An application of the DMECA technique implemented in important power plant industry (maintenance and production for electricity) to analyze, to evaluate and to improve job management process efficiency, suggest that it would also be interesting to apply the methodology in the field where the measure of process efficiency is more difficult than the production activities.

An application of the DMECA technique in an important power station to analyze, to evaluate and to improve job management process efficiency has already been made. Some typical suggestion that must be looked into by the management personnel to implement the DMECA method are given below:

- Top management commitment is indispensable.
- A motivational campaign from top management is a must.
- Develop a clear cut plan for the use of DMECA.
- Ensure all personnel who are to be involved with the DMECA are made aware of the potential benefits arising out of DMECA and the necessity for corrective action.
- Make it a part of regular job, not an optional one when you are free.
- Make DMECA meetings short but regular, throughout the early stages of the managerial dysfunctions.
- Documents plan and what have been done, review/update plans as per changed requirements.
- It is better to involves personnel from various departments including suppliers for DMECA. In fact it is a recommended part of TQM.
- DMECA is more cost effective at the earlier stage of management plan than at later stage when the plan is almost at the final one.

- It is never wise to prepare DMECA for execution in isolation by one individual.
- It is never wise to ignore participation of a less influential individual and allow important dysfunctions modes to be dismissed lightly with comment such as, "we have always done it like this", "don't talk like a fool etc", etc. let everybody to talk without shy and fear.

6.2 Recommendation for Further Study

The present study has been devoted to production and maintenance department of the power plant company. Other than this two, there are other departments too in the power plant to implement the DMECA methodology. It would be an interesting research topic to see the applicability of DMECA for other departments. Some of the recommendations for further study are as follows:

- The methodology can be used in the department of Administration, Purchasing and Finance etc. to see the improvement of the overall management process efficiency of the power plant.

- DMECA method can be used with other method such as Quality Function Deployment (QFD) to incorporate the customer voice. Quality function deployment is an extremely useful methodology to facilitate communication, planning and decision making within a production and maintenance team. Therefore, it would be interesting to integrate the DMECA methodology with Quality Function Deployment (QFD).

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Appendix A: Detailed activities, dysfunction causes, modes and effects

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	How many times does this dysfunctional cause happen? (a)	Gravity (b)	Detection (c)	RPN
1.1.1.1	Integrated stock check	1.1.1.1.1	Wrong evaluation of integrity	Work interruption	Money penalty				
		1.1.1.1.2	Wrong personnel involved						
		1.1.1.1.3	Absence of advanced technology						
1.1.1.2	Correspondence inventory and transport document	1.1.1.2.1	Less knowledge/involvement of the work force to the inventory control	Delay to completing work	Increasing man month				
		1.1.1.2.2	Less knowledge/involvement of the warehouse personnel to the practical task						
		1.1.1.2.3	Wrong/absence of software for document preservation and/or transportation						
1.1.1.3	Disassembly	1.1.1.3.1	Less tendency to documentation when disassembling	Wrong procedure to disassembly	It interrupts when assembling				
		1.1.1.3.2	Less secured preservation of the machines manual						
		1.1.1.3.3	Wrong personnel involvement						
1.1.1.4	Cleaning components	1.1.1.4.1	Absence of suitable machineries	Less cleaning	More time required when assembling				
		1.1.1.4.2	Wrong personnel						
		1.1.1.4.3	Application of wrong procedure						

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	How many times does this dysfunctional cause happen? (a)	Gravity (b)	Detection (c)	RPN
1.1.1.5	Visual and dimensional control	1.1.1.5.1	Less involvement of the skilled personnel	Failure for minor causes	Increases break down time				
		1.1.1.5.2	No standard inspection procedure						
		1.1.1.5.3	Less visual inspection tendency						
1.1.1.6	Chemical composition analysis	1.1.1.6.1	Absence of right personnel	Quick metallurgical damage	Increases conductivity and corrosion				
		1.1.1.6.2	No machineries present						
		1.1.1.6.3	Shortage of document about standard chemical composition						
1.1.1.7	Certification of collected data	1.1.1.7.1	Wrong data analyzing	Right data is not in right time	Difficult to identify the causes of failure				
		1.1.1.7.2	Less involvement of the skilled personnel						
		1.1.1.7.3	Redundancy and the information noise present						
1.1.2.1	Control of the customer	1.1.2.1.1	No improvement over previous solution	Miss understanding between departments	Takes more time				
		1.1.2.1.2	No preferences as its importance						
		1.1.2.1.3	Slow improvement of resources for customer satisfaction						
1.1.2.2	Requirements review	1.1.2.2.1	Requirement varied with time rapidly	Less idea generating capacity	Require exparts				
		1.1.2.2.2	Redundancy and/or shortage of required resources						
		1.1.2.2.3	Absence of previous data						

