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Selection of Best Maintenance Strategy A Case Study

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Abstract: The objective of this paper is to analyze and select the maintenance strategies of a chemical plant-FACT using Analytic Network Process. ANP model structures the decision problem in a hierarchical form and links the determinants, dimensions, and enablers with alternatives available to the decision maker. ANP is a powerful multi-criteria decision-making tool to consider interdependencies among and between levels of decision attributes. The comparative evaluation between alternatives was done based on the feedback of ten relevant executives. Geometric mode of their response was considered as the combined evaluation score. Thus, the ANP-based approach for enhancing the maintenance strategy selection proposed in this paper provides a more realistic and accurate representation of the problem. Further, a quantified value named as overall weighted score, which would give an indication of the maintenance of an organization and provide directions to managers where the improvement efforts has been derived. The paper concludes with managerial implication and scope for future work.

Index Terms **- AHP, ANP, super matrices, overall weighted score**

I. INTRODUCTION

Maintenance is about preserving the functions of assets. Almost every industry has some sort of maintenance programme for its physical assets. The main purpose of maintenance in an industrial perspective is to reduce business risks. In general, operation and maintenance is synonymous with high level of availability, reliability and assets operability linking directly with production capacity, productivity and business profit. For few machines it may be easy to keep track what need to be done and when, but when scope includes thousands of equipment it becomes significantly complex and expensive. With the advancement of technology and rapid growth of industries, the maintenance of production equipment is getting more and more important. In the earlier stages of the industrial growth, the maintenance of the equipment used to be a matter of attention only when the equipment suffered some set back or break down as a result of some minor/major fault which could not meet attention at the appropriate time. Such break downs did not only brings a serious production hold up but also used to upset smooth production in the industry by forcing other machine to idle. Poor maintenance lowers the capacity utilization when neglected, leads to frequent break downs, leading to costly repairs and faster deterioration of valuable equipment.

Maintenance can be defined as those activities required keeping a facility in as built condition so that it continues to have its original productive capacity. The main objective of a properly run maintenance department is to have plant, equipment and machinery available for productive utilization, during the scheduled life, operating under agreed standards with minimum waste and minimum total cost. Also, continuous development is needed in maintenance areas for developing new tools and techniques to cope up with the increased complexity, sophistication and automation of equipments and systems. As such over period of time many maintenance strategies have been developed, mainly basing on time for doing maintenance, frequency of maintenance, complexity and sophistication of equipments and value of total assets. Maintenance strategies are methodologies and software programmes which balance software costs against the impact of plant failure .by optimizing equipment maintenance strategies against both target availability and the penalty of failure; you can optimize your asset life-cycle costs.

Selection of best maintenance strategy is a type of MCDM problem, which can highly influence on the manufacturing expenditures. Because, maintenance plays vital role in keeping availability and reliability levels, product quality, and safety requirements and selection of best maintenance policy is important as the maintenance management is complex and the output of maintenance is hard to measure and quantify .Many conventional MCDM techniques are based on the additive idea along with the independence assumption, but each individual criterion is not often independent (Milad Aghaee and Safar Fazli, 2011). In the current competitive environment, managers have been making attempts to convert organizations under their supervision into competitive and responsive through creating capability of timely delivery of quality products and services. In line with this, maintenance as a system plays an important role in achieving these goals. The maintenance strategy selection is a kind of multiple criteria decision-making (MCDM) problem, which requires considering a large number of complex factors as multiple evaluation criteria. To solve the interactions among elements, the analytic network process (ANP) as a relatively new MCDM method was introduced. The ANP is a mathematical theory, which deals with all kinds of dependence systematically. The ANP has been successfully implemented in many areas .On the other hand, there are some researches by different techniques about selection of maintenance strategy but there is no research in the field of maintenance strategy selection with this technique and especially in chemical industry

II. COMPARISON OF MAINTENANCE METHODS IN FACT

Mainly there are three ways in which machines can be maintained.

