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Qualitative Risk Analysis of Box Type Heater using Failure Mode and Effect Analysis

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ABSTRACT*- Project Management is a set of principles, methods and techniques for effective planning of objective-oriented work, thereby establishing a sound basis for effective scheduling, controlling and re-planning in the management of projects. In other words, it provides an organization with powerful tools that improve the organization's ability to plan, organize, implement and control its activities and the ways it uses its people and resources. These principles are applied to project on construction and fabrication of a box type heater following different steps in project execution. Now, top management needs decision making tools to support them in identifying, analyzing, and evaluating potential risks. The objective of this research is to develop a model of risk management by integrating tool called failure mode and effect analysis.This integration is intended to improve decision making by providing quantitative and qualitative analysis at each step of project. Qualitative risk analysis is performed to discover probability of a risk event occurring at the planning stage and the impact the risk will have if it does occur. Risk analysis is done on the basis of schedule. Risks are identified and it is found that major risks are associated with schedule delays, identified risks are prioritized by setting risk priority numbers to them to focus on the risks having high priority number first. Required contingency/crash plans are taken in order to mitigate those risk and acquire catch up plan to meet the schedule delays.*

KEYWORDS-Scheduling, Risk Management, Mitigate, Contingency plan, Decision making

INTRODUCTION-Nowadays, construction industry is plagued by occupational risky situations and poor working conditions. Construction and manufacturing project risks, which are generally perceived as events that influence project objectives of cost, time and quality. To identify, analyze and mitigate these risks one should have a proper risk management plan. The project is about construction and fabrication of a DCU (Delayedcoker unit) or box type heater. The research work performed will go through risk assessment at each stage, finding probabilities of risky events, prioritization of the most risky event which will have direct impact on cost, quality and time of project and application of proposed mitigation plan in order to avoid schedule delays and successful closing of project ensuring higher satisfaction to customer as well as workers.

LITERATURE REVIEW - Managing risk in construction projects by **Nigel J. Smith** et al. [1]investigated that all projects are subject to risk. The world is in a state of constant change and survival relies on the ability to adapt to changes. Unfortunately, many project managers have not yet realized that there is a need to include project risk as a key process. It is a well known fact that managing risk has two major objectives i.e.to avoid the downside risks and to exploit opportunities.Risk management in oil and gas construction projects in Vietnam by **Van Thuyet**et al.[2]discovered that Projects are exposed to both internal risks (financial, design, contractual, construction, personal, involved parties and operational risks) and external risks (economical, social, political, legal, public, logistical and environmental risks). All the risks may influence cost, schedule or quality of the project in negative ways by **Charoenngam**et al. [3]. It is highly advisable to perform Failure Mode Effect Analysis [18] failure Mode and Effect Analysis is an important quality tool used in the manufacturing and other industries to improve the product quality and productivity [4,5]. It is a systematic procedure to identify the potential failure modes, and their causes and effects. In this research work, FMEA is applied to analyze the failures occurred in cogeneration process and is used to find out the most significant parameters affecting that process. It can also be used to asses and optimize maintenance plans. FMEA is

usually carried out by a team of experienced and skilled Engineers and expert's knowledge. The failure modes are identified and ranked with help of Risk Priority Number (RPN). RPN is the product of occurrence (O), severity (S) and detection (D) of failures. That is, RPN = O* S* D [6].

Traditionally, using the technology of FMEA to improve decision is in the order from bigger Risk Priority Number (RPN) to smaller ones. But Gilchrist [7]; questioned the calculation of RPN. Therefore, some scholars have advanced some other methods to improve traditional RPN calculation methods before, such as Criticality Score Evaluate, Level of Risk, Critical Analysis and Matrix Method, etc. But the above methods are still similar to the traditional FMEA, which are all subjectively transforming the qualitative linguistic into quantitative fraction, then to assess the risk of failure by concept of utility function as the foundation to improve priority order. Failure Mode and Effects Analysis (FMEA) is a kind of design and analysis technology of reliability of prevention, which is a structured systematic formula identifying the potential malfunction mode in design or manufacturing, then studying the influence of malfunction to the system and providing qualitative evaluation, then taking necessary correction measures and prevention methods while aiming at the problems lying in the systematic reliability. Then FMEA has been widely adopted and has become standard practice in Japanese, American, and European manufacturing companies [8].

METHODOLOGY –Risk assessment is carried in manufacturing of DCU heater byusing, Failure Mode and Effects Analysis (FMEA) is a risk management and planning technique that can be used to identify and prioritize potential errors/failures within a project/system/process and come up with possible solutions to avoid these errors. Identification of potential problems is achieved by brainstorming and opinion sharing between experts within the operating field.

