Designing a New Model for Evaluating the Maintenance System

Abolfazl Sherafat[1], Sayyed Mohammad Reza Davoodi[2*]
[1]Department of Management, Imam Javad University College, Iran
[2]Department of Management, Dehaghan Branch, Islamic Azad University, Dehaghan, Iran
*Email of Corresponding Author: smrdavoodi@ut.ac.ir
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Abstract
The previous studies about the maintenance systems were dealt with defining the evaluation criteria, grouping them, and using different techniques for evaluating. The main problem is that maintenance subsystems and the relationship between and within them in order to a reliable evaluation have never been identified before.
The contribution of this study is realizing the four maintenance subsystems consisting service and maintenance, inspection, chronic failure, and severe failure and investigating the communication between them that has never been done in previous studies. On the other hand, in each subsystem the relationship between causal conditions, phenomenon, mediator condition, strategies and consequences that had been neglected in previous studies are discussed for the very first time. Causal conditions, that cause each of four subsystems, are identified. Then phenomenon and mediator conditions are presented and the strategy that should be made based on the characteristic of phenomenon and mediator condition is determined as well. Since making a strategy can lead to a consequence, the consequences according to different strategies are identified that has never been done in previous studies. At last, the relations between these parts are presented in narratives.

Keywords
Maintenance Evaluation System, Meta-Synthesis, Grounded Theory and Maintenance Assessment Criteria

1. Introduction

Over many years in most organizations and companies the managements' focus was mainly on the productive activities, and the Maintenance issues were neglected. In recent years corporate policies, business requirements and the close economic competition on one hand, and sophisticated and complicated technology and the high cost of purchasing equipment and new devises on the other hand, have made the managers to pay more attention to the maintenance issues. Using a specific maintenance system tailored to the organization can play an important role in reducing the final price of the end product. But these effects are not merely limited to the costs; it can also affect the speed of product offering in the entire supply chain, the product quality, reliability, organization's agility, etc.
Assessing the efficiency and effectiveness of the maintenance system for promoting the organization is very important based on its roles on the survival and success of the organization. For assessing and evaluating the performance of the maintenance system, different criteria are defined and in some studies these criteria are categorized.

An important issue which is not addressed in a clear and systematic approach is the comprehensive survey of the correlation of the objectives and processes of implementing the maintenance system for using the evaluation feedback in order to improve the organization and the maintenance system. And this is the issue which will be discussed in this study. Another significant point is that there is no consensuses in identifying the objectives of the maintenance system and its major activities and most studied have sufficed to measuring and evaluating the criteria. It is necessary that the objectives and the related activities to the maintenance system will be identified and their interaction with the evaluation criteria of the maintenance system's success and ultimately the organization's success will be determined.

The present study has a qualitative research approach in which the Meta –synthesis analysis and Grounded theory are used. In the first stage of the research the meta-synthesis method is used for collecting the qualitative studies related to the research, analyzing their findings, discovering the main points and combining them into an overall alternative in order to determine the features of an appropriate model for assessment of the maintenance system. The next stage deals with using the Grounded theory for designing the original model of the investigated subject. With using this theory, subsystems of the maintenance systems are determined and the relationships between the subsystems of the maintenance system are specified .The function of the maintenance system is examined in a way which will lead to organization's promotion. Finally the designed maintenance evaluation system is validated by the specialists and the academic experts in terms of simplicity, Flexibility, understandability, practicality and functionality, continuous improvement and effectiveness, integrity, focus and evaluation prioritization were validated and confirmed.

2. The Necessity of the Research

Perhaps it could be argued that any activity in the organization would not be successful unless the necessary evaluation is done about it .Probably the most important issue which necessitates this assessment is that the forecasts and the operational programs in the organizations always face a percentage of errors and evaluation and control is the only solution for eliminating the errors and reforming and modifying the operations. The changing environment of the organization is another proof for the necessity of the evaluation. The organizations must be aware of these constant environmental changes and the necessary coordination must be performed to adapt these changes.

Just like the other systems in the organizations, the maintenance system must serve the objective of the organization. Therefore any evaluation and assessment will not be successful unless the organization's goals and consequently the maintenance objectives which serve the organization's goals are specified; On the other hand, The targets must be accessible through the applied maintenance system activities. Identifying these activities which lead to the results of the maintenance system performance are necessary .

These activities and their performances manner will have a direct effect on the results of the maintenance system .Determining the relationship between these activities and the results; will make it possible to focus on the critical processes by evaluating the results and this notice will speed up the maintenance system's promotion.

3. Literature Review

Since the purpose of this research is designing a new model for evaluating the maintenance systems, the mechanisms and the models which are used for evaluating the maintenance systems are reviewed in this section.

Measurement of maintenance performance is crucial for analyzing the effectiveness of maintenance decisions, because maintenance performance cannot be managed, if it cannot be measured. From this reason some authors [1-3] proposed a conceptual model of multi-criteria maintenance performance measurement (MPM), based on maintenance performance indicators (MPIs), which are used for measurement of maintenance impact on the process performance.

