ORIGINAL RESEARCH PAPER
Volume - 13 | Issue - 03 | March - 2024 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

A STUDY OF THE SOURCES AND MITIGATION STRATEGIES OF FINANCIAL RISKS IN LARGE-SCALE MAINTENANCE PROJECTS

Management

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ABSTRACT

Turnaround/Shutdown maintenance is one of the major maintenance activities for Oil & Gas and petrochemical plants. To implement the maintenance activities such as asset integrity checks, long pending repairs, and major overhauls the plant should be shutdown. These activities shall be carried out on a periodic basis to optimize a plant's performance, to meet statutory requirements such as government and Insurance norms. Normally complete plant shutdown during turnaround maintenance is taking place for 50 days and organizations normally hire external contractors to execute these massive activities in abbreviated period. Companies have economic loss during Turnaround time because of production loss, business opportunity loss, higher maintenance cost and Health, safety, and environmental issues. Projects are financed from company profits in the year in which they are executed. This study shares industrial best practices to reduce financial risk by reducing loss of profit which is occurring because of turnaround maintenance projects. This explore deliberates principal project cost constraints and industry best practices to address those risks.

KEYWORDS

Project Management; Turnaround Management; Shutdown Management; Risk Management. Turnaround Budget.

INTRODUCTION

Oil & Gas and petrochemical plants are capital intensive projects that involve projects investments among the process industries in the world. Indeed oil & gas industries are one of the backbones of the country's economy. Production capabilities of these plants are primary elements in competitive global market.

Oil, gas, and other petroleum products produce plants that process Carbon, Hydrogen with help of catalyst chemicals. They are highly corrosive and erosive in nature. These things damage the equipment over the period. Along with that plant operating conditions, involve extreme pressure and temperature which will speed up equipment deterioration over time. Normally processed plants are designed with parallel arrangement of equipment to provide higher availability of the plants. These arrangements provide an opportunity to maintain the equipment while plants are in operation. Expensive critical equipment is not designed with redundancy. Therefore, separation of the above said elements is not possible while plants are in normal operations. Hence, the plant needs to be stopped for restoration of deteriorated equipment to avoid increasing risks of complete failure.

Turnaround is one of the important business strategies, because of its high-cost nature. It impacts business profits and extends production capabilities. Organization funds turnaround maintenance cost from capital expenditure budget with the objectives of optimization. Companies spread total turnaround cost over 4 to 6 years to reduce the impact of it on profit of Turnaround year. Turnaround maintenance activities are performed at intervals of 4 to 6 years once, depending upon age of plant and operating conditions.

Various subjective exercises are followed in industries to estimate the total cost of turnaround maintenance precisely. Key contributors of budget vary from company to company, region to region and country to country. Industries are not considering production loss cost and opportunity loss as the part of Turnaround cost. They are only considering total maintenance cost which includes Service Cost, Materials Cost and Overhead Cost. Turnaround execution is normally planned for abbreviated period and all the planned activities need to be executed safely along with quality and on time. To complete the activity on time, a massive workforce, equipment, facilities, and other resources will be used. These activities in Parallel increase the potential harm to people and the environment. Turnaround executions inherently bring hazardous activities like handling chemicals, toxic gases, working under the confined space, and working on higher elevation with temporary platforms, and increase probability of loss. This adds to turnaround costs and affects the company's reputation when something happens.

Finally, Technical uncertainty is fundamental in the turnaround process because it is a technical project. It involves handling a lot of critical engineering equipment. The exact conditions Critical equipment may not be foreseeable before opening the equipment. Therefore, there is always a risk of budget overrun or duration of the event being extended or both, which result in extra total cost and loss of production.

THE PROBLEM

Context: Shutdowns and Turnarounds in Oil & Gas and Petrochemical industries.

In Complexity of the technology currently employed in the design and building of manufacturing plant, limitation of the technology used to maintain it and ever-increasing problem of its ageing. There will always be a need for maintenance work on the physical assets. In addition to that in a competitive global market, characterized by the increasing scale of production, the effective cost management of that maintenance activity is coming to be seen as a critical business process. Since, Industrial plants have significant size of the equipment, Maintenance of these equipment can be performed only when plants have been taken offline and decontaminated to made safe work environment. These are the prerequisite conditions because oil & gas industries are having hydrocarbons which are harmful to human beings.

