Claim Simulation: A Case Study in Piping Projects

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Abstract

Claims management is one of the most important challenges in mega projects and normally included with many financial losses. Effects of probabilistic claims clearly state a need for a comprehensive model to analyze claim risks in projects. In the present research, list of frequent claims are identified in a piping project (from contractor point of view). Then based on risk types, probabilistic claims are evaluated by questionnaire aimed at calculation of probability percentage and also probability of success. The questionnaires were distributed among experienced managers active in oil and gas piping project. In order to find out reliability of the questionnaire, statistical test was successfully applied. Result of the present study is to quantify claims in implementation phase of piping projects and finally by analyzing cost effects and running claim simulation, practical and useful outcomes including impact of claims on cost success rate of the project successfully obtained.

Keywords: claim, construction management, modeling, Monte-Carlo, risk management

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INTRODUCTION

Change has normally has significant effects on the performance of a construction project. Researches relevant to quantitative impact are limited, in-completed, and in some cases questionable. [1–8]

Significant numbers of disputes arising from construction contracts. Even with understanding of contract clauses and considering risk-allocation regimes, claims willing to present some problems if they are not strongly managed in practice. [9–22]

Management of claim in construction projects is one of the important challenges maybe happened with contractors. Nowadays, due to high competition, construction projects normally become at risk due to a several risk factors which will lead to extension of time and cost. [11]

Claim management is somehow similar to risk management procedure and consists of the following four processes:
(1) Claim Identification
(2) Claim Quantification
(3) Claim Prevention
(4) Claim Resolution.[14]

Specifically, simulation models are established to estimate the cost of the operation as planned by the contractor at bidding stage and to evaluate operational costs. [1] Here, reliable prediction of construction duration and consequently budget control is consolidated in decision making process and is an essential part of a successful management. [3]

THEORETICAL BACKGROUND

Risk Management

In this research, definition of the process risk management as previously presented by the Project Management Institute is illustrated as: "the Project Risk Management consists of the processes of planning, identification, qualitative and quantitative analysis, risk response planning, and monitoring on a project". [15]

The risk management loop according to Figure 1 is a guideline for establishment of a risk management system.

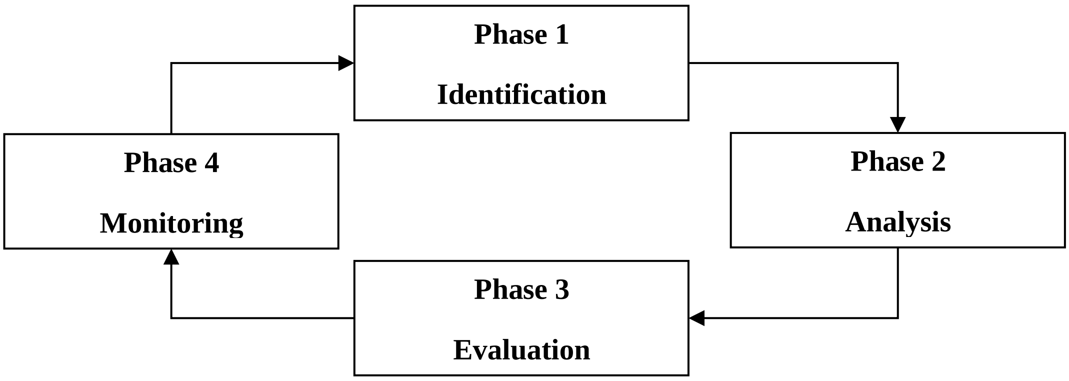

Fig. 1. *Schematic Risk Management Circle According to Ref.* [20]

When risk identification and registration completed, a probability of occurrence and consequence are assigned to each task. This assignment can be done through a quantitative assessment or a qualitative one or a mix combination of both. [19]

Monte-Carlo Simulation

Managerial decision analysis normally incorporates probability distributions of cost and schedule estimates, often using Monte-Carlo simulation to expand cost and schedule models. [23]

Monte-Carlo simulations incorporate probabilistic conditions to provide the total project cost and delivery date according to the fitted distributions. [21] Main advantage of using Monte-Carlo simulation is applying a powerful model for quantifying of the potential risk factors.

The Monte-Carlo simulation enables a manager to quantify project reserves by incorporating risk events during the project life cycle. [12]

Claim and Claim Management

Claim was initially proposed in 1978 as a risk and probability and consequences of the various claims considered during a project life cycle. [4]

Since there is no a unique terminology of this matter in the literature, a claim can be referred to "a request for compensation and damages happened by the other party".[18]

"Claim" may be also described as investigation of consideration or change by one of the parties involved in the project process. [17]

A claim happens when one party to the contract has suffered a detriment by the other party. [10]

Claim Management describes the processes required to eliminate, prevent or reduction of construction claims when they are expected to occur.

