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Deming Cycle Utilization In Construction Project For Modular Building Construction For Oil And Gas Industry

Fendy Pepe Sutanto[1], Budi Setiawan[2], Anugrah Mauludin[3], Rida Zuraida[4]

[1,2,3]Industrial Engineering Department, BINUS Graduate Program – Master of Industrial Engineering, Bina Nusantara University, Jakarta, Indonesia, 11480 Email: [1]fendy.sutanto@binus.ac.id , [2]budi.setiawan006@binus.ac.id , [3]anugrah.mauludin@binus.ac.id ,
[4] Industrial Engineering Department, Faculty of Engineering, Bina Nusantara University, Jakarta, Indonesia, 11480
[4]rzuraida@binus.ac.id

Abstract

Deming Cycle method, which is a standard method that contains a continuous improvement model developed by W. Edward Deming. This method consists of four main components arranged sequentially, namely the PDSA (Plan-Do-Study-Action) cycle. The workflow of the production department will be fast and efficient, while the Quality Control will be in a position to ensure that all work is completed to the exact specifications and terms according to the standards suggested in the project. The data collection method used to obtain data in writing this final project uses several data collection techniques of Observation, Interview and Documentation. The research model uses the Deming Cycle or PDCA Cycles. To re-check whether the corrective action is working as intended or not with FMEA analysis (Failure Mode and Effect Analysis). FMEA analysis is carried out with FMEA spreadsheet. The Deming Cycle Method is a methodology that will be used as a method to ensure that Total Quality Management will be able to reduce defects and repetitive work during production process for modular building construction in the oil and gas sector. This PDCA found that Quality Issues are the main factor of failures or delays which will impact to the cost.

Keywords: Deming Cycle, Modular Building, Oil and Gas Industry, PDCA, Quality Control

1. INTRODUCTION

Over the last three decades, nearly all operators in the oil and gas (Oil & Gas) industry have chosen to build facilities that are larger and more fit for purpose. Crude oil prices have risen by 350 percent (nominally) from a pandemic low in April 2020 to April 2022, making it the biggest gain for an equivalent two-year period since the 1970s. All energy prices rose sharply in 2022, in contrast to before where oil prices rose much more sharply than coal and gas prices, and this led to an increase in the number of projects and with crude oil prices at or above $100 per barrel.

Downstream industrial economies are under pressure due to the low cost of oil and natural gas and the uncertainty of their future due to the rapidly changing world economic situation. Large capital projects are being re-evaluated in a market where supply, demand and prices suddenly become uncertain. In addition, developing countries are rapidly building new factories and infrastructure to support a rapidly growing middle class that demands all the benefits of modern industrial production.

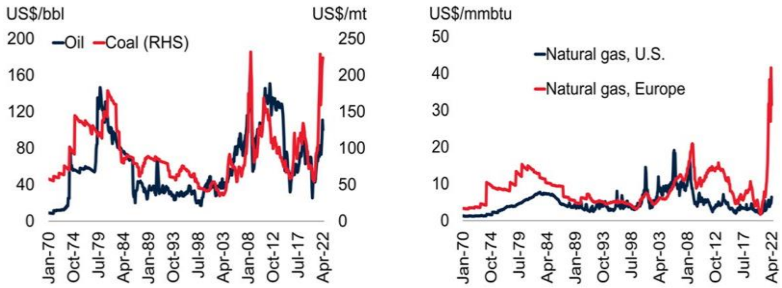

Figure 1. Table of Oil, Coal and Natural Gas Prices

Modular based construction is becoming widely used in many fields and this solution approach can also help the EPC (Engineering Procurement Construction) sector to use it as a successful standard approach that can yield many benefits. This highly efficient process can be a solution for projects located in remote areas where skilled labor is hard to come by. This provides the possibility to reduce schedule and cost uncertainty and can help achieve faster start-ups [1]

