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Cost Efficiency and Production Improvement through Cycle Time Optimization of Huff and Puff Thermal Stimulation Using Lean Sigma Method in New Steamflood Project

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ABSTRACT: Indonesia's effort to increase national oil production to 1 million BOPD requires significant improvements in production performance, especially in mature heavy oil fields such as the Dadali Field in the Rosela Block. In the new development Area N, requiring thermal stimulation before full Steamflood implementation. However, the conventional Huff and Puff process exhibits long cycle times typically 20 days/well resulting in long cycle times, production delays, high operational expenditure, and marginal oil gains. These inefficiencies directly hinder the achievement of PT XYZ's targets for both production and cost reduction. This research aims to optimize the cycle time of thermal stimulation in Area N using the Lean Sigma DMAIC framework. Data were gathered from operational daily activity and field trials. Process Flow Mapping, Fishbone Diagram, and FMEA were applied to identify and quantify root causes. The analysis revealed that the primary driver of inefficiency is the lack of a method to optimize heat distribution. Three improvement alternatives were evaluated using multi criteria analysis. The selected solution is parallel steam injection into two wells combined with optimized injection and soaking durations was validated through field trials. This method reduces cycle time from 20 days/wells to 7 days for two wells simultaneously. This approach reduce cost per job from USD 58,000 to USD 12,500 and significantly increases monthly job capacity and oil response. The research concludes that optimizing Huff and Puff cycle time through parallel steam injection delivers significant operational efficiencies and cost reductions, enabling PT XYZ to accelerate production growth while achieving its targeted operational expenditure savings.

KEYWORDS: Lean Sigma, DMAIC Framework, Thermal Stimulation, New Steamflood, Enhanced Oil Recovery, Huff and Puff

I. INTRODUCTION

Heavy oil fields play a critical role in supporting Indonesia's national strategy to increase crude oil production. Dadali field as the largest heavy oil field in Indonesia has oil production that continues to decline every year. As an effort to increase oil production in the Dadali field, a new steamflood area (Area N) is being developed in the Dadali field where steam flooding will be implemented. Currently, Area N is in immature phase as initial phase of Steamflood life cycle where the reservoir condition is still cold. According to the steamflood life cycle process, in the initial phase of developing a new area, thermal stimulation is required at the production wells. Thermal stimulation is one of methods used to increase oil production, particularly in heavy oil fields. This technology is designed to reduce oil viscosity around the wellbore by utilizing heat energy from steam, to increase fluid mobility towards the production well. The thermal stimulation in Area N is conducted using a portable Huff and Puff unit.

The thermal stimulation process using Huff and Puff unit consists of three stages: steam injection, soaking and production. Steam injection stage (huff) where steam is injected into the well for a certain period of time, soaking stage where the well is left closed so that the heat energy is distributed and absorbed by the oil, and re-production stage (puff) where the well is reopened and oil that has experienced a decrease in viscosity is produced. In the conventional process, the cycle time for thermal stimulation is 20 days, consisting of 13 days of injection and 7 days of soaking. As a result, the well undergoing thermal stimulation will be shut in for 20 days. This also leads to the loss of oil production from the candidate stimulation thermal well during the 20 days period. The operational cost for thermal stimulation is quite high, at USD 58,000/well, with a marginal oil gain. Given the issue of declining oil prices, the economic return from this thermal stimulation is considered marginal. The long cycle time in the thermal stimulation process causes production delays and operational cost inefficiencies. Thus, it will impact the achievement of operational expenditure and production of PT XYZ targets. Therefore, improvement is needed to increase oil production and reduce operational expenditure in the Dadali field, particularly in the new Area N, by implementing a more efficient thermal stimulation process.

II. RESEARCH QUESTION, OBJECTIVES, SCOPE AND LIMITATION

Through the identified problem that is currently encountered in Area N of Dadali Field, there are several research question, objectives, and research scope and limitation that needs to be addressed in order to have a focused analysis to close the gap and reduce the inefficiency.

A. Research Question

1. What are the factors contributing to the inefficiency in the cycle time duration of thermal stimulation?
2. How to improve these factors to reduce cycle time duration of thermal stimulation that affected to Opex?
3. What is the best alternative to improve cycle time duration of thermal stimulation that affected to Opex?

B. Research Objectives

1. To identify the factors that contribute to the inefficiency in the cycle time duration of thermal stimulation in the new steamflood project (Area N).
2. To propose improvements to reduce the cycle time duration using Lean Sigma methodology.
3. To evaluate alternative solutions and determine the best one for improving cycle time efficiency and reducing operational expenditure (Opex).