Recent technologies help industries to design a program cable for monitoring and maintaining plants online and resulting in reduction of costly outages. Turnaround enforces the companies to organize more resources to complete the turnaround activities on time. Often, internal technical personnel will be diverted from operational plants to support turnaround activities. However, Companies will not be equipped with internal resources fully which are required to execute the job. Therefore, external resources, through a contractor, must be arranged to manage the Turnarounds successfully.

Underlying financial concern should complete the Turnaround successfully as cost effective as possible. Successful completion will restore production capabilities as soon as possible. To meet companies' financial expectations of Turnaround, the planning team should define work scopes clearly. Moreover, budget should be allocated depending upon works' scope, age, and nature of the process plants. Production loss due to Turnaround and product quality on subsequent days will result in financial loss. This is another financial worry.

Challenges of project cost estimation.

Estimation of budget is one of the challenging tasks for project managers in Turnaround maintenance, because of the following reasons. 1). Turnaround occurs in periodic cycle of 5 to 6 years, depending on plant operating condition, if calculating cost from previous TAs will result incorrect result due to fact that economical

changes in previous years. 2). Normally early budgets are estimated before scope finalization, therefore it's difficult to identify the resource requirement, which results in incorrect budget estimations. 3). Management offers lower budget to compete with global market and meet shareholders expectations, which controls project manager from budget calculations. 4). Finally, unaware of equipment condition another challenge for budget estimation because if consider major repair, estimation will be higher, if consider minor repair estimation will be lower and both the cases reality is not matching with calculation will lead to erroneous budget estimation.

Stages of Turnaround (TA) management project cost estimation. *Enterprise plan estimation:* This is the first stage of budget estimation where project manager and management estimates budgets. Reference for this estimation is previous TA budgets and inflation. The previous TA budgets will yield normally 3 to 4 years before data. History comprises extremely basic information which results in an accuracy of this budget to the extent of 60% only. This estimation is used at enterprises level to make roadmap for upcoming major events.

Budget approval estimation: This is the second stage of TA budgeting. At this stage the project manager and project team are involved in preparing the budget. This occurs around 24 to 18th months before TA, where major works scope will be available to estimate. The team uses the current work scope and recent year contract prices for cost calculation to arrive at basic estimation. The accuracy of this budget is around 80% in industry practices. This estimation will be approved by top management to utilize its funds for project expenses.

Final Forecast: This is the last stage of estimation of turnaround cost. It's handled by the project manager and project control team. 3 Months before Turnaround starts, the final cost forecast will be calculated with accuracy of 90% and reported to management for final endorsement. This forecast shall imitate project financial status to management.

Final Cost: Actual project cost will be calculated after project completion and final payment and invoices are cleared. This normally occurs 3 to 4 months after TA. Actual cost includes actuals of basic scope cost and discovered scope cost. This information will be recorded for future turnaround budget calculations.

Formulation of project cost in practice.

Turnaround project cost is the combination of major following five components. Subcategories are covered under these components.

[1] Service cost
[2] Material Cost
[3] Overhead Cost
[4] Financial Inflation
[5] Contingency

Service Cost: It is a major part of turnaround cost. It includes contractor cost; vendor cost, original equipment manufacturer (OEM) visits cost and equipment & other resources rental cost.

Material Cost: It is the second highest part of turnaround cost. Material cost is the sum of all materials used in turnarounds. It consists of equipment's spare parts, consumables, and catalyst chemicals which for required for chemical reactions during normal operations.

Overhead Cost: It consists of Turnaround project team cost, organization's internally used resources cost, and other cost required for temporary facility creations.

Financial Inflation: Inflation is considered due to global inflation which is affecting the market price of services and materials. Normally it's calculated based on the percentage of the above three components. The percentage used for calculation depends on the country where the turnaround is.

Contingency cost: This component includes in total Cost to cover the unknown cost which will be realized only during Turnaround execution. It's calculated based on the percentage of the above first three components. Percentage used for calculation is depends on age of plant, operating conditions, and Maintenance history of the assets.

Turnaround project costs are normally estimated in two ways one is Top to Bottom approach and another one is Bottom to Top approach.
Top to Bottom approach: In this approach total cost is fixed and cost is distributed to all the above components based on percentage. This approach is normally used while doing estimation for Enterprise plan, as mentioned before, where detailed information is not available. This approach is used in the methods below, such as Rules of Thump, Benchmarking and Asset Replacement value.