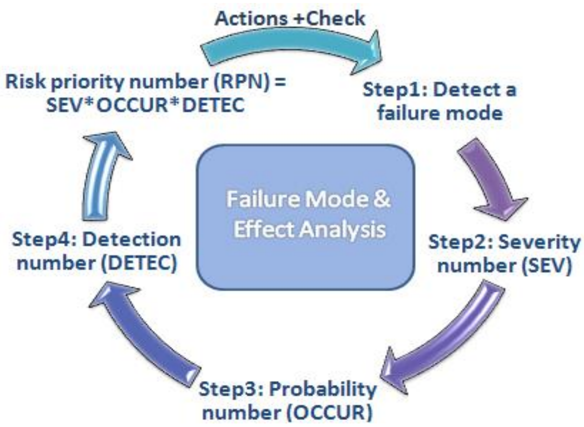


Fig 1: Failure Mode and Effect Analysis

Failure modes and/or errors are then ranked or prioritized based on a Risk Priority Number (RPN) which is calculated according to three main factors: severity of the risk, frequency of occurrence, and probability of detection..1 to 10 scale is assigned for severity, occurrence and detection respectively. Calculations are done by brainstorming and opinion sharing between experts within the organization.

RPN= Severity * Occurrence * Detection
Setting priorities to RPN - 0 to 50 Very low risk.

50 to 150 Low risk.

150 to 200 Medium risk

200 to 300 High risk

300 and above Very high risk

Table 1 below shows the identified risks in schedule delays by using failure mode and effect analysis as a part of qualitative risk analysis, risks are ranked and prioritized using RPN number. These risk are directly impacting the project performance, as project is running 24 weeks behind for which company may have to pay large amount of money as liquidated damage due to which the project cost will increase and profit will be less.

Table 1 : Risk register sheet

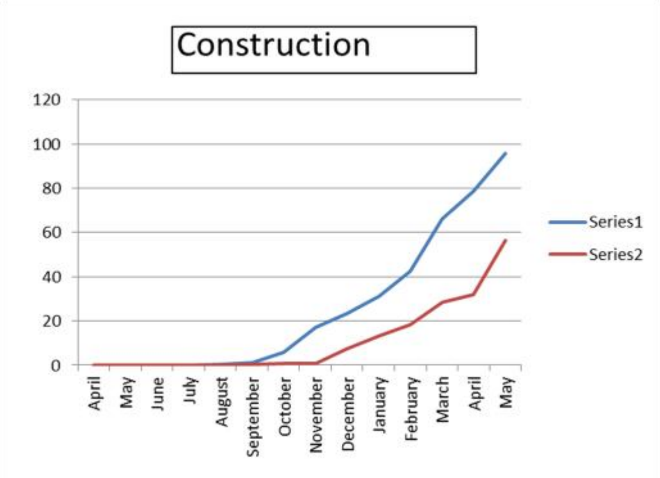
SR No	Risk registered	Causes	Stage	Impact	Occurrence	Severity	Detection	RPN
1	Delayed release of stack damper & SOB document	Specifications are not available	Design	2 week delay	7	4	6	168
2	Order placement of ID Fans	HV motor spec not available.	Ordering	Order on hold	6	6	8	210
3	Order placement of APH & SCAPH	Negotiations under progress	Ordering	2 week delay on order	5	4	6	392
4	Order placement of FD Fans	Slow response from vendor	Ordering	1 week delay in project schedule	6	5	7	210
5	Detailing of structure casing on hold	Response to TQ1 & TQ2 is awaited from customer	Design	3 week delay in schedule	6	7	6	168
6	Ordering of cast bends & plugs pending	Only one vendor Available	Ordering	2 week delay	5	4	5	100
7	Ordering of Refractory	TBE and CBE closure pending	Ordering	Delay in construction	7	6	6	252
8	Ordering of convection module	TBE & CBE closure pending	Ordering	schedule delay7		7	6	294

9	Ducting layout	All the inputs related to Fans, Burner & APH is provided to consultant and vendor	Design	layout failure	8	7	7	392
10	APH structure	All the inputs related to Fans, Burner & APH is provided to FW. Ducting layout will be given by FW based on their flow calculations.	Execution	4 week delay	8	8	8	384
11	Stack raw material ordering	Ordering got delayed meanwhile steel price increased.	Ordering	Increase in project cost	7	6	4	288
12	Improper execution as per design and material standard.	Negligence	Execution	Increase in project cost	10	6	7	420
13	Convection module erection	Item is 10Km away from site. Permission for railway gate dismantling not yet received.	Execution	Delay in schedule	7	6	4	288
14	Voltage drop for FD fan VFD motor	Due to the large length of cable from control room to FD fan motor,the voltage drop expected is more than 10%.	Execution	4 week delay	6	8	8	384

All risks registered above has combined effect on project progress, overall project progress and construction. Values in table 2shows progress in project till now, as construction has started. These values are obtained from project L4 schedule. It shows scheduled project progress and actual project progress.