C. Scope and Limitation

1. The research focuses specifically on the thermal stimulation process using Huff and Puff method used prior to Steamflood process in production wells which includes three stages: steam injection, soaking, and production. The emphasis is on analyzing and reducing the cycle time duration.
2. The research is confined to Area N as a pilot location for process improvement. It does not encompass the entire Dadali Field or other operational areas within the Rosela Block.
3. Determination of alternative solution using DMAIC Framework of Lean Sigma Methodology and select the best alternative.
4. Data usage in the research is limited to:
   - Only the Huff and Puff based thermal stimulation process is evaluated.
   - The analysis is heavily dependent on internal data provided by PT XYZ, including operational report, cost reports, and production history.

III. METHODOLOGY

A suitable research approach and thorough methodology are fundamental aspects of designing and conducting this research. The choice of the research approach used depends upon the purpose of the research and sources from which data for analysis are derived. In this case the main purpose is to provide information for PT XYZ management to give enlightenment about which part of thermal stimulation process cycle time that has performance inefficiencies which will be a be useful reference to conduct the new steamflood project in Area N. The research begins with a comprehensive analysis of the current operational conditions to identify issues through gap analysis. In this research the emphasis is on thermal stimulation process (Huff and Puff technique) due to its cycle time inefficiency and its immediate effect on oil production targets and operational expenditure (Opex). Given that Huff and Puff stimulation is a critical step before steamflood implementation, improving its efficiency is vital to meeting PT XYZ's Key Performance Indicators for production and Opex reduction.

Lean Sigma has been seen as a business improvement methodology integrating two distinctive management philosophies are Lean and Six-sigma complementing each other to improve enterprises processes and results (Tenera & Pinto, 2014). Lean Sigma (or Lean Six Sigma) as an integrated methodology that merges waste elimination focus of Lean with the variation reduction discipline of Six Sigma (Kubiak and Benbow, 2016). Based on Kubiak & Benbow, DMAIC framework is the core structured problem-solving method in Six Sigma and Lean Sigma projects. It provides a systematic way to improve existing processes that are not meeting performance expectations.

- Define Phase: The first step in the DMAIC framework. It establishes the foundation for a successful Lean Sigma project by clearly define problem to be solve, opportunity for improvement, understand customer requirements and project goals. SIPOC is a business management mapping technique which present an organized set of connected parts of activities from input to output. SIPOC concept was designed for manufacturing organization, but today service organization also use this concept to define service processes (Kathy A. Long, 2010).

- Measure Phase: The second step in the DMAIC framework. Its primary objective is to determine how to measure the process and how it is performing. For this project, author requires to measure the existing process clearly and to collect the data correspondent to the sequence that may create a problem to current situation. The goal is to measure the process to determine its current performance and quantify the problem.
- Analyze Phase: The third phase of the DMAIC framework. Its primary objective is to identify the root causes of the problem, validate those causes using data and statistical analysis, and understand how input factors affect process outcomes.
- Improve Phase: The fourth stage in the DMAIC framework. It focuses on developing, testing, and implementing solutions that eliminate the validated root causes identified in the Analyze Phase.
- Control Phase: The final phase of the DMAIC framework. Its purpose is to sustain the improvements achieved in the Improve phase and ensure that improvement is maintained over time.

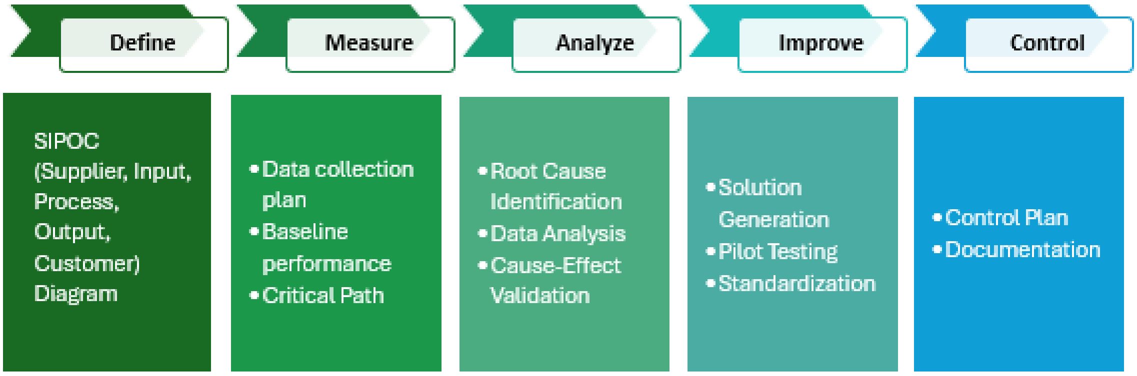

Figure 1. DMAIC methodology (Kubiak, T. M., & Benbow, D.W. 2016)

IV. RESULT AND DISCUSSION

A. Define Phase

Define phase is the step of identification and investigation process of the problem with its main activity including observation and discussion. The oil characteristic in Area N is classified as heavy oil, with high viscosity, making it difficult to flow at low temperatures. Therefore, heating process is a crucial factor in supporting oil production. Given the current limited resources, the huff & puff method was chosen as an alternative to provide a heat source to the reservoir. Therefore, providing heat is an important factor in supporting smooth production. In the current condition, the thermal huff & puff stimulation method was chosen as an alternative to provide a heat source into the reservoir with limited surface facilities in Area N. However, due to the limited number of units and high costs, currently only one huff & puff unit can be operated in the area. Although the huff & puff unit has been operated to increase the reservoir temperature to improve oil flow, production in Area N is still not optimal, coupled with the addition of high operational costs.