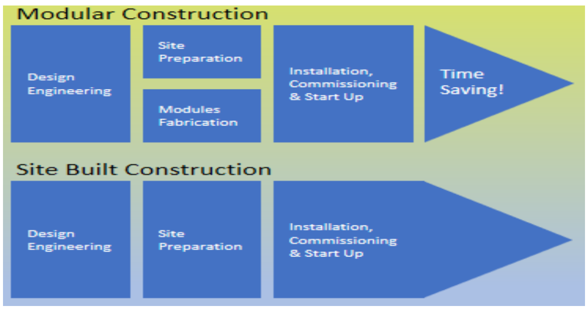

Figure 2. Typical scheme Modular vs Site-built Construction

Modularization has become very prominent in the offshore oil and gas industry. By manufacturing key components in a controlled environment,

it is possible to minimize risk, improve quality and increase overall safety. Units originating from a fabrication workshop can be pre-assembled for delivery anywhere in the world and modular construction can be more easily carried out with available on-site skills.
Modular based construction involves prefabricated equipment and systems for offsite modules in controlled manufacturing facilities. Once built, the modules are shipped to a building or production site where they can be installed and commissioned. This approach offers a number of advantages over traditional stick-built construction methods where most of the work is done on site. Some of them are:

a. Skilled Workforce
b. Shorter Work Schedule

Modular-based construction can reduce the duration of a project's work schedule, and it does so in several different ways as follows:

a. By assembling the modules using off-site prefabricated parts at the designated facilities, the possibility of delays caused by weather or other environmental related factors can be minimized.
b. Off-site building also gives the operator the advantage of being able to work in multiple areas of the facility simultaneously. This is not always possible when using the traditional, stick-on approach, especially when it comes to offshore facilities, as the amount of workspace on site is often limited.
c. By performing off-site work, operators can remove certain activities from the critical path of the schedule and reduce the possibility of trickle-down delays.

- Safety Improvements
- Improved QA and QC

Modular based construction techniques have been used throughout the oil and gas industry for many years. However, with increasing pressure on operators to reduce development schedules, cut costs and become more efficient their use in both onshore and offshore areas are becoming more common. This is likely to continue as the industry faces low commodity prices and seeks ways to maintain profitability.

Supporting building construction projects for the mobile oil and gas industry such as Local Equipment Room, E-House or Substation Module, Electrical Skid House, Integrated Power Room and also Living Quarters are usually carried out in locations that have facilities and a reliable and experienced workforce. and has sea access with deep draft berthing and allows heavy lift barges to dock and transport and bring the building to the nearest port to the destination.

Modular based construction can be a solution for projects located in remote areas where skilled labor is hard to come by. However, due to special planning and transportation measures are required to deliver the module to the site safely. Shipping becomes more difficult in winter, as many routes to remote areas are closed. One of the biggest challenges associated with off-site prefabricated modules is transportation.

This condition makes all construction projects in the oil and gas industry have to be planned with very careful scheduling to avoid delays in the completion of the work, while all components such as heavy lift barges and tug boats or even in certain trajectories the scheduling is adjusted to the situation of seasonal climate cycles that cause freezing of seawater in certain areas.

The workflow of the production department will always require fast and efficient work, while the Quality Control will be in a position to ensure that all work is completed to the exact specifications and terms according to the standards suggested in the project. What usually happens is that because the production team pursues the construction schedule target, there will be a lot of neglect and neglect of small things that actually cannot be ignored, so that in the final inspection at the end of the project there will be various kinds of punch list defects that will actually cost money. a lot of costs for rectification, both while the work is still in progress at the shipyard or carry over work which is very expensive because it is carried out at the final destination location.

The formulation of the problem is described in the following points:

a. How to improve the inspection system from the Quality Control department to reduce the occurrence of Architectural defect punch lists, both while the module is still in the shipyard or after being at the final destination (refinery)?
b. How is the quality control system (quality) for various scopes efficient so as to minimize production delays?

The Deming Cycle or commonly called the PDCA Cycle (Plan – Do – Check – Action) was first developed by management consultant Dr William Edward Demings in 1950. It is more accessible in the construction industry which is in the revolutionary phase of project management systems. This approach divides the process into simple basic steps that help in improving the process in-country and eliminating repetitive errors.

