Evaluating Storage Tank Cap 10000L Manufacturer by Using Lean Project Management

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Abstract. Business competitions between manufacturing fabrication industries increase fiercely. Companies were demanded to produce high quality products with competitive price that can be delivered to the consumer on time. Storage tank (10000 liter capacity) is one of the most ordered item but most of the time the delivery is unpunctual. During the initial planning, buffer time was unavailable, which caused 32% cost increase by waste. In this study, the concept between lean manufacture and lean project management was bridged to obtain minimal delay. The first research methodology was to identify and analyze waste, second method was risk analysis by FMEA, and final method was cost and time estimation by critical chain project management. S Curve depicted the decrease of delay, and value stream mapping was used to map optimum result from lean project management. Potential waste was “waiting”, and the highest FMEA risk value was material delay caused by weather conditions. Project buffer result shows 39% decrease in engineering task and the actual cost was still within the budget. The company need to integrate HR cost in the project and measure the time buffer to predict delay gap.

Keywords: CCPM, delay project, lean project management, value stream mapping

1. Introduction

Lean philosophy was first introduced by Toyota as “Lean Manufacture”. This concept believes that through waste identification and elimination, efficient process can be reached and customer value can be fulfilled [5]. Lean Management is a systematic and integrative method that is implemented continuously to minimize waste. Separation of non-value added process through continuous improvement. In value stream, all employees starting from operational field to top management were mapped. This concept is applied in service companies, government agencies, health, and education services to provide more effective and efficient process, faster service, lower cost, and better quality [6].

Project management is often used to handle design-to-order demand. Products related to the design-to-order demand type has total uniqueness in every unit. A few of product example that is produces with project management approach such as: plane, ship, building, bridge, etc. [4]. Unique characteristic that differentiate project from other manufacturing project is that there is no product flow. Materials, tools and workers are brought into the project location to be done on site. Nevertheless, a project still has order of activities. Project also has a tendency to spend a high cost and relatively difficult to plan and control compared to other manufacturing process [4].
This paper objective is to decrease the project manufacturing fabrication delay that is ordered by the consumers with product variety and the single or repeated order. Each company project new design has to make a new customized product plan [1] [2]. Work divisions are classified into a few project, high product variety, risk complexity in the project, dense time with high cost, competent worker skill and high work standard [1] [2] [3]. Lean Project Management approach with VSM emphasize added value, decrease waste and unproductivity Non Added Value and Non Value Added [4] and help in implementing the system [7] Assessment evaluation of project risk, project cost, project difficulty, HR quality and project completion time [5] [2] is subjective and determined by the boards. The use of S-Curve [4] is to estimate project total cost if it is according to project value that has been determined by project owner or might be exceeding. Cost estimation is conducted by detailing required material and human resource in every type of work. Critical Chain Project Management (CCPM) approach [3] [4] change safety time with buffer time. Project buffer is a buffer time that is placed in the end of critical chain of a project as a backup time of the whole project [6]. The determination of buffer size can be conducted by Square Root of the Sum of Square (SSQ) method [4]. The obstacles encountered by company are the unknown of process difficulty and production of products, scheduling suitability, human resource and target achievement that has been determined earlier [2] In this research, manufacturing fabrication for storage tank L10000 is conducted by (1) Fishbone diagram and If then formulation to understand the root that cause waste, [9] [10] (2) Right Solution [4] [3] [10]. (3) Lean Project Management approach with VSM (4) Critical Chain Project management (CCPM) approach [3] [4] changing safety time into buffer time.

Recent project management researches [12] [13] show its efficiency of CCPM in construction management, telecommunication [14] and ganggar construction. Comparative analysis between CPM and CCPM [21] showed that CCPM is more efficient and should be considered as the new paradigm [15]. Several studies on project risk management [16] combined with lean project management and CCPM for safety during waste arrival combined with scheduling [17][18] revealed a decrease in working hour, cost saving, and worker. Value Stream Mapping (VSM) dan Value Stream Analysis Tools (VALSAT) [18] [19] also showed the decrease of project waiting time 9% to 1.09%.

2. Methodology

![Figure 1. The Research Framwork](image)

3. Results And Discussion

3.1. Cause of Waste Identification

The project system work consists of the following activities: material description, consumable, shrearing, bending, bending roll, welding filter, TIG welding, polishing, fabrication manpower, lathe,
milling, packaging and delivery, Quality Control, and engineering services. Occurred wastes were identified by questionnaire which caused delays in 1000L Storage Tank Cap projects. The cause of waste were analyzed with fishbone approach.