In one study, time horizon is used for classifying the maintenance performance in 3 levels of strategic, tactical and operational [4]. Campbell has categorized the maintenance performance indicators in 3 groups of equipment performance, Cost performance and process performance [5]. Dwight developed an Evaluation mechanism based on the implicit assumptions of the maintenance and repair system impact on the business [6].

In Liu's study, the evaluation of the factories maintenance system is done based on the DEA -Data envelopment analysis-techniques [7]. Weber developed 26 functional criteria in 2 groups of lead and lag indicators [8]. In Parida's study, the hierarchical criteria are divided into indicators related to equipment process, cost, responsibilities, employee's satisfaction, customers, and safety [9].

Six categories have been considered for evaluation by Bakhtiar and the assessment is done based on The Balanced scorecard method [10]. In Chen study, AHP, GRA and TOPSIS techniques are used for evaluation [11].

Two groups of criteria consist of process criteria and results criteria are developed for evaluating the maintenance system [12, 13]. Pati designed a model. This model is developed in four categories including: efficiency, Organizations business, Timeliness and policy for evaluating the maintenance performance [14]. In Ruiping's model, some indicators are developed for evaluating the total effectiveness of equipment [15].

In another study done by Yanbin, the first grade evaluation indicators are divided in different groups of technical, operational, protective and reliable. This paper evaluates the electrical equipment maintenance [16]. Macchi provides a scoring method for maturity of maintenance systems [17]. Kutucuoglu's study provides a framework for maintenance management based on QFD [18].

Coetzee provides a list for performance indicators in four groups [19]. Pintelon developed a model. The main feature of this model is considering the various features of maintenance in terms of organization's groups and grades [20]. In Sharp's study, the Quality Management Philosophy is used to improve the maintenance performance system [21]. In a study, basic values, targets and weights are used to improve the maintenance system and organization's strategy [22]. Nakajima provides OEE index for comprehensive maintenance system [23].

Muchiri summarized the maintenance objectives under five headings: ensuring the plant functionality (availability, reliability, product quality, etc.) ensuring the plant achieves its design life; ensuring plant and environmental safety; ensuring cost effectiveness in maintenance and effective use of resources [24].

In a study about maintenance indicators, Key Performance Indicators (KPI) issue, [25] proposes three hierarchical levels of indicators based on the classical organizational levels: operational, tactical and strategic levels.

The North American Excellence Maintenance model (2007) through its annual program recognizes organizations that make a difference in the performance of the maintenance process to enable excellence.

According to the literature reviewed above, the previous studies about the maintenance systems were dealt with defining the evaluation criteria, grouping them, and using different techniques for evaluating. But the main issue of this study is the relationship between the assessment criteria and the processes and the objectives of using the maintenance system and using the evaluation feedback in order to improve the maintenance system, in a systematic and transparent way which has been neglected in the previous studies.

4. The Research Method

The present study is a qualitative research in which the meta-synthesis method and ground theory are used.

In the first stage of the research meta-synthesis method is used to collect data, analyze the findings, discover the main points and comb in them and convert them into a general alternative in both the studied models for organizations evaluation systems and the studied models for maintenance evaluation systems. Finally by using the meta-synthesis model the characteristics of a perfect model for maintenance evaluation system were identified.

The next stage is using the ground theory for designing the master model of the studied case .By using this theory the subsystems of the maintenance systems are determined and the relationships between the subsystems are specified and the function of the maintenance system is investigated in a way which leads to organization's promotion. Finally the evaluation system of the maintenance system was designed and validated.

The main source of research data collection in this paper was interviewing maintenance experts who were quite aware of maintenance systems and equipment. The first interviews were done due to recognition of main contents and categories. At the meantime, the researcher tries to find those who can give specific point of view at the time of data analyzing process about those categories that haven’t been developed or have been developed less, using theoretical adequacy method. After recognizing the main contents and forming the first edition categories, the second step of interview was started. The researcher succeeds to find the categories using two steps of primary interviews and analyzing the text of these interviews.

After the recognition of categories and being assured of their theoretical adequacy, it was time for the third step interviews. In this step, the researcher tried to provide a refinement for his theory by finding the relations between categories. To analyze the relations between categories a meeting was set up with maintenance experts and relations were studied in form of narrations and they were finally registered.

For doing interviews, main and secondary questions were designed. The main question was, “how can we make sure that the maintenance system works properly?” The research team with regard to the question above also came to the following questions:

- What are the expectations of the maintenance system? (Why maintenance system?)
- What are the features and specifications of the maintenance system?
- What are the maintenance system strategies?
- What activities are associated with the maintenance system?
- What are the consequences of the maintenance system' settlement?
- What factors and conditions affect the maintenance system?
- How can we ensure that the maintenance system has met expectations?
- What is the reaction of not meeting expectations?

The research team checked out every page, paragraph, sentence and word of the interviews after wards and then assigned a label to each part of interview's texts due to the retrieval of contents in the researcher's mind. These labels are known as "codes" in Grounded theory. These codes basically point to one unique subject.

The research team used the codes from the text or the word being used by the person interviewed or they assigned a code according to their understanding of the terms. If the sentences expressed by the interviewee were an acknowledgment of an issue that was already mentioned in an interview, the previous code was used.