Claim management is an important process in mega construction projects. [14]

Construction Claims

Construction claim can be named as "request by a construction contractor for compensation over and above the agreed-upon contract amount for additional works or damages probably resulting from items were not included in the initial contract”.[2]

Construction claims and disputes occurring in both public and private sectors, and in projects. In fact, no project can be considered isolated from a potential claim. Also much kind of claims can lead to financial damages.[5] Construction claims are observed by many participants as an unpleasant event in a project.[6] Generally claims are considered a common part in a construction project and may be happened due to several reasons. On schedule accomplishing of a project is sometimes a difficult task to do in uncertain, construction projects due to the risks may be happened. [10]

Claims may arise on a construction project due to number of reasons. Some well-known ones include as given below:

- Creep in scope of work (changes, extras and errors)
- Inadequate bid/tender information
- Faulty and/or lately supply of equipment and materials by owner
- Low quality of drawings and/or specifications
- Insufficient time through biding analysis
- Interruptions through proceeding of the operations due to lack of coordination, design information, equipment or, etc.
- Blocked work
- Re-schedule of works ordered by owner
- Unbalanced bidding[9]

In addition, based on investigations in 91 projects, it is summarized the most influencing factors of claims are unclear documentations, weak instructions, variations initiated by the employer/engineer, measurement related issues, weather conditions, change and time extension assessment. [24]

On the other hand, the data collection was performed to investigate the reasons related to construction delay and overruns:

- Contract planned duration
- Actual completion date
- Design changes
- Disputes
- Extra works
- Delays
- Conflicts observed between the drawings and specifications
- Time extensions
- Late delivery of materials and equipment[3]

Claims of Piping Projects

Probabilistic claims in piping construction projects may include, but not limited to:

Material control: The shortage documents due to lack of materials will be a cause of loss for contractor or employer. Thus presence of Non-Issues (NIS) documents implies loss claims by contractor or employer.

Organizational communications: Some examples of communications among groups in an executive project are include, “Agendas for meeting” and “Technical letters” and coordination procedures.

Documents and piping plans: Isometric drawing is the most executive type of piping plans. In case of any change happens in any part of the plan, a new revision will be issued and the last plan will be voided. Change in any executive stage could affect the cost and schedule of project and will lead to claims (Figure 2).[16]

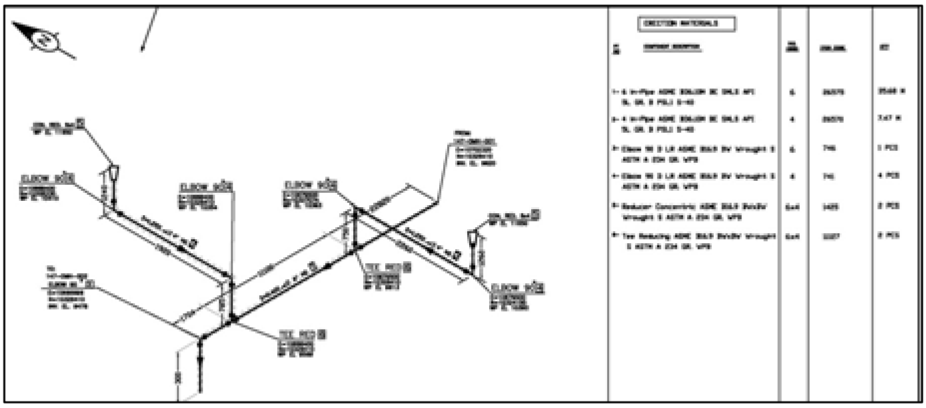

Fig. 2. *Typical Isometric Drawing for Piping Operations [Author].*

To find out the importance or magnitude of a cause from a set of causes for occurrence of claims, two factors entitled "probability of occurrence" as well as "chance of claim occurrence" were examined and they evaluated the most probabilistic causes of claims.

Thus, a questionnaire including 15 questions related to probabilistic claims in oil and gas piping construction were prepared. Contents of questions in questionnaire have been designed by experts with more than 10 years of experience in this field.

According to 5-fold Likert scale (very low, low, moderate, high, very high) rate of each index for each claim was rolled up and scored. [7] The statistical population's size was selected based on comments made by project managers, piping managers, planning and project control managers, contract managers with high executive experiences working in gas and oil projects for several companies. Selection of people was performed based on communications and their involvements in projects especially in piping and their individual experiences and effective views of oil and gas industry. Finally, about 20 answered questionnaires were collected for claim analysis and monitoring stage.

Verification and Validation

In the present study, to check the validation for questions of questionnaires,

Research Gap

In general, so far, Monte-Carlo simulation has been presented under category of risk management.