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	How many times does this dysfunctional cause happen? (a)	Gravity (b)	Detection (c)	RPN
1.1.2.3	Data review	1.1.2.3.1	Less physical practice for recording data	Proper data is not available	Work becomes relatively difficult				
		1.1.2.3.2	Wrong data acquisition procedure						
		1.1.2.3.3	Tendency to manipulate data by recorder						
1.1.2.4	Know-how availability check	1.1.2.4.1	Motivation by certain/some groups	No right man in the right place	Less efficiency in the work				
		1.1.2.4.2	Influences of trade unions						
		1.1.2.4.3	No/too small reward for availability of best knowledge						
1.1.2.5	Resource availability review	1.1.2.5.1	Wrong/no sufficient data	Difference between documentation and physical requirement of resources	More money involvement				
		1.1.2.5.2	Wrong/time consuming procedure to represent data						
		1.1.2.5.3	Difference between documentary and practical information						
1.1.2.6	Economical value review	1.1.2.6.1	Wrong personnel	Wrong decision to replacement	Economical loss				
		1.1.2.6.2	Wrong way to calculate						
		1.1.2.6.3	Less factor involvement						
1.1.2.7	Check of respective time	1.1.2.7.1	Less tendency to preserve data	More time to maintenance	Money penalty				
		1.1.2.7.2	Tendency to using of the thumb rule						
		1.1.2.7.3	No software present						

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	How many times does this dysfunctional cause happen? (a)	Gravity (b)	Detection (c)	RPN
1.1.3.1	Work cycle	1.1.3.1.1	Impractical due to the pressure of the government	Fault increasing	More breakdown time				
		1.1.3.1.2	Too short/too long to execute the specific work						
		1.1.3.1.3	Interferance of the third party						
1.1.3.2	Quality control	1.1.3.2.1	No body is responsible	More frequency	Money penalty				
		1.1.3.2.2	Shortage of high tech machinery						
		1.1.3.2.3	Shortage of know-how about hi tech						
1.1.3.3	Waiting for drawing	1.1.3.3.1	It consumes long time	Work supervision is critical	Require more time				
		1.1.3.3.2	No detail drawing of a project						
		1.1.3.3.3	Immature drawing and language problem						
1.1.3.4	Technical data	1.1.3.4.1	Insufficient data	Redundancy of the data	Data screening is difficult				
		1.1.3.4.2	Error in preparing data						
		1.1.3.4.3	Redundancy of the data						
1.1.3.5	Contractual conformities review	1.1.3.5.1	Less concentration about review	Difficult to supervise maintenance	Interest of the higher				
		1.1.3.5.2	Absence of skillness						
		1.1.3.5.3	Overlooking tendency						

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	How many times does this dysfunctional cause happen? (a)	Gravity (b)	Detection (c)	RPN
1.1.3.6	Waiting for contract modification	1.1.3.6.1	Wrong coordination	Takes more time	Overall financial condition becomes critical				
		1.1.3.6.2	Present rules about the time frame						
		1.1.3.6.3	Contractor/supplier get more flexibility						
1.1.3.7	Material	1.1.3.7.1	Wrong material selection	Less longevity	Frequent maintenance required				
		1.1.3.7.2	No metallurgical expert						
		1.1.3.7.3	No previous data about certain material						
1.1.3.8	Spare parts	1.1.3.8.1	Wrong spare parts selection	Redundancy of the spare	Money involvement				
		1.1.3.8.2	Redundancy of the spare parts						
		1.1.3.8.3	Specification of the spare parts						
1.1.3.9	purchasing	1.1.3.9.1	No individual purchasing rules	Works goes slowly	Takes more time				
		1.1.3.9.2	Uncertainty about time						
		1.1.3.9.3	Fairness about purchasing						
1.2.1.1	GANT diagram	1.2.1.1.1	Work sheet incomplete	Contractual delivery time not respected and activities overlaping	Work sheet revision				
		1.2.1.1.2	Incomprehensible work sheet						
		1.2.1.1.3	Wrong work sheet						
		1.2.1.1.4	Wrong/partial use of Project Software						