5. Research and Model's Designing Procedures

According to previous studies based on meta-synthesis steps, we could eventually derive the main concepts and key themes that are used in maintenance evaluation models and organizations' evaluation models. With examining the meta-synthesis analysis in those studies we came to this conclusion that a reliable maintenance model should meet the following characteristics:

- Simplicity , Flexibility and being understandable
- Usability and being applicable
- Considering continuous improvement and effectiveness
- Integrity (Considering internal and external environment, stakeholders and competitors)
- Focusing and prioritization in assessment and improvement and generally paying attention to the proper resource allocation and priorities.

The Grounded theory goes beyond description and tries to collect and provide a theory or an abstract model of the process (action or interaction).Thus the developed theory helps to explain the intended process or it can provide a framework for future research [26].

In this method the development of the theory is not done in a (ready and prepared) manner, but the theory is derived from the context of the information obtained from the participants who have experienced the process [27, 28].

The grounded theory uses the extensive and detailed procedures for analysis. This procedure involves three steps: Open coding, axial and selective coding which is proposed by Strauss and Corbin [26].

The Grounded theory provides an approach for development of information items (Open coding), development of categories (Axial coding) and providing a narrative for linking the categories together (Selective coding) and it ends with a set of theorems and theoretical arguments [29, 30].

In this paper, for coming to a reliable methodology and to trust in the results of this study, we enquired of maintenance experts to cooperate for designing the maintenance evaluation model and

snowball sampling method was used .So that an interview was done with the first expert and other specialists were identified through him until the study reached the theoretical adequacy and the comments of the new experts could not add new concepts to the discussions. Since the analysis method was Grounded theory, the question which was asked from the experts was: How do you ensure that the maintenance system is acting efficiently and effectively .For each interviewed individual, all the stages of the Grounded theory analysis, including open coding axial and selective coding were conducted and after conducting interviews with the other experts, the results were gradually completed.

The further results of the interviews were summarized as bellow:

A. Open coding: In this section, four main categories including inspection, service and maintenance, chronic failure and severe failure and theirs interactions were identified. Then the characteristic and dimension of each category were determined.

B. Axial coding: in this section, by using the paradigm, sub-categories and their relationships were identified.

C. Selective coding: In this section, the anecdotes were identified and they were expressed in the form of communication narratives of the model.

6. Presentation of the Model

6.1 Designed Model

In this part, the designed model, the communications within and its performance are described. In this model as mentioned above, four issues were identified: inspection, maintenance, chronic failure and severe failure. General communication in the designed model for maintenance system indicates that if the maintenance performance is not appropriate it can cause problem for the system and it can lead to chronic failure. If proper decision and management is not taken to overcome the chronic failure, it can cause severe failure and this will cause many problems for production unit and this will result in lack of proficiency. On one hand the maintenance inspection affects the maintenance and service system and is also influenced by it and on the other hand it can be effective in chronic and severe failure. The overview of the designed model is as follow:

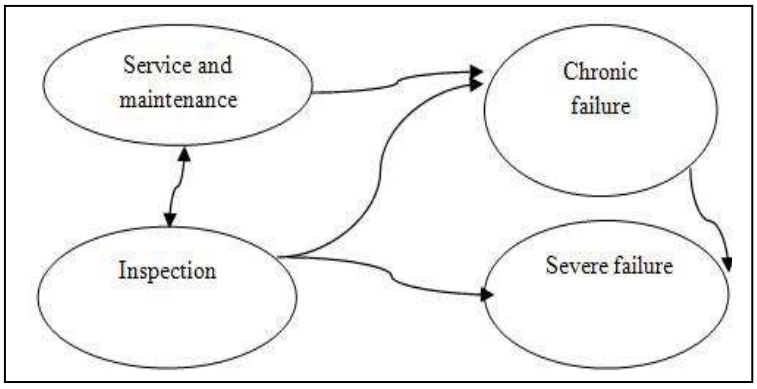

Figure1. Communication overview in the maintenance system

6.2 Communication within each of the Four Categories

In this part, paradigm and internal communication within each of the four categories; inspection, service and maintenance, chronic failure and acute failure and the related narratives are included.

A) Inspection:

In case of any difficulty in case of index : Issues related to safety (accidents), environmental issued, energy dissipation, fault diagnosis and troubleshooting time, preventive maintenance time, loss of raw material and spare parts or defects in the process of chronic or acute failure , we can inspect and predict the reasons in inspection process. In this case maybe the strategy which is selected by the organization (the strategies indicated in Figure 2), is not correct or the selected strategy is not correctly implemented.