Rules of thumb: a rule of thumb is defined as a method of estimating based on a rough and simple, practical rule that is not based on science nor on exact measurement. These rules are typically defined by a simple formula using a ratio between a previous Turnaround's actual cost and a cost inflation factor. However, estimates developed using rules-of-thumb are often inaccurate and very conservative. Also, these rules typically have an extremely limited range of applications in which the results make sense. Outside of that range the results will be erratic and more wrong than right.

Benchmarking: This methodology refers to a more exact measurement of cost factors and it can be used to compare similar facilities in terms of Turnaround cost. This requires a basic understanding of the facility and its processes. It shares, same kind of other competitive plant turnaround cost to compare the estimation.

It helps us to locate our position in the global competitive market. Replacement Asset Value: The RAV represents the cost of replacing a certain piece of equipment or a plant component in kind at the present time. It can be determined by getting a quote from a vendor or manufacturer based on the original specification of the equipment or plant component. There are acknowledged methods of escalating equipment prices over time based on raw material prices, inflation rates, and market analysis.

Top to Bottom approach: In this approach complete projects are divided into various activities, and resources are assigned for each activity, finally cost calculated at activity level. Activity level costs are rolled out from bottom to top to conclude the total project cost estimation. Project team use this approach at the time of *Budget approval estimation, Final Cost Forecast and Final Actual Cost* calculations. Calculation on this approach is an overly complicated process because turnarounds are very massive projects which contain major assets and huge number of activities. Calculating the cost for each item is a very tedious task. Each work item is divided into 3 components includes Service, Material and Overhead. Costs are estimated for these components for all the work items.

Service cost of each line items can be estimated in several ways, first is use previous TA actual cost, second is request quotation from vendor and third is refer any other relevant service contract available in the organization. Material cost can be estimated using earlier purchase order history or requesting supplier quotation. Supplier quotation would be more exact than earlier purchase orders. The same way overhead cost can be calculated using existing labor unit price.

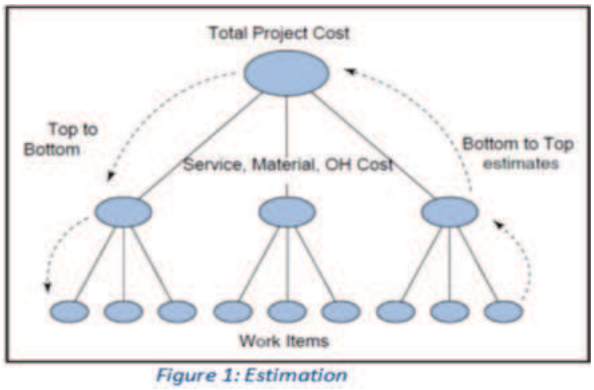

Figure 1: Estimation

Practical Constraints in project cost estimation

Constraints are unavoidable in any project management, moreover Turnaround projects are cost and labor- intensive projects where constraints are inheritable. Oil & Gas and Petrochemical industries project managers are mandated to address the below listed concerns while estimating project cost. Failed to do, will result in cost overrun.

- *Early Estimation*
- *Government's Regulation*
- *Pandemic Guidelines*
- *Companies Procedures*

- *Inflation of Service and Material cost*

Early Estimation:
Project costs are estimated well in advance, as mentioned before first time 3 to 4 years before and second time 1.5 years before the projects. There are many ambiguities will be there in initial stages which need addressed. Since plants are in operation, added activities will be added to scope of works. After the estimation, during detailed planning stage many changes can happen in scope, which will affect the estimated cost.

Government's Regulation:
Project estimation team must regularly contact with regulation team to understand the government policies because changes in government policies will direct impact TA cost. Since Turnarounds are labor intensive, and the requirement of huge amount of work forces cannot managed from same location where the Turnaround is. Contractors normally mobilize people from nearby countries where laborers are available for lower prices, which involves government procedure like Visa requirement, Health check-up requirement and wages policies. If there are any changes after budget estimation, this will bang TA budget.

Pandemic Guidelines:
Before November 2019, the word pandemic may not be familiar, however after that COVID-19 pandemic situation showed us the cost impact. Increased service cost due to pandemic it's not coming down. Therefore, TA cost estimation should consider the pandemic as one of the constraints.

Company procedures:
To run the business successfully, the company should follow world-class procedures to compete with the global market. This procedure helps companies to achieve, worlds work environment, reliable plants operations, productivity, and increased efficiency. However, Implementation of those company procedures will cost as well. TA Cost estimation should consider this as well.