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	How many times does this dysfunctional cause happen? (a)	Gravity (b)	Detection (c)	RPN
1.2.1.2	Spare parts availability check	1.2.1.2.1	Missing/wrong evaluation of spare parts conformity	Delay with possibility of work interruptions	Efficiency loss and money penalties				
		1.2.1.2.2	Missing/wrong evaluation of spare parts shortage						
		1.2.1.2.3	Missing/wrong evaluation of spare parts quantity						
1.2.1.3	Works loads check	1.2.1.3.1	Missing/wrong finding of resources saturation	Delay with possibility of work interruptions	Efficiency loss and money penalties				
		1.2.1.3.2	Missing/wrong finding overlapping use of machineries						
		1.2.1.3.3	Missing/wrong scheduling with GANTT chart						
1.2.1.4	Job assignment	1.2.1.4.1	Missing/wrong suitable personnel allocation	Work interruption or slow down; possibility of non conformity	More costs for re-work or external work				
		1.2.1.4.2	Missing/wrong finding of suitable machineries						
		1.2.1.4.3	Missing/wrong suitable space allocation for work						
		1.2.1.4.4	Missing/wrong scheduling with GANTT chart						
1.2.2.1	Mechanical works	1.2.2.1.1	Impractical time sanction	Tendency to finish maintenance quickly	Proper work done is not possible				
		1.2.2.1.2	Wrong expectation of the higher authority						
		1.2.2.1.3	Wrong/no use of the maintenance software						

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	How many times does this dysfunctional cause happen? (a)	Gravity (b)	Detection (c)	RPN
1.2.2.2	Welding	1.2.2.2.1	Shortage of manpower	Frequent breaks of the joints	Time and money penalty				
		1.2.2.2.2	No checking of welders capability						
		1.2.2.2.3	Welders know-how too small about welding defects						
1.2.2.3	Thermal processing	1.2.2.3.1	Little know-how	Less tendency to follow the standard rule	Reduces life of the machine				
		1.2.2.3.2	Dependency on third party						
		1.2.2.3.3	Wrong use of thermal equipment						
1.2.2.4	NDT and check	1.2.2.4.1	Dependency on third party	Breaks through imperfection	Increasing maintenance cost				
		1.2.2.4.2	Little know-how						
		1.2.2.4.3	Limited/no use of the NDT						
1.2.2.5	Waiting for the job engineer master	1.2.2.5.1	Less involvement of the in-house engineer	Waiting for experts	Takes long time				
		1.2.2.5.2	More dependency on the foreign engineer						
		1.2.2.5.3	It takes long time						
1.2.2.6	Other waiting	1.2.2.6.1	Wrong coordination	Waiting for spare and machinery	Money penalty				
		1.2.2.6.2	Apathy for the time binding of the out sources						
		1.2.2.6.3	Weak procuring procedure						

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	How many times does this dysfunctional cause happen? (a)	Gravity (b)	Detection (c)	RPN
1.2.2.7	Material handle between job shops	1.2.2.7.1	Miss coordination	Wrong coordination	Takes more maintenance				
		1.2.2.7.2	Wrong management about time						
		1.2.2.7.3	Wrong communication with each other						
1.2.2.8	Spare parts requirement	1.2.2.8.1	Wrong use of bin card	Miss allocation of spare parts	Production loss				
		1.2.2.8.2	Wrong storage procedure						
		1.2.2.8.3	Salty weather reduces the parts quality						
1.2.2.9	Assembly	1.2.2.9.1	Wrong documentation when disassembling	Data missing	Requiring experts				
		1.2.2.9.2	Training of the associated personnel						
		1.2.2.9.3	Dependency of the workers know-how						
1.2.2.10	Balancing	1.2.2.10.1	Wrong tool allocation for work	Increase vibration and temperature	Increasing frequency of the same break downs				
		1.2.2.10.2	Wrong findings of suitable equipment						
		1.2.2.10.3	Wrong suitable person allocation						
1.2.2.11	Final checks	1.2.2.11.1	Only visual check that is insufficient	Less concentration to final checking	Frequent breakdown				
		1.2.2.11.2	Wrong/less factors are considered						
		1.2.2.11.3	Skill of the personal						