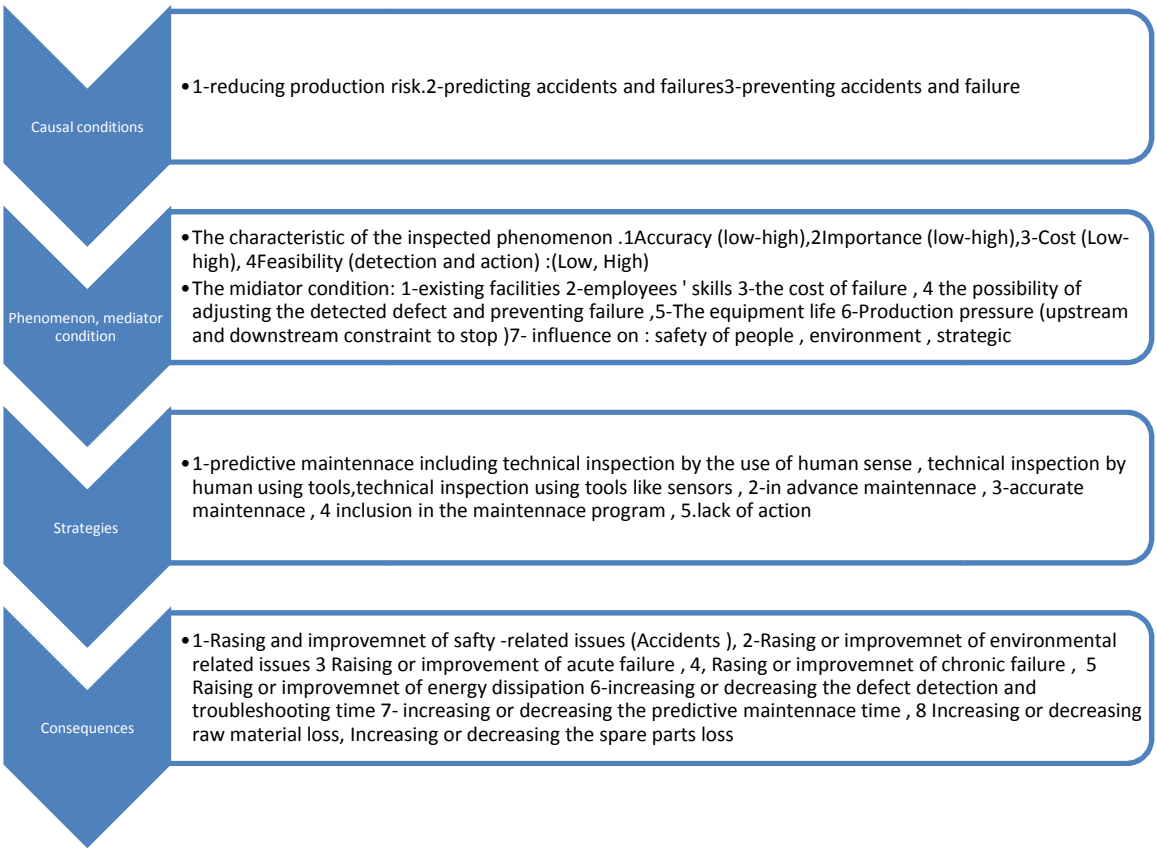

Figure2. Communications in the inspection category based on the analysis of the Grounded theory

According to the results of the Grounded theory analysis, the inspection process is followed for reducing the production risks, predicting accidents and preventing accidents and failures. The inspection phenomenon can be done with high or low accuracy, it can have high or low importance for organizations and the possibility of defect detection through inspection can be high or low (The characteristics of the inspected phenomenon).

The phenomenon features and existing of any of the causal conditions stated in Figure 2, can lead to adapting different strategies .The adaption of any of the strategies can be explained based on bellow narratives.

- Narrative

The predictive maintenance strategy: Including the sub strategies of technical inspection using human senses, Technical inspection using tools, and technical inspection using tools like sensors.

Once we use the predictive maintenance, vital signs such as moisture, pressure, electricity flow rate and friction are defined, then the upper limits, lower limits and critical levels are specified for each of the symptoms and by constant monitoring in case of any crisis in each of the signs, the maintenance work will be done. This approach is based in the equipment status assessment and the questions that whether the corruption will happen in future or not and then the necessary actions are carried out to prevent failure consequences.

The first strategy is used when the equipment is not complex, the failure risk is acceptable due to the lack of accuracy and there is also the possibility of using the specialized employees in the field for the organization and also then the cost of a more accurate and precise inspection is high and the organization accepts the failure risk which is caused due to the lack of inspection accuracy.

The second strategy is used when the equipment is a bit more complicated and the failure risk is acceptable due to lack of accuracy.

The third strategy is used when the equipment are complex and the failure risk due to lack of inspection is not acceptable.

✓ In advance maintenance strategy:

This strategy is used when the failure analysis is necessary due to the high sensitivity of the equipment and the strategic production of the device, and the organization has the necessary funds for such approach.

✓ The accurate maintenance strategy

✓ In accurate maintenance strategy in addition to the items mentioned for in advance maintenance strategy, the use of the parametric technical inspection devices is increased. Among these devices the thermography camera and oil analysis kit can be pointed out. This strategy is used when the sensitivity of the equipment is high and we cannot accept the failure risk. In addition when the continued production of the device is vital for the organization and the organization has the necessary for adapting such approach.

✓ The strategy of including the inspection in the maintenance program

✓ Due to lack of device's strategic product for the organizations and some prerequisites such as stopping the machine for doing inspections, this strategy is adapted.

✓ The inaction strategy:

✓ This strategy is adapted for the worthless equipment and devices and the equipment which their reparation is not cost effective.