Figure 2. Oil Production Trend in Area N using Huff & Puff Conventional

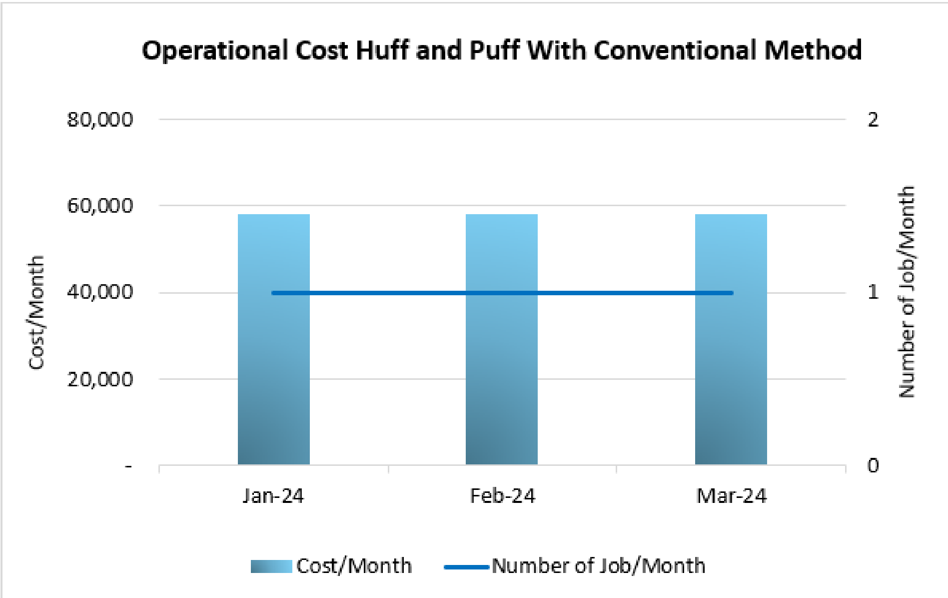

Figure 3. Operational Cost Huff and Puff Unit Using Conventional Method

Figure 2 shows the oil production trend in Area N in 2024 using the conventional Huff & Puff method. Before implementing this method (the Cold Production period in early 2024), oil production rates were very low that indicate the oil in the reservoir was having difficulty flowing because the heat had not yet been distributed within the reservoir. After the commencement of Conventional Huff & Puff operations, oil production rates increased, but oil production decreased over time due to the diminishing heat effect in the reservoir. This decline in production indicates the need for restimulation to maintain production. Figure 3 shows the monthly operational costs and the number of Huff & Puff jobs per month with the conventional method that the operational costs is USD 58,106 per well with the number of Huff & Puff jobs limited to a maximum of 1 jobs/month. After identifying the problems, a simple SIPOC diagram will be used as a tool in the define phase of Lean Sigma process to help identify the parameter of input of the problem, process, and the desired output of this research. The input items are the basis of problems in every stimulation thermal job using Huff and Puff that needs to be improved, while the output items are the objectives that is desired through a discussion with stakeholders (figure 4).