Table 1. Summary of Waste Identification for Storage Tank 10000L

| No | Type of Waste          | Ranking | Weight | No | Type of Waste          | Ranking | Weight |
|----|------------------------|---------|--------|----|------------------------|---------|--------|
| 1  | Defect                 | 21      | 0.15   | 5  | Unnecessary Motion     | 7       | 0.05   |
| 2  | Overproduction         | 9       | 0.064  | 6  | Excessive Transportation|15       | 0.107  |
| 3  | Waiting                | 35      | 0.25   | 7  | Unnecessary Inventory  | 12      | 0.086  |
| 4  | Unappropriate Processing| 18      | 0.129  | 8  | Unsatisfied Design     | 23      | 0.164  |

The waste in Storage Tank 10000L production shows the highest delay in waiting activity (35), unsuitable design (23), and defect (21).

3.2. Fishbone Diagram
The fishbone diagram explains the highest cause of waste: waiting time, unsuitable design, and defect as described:
- Cause of delay: waiting factor are length of drawing approval waiting from the customer and sub contractor work;
- Cause delay: man factor are lack of engineering skill in drawing and drawing reading. Method factor: mixed up drawing and BOM before and after revision.
- Cause of delay method factor are: SOP violation and tight deadline. Material factor: argon level below standard & welding wire not suitable to the welding machine.

3.3. If Then Formulation
The If Then formulation is a follow-up of some action-solutions for each cause of waste. The causes that have more than one proposed solution will be processed into the evaluation matrix to get the best solution based on the criteria and conditions that have been set. Hence, each event that causes waste has only one best solution.

Table 2. If Then Formulation as Solution for Every Cause of Waste

| If                                      | Controlling Waste                                                                 | When                                                                 |
|-----------------------------------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------|
| Waiting for sub contractor work 5 days late production work becomes 41 days late | Provide a reminder letter to the sub contractor 2 times a week to control progress stor work Do other work that does not use part of sub contractor work | implementation sub work contractor                                  |
| Waiting for drawing approval from The customer results in a withdrawal engineering work for 64 days | Provide approval drawing drawing reminders to customers intensively that is 2 times a week Give deadline drawing approval for 7 the day after the customer order process | Implementation work engineering                                      |
| Lack of skills in engineering in drafting drawing / P17155 / VIII so there was a revision on the drawing | Provide in house training and seminars for as long as less than 3 days Give sanctions to workers with poor performance based on assessment results workers according to SOP-HR-03 standards | Implementation work engineering                                      |
| Less careful in reading drawings and specifications BOM / P17155 / VIII by the parties production and PPIC | Checking drawing / P17155/ VII for reference or for working before the distribution of data to production side and PPIC Hold a project kick of meeting with the division related before the project implementation process | Implementation work production and PPIC                            |
Table 2. If Then Formulation as Solution for Every Cause of Waste (cont.)

| If | Controlling Waste | Then | When |
|----|-------------------|------|------|
| Project work is 43 days late so the deadline for completion urgent project | Hold overtime with maximum limits working hours until 21.00 WIB | Adding worker personnel | Implementation work production |
| There is a violation of MS / SOP SOP HR/ SOP QC/ SOP PC | Give sanctions to violators accordingly provisions of SOP MS / SOP HR / SOP QC / SOP PC | Provide training and evaluation regarding understanding SOP regularly, which is 3 months | Implementation work production and engineering |
| The quality of argon is less than 99.999% standard and wrong use welding wire type or welding wire does not match ampere voltage on the welding machine | Provide a warning letter to the supplier if the material does not match the order | Check the quality of the material periodically, every 3 months | Implementation work production |

3.4. Right Solution

Aims to choose solution based on criterias such as cost, time, impact towards output and project risk by using weighing and it is obtained a score for “Go” or “Not Go”. The ranking scale given is 1-10 (highest rank) based on expert judgement. Total value can be obtained by formula:

Weighted Score = Weight Factor x Ranking

Table 3. Evaluation Matrix on the Cause of Sub Contractor

| Criteria          | Weight factor | Weighted Score (Weight factor x Ranking) | Weighted Score (Weight factor x Ranking) |
|-------------------|---------------|------------------------------------------|------------------------------------------|
| Cost              | 7             | 9                                        | 63                                        | 8                                        | 56 |
| Time              | 7             | 8                                        | 56                                        | 7                                        | 49 |
| Impact of results | 5             | 7                                        | 35                                        | 9                                        | 45 |
| Risk              | 8             | 10                                       | 80                                        | 10                                       | 80 |
| Total Weight Score|               | 234                                      | 230                                       | Go                                      | NOT GO (GO II) |

The action recommendation table that is done by project executor of the company after conducting evaluation with evaluation matrix.