In claim management most studies conducted about the roots and causes, prevention, and settlement of claims, however, claims management and simulation by Monte-Carlo to obtain project success rate have not been discussed in the literature.

Main approach of this research is to identify and study potential claims which are discussed in oil and gas piping construction projects and by prioritization and ranking of the claims in a specialized form, quantification of claims by Monte-Carlo simulation is analyzed which never been focused by the other researchers in the literature.

SOLUTION PROCEDURE AND METHODOLOGY

Methodology

The present research is an applied research which attempts to examine the claims and provides solutions for claim management in oil, gas, and petrochemical construction projects.

Two factors entitled "probability" and "impact" had been evaluated by questionnaire and required data were collected.

present and past projects, potential claims of the projects were evaluated.

The Cronbach's alpha coefficient for questions about probability was 0.766 and for questions was 0.709 which are acceptable measurements (Figure 3).

surface and content of questionnaire were examined by independent interviews conducted by 10 experts whom experienced in the field of construction projects in oil and gas industry and finally by comparison among conditions of the

Modeling

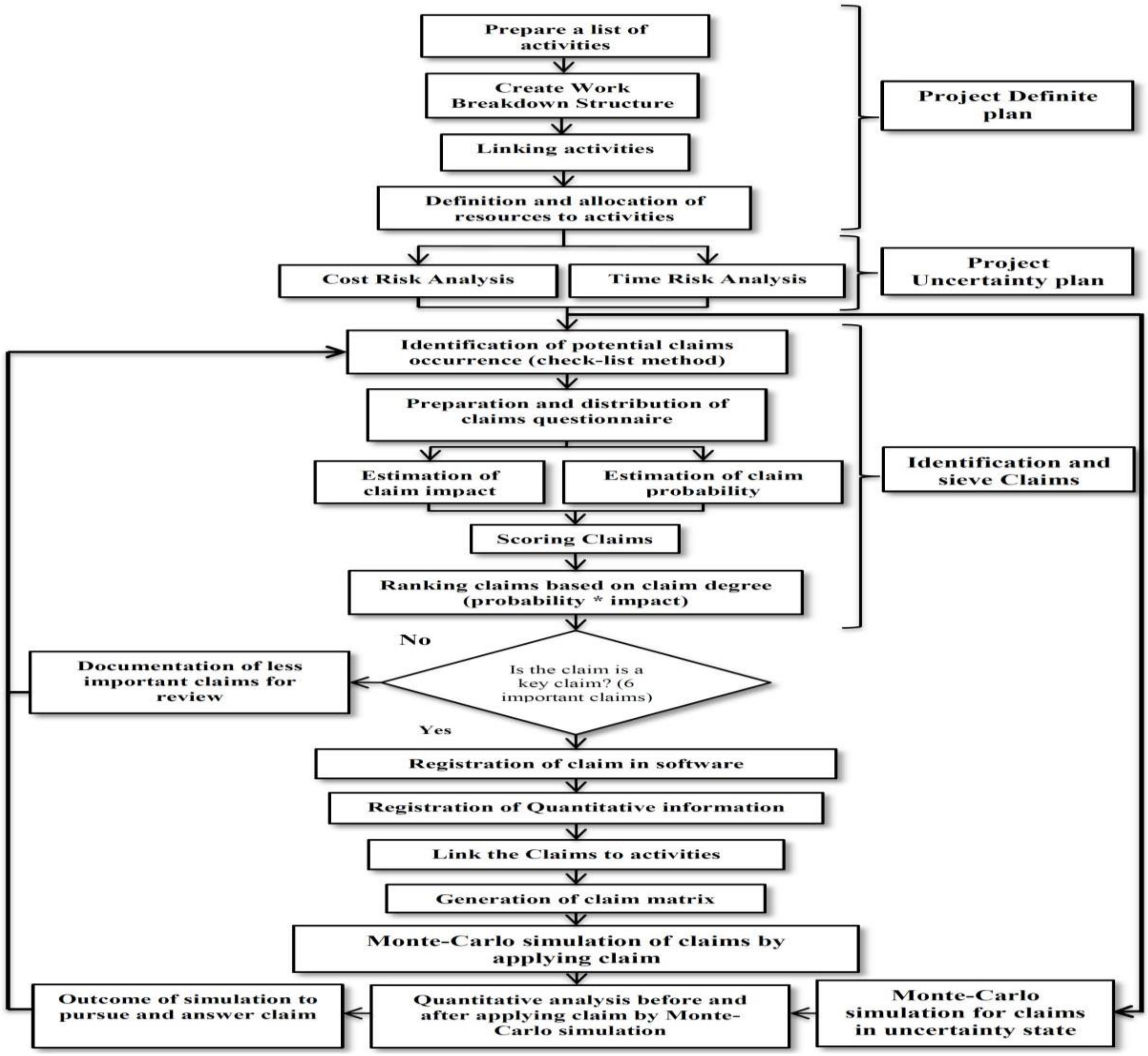

Fig. 3. *The Modeling Analysis of Claim [Author].*

Deterministic Planning of Piping Construction Project

First stage in project planning is to include claim through deterministic planning. It is implemented.