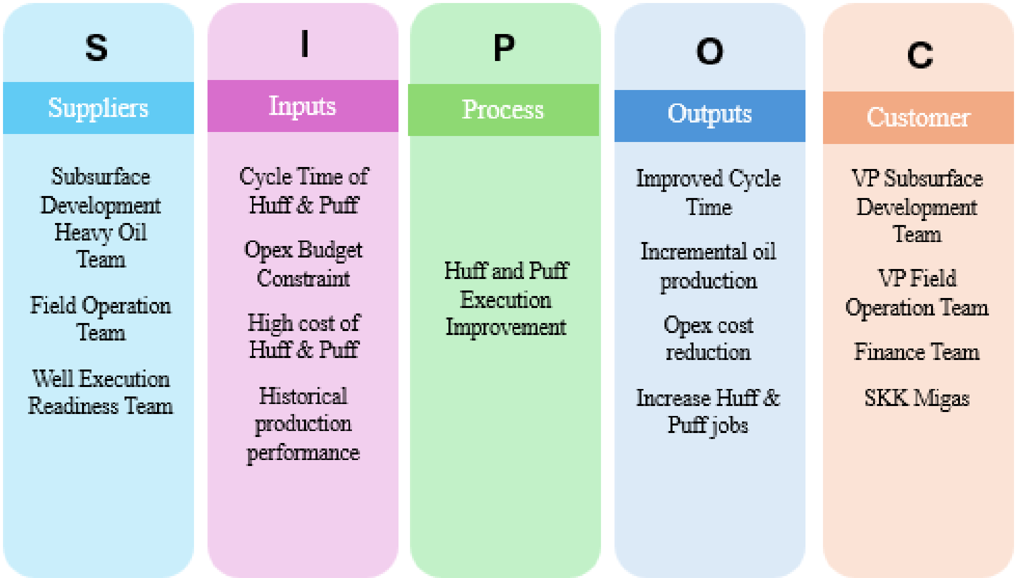

Figure 4. SIPOC Diagram

B. Measure Phase

Process flow mapping analysis is one key analytical tool in Lean Sigma methodology to displayed a structured visualization on the process of how inputs, activities, and decision are combined to produce a specific output. This tool will help in visualizing the process of how the current condition is happening systematically from the planning until the result of the execution as shown in figure 5.

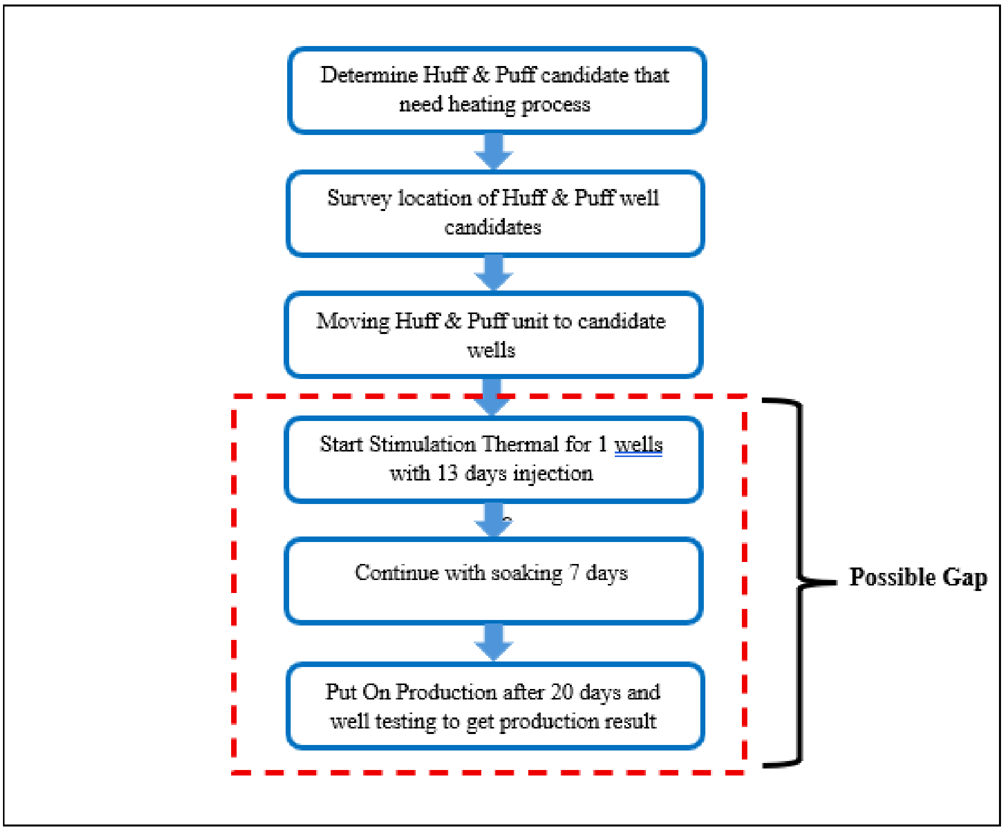

Figure 5. Process Flow Map of Conventional Huff and Puff Execution Process

Figure 5 depicts the conventional workflow of implementing the Huff & Puff Thermal Stimulation process, starting from determining well candidates to execution stage. The gap cause heat distribution in producer wells in Area N is not optimal, in addition to that, the conventional Huff and Puff method applied in Area N causes high operational costs. Possible gap is the long cycle time duration of thermal stimulation job with Huff and Puff, which causes Loss of Production when thermal stimulation is executed (the producer well is shut off when thermal stimulation is carried out), in addition, one Huff and Puff unit can only work on one well at the same time. Overall, this process flow map illustrates the conventional Huff & Puff operation flow, which is still sequential and single well based, leading to opportunities for improvement. Analysis of these possible gaps then forms the basis for developing alternative solutions.