B) Service and maintenance

In case incensement in chronic damage, energy dissipation and guarantee expiry, the reasons can be traced back in maintenance and service process. In this case either the selected strategy (Strategies outlined in Figure (3) by the organization is not correct or the selected strategy is not correctly implemented.

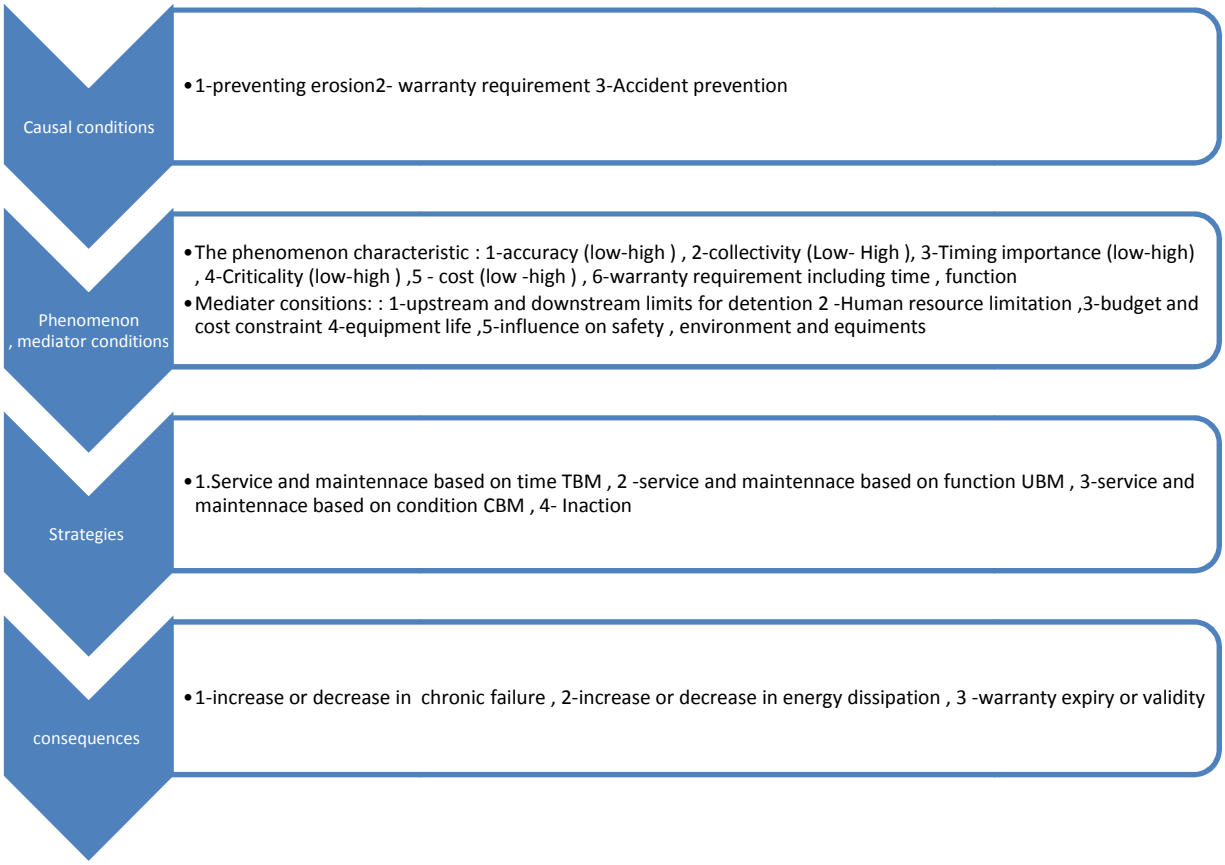

Figure3. The relationship between the service and maintenance issue based on the grounded theory analysis

Service and maintenance is done to prevent device erosion, compliance with warranty requirements, and preventing the accidents. In the following, the narratives will be explained based on the adapted strategy.

- Narrative

If the maintenance is done due to the warrantee requirement, the service time is specified and time consideration has a high significance, the time base maintenance strategy is adapted.

If the maintenance is done due to the warrantee requirement and the equipment utilization time is specified, and if service plays an important role in the performance and its efficiency, function based maintenance strategy must be adapted.

If due to lack of time importance or operation, the maintenance time can easily be detected, the operation condition-based maintenance strategy is used.

If the reason is high cost of service and maintenance or providing the equipment needed for diagnosing the maintenance time or more economical use of the service through time and function, it is better that the maintenance adapt operation condition-based strategy .

C) Chronic failure

In case of difficulty in lesion index of non-productive movement and minor and short-term stoppages (including energy losses) and the lesion of production deceleration, and rework and quality lesion(including raw material losses) or in case of acute failure (including correct or

incorrect consumption of spare parts), the reason can be traced in chronic damage. In this case, either the strategy adapted by the organization (strategies stated in Figure (4)) is not correct, or the strategy is not implemented correctly.