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	How many times does this dysfunctional cause happen? (a)	Gravity (b)	Detection (c)	RPN
1.2.2.12	Machine operation	1.2.2.12.1	Miss allocation of the operator	No right man for the right machine	Wrong operation				
		1.2.2.12.2	Wrong suitable machine allocation to the operator						
		1.2.2.12.3	Apathy to study previous document						
1.2.2.13	Generation	1.2.2.13.1	Frequency problem	No smooth generation	Machine fluctuating				
		1.2.2.13.2	Blackout start problem						
		1.2.2.13.3	Wrong coordination with the grid substation						
1.2.3.1	Activity progress audit	1.2.3.1.1	Depends on contractor	Miss communication between local and higher authority	Takes more time of a project				
		1.2.3.1.2	Irresponsible tendency of the contractor						
		1.2.3.1.3	Local authority does not give reports to the higher authority						
1.2.3.2	Audit of the checks	1.2.3.2.1	Fairness on contractor	Difficult to check	Require extension of the project time				
		1.2.3.2.2	High level of linkage of the contractor to the higher authority						
		1.2.3.2.3	Skill of the personnel						
1.2.3.3	Purchasing activities to be audited	1.2.3.3.1	Shortage of knowledge of the government rule	Fairness about audit	Less tendency to purchase				
		1.2.3.3.2	More complex rules of the government						
		1.2.3.3.3	No individual rules present for the technical work						

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	How many times does this dysfunctional cause happen? (a)	Gravity (b)	Detection (c)	RPN
1.2.3.4	Data check	1.2.3.4.1	Wrong data access procedure	All type of data are not available	Takes more resources				
		1.2.3.4.2	Wrong storage of data						
		1.2.3.4.3	Less dependency on data						
		1.2.3.4.4	No action taken by the study of the previous data						
1.2.3.5	Delay control	1.2.3.5.1	No power for controlling delay on the local authority	Unethical relation between authority and the contractor	Third party gets more time				
		1.2.3.5.2	Contractors are pioneer so delay in most of the cases						
		1.2.3.5.3	Apathy of the higher authority						
		1.2.3.5.4	Own interest of the higher authority or the contractor						
1.2.3.6	Corrective action proposal	1.2.3.6.1	Lack of know-how of the personnel	Shortage of knowledge	No correct proposal				
		1.2.3.6.2	Wrong proposal						
		1.2.3.6.3	incomplete proposal						
1.2.3.7	Update GANTT chart	1.2.3.7.1	Complex procedure	Less know-how about the time value of money	Money penalty				
		1.2.3.7.2	More effort involved for their own interest						
		1.2.3.7.3	Absence of all level awareness about GANTT chart						

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	How many times does this dysfunctional cause happen? (a)	Gravity (b)	Detection (c)	RPN
1.2.3.8	Delay information to customer	1.2.3.8.1	Wrong/miss information reaches to the customers	No pressure from end for completing the work	Takes more				
		1.2.3.8.2	Customer are not aware						
		1.2.3.8.3	Little knowledge of the customer						
1.2.4.1	Man machine control	1.2.4.1.1	Man vary with time	Particular man not involved for the particular machine	Wrong operation				
		1.2.4.1.2	Apathy to collect data						
		1.2.4.1.3	Wrong/Faulty work places						
1.2.4.2	Machine hour control	1.2.4.2.1	Manual system	Control problem due to human error	Critical to calculate the operating hour of a machine				
		1.2.4.2.2	Missing information						
		1.2.4.2.3	Wrong selection of hour per machine						
1.3.1.1	Documentation review	1.3.1.1.1	Wrong documentation	No right documentation	Data missing				
		1.3.1.1.2	language problem						
		1.3.1.1.3	Standard format is not present						
1.3.1.2	Dimensional review	1.3.1.2.1	Dependency on contractor or third party	Dependency on the manufacturer	Maintaining dimension locally is a				
		1.3.1.2.2	Shortage of skilled personnel						
		1.3.1.2.3	Wrong/no knowledge of thermal impact on dimension						