Table 2 : Project progress

	Construction		Overall Project	
	Scheduled	Actual	Scheduled	Actual
April	0	0	8	7
May	0	0	10	9
June	0	0	10.53	9.2
July	0	0	11.9	9.8
August	0.2	0	22.5	17.2
September	1	0.5	35	23.5
October	5.8	0.6	45.1	29.1
November	17	0.6	55	35.01
December	23.2	7.4	63.9	44.4
January	31.3	13.3	73.4	50.3
February	42.3	18.2	79.1	58.4
March	66.1	28.5	87.3	64.7
April	78.7	31.8	91.2	69.4
May	95.6	56.4	97.1	78.4



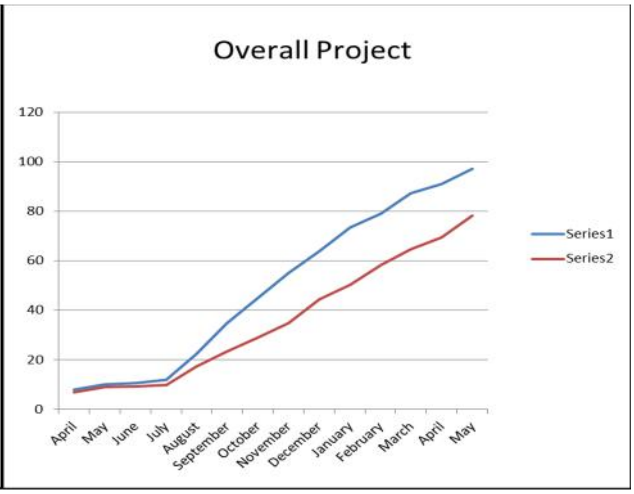


Fig 2 : Construction progress **Fig 3 : Overall project progress**

Above figure 2 shows monthly progress in manufacturing of a heater. From this figure it is observed that actual progress is too much lagging behind with approximate 39% of a scheduled progress. Improvisation in construction progress is needed else project might be in a serious risk. And above figure 3 shows the overall project progress and the major risk identified in that is project is lagging behind by approximate 18 % of the scheduled project. Which is directly impacting cost, quality and performance of project.

To meet the schedule delays required contingency and catch up plans are taken as shown in table 3 below

Table 3 : Contingency/ Crash plan

Sr No	Risk registered	RPN	Contingency/ Crash plans taken
1	`Ducting Layout	432	1. Preliminary ducting layout from consultant is received. 2. Some technical clarifications were needed in ducting layout. 3. Engineering meeting is conducted at consultant office to resolve issues related to ducting layout. 4. Total impact on project schedule is delay in manufacturing by 12 weeks. 5. To expedite the project & meet schedule, company did the Engineering of the supporting structure i.e. APH structure.
2	Improper execution as per material design and material standard	420	1. All the inputs related to Fans, Burner & APH is provided to consultant. 2. Revised ducting drawings released. 3. 60% model review submitted.
3	Order placement of APH & SCAPH	392	1. Pricing negotiations expedited. 2. Order closed immediately.
4	APH structure	384	1. Details not received from Foster Wheeler. 2. Materials made ready .

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			3. Structure detail drawings are completed & approved by consultant. Fabrication under progress.
5	Voltage drop for FD fan VFD motor	384	1. Due to the large length of cable from control room to FD fan motor, the voltage drop expected is more than 10%.
			2. EIL to confirm the cable sizing for VFD mode of motor for starting.
6	Ordering of Convection module	294	1. Technical bid analysis and commercial bid analysis is done. 2. Final TBE and CBE closure is done with vendor visit to company Limited office.
7	Convection module erection	288	1. Item is 10Km away from site. Permission for railway gate is received. 2. All formalities with railway authorities are under progress and about to finish.
8	Stack raw material ordering	288	1. Ordering got delayed meanwhile steel price increased.
			2. company buyer visited TOWELL Engineering and pricing negotiations are under progress.
9	Ordering of Refractory	252	1. Technical bid analysis and commercial bid analysis is done.
			2. Final TBE and CBE closure is done with vendor visit to company Limited office.
10	Order placement of ID Fans	210	1. HV motor specifications made available immediately. 2. Handed over specifications immediately for order placement.
11	Order placement of FD Fans	210	1. Timely follow ups taken from vendor for their slow response. 2. Asked vendor to visit our office for across the table finalization.
12	Detailing of structure casing on hold	168	1. TQ1 and TQ2 are resolved with customer. 2. Follow ups taken from EIL for detailing.
13	Delayed release of stack damper & SOB document	168	1. Specifications made available and handed over those specifications immediately.
14	Ordering of cast bends & plugs pending	100	1. Discussions are under progress with available one vendor.

CONCLUSION -Based on prepared contingency plans in table above, it is observed that gap between scheduled progress and actual progress is drastically reduced from 28% to 20% in the month of April. And it is reduced from 31% to 28% in the month of MarchTable 4 below shows the manufacturing progress of project. Schedule column shows scheduled progress values and actual column shows actual progress values.

Table 4: Final outcome

Manufacturing progress in percent (%)			
Month	Scheduled	Actual	Gap Analysis
SEPTEMBER	32.2	27	5.2
OCTOBER	47.8	30	16.9
NOVEMBER	61	40	21
DECEMBER	72	47	25
JANUARY	90	55	35
FEBRUARY	97	66	31
MARCH	99	71	28
APRIL	100	79.3	20.7
MAY	100	83.2	16.8

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