C. Analyze Phase

In the analyze phase, a comprehensive evaluation is conducted to identify the root causes contributing to inefficiency of stimulation thermal in Huff and Puff operation in Area N. This phase aims to investigate and validate the most significant variables by utilizing Failure Mode and Effect Analysis (FMEA) and Fishbone Diagram (Ishikawa/Cause-and-Effect). A fishbone diagram was used to identify the root cause of the main problem, namely lack of heat distribution in the Huff & Puff, which resulted in long cycle times, limited heating coverage, not optimal oil production, and high operational costs. This Fishbone diagram groups the causes into five main categories such as Method, Tool, Material, Man/People, and Environment as shown in figure 6. This fishbone diagram (Ishikawa diagram) in figure 6 identifies the root cause of the main problem, namely poor heat distribution in the Huff & Puff process, resulting in not optimal oil production in Area N. This fishbone diagram aims to systematically identify factors contributing to poor heat distribution during thermal stimulation using Huff & Puff in heavy oil field especially Area N. The diagram divides the causes into five main categories are environment, tools (equipment), methods, people and materials (reservoir characteristics). Of these 5 main factors, only 3 factors are truly correlated with the root cause, namely Method, Material, and Equipment. From the method factor side, there is no appropriate method to optimize heat distribution so that the area or number of wells that are heated is small. From the material factor side, it is related to the location of the well which is on the flank area of the field, causing the area affected by heat is limited because of the water contact that blocks heat conduction. And from the tools factor side, there is no tool to increase the capacity of huff & puff so that the steam injected into the producer well is limited.

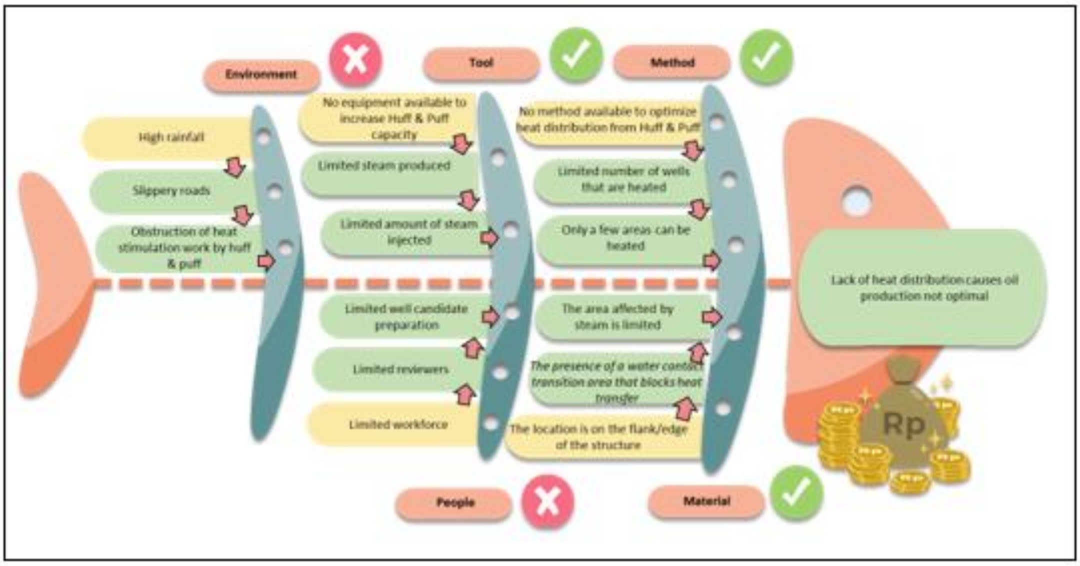

Figure 6. Fishbone Diagram

Failure Mode and Effect Analysis (FMEA) using Pareto Chart to identify the dominant factors that cause most problems, quantify and rank the frequency or impact of each cause based on actual data. In this research, Failure Mode and Effect Analysis (FMEA) is used to determine the dominant factor causing ineffective Huff & Puff thermal stimulation process in Area N. There are three main categories of causes, namely Methods, Materials, and Tools. In FMEA analysis, each potential cause of the problem is evaluated with three main parameters, namely

- Severity (S) which shows the severity of the impact of failure on the process or work results. The severity rating scale is 1 (not significant) → 10 (very critical).
- Occurrence (O) which shows the frequency or possibility of failure. The assessment scale for occurrence is 1 (rare) → 10 (often).
- Detection (D) which shows the system's ability to detect failures before they impact. The rating scale for detection is 1 (easy to detect) → 10 (difficult to detect)