Before getting started with the computer package, the Work Breakdown Structure (WBS) for oil and gas piping construction project is prepared and reviewed by the relevant experts. The dependency relationships and resource assignment should be then applied in order to finalize the deterministic plan.

Risk Planning for Claims in Piping Construction Project

In a project plan along with risk analysis, different outcomes and ways could be examined for the given project. In this project, by analyzing claims, different outcomes and ways to complete the project are examined and impacts of claim risks on the project success are determined.

Risk Analysis for Cost and Time of Project

Through running risk analysis, three optimistic (minimum), the most probabilistic, and pessimistic (maximum) scenarios have to be considered instead of incorporating a deterministic cost and time analysis. By applying project claim analysis, more realistic scheduling is obtained. Before a cost is allocated with a risk, a resource should be defined so that the cost could be allocated. Cost allocation to an activity is the best cost estimation approach for the activity definition. In piping construction projects, once resource for an activity is defined Cost, planned cost for any activity is determined and then triangular distribution has to be used to estimate maximum and minimum costs for any individual activity. For this project, triangular distribution is used for cost risk of activity and minimum and maximum costs are assumed to be 90 and 110% of the estimated cost for an activity, respectively, according to comments made by experts (Figure 4).

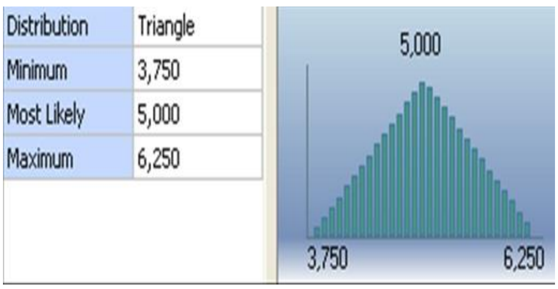

Fig. 4. *Triangular Distribution of Resources.* [13]

Claims Identification and Screening Process

Claims in piping construction sector were identified by incorporating 10 experienced managers in piping construction projects for gas and oil industry at management level by a check-list method. A check-list of potential claims were prepared for running a comparison between identified potential claims in current and the projects completed in the past. Outcome of this stage was a list of potential claims for the present project with a certain range of influencing factors. Thus the claims effective on objectives of the project in EPC contracts of gas and oil industry piping are identified, determined, and truly documented.

Preparation and Distribution of Questionnaire

To find the most important claims, two factors “probability of occurrence” and “claim’s chance of success” (intensity of claim) were examined and evaluated by questionnaire; descriptive terms for both factors in questionnaire included: very low, low, moderate, high, and very high (Table 1).

Scoring the Claims

Variables used in scoring include:

(i) Claim’s probability of occurrence (P)
(ii) Claim’s impact or chance of occurrence (I)
(iii) Claim’s degree of risk (C)

Table 1. *Impact and Probability Scoring Factors.*

Natural language expression	Numeric score
Very low (VL)	1
Low (L)	3
Medium (M)	5
High(H)	7
Very high (VH)	9

To rank and classify claim risks, once average probability and impact of claim's risk is calculated, by probability of occurrence (P) multiplied by impact (I), claim's degree of risk (C) is obtained:

$C = P * I$ 1–1

Registration of Claims on Computer Package

According to prioritization of claims, 6 important claims that are likely to have the highest effect on the project have entered in the software.

Registration of Quantitative Information of Claim

Quantitative values are entered to the program. According to the data entry of quantitative values for probability and impact of claims, those could be scored and finally ranked. Since it is possible that available resources in organization are not enough in order to deal with all claims presented in the project, ranking the risks based on the obtained scores could be very helpful to identify important claims of the project. Given the information about probability and impacts of claims are collected as a questionnaire and are made quantitative and accurate by ranking and scoring, registration of information on the software is performed through a quantitative basis.

A risk could have positive or negative effects on the project. If it has a positive effect on the project, it is called an opportunity and if it has a negative effect on the project, it is called a threat. Since the claim could be either a positive risk or a negative one, we consider opinions of employer or contractor in claim risk analysis.

Mapping the Claims on Project Activities

Claims could be mapped to an individual activity in the project to run an integrate analysis. Effect of claim on costs of activities is found quantitatively by questionnaire and based on the claim scores (Table 2).