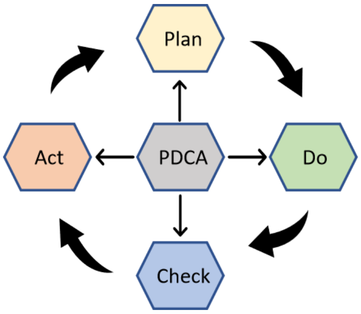

Figure 3. Deming Cycles (PDCA)

The PDCA cycle is shown in Figure 4. There are 4 cycle steps for problem solving which include:

a. Plan (Planning)

This is the initial stage of the cycle, namely identifying problems, planning and developing strategies to reduce risks. The planning stage is further divided into 4 stages:

- Identification of recurring errors: It analyzes the stages based on the obtained results and general observations.
- Detailed Investigation: Retrieve information and deploy tools to investigate issues such as basic surveillance surveys or conducting activities in front of subject matter experts.
- Finding Root Causes: Analyzing all the details extracted in the previous phase and analyzing through management tools such as cause and effect diagrams ?
- Summary of the plan: Develop a strategic plan for improvement.

All quality processes are defined in the planning stage along with the work authority matrix and this should include who is authorized to carry out what type of quality control and at what frequency. It also includes a checklist to follow for construction work.

b. Do (Implement Planning)

This is the execution phase which requires a designated person to carry out the tasks as per the given directions. This requires precision because the results of these small steps will affect the overall task performance. Simultaneous tasks that run along with implementation are quality control, minute details, and observations that serve as input for the next stage.

c. Control (Check)
The input data from the previous stage is sorted, organized and analyzed here. Analytical tools are introduced to find correction points in a previously known perfect plan. This strategy has successful results and can be implemented on a large scale if not found. The main feature of this stage is the comparison of the results achieved with the expectations outlined. Periodically, quality data and processes followed are reviewed. Root cause analysis and (trend reports are generated to identify the causes of problems.

d. Act (Remedial Action)
This is the standard approach to winning strategy. The resources required for implementation are calculated for a successful approach.

2. RESEARCH METHODS

2.1. Research Stage

The research stage begins with identifying the problem and the background why this research is important. The problem behind this research is that oil and gas exploration is usually carried out in quite remote areas so that it requires a lot of supporting facilities which would be very difficult and expensive if it had to be carried out in the exploration area.

Modular based construction is a solution to overcome this difficulty. In this case, Total Quality Management must be observed and implemented consistently considering the high quality standards applied in the oil and gas industry.

In modular-based construction work, Quality Management problems are found which often conflict with the interests of the production party who will always pursue project completion targets due to various time and cost constraints that limit the duration, so that many defects and rejects will become obstacles in the final stages of the project.

2.2. Research Methods

The research model uses the Deming Cycle or PDCA Cycles. The Deming Cycle Method or commonly called PDCA is a methodology that will be used as a method to ensure that Total Quality Management will be able to reduce defects and repetitive work during the production process.

The use of the PDCA methodology is because the model for the continuous improvement process will consist of four iterative steps for continuous improvement, namely: PLAN (Plan), DO (Work according to plan), CONTROL (Check) and ACT (Action as a continuation of the inspection results), so we can use it until we get the best quality product. With the help of the PDCA Methodology reducing rejection problems we will improve product quality as well as productivity. The technical work will be explained in the workflow in Figure 5.

Every research requires a research framework (methodology) as a foundation so that the research process can run systematically, structured, and directed. In general, there are four stages, namely the observation stage, the data collection and processing stage, the analysis stage and the conclusion and suggestion stage. This study has a methodology as shown in Figure 5