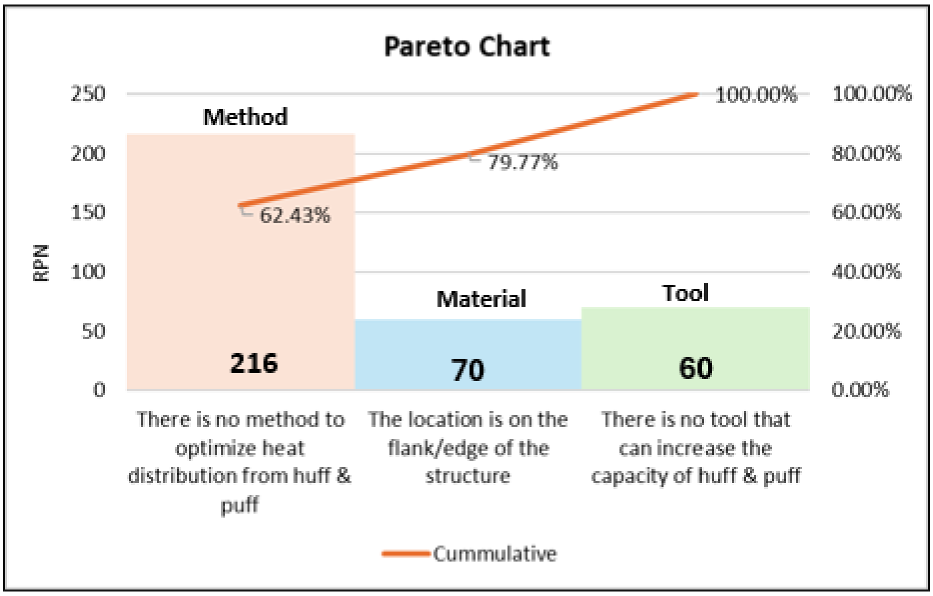

Figure 7. Pareto Chart

The 3 factors obtained through analysis using the fishbone diagram were then further analyzed using FMEA analysis to find the cause of the dominant factor occurring. From the results of the Risk Priority Number (RPN) calculation, the method factor occupies the highest position with a value of 216 (62.43%), followed by material factors (70 / 17.34%) and tools (60 / 20.23%). Pareto analysis (figure 7) resulted that main cause of inefficiency in the cycle time duration of thermal stimulation that makes oil production is not optimal is there is no method yet to optimize heat distribution from Huff & Puff, which resulted in a limited number of wells being heated and a narrow heating area. This condition has implications for long heating cycles, low utilization capacity of the Huff & Puff unit, and high operational costs per well.

D. Improve Phase

With method identified as the main cause, the team then explored several solutions to address it. Three alternative methods were compared by evaluating their effectiveness, cost, time, and mobilization risk. There are three alternative methods compared in terms of effectiveness, cost, time, and mobilization risk:

- Alternative 1: Using the previous method, using one huff & puff unit, which can only inject steam into one well.
- Alternative 2: Adding another huff & puff unit to increase the amount of thermal stimulation work.
- Alternative 3: Using the existing huff & puff unit and using parallel injection into two wells and reduce cycle time of steam stimulation in the producer well.

The following is a comparison evaluating the effectiveness, cost, cycle time and mobilization risk as shown in table 1.

Table 1. Comparison Alternatives Method

Parameter	**Alternative-1** 1 unit huff & puff for single well	**Alternative-2** Adding huff & puff units	**Alternative-3** 1 unit Huff & Puff parallel injection two wells
Effectiveness of production increase	Moderate	High	High
Cost of Huff & Puff operation	57.8 MUSD	115.6 MUSD	25.1 MUSD
Cycle Time (days/job)	20 days	20 days	7 days
Mobilization Risk	Moderate	Moderate	Low
Summary	**Not selected**	**Not selected**	**Selected**

From this comparison, the third alternative was selected, in which the parallel injection method on two wells simultaneously can increase the number of thermal stimulation operations, thereby increase oil production in Area N. In addition, the method used in the third alternative can also optimize the steam injection cycle time and soaking duration based on empirical analysis or field trials that have been conducted. This approach can reduce the cycle time from 20 days per well to 7 days for two wells at once, thereby significantly reducing thermal stimulation operational costs using the Huff and Puff unit, while achieving a high level of effectiveness that beats the current practice.

The improvement plan will focus on how to reduce cycle time in previous method and how to increase number of thermal stimulation jobs. The improvement plan will be implemented through a field trial in several of the producer well and later to be implemented to the all producer wells in Area N if the result is acceptable. In this research, to obtain an optimal cycle time and determine the appropriate method to increase the number of thermal stimulation jobs while maintaining result post-stimulation oil production and reducing Huff and Puff operational costs, a field trial was conducted by branching the steam injection line, enabling thermal stimulation to be performed simultaneously on two wells. In addition, another field trial was carried out to gradually reduce the steam injection cycle time and soaking duration until optimal results were achieved, both in terms of operational cost efficiency and oil production after thermal stimulation as an output. The following is the process flow used during the execution of parallel steam injection on two wells simultaneously as shown in figure 8 and figure 9.