Table 2. *Claims Quantitative Analysis on Activities.* [13]

Title	Quantified	Probability	Impacted Task ID(s)
Delays in delivery of materials to the contractor or NIS to material	☑	55%	A12840,A9060,A10730,A9050,A8490,A8430,A12460,A1...
Lack of preparation and holding requirements for piping operations	☑	51%	A7120,A12570,A6280,A12090,A9160,A9260,A9270,A87...
Employer delays in delivering isometric drawings to contractors	☑	42%	A8720,A8700,A8510,A8780,A9080,A7110,A8440,A6280,...
Differences and deficiencies in particular Condition of Contract and provisions	☑	42%	A8540,A9090,A8820,A6280,A12570,A11950,A11890,A1...
Delays in payments to Invoice	☑	36%	A10160,A10420,A11890,A11950,A12570,A7060,A8530,...
Claims of Technical Query (TQ)	☑	34%	A9270,A9260,A8810,A8730,A10410,A8470,A8460,A631...

Preparation of Risk Matrix of Claim

Risk matrix allows evaluation of the linguistic terms (very low, low, moderate, etc.) which could improve quality of data and ranking process of claims and it could be used in other projects.

Once questionnaires collected, risk ranking matrix may specify position of each claim based on probability and its effect on Probability-Impact Matrix (PI-Matrix). It indicates importance of claims properly (Table 3).

Table 3. *Claims PI Matrix*

	Impacts				
	Very Low	Low	Medium	High	Very High
Very High %	9	27	45	63	81
High %	7	21	35	49	63
Medium %	5	15	25	45	45
Low %	3	9	15	21	27
Very Low %	1	3	5	7	9

The above figure indicates the importance of the risks.

MONTE-CARLO SIMULATION FOR CLAIMS OF PIPING CONSTRUCTION PROJECT

An analysis includes a number of repetitions and in each epoch, cost for each activity changes according to the distribution assigned. After the end of a repetition when all costs revised, cost for project completion is then registered. Each repetition simulates the state a project could be implemented in the real world by Monte-Carlo method (Figure 5).

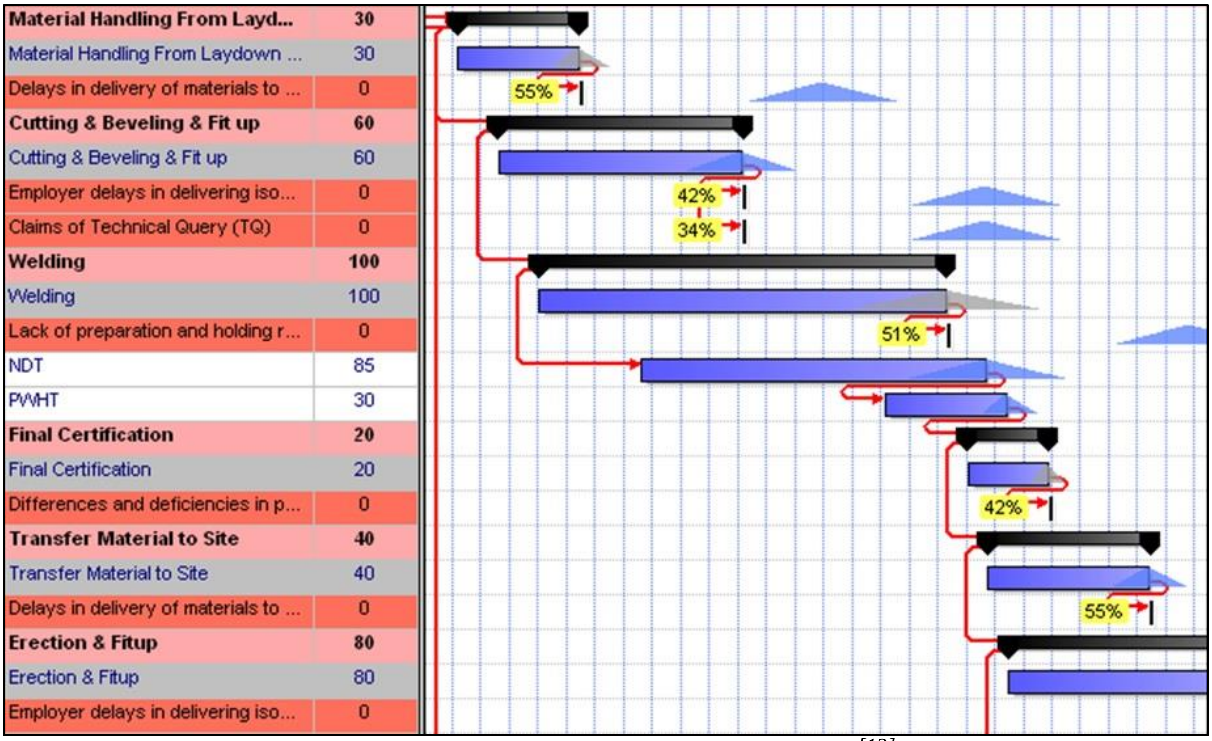

Fig. 5. *Project Schedule Included Claims.* [13]

Simulation in Uncertainty State

First, a distribution is applied in scheduling some activities. In this project triangular distribution is used to schedule activities. Doing risk analysis by Monte-Carlo simulation with 1000 times repetition of simulation graphs in an uncertainty state or before applying claim, the schedules of activities are registered.