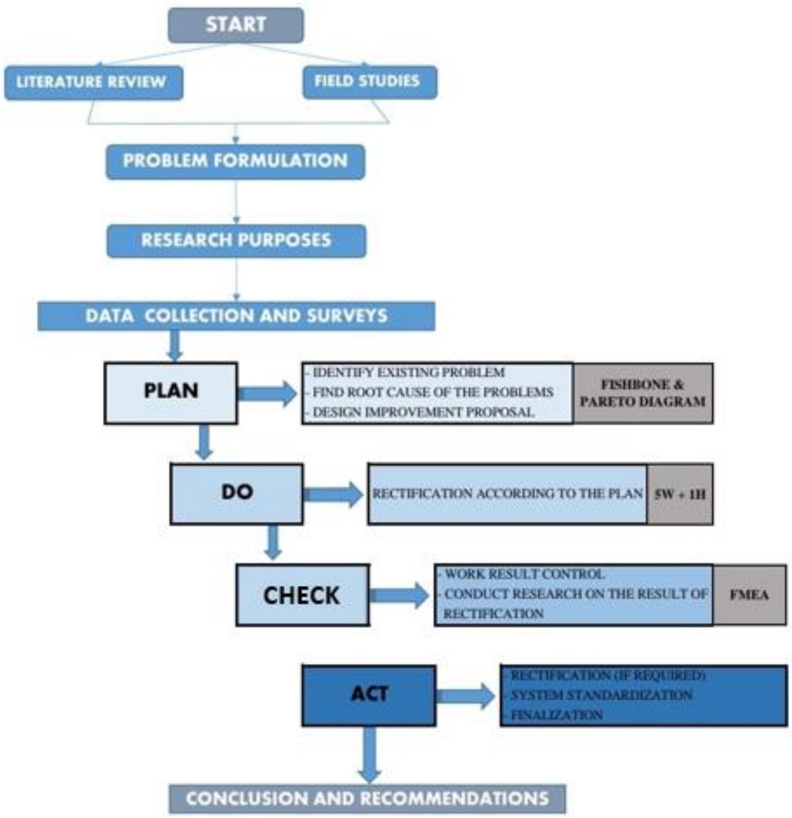

Figure 4. Deming Cycles (PDCA)

2.2.1 Field Study and Literature Study

Field study or observation is a method of collecting data by taking notes carefully and systematically, so this field study/observation study makes observations directly to the company by looking at the production process for the problems being studied at PT Dynatech Rekayasa (Batam). Literature study aims to obtain theories, concepts and methods related to the problem and research objectives. In addition, to obtain information from previous studies related to this problem, the literature used is a theory related to the PDCA Cycle.

2.2.2 Problem Formulation

a. How to improve the inspection system from the Quality Control department to reduce the occurrence of Architectural defect punch lists, both while the module is still in the shipyard or after being at the final destination (refinery)?
b. How is the quality control system (quality) for Architectural scope efficient so as to minimize production delays?

2.3. Research objectives

The purpose of this research is the problem that has been formulated, namely:

a. Making system improvements to reduce the occurrence of Architectural defect punch lists with Total Quality Management capable of controlling the quality of work starting from the zero point of the work starting until the final inspection.
b. Designing a quality control system for Architectural scope using the Deming Cycle method or PDCA Cycles as a tool of Total Quality Management

2.4. Data Collection and Processing

2.4.1 Data collection

The data to be taken is divided into:

a. Primary Data

Includes data obtained from the company directly either through direct observation in the field or interviews with employees.

b. Secondary Data
Includes data obtained from the construction activities that have been processed and calculated

The data collection method used to obtain data in writing this final project uses several data collection techniques as follows:
a. Observation
Collecting data by observing directly to the location of the research place and also collecting data on the necessary information
b. Interview
Interview is a data collection technique that is carried out through face-to-face and direct question and answer between data collectors and researchers to informants or data sources. In this study, researchers interviewed employees of the Quality Control and Production Section divisions.
c. Documentation
Data collection by recording or copying company data in accordance with the problems studied. Data collection This data collection method involves competent people within the company and the types of data in 2020-2022.