3.5. Managing Risk

Risk Identification arrange list of unexpected events that cause failure in the making of Storage Tank Cap. 10000 L. Source of risk are from external (unpredictable), internal (predictable) and internal non-technical. Table 4 result of assessment each risk indocators. Equation determines FMEA Risk Value = Impact x Possibility x Detection (4)
### Table 4. Risk Assessment Form in Making Storage Tank Cap. 10000 L

| Risk Indicators                          | Possibility | Impact | Difficulty Detection | FMEA | Time              |
|-----------------------------------------|-------------|--------|----------------------|------|-------------------|
| Natural disaster                        | 9           | 8      | 9                    | 648  | All the time      |
| Argon material and welding provision do not meet standard. | 4           | 7      | 2                    | 56   | Before & on execution |
| Worse project cost condition            | 3           | 5      | 3                    | 45   | Before & on execution |
| Worse project time condition            | 3           | 5      | 2                    | 30   | On execution      |
| Violation in Work Health and Safety     | 1           | 8      | 2                    | 16   | On execution      |
| Stealing, Negligence and Dishonesty     | 3           | 9      | 6                    | 162  | All the time      |
| Damage in measuring tools, welding and grinding machine | 3           | 5      | 3                    | 45   | On execution      |

#### 3.6. Risk analysis

Responses to risks are grouped as mitigation, avoiding, transferring, sharing and retaining and also contingency planning, risk response matrix tools in Table 5.

### Table 5. Risk Response Matrix

| Risk Indicator             | Possibility | Contingency Plan                                      | Trigger                                      |
|---------------------------|-------------|--------------------------------------------------------|----------------------------------------------|
| Natural disaster          | Reduction   | Submitting project delay letter to the customers       | Bad weather or natural disasters             |
| Argon material and welding provision do not meet standard. | Prevention  | Planning a standar material and worker requirement before executing project | Lack of preparation and material and worker control by the executors |
| Worse project cost condition | Reduction  | Planning cost and provides contingency fund through investors | Overloaded project in the same time |
| Worse project time condition | Reduction  | Planning schedule properly using buffer time as backup time | Worse schedule planning and lack of preparation by the project executor |
| Violation in Work Health and Safety | Prevention | Increase Work Health and Safety training, supervision implementing SOP | Negligence supervision in |
| Stealing, Negligence and Dishonesty | Prevention | Give sanction to raise supervision and security | Negligence supervision in |
| Damage in measuring tools, welding & grinding | Reduction | Increase maintenance periodically | Error in utilization |

#### 3.7. Managing Variation:

To estimate at before project execution in terms of cost, time, and resource that is used previously. From the cost details Rp. Rp 200,530,548.03 has not included by human resource cost, and that is still below project value Rp. 385,486,000.00. Therefore, the project cost can be accepted, worker cost is counted based on 5% yearly omzet and do not impact in execution of only one project.
Table 6. Project Cost

| No | Job Description                  | Cost (IDR) | Total (IDR) |
|----|-----------------------------------|------------|-------------|
|    | PPIC Works                        |            |             |
| 1  | Material Descriptions             | Rp 130,047,960.65 | Rp 140,958,288.03 |
|    | Consumable                        | Rp 10,910,327.38  |             |
|    | Production Works                  |            |             |
| 2  | Shearing                          | Rp 4,183,200.00   |             |
|    | Bending                           | Rp 1,738,800.00   |             |
|    | Bending Roll                      | Rp 5,796,000.00   |             |
|    | Fitter WELDING                    | Rp 6,350,400.00   |             |
|    | Welding TIG (316)                 | Rp 8,424,000.00   |             |
|    | Polishing                         | Rp 10,395,540.00  |             |
|    | Fabrication Manpower              | Rp 2,747,520.00   |             |
|    | Lathe                             | Rp 5,832,000.00   |             |
|    | Milling                           | Rp 3,304,800.00   |             |
| 3  | Delivery                          |            |             |
|    | Packing and Delivery              | Rp 4,050,000.00   | Rp 4,050,000.00 |
| 4  | Sub Contractor Works              |            |             |
|    | Dieshing, Forming, Flanging Head  | Rp 3,150,000.00   |             |
|    | Transport to Vendor               | Rp 900,000.00    |             |
| 5  | QC Works                          |            |             |
|    | Inspection and Documentation      | Rp 900,000.00    |             |
|    | Test and Commissioning            | Rp 900,000.00    |             |
| 6  | Engineering Works                 |            |             |
|    | Drawing Engineering               | Rp 900,000.00    | Rp 900,000.00 |
|    | Total                             | Rp 200,530,548.03 | Rp 200,530,548.03 |