Then triangular distribution is selected and applied for costs of resources. By doing risk analysis of graphs before applying claim, cost of the project can be registered.

Simulation of Claims

Simulation of claims and impact of claim on the affected activities and performing risk analysis is registered by implementing Monte-Carlo technique for simulation graphs at a state of claims.

Quantitative Analysis of Claim

After running Monte-Carlo simulation through cost analysis of an uncertainty state both before and after application of claim (post-mitigation), the time schedule will yield applied reports and graphs. Distribution graphs could facilitate reply to the following questions by application of probabilistic project claims:

(i) What is the probability the project is finished with a certain cost?
(ii) What is the probability a specific activity completed with a certain cost?
(iii) How much does it cost to complete 95% of the project?

(iv) What activity could have more cost sensitivity on the project cost?
(v) What is claim impact on rate of project success?

RESULTS AND ANALYSIS OF CLAIMS FOR PIPING CONSTRUCTION PROJECT

Fifteen claims related to the most important actionable claims in piping construction projects for gas and oil industry are given in appendix 1.

Now the claims could be examined and the most probabilistic and effective causes could be found and also considering index of claim's degree (combined effect of probability of occurrence and impact), the most important factors could be found.

Ranking the Most Important Claims of Piping Construction Project

By ranking of associated risks, we could prepare preferences for simulation and specify the most important and effective claims. Since scores of claims are determined in terms of probability and risk impact, the ranking indicates the importance of risks as compared to each other properly. The most important claims are given in Table 3 by preference (Table 4).

Analysis of Claims' Results

Any claim in the plan has a probability of occurrence which is applied after application of claim. If a claim is considered a negative risk for a contractor, the claim influencing the activities by increasing or reducing costs. Outcomes of an analysis model should be able to answer questions proposed by decision makers and managers.

Cost Distributions

Process of repetition for any activity repeats several times and any repetition simulates the state which could be faced by a project and establishes a cost plan for a project. After completion of analysis, cost for any repetition is displayed on a graph which illustrates distribution of project cost (Figure 6).

Table 4. *Piping Construction Claims.*

Rank	Claim event	Factor	Average score	Score (I*P)100
1	Contractors' claims, in case of issuance of material issue voucher (MIV) and delay in delivery of material or non-issue (NIS)	Probability	7.6	55.48
		Impact	7.3	
2	Requirements for piping operations to be hold or not met	Probability	7.2	51.12
		Impact	7.1	
3	Client delays in delivering isometric drawings	Probability	6.6	42.9
		Impact	6.5	
4	Discrepancies and shortcomings in contract terms	Probability	6.7	42.88
		Impact	6.4	
5	TQ (Technical Query) due to failure, inadequacy and deficiencies information plan	Probability	6.2	36.58
		Impact	5.9	
6	Delay in piping invoices payment	Probability	5.8	34.22
		Impact	5.9	