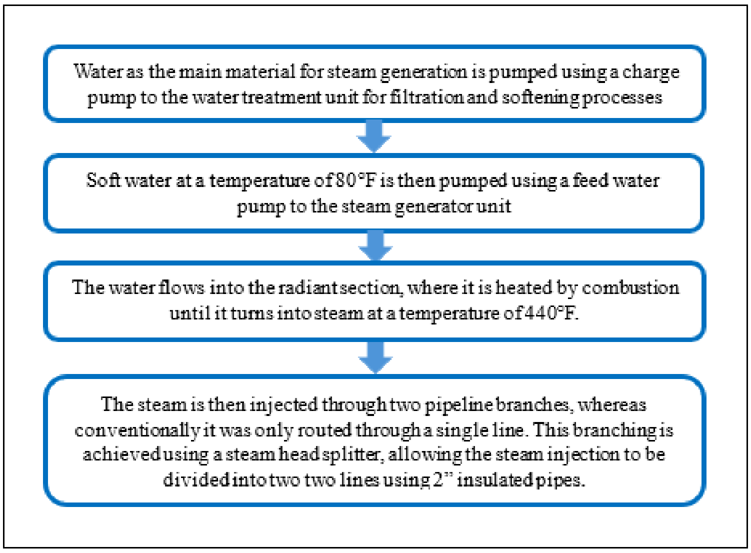

Figure 8. Flow Process of Parallel Steam Injection

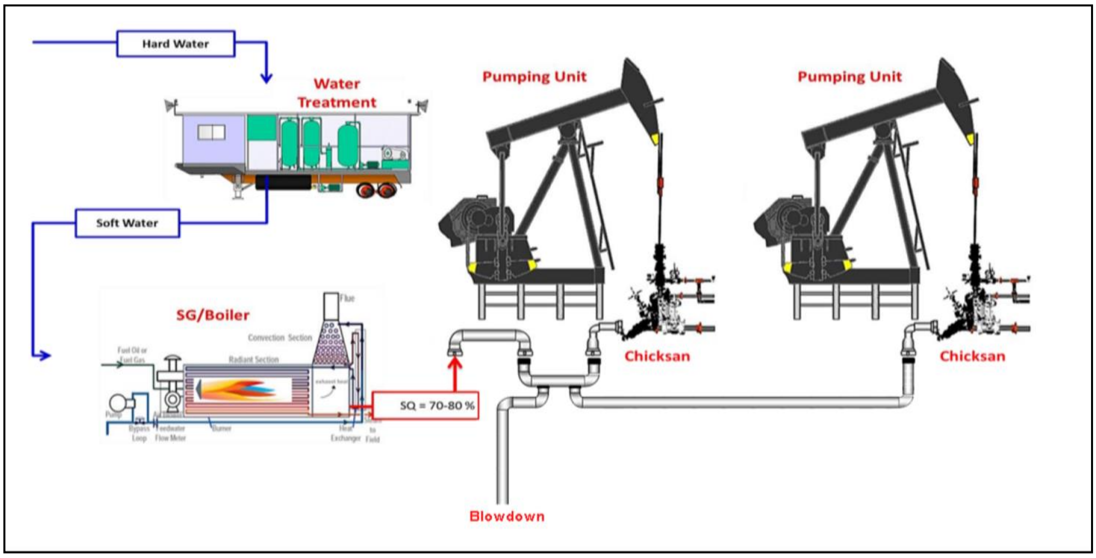

Figure 9. Illustration of the equipment components in the H&P unit for performing parallel steam injection

A field trial was also conducted to determine the optimal cycle time for thermal stimulation using the Huff and Puff unit. Based on previous practices carried out in other oil fields, Huff & Puff operations to deliver thermal energy have used a steam injection volume of 1.6 BBTU, which is equivalent to injecting through the annulus for 13 days followed by 7 days of soaking (total cycle time of 20 days). After completion, the surface equipment will be dismantled and the unit will move to the next candidate well, with an estimated moving duration of 3–7 days depending on location, manpower, and well distance. Therefore, the number of thermal stimulation jobs using the Huff & Puff unit is limited to only 1 job per month. With the improvements in the method that optimize the cycle time of the Huff and Puff unit based on the field trial results, the optimum thermal energy obtained is 0.5 BBTU per well, which is equivalent to 4 days of injection and 3 days of soaking. The total cycle time is 7 days for 2 wells that are injected in parallel simultaneously. Various cycle time scenarios conducted during the field trial to determine the optimum cycle time are shown in table 2.