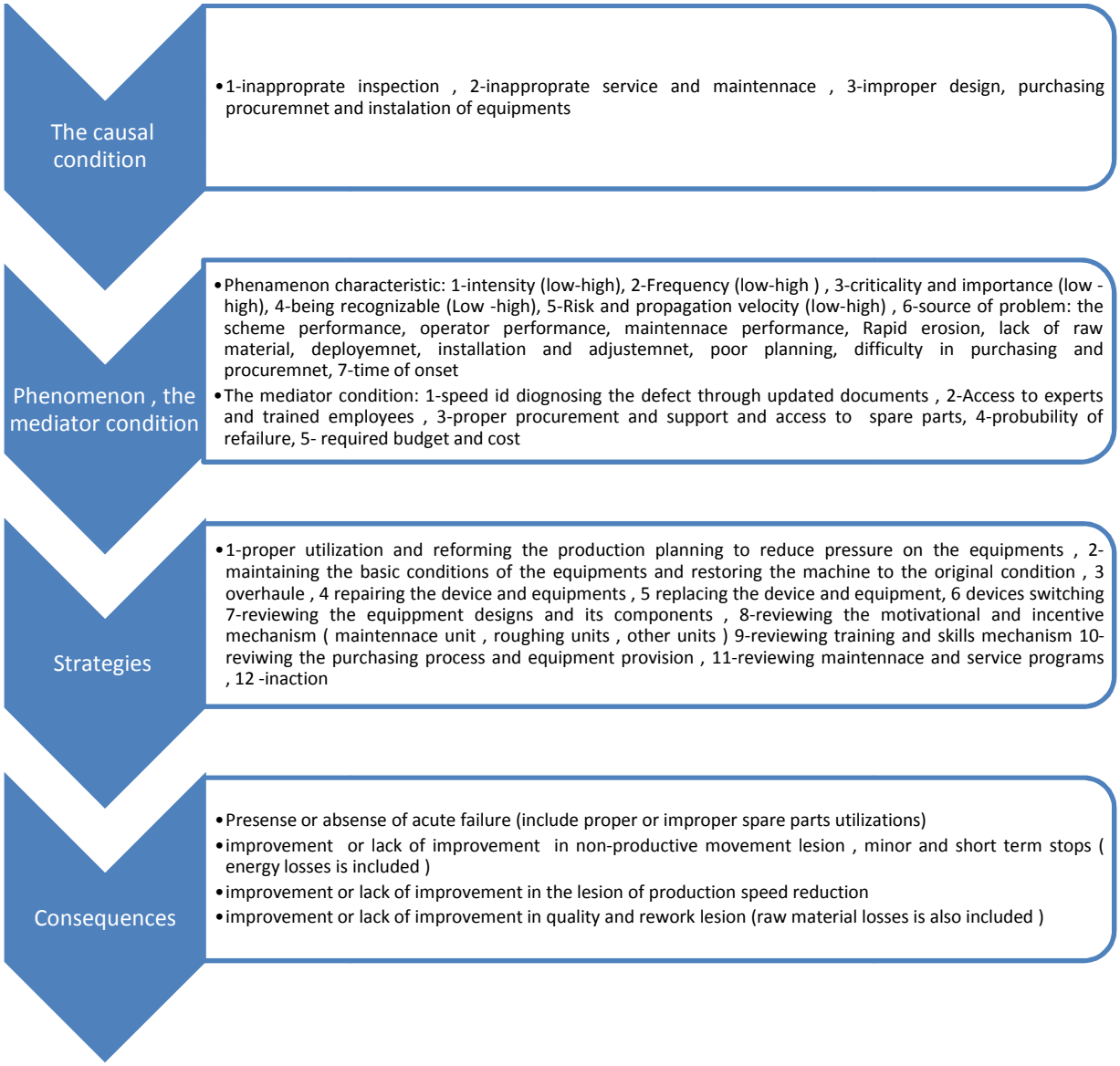

Figure4. The communication within the chronic failure based on the Grounded theory analysis

Chronic failure is occurred based on the improper inspection, improper service and maintenance, inappropriate design, purchasing, procurement and installation of the equipment. In this part the available strategies on chronic failure condition based on the phenomenon and mediator conditions are narrated in the forms of stories.

- Narrative

✓ First mode:

A manufacturing unit during its operation period may face problem through the improper performance of production and operation unit and in this condition, based on the phenomenon and mediator condition, something must be done to solve and fix the problem.

In this situation, regarding the phenomenon characteristic, if the frequency is medium to high, if the criticality and importance are from medium to high, and the risk and speed of influence propagation on the production line are high, and the required budget in terms of mediator is estimated as low to moderate, proper exploitation and production planning modification will be decided to reduce the pressure and the equipment.

✓ Second mode:

Inaction in chronic failure mode is occurred while in the exploitation and scrapping period the problem source is unclear, the problem's severity is from low to medium, the frequency is from low to medium and importance, criticality and risk and speed of influence propagation on the production line is low. The mediator condition in this situation includes the high speed of defect detection via updated documents, lack of access to skilled and trained employees, low support condition and low access to spare parts. It should be noted that the probability of further failure in this decision is from low to high and high amount of budget and cost is estimated.

✓ Third mode,

In this mode, during the set up and operation and due to the improper performance of the production and utilization unit, the manufacturing unit tries to maintain the basic conditions of the equipment and also tries to restore the machines to the initial conditions. This happens while the problem severity is from low to average, the frequency is from low to average, and the criticality and the importance is estimated as average to high. In terms of mediator in this mode, the required budget and cost is estimated to be low to medium.