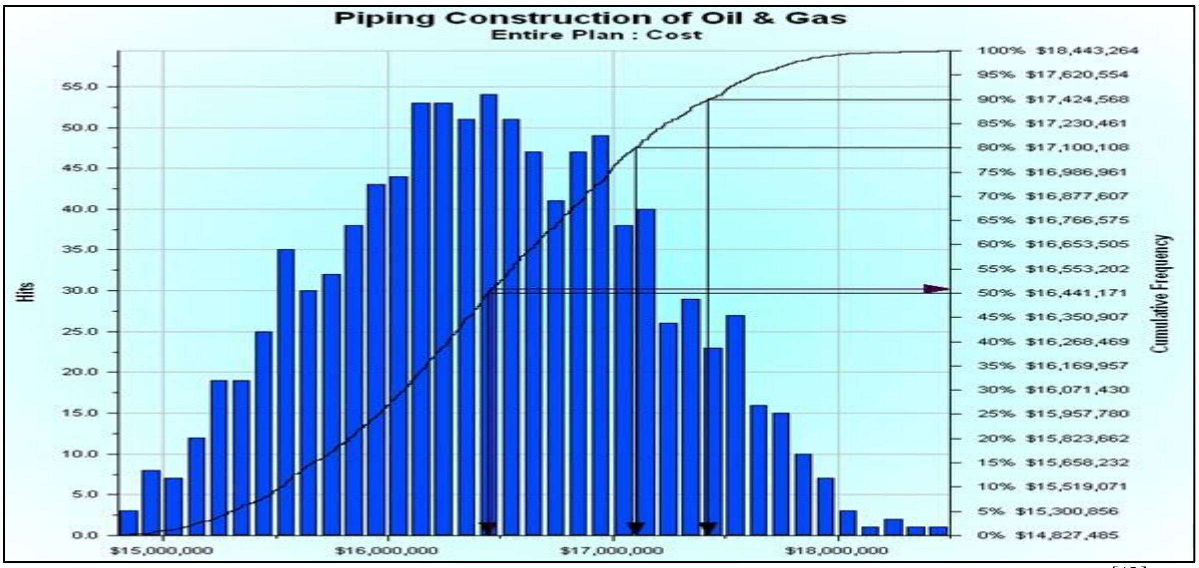

Fig. 6. *Cost Distribution of Piping Construction Project in Uncertain Conditions.* [13]

Outcomes of Monte-Carlo simulation in claim risk analysis of piping construction projects indicate frequencies of different values due to occurrence of various states of uncertainty. As can be seen from the Figure 6, with a 90% confidence interval, total cost of piping construction project is $17,424,567 and the estimated probability for completing the estimated cost equals to $16,460,200 is only 51%.

Implementing claim risk analysis by the

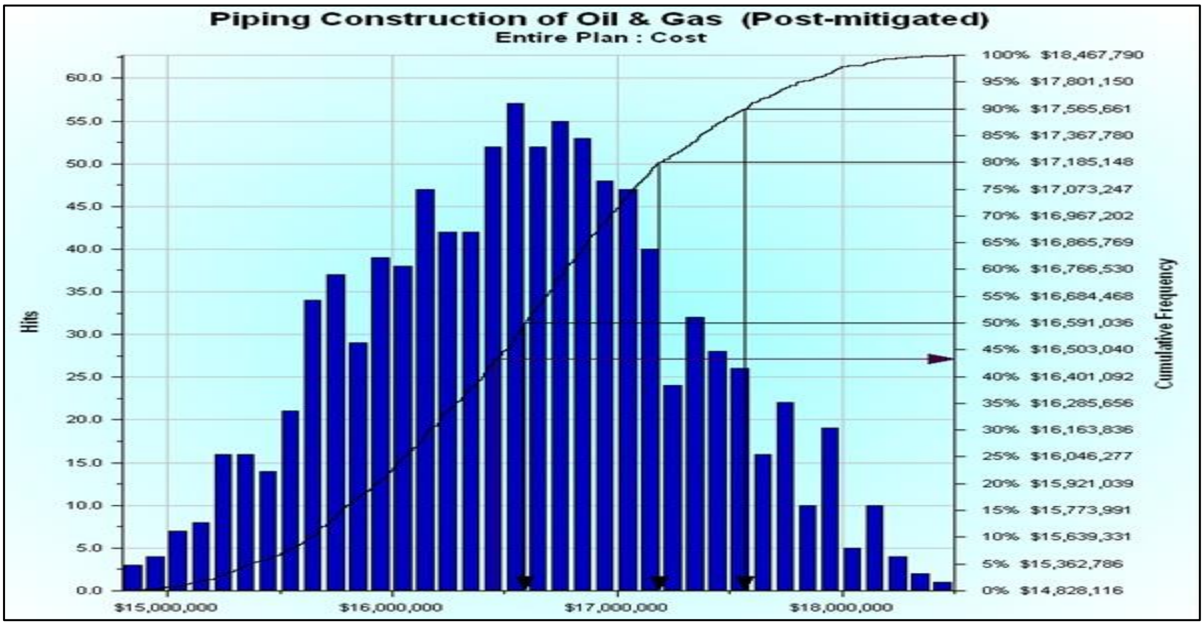

Fig. 7. *Cost Distribution of Piping Construction Project After Application of Claims (After Preventive Action).* [13]

application of claims after taking a preventive (post-mitigation) action, below distribution graph is registered. As could be seen in Figure 7, there is 43% probability the project is completed with the initial estimation $16,460,200. Also, this figure shows with an 80% confidence the final cost of project could be considered $17,185,148.

Table 4 shows statistical values including minimum, maximum, mean, 90% confidence level, and probability of occurrence, and project costs for both states before and after application of claim (Table 5).

Table 5. *Comparison of Costs Before and After Application of Claim.*

	Deterministic (%)	Minimum	Mean	Maximum	90% Confidence level
Project cost with uncertainty taken into account before application of claim($)	51	14,827,485	16,465,689	18,443,264	17,424,568
Project cost with uncertainty taken into account after application of claim($)	43	14,828,116	16,583,807	18,467,790	17,565,661

Analysis of Cost Distribution for Piping Construction Project

If states before and after application of claim are defined, two states could be compared after performing the analysis.