1. Break down maintenance

(Maintenance when machine fails)

2. Scheduled maintenance

(Periodic disassembly and inspection)

3. Predictive maintenance

(On the advance warning of future maintenance)

With break down maintenance a machine is allowed to run until complete failure, inefficiency or product spoilage forces a shut down. Although mainly machines are maintained in this way, break down maintenance has several disadvantages. First, failures can be most uniformly and there is little one can do before hand to anticipate tool, manpower extensive repair than would have been required if the problem had been detected and corrected early. Some failure can be catastrophic, requiring total replacement of the machine. This involves a safety hazard to operators and other personnel. In addition cost of lost production while the unit is down can be staggering.

Compared to break down maintenance, a program of periodic disassembly and inspection has the distinct advantages of lessening the frequency of break down repairs and permitting scheduled shut down. Under this program each critical machine is shut down after a specified period of operation and partially or completely dismantled for a thorough inspection and replacement of worn parts if any. This approach to machinery maintenance too has disadvantages. First to periodically dismantle every critical piece of equipment in the plant is expensive and time consuming. Second, the interval which is operating satisfactorily may actually be degraded by frequent disassembly. Chances of human error while assembling is also high.

On line detection and diagnosis of machinery problem is obviously the most desirable way to machinery. If a problem can be detected early, when defects are minor and do not affect machine operation, and if we diagnose the problem as the machine runs the following advantages can be derived.

- Shut down for repairs can be schedule for a convenient time.
- A work schedule, together with the requirements for manpower, tools and replacement parts can be prepared before the scheduled shutdown.
- Extensive damage to the machine resulting from forced failure can be minimized.
- Repair can be kept to a minimum, resulting in less machinery downtime.

Of course machines in good operating condition can be continued to run as long as no problems develop. Time and money are not wasted dismantling machines which are already operating smoothly.

III. METHODOLOGY

ANP is an improved method of AHP applied in MCDM. The ANP extended the traditional AHP scope by accounting with dependency among criteria and alternatives, and then occasionally it is called as a generalization of AHP. Since, the AHP assume that each concerning element in hierarchy model is specified to be independent. However, generally, decision problems are unable to be structured in hierarchy model totally, and, moreover, problems may involve with the dependence between upper-level elements and lower-level elements in a hierarchical model, since the AHP is not suitably applied with these interrelation problems. Therefore, Saaty proposed the ANP to solve the mentioned problem. The ANP can be conducted in four main steps as follows

1) Model the problem as a dependency network

The problem will be constructed to a network model consisting of elements and clusters. Each element in a cluster can depend on some or whole of the elements of any cluster, and this relationship is called outer dependence represented by arc connecting to other nodes in any other cluster. In the other hand, an interrelationship among elements within cluster is named inner dependence represented by a looped arc.

2) Calculating priorities among elements and establishing original or unweighted super matrix

The second step concerns with prioritizing elements among inner elements and also outer elements. These priorities are obtained by making pair wise comparisons. In order to make a comparison, a generic question that must be encountered with is: How much more does one element influence on another element than the others? The process to perform pair wise comparisons and to obtain priority vectors of ANP is similar to the AHP.

3) Calculating priorities among clusters and establishing weighted super matrix

The super matrix is constructed according to the dependency network model and after that this matrix is processed to the weighted super matrix. The weighted super matrix can be obtained by determining a cluster comparison to acquire a priority vector. These comparisons indicate a relative importance of influences between each cluster. Subsequently, the perceived priority vector is multiplied to relating segments of the unweighted super matrix. The obtaining vector will be applied to weight the relative matrix segments. For example, the first entry of priority vector is used to multiply with all concerning elements in the first matrix segment. Following this process for all columns, finally, weighted super matrix can be obtained.

4) Calculating limit super matrix and obtaining final priorities

After the weighted super matrix is acquired, then multiplying the matrix by itself until every column in the matrix is totally similar. This process derives the limit super matrix which the final priorities can be obtained from the corresponding columns. Then, read off the highest priority alternative or the desired mix of alternatives.

As presented, the ANP accounts the dependencies between considered elements by replacing the hierarchical model with the network model, so in recent years, many ANP studies have been highly applied in various fields. For instance, in research and development process in environmental impact assessment process and in logistic and supply chain management process

3.1 Data Collection

In order to achieve the objective, main source of data collection was questionnaire and expert interview. While the database was being selected, a questionnaire was designed meeting the objectives that had been set. Based on the review of literature four critical factors and thirteen critical sub factors were identified, but it can't measure directly. So to select the best maintenance strategy of FACT, indirectly a questionnaire was developed consisting of questions covering different factors. For evaluation and comparison of goals, criteria and sub-criteria with scores, by experts, questionnaires were used with linguistic variable and finally transformed them.