ID	Activity	ID	Dysfunctional cause	Dysfunctional mode	Dysfunctional effect	How many times does this dysfunctional cause happen? (a)	Gravity (b)	Detection (c)	RPN
1.3.1.3	Interface review	1.3.1.3.1	Skill of the personnel	Wrong review	Wrong interface				
		1.3.1.3.2	No right man in right places						
		1.3.1.3.3	Dependency on the experienced workers						
1.3.2.1	Customer satisfaction data	1.3.2.1.1	No survey about customer satisfaction	No data about customer complain	Less tendency to production development				
		1.3.2.1.2	Apathy to preserve customer complains						
1.3.2.2	Time respect	1.3.2.2.1	Wrong expectation of time by the third party	Third party does not obey the time bindings	Increases time value of money				
		1.3.2.2.2	Less involvement of the local authority						
		1.3.2.2.3	National requirement is not considered						
1.3.2.3	Cost respect	1.3.2.3.1	Less involvement of the local authority	Frequency of breakdown increases	Total break down time increases				
		1.3.2.3.2	Direct supervision of the higher/head office						
		1.3.2.3.3	Overlook tendency of the national profit						
1.3.2.4	Quality respect	1.3.2.4.1	No headache on the long durability	Wrong supervision procedure	Cost increases				
		1.3.2.4.2	Complex government purchasing rules						
		1.3.2.4.3	Wrong financial auditing procedure						
		1.3.2.4.4	Less emphasis on the national demand						

Appendix B: Corrective action planning and design scheme											
Critical activity				**Corrective action ***							
ID	**Activity**	**ID**	**Dysfunctional cause**	**Improvement actioin**	**Frequency**	**Time**	**Interuption**	**Responsible**	**Executor**	**Cost**	**Benefit**
1.1.1.1	Integrated stock check	1.1.1.1.1	Wrong evaluation of integrity								
		1.1.1.1.2	Wrong personnel involved								
		1.1.1.1.3	Absence of advanced technology								
1.1.1.3	Disassembly	1.1.1.3.2	Less secured preservation of the machines manual								
1.1.1.5	Visual and dimensional control	1.1.1.5.2	No standard inspection procedure								
1.1.1.6	Chemical composition analysis	1.1.1.6.1	Absence of right personnel								
1.1.1.7	Certification of collected data	1.1.1.7.3	Redundancy and the information noise present								
1.1.2.2	Requirements review	1.1.2.2.3	Absence of previous data								
1.1.2.3	Data review	1.1.2.3.1	Less physical practice for recording data								
1.1.2.4	Know-how availability check	1.1.2.4.2	Influences of trade unions								
1.1.2.7	Check of respective time	1.1.2.7.2	Tendency to using of the thumb rule								
1.1.3.1	Work cycle	1.1.3.1.1	Impractical due to the pressure of the government								

* Corrective Action will be recovered when action is taken by respective authority.

Critical activity				Corrective action *							
ID	Activity	ID	Dysfunctional cause	Improvement actioin	Frequency	Time	Interuption	Responsible	Executor	Cost	Benefit
1.1.3.3	Waiting for drawing	1.1.3.3.3	Immature drawing and language problem								
1.1.3.5	Contractual conformities review	1.1.3.5.3	Overlooking tendency								
1.1.3.7	Material	1.1.3.7.2	No metallurgical expert								
1.1.3.9	purchasing	1.1.3.9.3	Fairness about purchasing								
1.2.2.1	Mechanical works	1.2.2.1.1	Impractical time sanction								
1.2.2.2	Welding	1.2.2.2.2	No checking of welders capability								
1.2.2.4	NDT and check	1.2.2.4.3	Limited/no use of the NDT								
1.2.2.8	Spare parts requirement	1.2.2.8.2	Wrong storage procedure								
1.2.2.12	Machine operation	1.2.2.12.2	Wrong suitable machine allocation to the operator								
1.2.2.13	Generation	1.2.2.13.3	Wrong coordination with the grid substation								
1.2.3.3	Purchasing activities to be audited	1.2.3.3.2	More complex rules of the government								
1.2.4.1	Man machine control	1.2.4.1.2	Apathy to collect data								
1.2.4.1	Man machine control	1.2.4.1.3	Wrong/Faulty work places								
1.2.4.2	Machine hour control	1.2.4.2.1	Manual system								
1.3.2.1	Customer satisfaction data	1.3.2.1.2	Apathy to preserve customer complains								