Inflation:
Inflation measures how much more expensive a set of goods and services has become over a certain period, usually a year. Since TA happen periodically, Cost of last TA cannot be same as next TA due to inflation. The same way budget also estimated around 2 years before, actual price also may not be same, it may inflate. Therefore, project managers should consider inflation in budget estimation.

OVERVIEW OF LITERATURES

Literatures are reviewed, analyzed the given solutions, based on financial risk in Shutdown and Turnaround projects.

Garold D. Oberlender and Steven M are suggesting that accuracy of estimation is improved by improving estimate quality. They declared results that significant correlation between the estimate accuracy and the accuracy of the estimate.

Barraza G. A., Bueno R. A are focusing on contingency cost and confirming that it should be properly calculated and added to budget estimation. They are suggesting the Monte Carlo simulation approach for cost contingency calculation, which also includes a heuristic for contingency assignment (allocation) among project activities, if the activities have some degree of uncertainty about their future costs.

Farag Elfeituri and Salah Massoud Elemnifi did study on perfecting turnaround maintenance performance aimed at moving maintenance and inspection activities from a time-based approach to proactive maintenance. The result of proactive maintenance showed that the turnaround duration could be optimized. Proactive maintenance helps the maintenance team to show the condition of equipment. If the equipment's condition is normal and there is no reason to open this equipment, will result in reducing activity time. Finally, they are confirming that turnaround performance optimization can generate increased profit for the organizations.

The contingency part of the budget is used to manage unexpected cost overruns by the project team. C. Capone, T. Narbaev are focusing on importance of right contingency calculation by machine leaning based approach to estimators. They are integrating Expected Monetary Value (EMV) method and binomial distribution concepts.

Johan van der Westhyssen labeled the benefits of improving the front-end contractor hiring process. Turnaround execution can be controlled and completed without any harm to people and equipment by improving the contract selection process. Moreover, it's not only improving the safety dialogue, but also treats the financial and practical implications of incorporating expectations into contractors. They are proving process steps for selection of contractors with demonstrated satisfactory safety performance, contractual requirement to work safely and clarification of safety expectations upon award.

ANALYSIS AND DISCUSSION

This work analyzes the factors affecting shutdown and Turnaround project cost and suggesting industrial solution to manage financial risks in Shutdown and Turnaround maintenance projects by interacting with various team involved in Turnaround projects like, Contractor – Who is executing the major activities by hiring external resources from outside the country. Turnaround project team – Who manages complete the project including budget preparation and control. Buyers – Who manage procurement of service and materials. Planning Team – Who manage detailed planning of work scope.

Long-term agreement

Turnaround projects are long term planning events, occur periodically, and every time bigger tendering process to select contractor. This study suggests the option of a long-term agreement with a turnaround contractor. Long-term contracts mitigate the following risks which were discussed in section 2.

Risk of Early Estimation will be mitigated by fixed price of long-term agreement. Even though the project team estimates earlier, the project team shall use the agreement price, which shall be valid for a period. Because of the fixed price, cost estimation shall be 100% proper. Since service cost is a major part of Total TA cost, our suggestion can fix most of the financial risk in projects.

Company Procedures: Once a long-term contract has been signed, the contractor team will be part of the organization. They will be aware of all the company's procedures, process, and people. They can handle the project in an improved way and cost escalation risk, due to procedural changes, will not be there.

Negotiation with Contractor and Supplier

The first two major components of Total TA cost are Service and Material cost. These components can be perfected by negotiation with contractors and suppliers.

Possible for the procurement team to negotiate for lower prices when awarding the long-term contract, because long term contract gives business opportunity for bidders in the long run, which helps their company's growth. It will be a win-win situation for contractors and companies to deliver the business successfully with lower financial risks.

The same way, during material ordering time, buyers can negotiate with supplier and have an agreement to repeat the supply up to the TA completion with same price same items. Which will fix the price of materials and avoid inflation costs. Repeat orders are very much possible for fast moving or consumable items. Procurement and Engineering team can prefer the local suppliers instead of choosing equipment manufacturers spares. This concept will help organization in following ways, product is locally available, and lead time is very less, logistics problems will not be there, faulty items can be replaced immediately, and price will be lesser. It gives business opportunities for local suppliers and promotes the country's economy as well. Procurement teams shall interact with suppliers to understand market conditions and Inflation of Service and Material cost. Project manager can seek the support from market intelligence team to find inflation percentage which will help for exact estimations.

Owning the Risk.