✓ Fourth mode,

The overhaul is one of the decisions made during the exploitation and scrapping period with the problem source in case of erosion.

The Overhaul is done while the problem severity is high, frequency is high, the problem importance and severity is high and risk and speed of propagation is concluded to be average to high . In this circumstance in terms of mediator condition, via updated documents, the defect diagnosis speed is low to average, access to the trained and skilled employees is high, the probability of failure is high and high amount of budget and cost is required.

✓ Fifth mode:

If the performance of the operational and maintenance unit is improper , the manufacturing unit will face problem and based on the phenomenon features like: the problem severity (low to high), the problem frequency (low to high), the importance and criticality of the problem (average to high) , low risk and speed of influence propagation and the mediator feature: high speed of defect diagnosis, high access to trained and skilled employees , high support condition and high access to spare parts , the decision will be made for changing the device or equipment. In this circumstance the probability of further failure is average and the required budget and cost are estimated to be low to average.

✓ Sixth mode:

If the phenomenon features include the problem severity (average to high), problem frequency (average to high), high importance and average risk and speed of influence propagation on the production line, and in terms of the mediator if we face high speed of defect diagnosis, average or low access to trained and skilled employee and high support and access, the unit will decide for replacing the device or equipment. The probability of further failure in this mode is average to high and the required budget or cost is estimated to be average. This decision is made if the problem occurs during the operation period and due to the improper function of the operation unit and maintenance.

✓ Seventh mode:

Sometimes the manufacturing unit decides to replace the device and the device replacement depends on the source of performance problem (if it is in the operation and maintenance unit), the period in which the problem is occurred (the operation or scrapping period) and when the problem severity is high, the problem frequency is high, and the problem importance and criticality and risk and speed of influence propagation on the production line are concluded to be high.

Surveying the mediator condition we face a state in which via updated documents the defect diagnosis time is low to average, access to trained and skilled employees is low to average, and support and access to spare parts are low to average. The probability of further failure is high and high amount of budget and cost is estimated.

✓ Eight modes:

In this mode, we may face problem in purchasing and launching procurement, problem severity is average to high, frequency is average to high, importance and criticality of the problem is high, and the risk and speed of influence propagation on the production line are high. In this mode, in terms of the mediator condition including low speed of flaw diagnosis time, low access to trained and skilled employee, average to high support condition, procurement and access to spare parts, decision will be made for reviewing the equipment designing and their components .The probability of further failure in this decision is average to high and the required cost and the budget is estimated to be average to high.

✓ Ninth mode:

In case of using the reviewing strategy of the motivational mechanism, Frequency is high, importance and criticality are average to high. This strategy is used for solving the problem, while during the operation period, the maintenance and operational employee do not have a proper performance, and in terms of mediator condition the required budget and cost are estimated to be average to high.

✓ Tenth mode:

While in terms of mediator condition the required budget and cost areaverage, and in terms of the problem feature, the manufacturing unit face high frequency and average to high importance and criticality, we will begin to review the learning and skill mechanism. This case the problem is due to the improper performance of the employee in maintenance and operation unit during the operation period.

✓ Eleventh mode:

If during the operation period, the production unit does not act properly in purchasing and logistics and the problem frequency is high, the problem criticality is average to high, and in terms of the mediator the required is low to average, the solution is revising the purchasing and logistics process (raw material, Spare parts)

✓ Twelfth mode:

In the twelfth mode all the conditions are the same as the eleventh mode and the difference is in the frequency (average to high) and the period, in which the problem occurs during the startup and operation. Considering these two differences, the selected strategy is reviewing the purchasing and equipment procurement process.

✓ Thirteenth mode,

In the thirteenth and the last conceivable state, we face high severity of the problem and average to high importance of the problem and in terms of mediator, the estimated cost and budget is low to average. The state is occurred during the operation period and due to the inappropriate performance of the maintenance unit and the selected strategy in this state is reviewing the maintenance and service program.

D) Severe failure

In case of any difficulty in terms of the accessibility and emergency breakdowns, the reasons must be traced back in acute damage. In this case either the strategy is not correctly selected by the organization or the selected strategy is not appropriately implemented.

Figure5. Communication within the severe failure, based on the analysis of the grounded theory

Acute failure is occurred due to the chronic failure continuity, improper inspection, damage continuity, inappropriate designing, purchasing, procurement and installation of the equipment. The available strategies in acute failure circumstance are narrated in the forms of bellow states based on the phenomenon and the mediator features.

- Narratives

✓ First mode,

In a production unit , if in the operation period , the performance of the maintenance and operation unit is not appropriate , based on the phenomenon features including severity , importance and criticality and propagation risk , and also based on the mediator feature including : the speed of defect diagnosis via updated documents , access to experts and trained employees , proper support and procurement , access to spare parts, probability of the further failures and the required budget , the unit may decide for repairing the device or equipment .

This happens while the problem severity is low to average , The importance and criticality are average to high , and the speed and the risk of the propagation are average to high and in terms of mediator via updated documents the speed of defect diagnosis is high , we have high access to experts and trained employees and the unit access to high and appropriate level of support and procurement to the spare parts for repairing the device or equipment and also the probability of further failure is average and also the required budget is estimated to be low to average .