3.8. Buffer Calculation

Critical Chain Project Management (CCPM) prioritize more in the whole project success, and focused in critical chain project completion. Below is the project plan and actual project in making Storage Tank Cap. 10000 L. Based on previous project buffer, it is obtained an optimum time of project execution by giving suggestion in using buffer time as a backup time in plan scheduling. To determine buffer:

\[
B = 2 \sqrt{\left(\frac{S_1 - A_1}{2}\right)^2 + \left(\frac{S_2 - A_2}{2}\right)^2 + \cdots + \left(\frac{S_n - A_n}{2}\right)^2}
\]

Description: B : Buffer time; S : Most Likely (average standard time that is assumed as time that still save backup time); A: Optimistic (fastest time that is assumed without backup time)

Table 7 Suggestion Result of Project Execution

| Work          | Plan (days) | Actual (days) | Buffer (days) | Proposed (days) (Plan + Buffer) | Description               |
|---------------|-------------|---------------|---------------|---------------------------------|---------------------------|
| Engineering   | 7           | 71            | 64            | 71                              | Maximum 71 days           |
| PPIC (Material) | 15          | 15            | -             | 15                              | The same as the actual    |
| Production    | 21          | 62            | 17            | 38                              | Maximum 38 days           |
| Sub Contractor| 3           | 8             | 5             | 8                               | Maximum 8 days            |
| QC            | 1           | 1             | -             | 1                               | The same as the actual    |
| Delivery      | 3           | 1             | -             | 1                               | The same as the actual    |

PPIC (material) work remains 15 working days, however the production work, project execution within 38 days and sub contractor work, it is suggested 8 days. In QC and delivery work it is suggested 1 day where there is no change from the actual project execution.
3.9. **Buffer Cost calculation**

Executors can save cost in resource which is in production work, because production worker is paid based on working hours per day. In engineering work and sub contractor, saving can not be counted because the human resource cost calculation is calculated based on company’s project revenue per year and the number of unit done, even if the execution experienced acceleration.

| Table 8 Recapitulation of Project Total Cost |
|-------------------------------------------|
| Actual Project Costs | Rp 200,530,548.03 |
| Project Plan Costs   | Rp 168,642,288.03 |
| Project Buffer Costs | Rp 20,303,100.00 |
| Proposed Project Costs (Plan+ Buffer)    | Rp 188,945,388.03 |
| Cost Savings Using Buffers                  | Rp 11,585,160.00 |
| (Actual Costs - (Plan + Buffer))            | 6 % |

3.10. **Value Stream Mapping**

All value stream that existed in the company by making an end of Big Picture Mapping, that describe optimum lead time as an improvement to the company. In Value Stream Mapping in the early production work (Table 7) and QC actually executed in 63 days, and in the end of Value Stream Mapping, project execution suggestion by using buffer time in the production work and QC is 39 days (Figure 3).

Based on CCPM scheduling estimation, it is obtained an optimal timeline condition in the making of Storage Tank Cap 10000 L that is illustrated in the form of Value Stream Mapping ending. Project execution suggestion with buffer time in the production work and QC is 39 days, and for production and QC work is actually done in 63 days

![Figure 2. Value Stream Mapping Project Buffer](image-url)
4. Conclusion
Storage Tank Cap 10000L evaluation by the Lean Project Management approach shows the cause of the biggest project implementation delay is waiting and unsatisfied design. Some indicators of risks that occur in the project are natural disaster and natural hazard, if both risk can be handled, work finalization can be accelerated. Application of buffer time save 0.06% cost and the work schedule is reduced by 39%. The CCPM approach to lean management programs helps companies reduce risk and reduce financial inputs. The S curve shows the comparison of the actual conditions and the use of buffer time, especially engineering tasks.

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