Table 1. Data Collection Technique

No	Type of Data	Data Category	Sampling Method	Source of Data
1	Actual Duration of Completion	Primer	Interview	Construction Manager
2	Problem root cause	Primer	Interview	Construction Manager
3	Problem Solving Method	Primer	Interview	Construction Manager
4	Scope of Works	Primer	Interview	Project Manager
5	Method Statement	Primer	Observation	Construction Manager
6	Organization Chart	Primer	Documentation	Project Director
7	Specification	Primer	Interview	Quality Assurance
8	Inspection Test Plan	Primer	Documentation	Quality Control
9	Construction Schedule	Primer	Documentation	Construction Manager
10	Request for Inspection	Secondary	Documentation	Quality Control
11	Defect Punch List Items	Secondary	Documentation	Quality Control
12	Non Conformance Report	Secondary	Documentation	Quality Control
13	Site Observation Memo	Secondary	Documentation	Quality Control

2.4.2 Data management

a. Plan

- Identifying problems that exist in the object of research from production data
- Collecting sample data in the form of the total number or type of work, defect punch list items, data on the number of Non Conformance Records (NCR), Site Observation Memo (SOM) and product quality specification data.
- Perform data processing using several Pareto and fishbone diagrams.
- Finding the cause of the problem that is the object of research
- Designing improvement proposals. At this stage, brainstorming is carried out and formulating KPI (Key Performance Index) that will be applied.
- The design of proposals that are adapted to the system running in the company

b. Do

After planning improvements to product defects that occur, the next step is to carry out and implement improvements to the production process using the 5W+1H (What, Why, Where, When, Who + How) method. The 5W+1H method aims to determine what repair items will be carried out based on the data that has been checked and determine the steps that will be taken to overcome the problems that occur.

- What: What is the initiate of the basic issues
- Why: Asking 'Why' entails clarifying why the issue, problem or situation at hand occurred
- When: This element is about time-stamping the occurrence of an issue
- Where: This element is used to pinpoint the location or place of occurrence
- Who: This is about identifying people who may have direct or indirect involvement in causing or contributing to the issue or problem.
- How: This element of technique is used to examine the sequence of things and triggers how the resultant problem or issue unfolded.

c. Control

The next step is to re-check whether the corrective action is working as intended or not with FMEA analysis (Failure Mode and Effect Analysis). FMEA analysis is carried out with FMEA spreadsheet. Control Chart is a technique known as a graphical method used to evaluate whether a process are in statistical quality control or not so that they can solve problems and produce quality improvements. This method can assist companies in controlling their production processes by providing information in graphic form.

d. Act

The next step that must be taken is to maintain the quality control results that have been achieved to prevent the recurrence of the same problem and further minimize the level of product defects in subsequent production activities by setting standards for the company after providing suggestions for improvement.

Table 2. Score of Occurrence, Severity and Detection

Score	Occurence	Severity	Detection
1	If Problem has never happened	If the problem has no effect (minor)	If the problem is very can be solved in a matter of hours (very high)
2	If Problem sometimes happened	If the problem is very little effect	If the problem can be resolved quickly in under 3 days (very high)
3	If the problem is very rare, relatively few (low)	If the problem is of little effect and not too critical (low)	If the problem is likely to be solved (high)
4			
5			
6	If the problem occurs occasionally (moderate)	If the problem is sufficiently influential, and the influencer is critical enough (moderate)	If the problem is possible to solve (moderate)
7			
8	If the problem occurs frequently (high)	If the problem is very influential and critical (high)	If the problem is unlikely to be solved (low)
9	If the problem occurs very often (very high)	If the problem is very influential and very critical (very high)	
10	If the problem always occurs (Extreme)		If the problem is almost impossible to solve

3. RESULTS AND DISCUSSION

FMEA shows that Quality issues have become the biggest factor of the delays and cost impact. This research attempted to determine decision-making factors and derive future research needs that are associated with modular construction. To this end, the authors conducted an extensive review of the literature collected and analyzed articles from the literature addressing modular construction, identified and defined the decision factors related to modular construction.