✓ Second mode,

In the other state, it is probable that the production unit during its operation period faces problems due to the improper performance of the maintenance and operation unit, and replaces the device or equipment.

This decision is made in the condition that the severity of the problem is average to high , the importance and criticality the problem and the risk and the influence of influence propagation are high and in terms of the mediator condition via updated documents , the speed of the defect diagnosis is high , access to experts and trained employees is high , and the manufacturing unit has high level of accessibility to support , procurements and spare parts and also while the probability of further failure is average to high , and the required budget and cost is estimated to be average .

✓ Third mode,

The device replacement in a manufacturing unit is done while in the operation and scrapping unit and due to the improper performance of the maintenance and operation unit , the problem severity is high , importance and criticality and also the speed and the risk of the influence propagation are high and in terms of the mediator condition in the manufacturing unit , there are updated documents , the low to medium speed of defect diagnosis' time , low to medium access to experts and trained employees , appropriate support and procurement and , low or average access to spare parts and also it occurs while the further failure is high and the required budget and cost for replacing are estimated to be high .

✓ Forth mode,

The manufacturing unit might do overhaul in order to achieve a more desirable result.The decision is made while the severity of the problem is high, the importance, criticality and the risk and speed of influence propagation is high and in terms of the mediator condition, via the updated document, we face low to average speed of defect diagnosis. Access to trained and expert employee is high, the probability of further failure is high and the required budget is estimated to be high. It should be noted that in the overhaul condition the problem source is erosion and it occurs during operation and scrapping period.

✓ Fifth mode,

The other decision the manufacturing unit might make in special circumstance is reviewing the equipment designing and their components. This decision is made while during the startup and operation, purchasing and designing procurement have caused problem. The reviewing condition for the equipment designing happens while the problem severity is average to high, importance and criticality and the risk and speed of propagation is high.

Low speed of defect diagnosis, low access to experts and trained employee, average to high support and procurement are the mediator features in this decision. The probability of further failure is average and average amount of budget is required.

✓ Sixth mode,

If the severity of the problem is low, importance and criticality and risk and speed of propagation are concluded to be low, the manufacturing unit is in its operation and scrapping period and the problem source are unknown, in this condition, no attempt will be done for fixing the damage.

This decision is made while in terms of mediator we face high speed of defect diagnosis, low access to experts and trained employees and low support and procurement in the unit, the probability of further failure is low and the estimated required budget and cost is high.

6.3 Model's Performance Manner (How the Model Operates)

Based on the model's performance mechanism, first the indicators with critical values must be identified and then theses index are categorized in the four sub-categories maintenance and service identified based on the grounded theory.

In case of index criticality and lack of consistency with norms and expectations, it is required that the examination will be done in the corresponding sub-process to check whether the appropriate strategy is applied for improving the index or not. If appropriate strategy is not selected, the appropriate one must be applied. Otherwise the strategy implementation is not suitable and it should be investigated to see whether the requirements of the proper implementation of the strategy have been met or not next the necessary action must be done for the appropriate implementation of the strategy.

6.4 The Model Validation

However based on the logic and the procedure of the grounded theory after interview with each expert and adjusting the result with previous interview, the findings are validated. Yet for evaluating the designed maintenance system, a sample of 30 comprised of the experts from university and industry (12 university experts and18 industry experts) is selected .The designed model is elaborated for them and a questionnaire was designed based on the perspectives derived from the general meta-synthesis. These perspectives include: simplicity, flexibility, understandability, functionality and practicality, continuous improvement and efficiency, integrity, focus and prioritization in evaluation. Then the questionnaires were distributed among the sample group. The result derived from the questionnaire analysis for the validity percentage of each criteria is listed in bellow Table 6.

Table6. The model validation result

Focus and prioritization in evaluation	Integrity	Continuous improvement and efficiency	Practicality and functionality	Simplicity , flexibility and understandability	Model validation index
73	77	76	80	81	Validation percentage

7. Summary and Conclusion

The purpose of the present study is designing a model for evaluating the maintenance and repair system. Since the previous models and mechanism don't have the fealties of an efficient and effective models, therefore the grounded theory was used for gathering the qualitative studies related to the research, analyzing their findings, discovering the main points, combining and transforming it in to an overall alternative for determining the features of a suitable model for evaluating the maintenance and repair system and the Grounded theory was used for designing the related model.

Finally a model was designed with main categories including: inspection, service and maintenance; chronic failure, acute failure and their interconnections. Then for each category, the features and the dimensions were stated and by the use of paradigm model in axial coding, the sub-categories and their interconnections were identified. In the last phase of model designing, the items which can affect or prevent achieving the effectiveness and efficiency indicators of the maintenance system were identified.

In this way , in case of facing critical index and lack of complicity with norms and expectation,at first it is required to investigate the related sub-categories to check whether the correct strategy is applied for improving the index or not and if the suitable strategy is not applied , otherwise the problem is in implementing the strategy and we should investigate whether the requirements of proper implementation of the strategies are met or not , in the second step , the required action for correct implementation of the strategies must be carried out.

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