Thus, with uncertainty and claim risk into consideration, estimation rate of total project cost with a 90% risk will be about $141.094 more than the rate before application of claim. Difference between probability of final project cost before and after application of claim indicates a more accurate estimation of project cost given portions of claims for project; impact of claim on project success rate in this project is 8%. In order to discover the importance and relevancy of the activities to be further performed, cost impact for an activity on project budget has to be evaluated. Sensitivity analysis here is a correlation maybe occurred between cost of the activity and project total costs. This index indicates impact of cost for an activity on cost and completion of the other activities or whole project. Claims are graded in terms of relative sensitivity on final cost of the project. In this case, claims with the highest degree could be focused.

The activity with highest cost sensitivity may have more effect on increasing project cost. Figure 8 illustrates rate of sensitivity based on the correlation between costs of the first 6 activities and total cost of piping construction project.

Fig. 8. *Analysis of Cost Sensitivity for Piping Construction Project.* [13]

The graph shown in Figure 8 indicates sensitivity analysis in percentage. As shown, the correlation between cost of welding activity and cost for project completion is 95%. Therefore, claims resulting from occurrence of uncertainty associated with estimated costs of activities with high percentage require more accurate evaluations. Furthermore, it is still possible to have a new concentration on the sensitive items as above detected.

This study has important achievements for oil and gas piping construction project and the important results include:

(1) Identification of actionable claims in piping construction projects and also ranking and prioritization of the most important claims

(2) By simulation of claims, impact on project success rate is 8% for project cost overrun

(3) Understanding cost sensitivity indicates impact of cost of an activity on the total cost

APPENDIX

Piping Construction Claims

Row	Claim event	Factor	Average score	Score 100(I*P)	I & P average	Rank
1	Discrepancies and shortcomings in contract terms	Probability	6.7	42.88	6.55	4
		Impact	6.4			
2	Requirements for piping operations to be hold or not met	Probability	7.2	51.12	7.15	2
		Impact	7.1			
3	Claims related to issuance of different permits	Probability	3.4	11.56	3.4	12
		Impact	3.4			
4	Contractors' claims, in case of issuance of material issue voucher (MIV) and delay in delivery of material or non-issue (NIS)	Probability	7.6	55.48	7.45	1
		Impact	7.3			
5	Client delays in delivering isometric drawings	Probability	6.6	42.9	6.55	3
		Impact	6.5			
6	Changes in drawings and isometric at different times (revision)	Probability	5.7	33.63	5.8	7
		Impact	5.9			
7	Contractor claims related to the FIN(Field Inspection Notification) various stages	Probability	2.8	7.56	2.75	15
		Impact	2.7			
8	Changes in project specification and ITP(Inspection and Test Plan)	Probability	4.5	18	4.25	11
		Impact	4			
9	TQ (Technical Query) due to failure, inadequacy and deficiencies information plan	Probability	6.2	36.58	6.05	5
		Impact	5.9			
10	Interferences with other contractors	Probability	5.7	32.49	5.7	8
		Impact	5.7			
11	Miscellaneous delay factors and costs of piping project	Probability	3.4	11.22	3.35	13
		Impact	3.3			
12	Absence of executive supervisor Client	Probability	3.1	9.92	3.15	14
		Impact	3.2			
13	Technical writing letters and correspondence in relation to the executive affairs	Probability	5.7	29.64	5.45	9
		Impact	5.2			
14	Delay in piping invoices payment	Probability	5.8	34.22	5.85	6
		Impact	5.9			
15	Test package and testing operations	Probability	4.7	20.68	4.55	10
		Impact	4.4			

CONCLUSION REMARK

This paper, identifying common claims in oil and gas piping construction contract, was performed by questionnaire distributed among senior experienced managers and experts in this industry. Once the most important claims were determined by quantifying the claims and by applying outcome of Monte-Carlo simulation, project success rates before and after applying the claim were found and difference between the obtained values indicated impact percentage of claim risk in piping construction projects. Furthermore, cost for project completion with claim taken into account is one of the other results of Monte-Carlo simulation study. Research results indicate the values obtained by probabilistic approach indicates a range of numbers as a result of cost estimation are close to reality. Finally, using this information, the project could be estimated and evaluated more accurately a proper plan may be adopted to reduce project cost. Similarly, claims affecting aims of project are identified and documented according to expert judgments.

Identifying common claims in gas and oil piping construction project and also application of outcome of Monte-Carlo simulation for each claim of project successfully applied and the obtained results verified.

Further study can be made on applying fuzzy modeling through project claim management and combination of fuzzy–simulation analysis also can be elaborated through the case.

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