The number of experts (top level managers and chief engineers) in the company that participate in this project was ten. Therefore, for the aggregation of expert's opinion the geometrical mode value was used to combine it.

Pair-wise comparisons are done to consider the interdependencies among the enablers. It represents the result of SF–RSK cluster with PS as the control attribute over other enablers. The maximum impact on SF–RSK cluster with PS as the control enabler over others. It is also observed that the impact of EA on PS in SF–RSK cluster is minimum (0.14). Therefore, EA is not a problem for the company and it will have less impact this cluster. For each determinant, there will be 13 such matrices at this level of relationship. The eigenvectors from these matrices are used in the formation of super matrices. As there are four determinants, 52 such matrices will be formed.

3.2 Managerial Implications

The model and the research methods used in this study have several important implications for managers. First, this method can be very useful to the company to identify those characteristics often mentioned in the maintenance literature that may provide an opportunity to increase the level of maintenance in a specific environment. The model developed in this research illustrates one approach to review occasionally if the ongoing maintenance programmes/strategies are really what they think of and is it giving the result what they want for such review, they have to dig into effectiveness of maintenance programmes/strategies.. The approach described in this research begins by identifying and analyzing the significant tangible and intangible parameters. Second, managers can use these significant parameters to obtain a better understanding of the existing maintenance strategy selection shortcomings, if any and to assign responsibilities within the company for achieving company-wide improvements in maintenance. Finally, the methodology reported in this study can again be used by managers to reevaluate the company's position and to suggest further improvements if required. Managers will obtain a clear idea regarding real time maintenance strategies in similar industries

IV. RESULTS AND DISCUSSION

As maintenance management is taking on an important strategic role, company is expecting their maintenance to be performed effectively in order to leverage and transform the maintenance into competitive advantages. More importantly, the successful maintenance management starts with a proper maintenance system strategy produced through a robust evaluation method. However, the maintenance strategy selection is a kind of MCDM problem, which requires considering a large number of complex factors as multiple evaluation criteria. Although numerous creditable works are devoted to the study of how to build a maintenance strategy and to execute it successfully, few of those have provided methods, which can systematically evaluate and model complex factors of the maintenance strategy. The implementation of a new strategy may be a risky endeavor for the top management as it involves financial and operational aspects, which can determine the performance of the company in the long run.

To deal with the MCDM problem of this maintenance strategy selection, it is better to employ MCDM methods for reaching an effective solution. The ANP model presented in this paper can aid the top management in the evaluation of the various alternatives available with them as it measures the relative strengths of impacts between elements in the hierarchical model. The ANP is a relatively new MCDM method, which can deal with all kinds of interactions systematically, unlike traditional MCDM methods, which are based on the independence assumption. Hence, this paper proposed a solution based on ANP approach to help companies evaluate and select maintenance strategies. The model presented in this paper gives a holistic view of maintenance strategy selection involving four main dimensions of safety, cost, strategic and technical requirements .This decision model integrates and relies upon the various characteristics of determinants, dimensions, enablers and their relationships. The utility of the ANP methodology in integrating both quantitative as well as the qualitative characteristics need the attention of the decision maker in arriving at the best possible solution.

The results of this study show that the most desired purpose was ''selection of best maintenance strategy'', and ''Break down Maintenance'' was preferred. In the Indian industrial scenario, difference of purposes, conditions of resources and capabilities it is better to adopt BM in the plant. The proposed solution can handle the effects of dependences; it is relatively useful and makes the evaluation result to be more reasonable. It is an attempt in this regard to aid the decision makers in the complex task of prioritizing their options. Additionally this study has contributed to extend practical applications of ANP in maintenance management field. Furthermore, using the suggested analytical procedure, it can effectively handle any problem of selection with multi-faceted factors. However, there are some limitations, such as the assessment scales of the ANP are not unified. Therefore, in order to promote and deepen continuing research in future, it is worthwhile to investigate more cases and exemplary companies in order to uncover invaluable new study issues.

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