The purpose of engaging the TA contractor is to transfer the risk of enabling a massive workforce and arranging more heavy equipment. The same way, contractors are getting paid to manage the risks. The more risk, the more Money to contractors. Company believes, risks of executions are transferred by engaging TA contractor, and changing the responsibility of project execution to them; however, accountability is still with company to complete the project

successfully. Companies shall manage some of the tasks internally, it means owns some of the risk, for example, Internal technical team owns the risk and hire some people temporarily and execute some of task with internal supervision, this results quality of execution with lower cost. Instead of going for complete plant shutdowns, plant operations team can isolate plant sections or areas, by owning the risk, for maintenance which can be achieved internally with lower cost of maintenance.

Crashing the project.

To reduce the overall turnaround execution time, more resources are applied in the form of added personnel or overtime. As more resources are applied, the turnaround execution duration can be shortened. When the maximum effort is applied so that the activity can be completed in the shortest possible time, the activity is said to be crashed.

The crash condition (see Figure 2) stands for not only the shortest duration, but the costliest as well. This is also called the time–cost trade-off. Time–cost trade-off is not possible for fewer activities.

In a narrow vision, this crashing idea will be costlier, however, from an overall business point of view this will support financial risk management in projects.

Because, cost of increased resources, to achieve the saving of 1 or 2 days from turnaround execution, will be very less compared to production loss of those days.

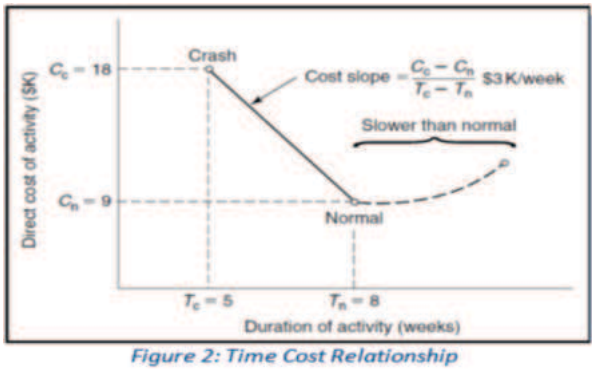

Figure 2: Time Cost Relationship

Promotes Incentives

During turnaround execution activities will be worked by various people at same time at same location. Everyone's goal is to complete the turnaround activity with safety, quality and on time. Achieving this goal is impractical unless supported by everyone involved in executions. Industries use standard practices to engage people towards safety and quality mind set. One of them is to supply incentives to individuals who are focusing on safety and quality. The same way, incentives can be provided to contractor level as well to achieve Pandemic Guidelines. Incentives may cost the projects additionally, however, in the longer run it improves working environments. These results will boost the company's reputation as well.

CONCLUSIONS

The contribution of this paper is delivering a list of financial risk constraints in shutdown and Turnaround project and storing industrial best practices to manage those constraints, which can help industries to manage the constraints of total project cost.

We reviewed past research about the constraints and its best practices related to turnaround projects cost management. This paper presents five different constraints related to turnaround and shutdown projects cost management and its solution to oversee them successfully based on real life industrial experiences. We illustrated our method using turnaround project experiences in oil and gas industries wherein we compared best practices we discovered through the literature reviews. Implementation of the recommendations and guidelines provided in this paper by managers and engineers involved in turnarounds is expected to contribute significantly to better performance, fewer possibilities of cost overruns, and less considerable time delays in future shutdown and turnaround projects. The constraints and control measures proposed here can be implemented by any company involved in shutdown and turnaround projects to improve their existing cost management functions in turnaround projects.

In future, this study can be extended to identify new constraints in project cost management because economical and industrial development will enable new challenges.

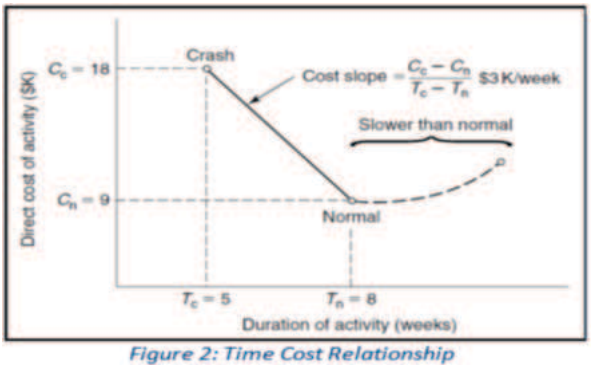

Figure 2: Time Cost Relationship

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