Table 3. FMEA Table

Process Step / Input	Potential Failure Mode	Potential Failure Effect	SEVERITY (1-10)	Potential Causes	OCCURENCE (1-10)	Current Control	DETECTION (1-10)	R P N (Risk Priority Number)	Action Reccomended	Responsible	Action Taken	SEVERITY (1-10)	OCCURENCE (1-10)	DETECTION (1-10)	R P N (Risk Priority Number)
What is the process step or feature under investigation?	In what ways could the step of feature go wrong ?	What is the impact on the customer if this failure is not prevented or corrected ?		What causes the step or feature to go wrong ? (how could it occur?)		What controls exists that either prevent or detect the failure ?			What are the reccomended actions for reducing the occurence of the cause or improving detections?	Who is responsible for making sure actions are completed ?	What action were completed (and when) with respect to RPN?				
Installation Procedure	AFC Drawings updated revision	Works Rectification (longer duration)	9	Information from Engineering and Document Control are not sistematically consistent	8	Obselete Previous Drawings Revision	3	**216**	Dispose the previous revision	Engineering Manager	Only Latest revision of aproved drawings signed by Engineering Manager allowed to be onsite	9	7	4	**252**
	Wrong Materials	NCR and Carry Over Works for replacement materials	9	Poor Communication with Client on the Specification Perceptive	3	Submit all TDS, MSDS and Certificates and getting official approval from Clients	5	**135**	Propose a sample board of approved materials and signed by client	Project Manager / Engineering Manager	Submitting Certs/TDS/MSDS is in progress, awaiting for approval	9	9	5	**405**
Poor Workmanship Quality	Quality Issue	Works Rectification (longer duration)	9	Skilled Workers are not well trained on the specific task	9	To combine the new workers with the senior workers in small grouping	7	**567**	Implement Internal Regular QC Inspection system	QC Manager	Already Implemented	8	8	3	**192**
	Method Statement	Works Rectification (longer duration)	7	Briefing, Learning and making mock up before the installation are not implemented	8	To make a mock up following the procedure and let client witness and approve before construction	7	**392**	To make mock up with step by step installation sequence witnessed and approved by client's rep	Constrution Manager	Already Implemented	8	8	3	**192**

Therefore, research attention should be focused on investigating the dynamics and various aspects of the above-mentioned factors in modular construction projects. Another key result of this paper highlights the lack of a holistic decision-making model that includes all identified decision-making factors.

Therefore, there is still a need to develop a decision model and framework that covers all management and operational aspects related to modular construction projects. As such, future research efforts can develop decision models, tools and frameworks based on them decision factors identified in this paper. Although the need for such a comprehensive model is theoretically justified in this paper, the practical applications and benefits of this new model will be evaluated in the future.

Table 4. State Of The Art

No	Research Title	Author	Year	Method
1	Implementing Total Quality Management in Construction Firms	Low Sui Pheng and Jasmine Ann Teo	2004	Analytical Hierarchy Process (AHP)
2	A Survey of the advancement of QA (Quality Assurance) to TQM (Total Quality Management) for construction contractors in Hong Kong	Andrew W.T. Lau and S.L. Tang	2008	Full scaled Survey
3	The Application of PDCA Cycle Management in Project Management	Meng-meng Ren, Xia Wei, Ning Ling, Shu-hai Fan	2015	PDCA Cycle in Project Schedule, Quality and Engineering Cost Management
4	Developing an Appropriate Performance Measurement Framework for Total Quality Management in Construction and other Industries	Behnam Neyestani and Joseph Berlin P. Juanzon	2016	Balance Score (BSC)
5	Applying the Plan-Do-Check-Act (PDCA) Cycle to Reduce the Defects in the Manufacturing Industry.	Realyvásquez-Vargas, Karina Cecilia Arredondo-Soto, Teresa Carrillo-Gutiérrez and Gustavo Ravelo	2018	PDCA supported by Pareto Charts and Flowchart

4. CONCLUSION

This stage is the final stage of the research where conclusions will be drawn as a result of the overall research that has been done and the solutions obtained to solve the problems that occur. While the suggestions section contains notes that can be given for improvement efforts that may be carried out by the company and for development that is useful for further research.

From the FMEA table we can conclude that Quality Issue and Material Approval issue are the major aspect of the high cost and delays reason, hence training of the workers to and identifying of appropriate material according to the specification must be documented from earlier and well transfer to all the staff and workers.

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