Table 2. Field Trial Scenario for Huff & Puff Cycle Time

Well	Start Inject	Target BBTU	Inject Dur. (days)	Soak Dur. (days)	Put On Production	Total Cost (USD)	Remarks
A	16-Jan-24	1.6	13	7	05-Feb-24	58,106	Baseline
B	12-Feb-24	1.6	13	6	02-Mar-24	58,106	Baseline
C	18-Mar-24	1.6	13	6	06-Apr-24	58,106	Baseline
D	14-Jul-24	1.0	8	4	26-Jul-24	35,469	Field Trial
E	29-Jul-24	1.0	10	4	12-Aug-24	40,665	Field Trial
F	16-Aug-24	1.0	9	4	29-Aug-24	38,067	Field Trial
G	11-Sep-24	1.0	9	4	24-Sep-24	38,067	Field Trial
H	26-Sep-24	1.0	8	4	08-Oct-24	35,469	Field Trial
I	12-Oct-24	1.0	6	3	21-Oct-24	30,274	Field Trial
J	28-Oct-24	1.0	9	3	09-Nov-24	38,067	Field Trial
K	25-Nov-24	0.75	7	4	06-Dec-24	32,871	Field Trial
L	11-Dec-24	0.75	7	4	22-Dec-24	32,871	Field Trial
M	26-Dec-24	0.75	7	3	05-Jan-25	32,871	Field Trial
N	11-Jan-25	0.5	4	3	18-Jan-25	12,539	Improvement
O	11-Jan-25	0.5	4	3	18-Jan-25	12,539	Improvement
P	29-Jan-25	0.5	4	3	05-Feb-25	12,539	Improvement
Q	29-Jan-25	0.5	4	3	05-Feb-25	12,539	Improvement
R	10-Feb-25	0.5	4	3	17-Feb-25	12,539	Improvement
S	10-Feb-25	0.5	4	3	17-Feb-25	12,539	Improvement
T	12-Mar-25	0.5	4	3	19-Mar-25	12,539	Improvement
U	12-Mar-25	0.5	4	3	19-Mar-25	12,539	Improvement
V	26-Mar-25	0.5	4	3	03-Apr-25	12,539	Improvement
W	26-Mar-25	0.5	4	3	03-Apr-25	12,539	Improvement
Y	22-Apr-25	0.5	4	3	29-Apr-25	12,539	Improvement
Z	22-Apr-25	0.5	4	3	29-Apr-25	12,539	Improvement
AA	15-May-25	0.5	4	3	22-May-25	12,539	Improvement
AB	15-May-25	0.5	4	3	22-May-25	12,539	Improvement
AC	28-May-25	0.5	4	3	04-Jun-25	12,539	Improvement
AD	28-May-25	0.5	4	3	04-Jun-25	12,539	Improvement
AF	19-Jun-25	0.5	4	3	26-Jun-25	12,539	Improvement
AG	19-Jun-25	0.5	4	3	26-Jun-25	12,539	Improvement
AH	28-Jun-25	0.5	4	3	5-Jul-25	12,539	Improvement
AI	28-Jun-25	0.5	4	3	5-Jul-25	12,539	Improvement
AJ	10-Jul-25	0.5	4	3	17-Jul-25	12,539	Improvement
AK	10-Jul-25	0.5	4	3	17-Jul-25	12,539	Improvement
AL	20-Jul-25	0.5	4	3	27-Jul-25	12,539	Improvement
AM	20-Jul-25	0.5	4	3	27-Jul-25	12,539	Improvement
AN	1-Aug-25	0.5	4	3	8-Aug-25	12,539	Improvement
AO	1-Aug-25	0.5	4	3	8-Aug-25	12,539	Improvement
AP	12-Aug-25	0.5	4	3	19-Aug-25	12,539	Improvement
AQ	12-Aug-25	0.5	4	3	19-Aug-25	12,539	Improvement

AR	23-Aug-25	0.5	4	3	30-Aug-25	12,539	Improvement
AS	23-Aug-25	0.5	4	3	30-Aug-25	12,539	Improvement
AT	3-Sept-25	0.5	4	3	10-Sept-25	12,539	Improvement
AU	3-Sept-25	0.5	4	3	10-Sept-25	12,539	Improvement
AV	13-Sept-25	0.5	4	3	20-Sept-25	12,539	Improvement
AW	13-Sept-25	0.5	4	3	20-Sept-25	12,539	Improvement
AX	23-Sept-25	0.5	4	3	30-Sept-25	12,539	Improvement
AY	23-Sept-25	0.5	4	3	30-Sept-25	12,539	Improvement
AZ	4-Oct-25	0.5	4	3	11-Oct-25	12,539	Improvement
AAA	4-Oct-25	0.5	4	3	11-Oct-25	12,539	Improvement
AAB	15-Oct-25	0.5	4	3	22-Oct-25	12,539	Improvement
AAC	15-Oct-25	0.5	4	3	22-Oct-25	12,539	Improvement

With the implementation of the parallel injection method combined with cycle time optimization, the results can be seen from the significant increase in well production in Area N, where an oil gain of 18 BOPD per well was achieved (figure 10). Therefore, total value creation from increased oil production and reduced operational costs of the Huff and Puff unit amounts to USD 5,100,000.

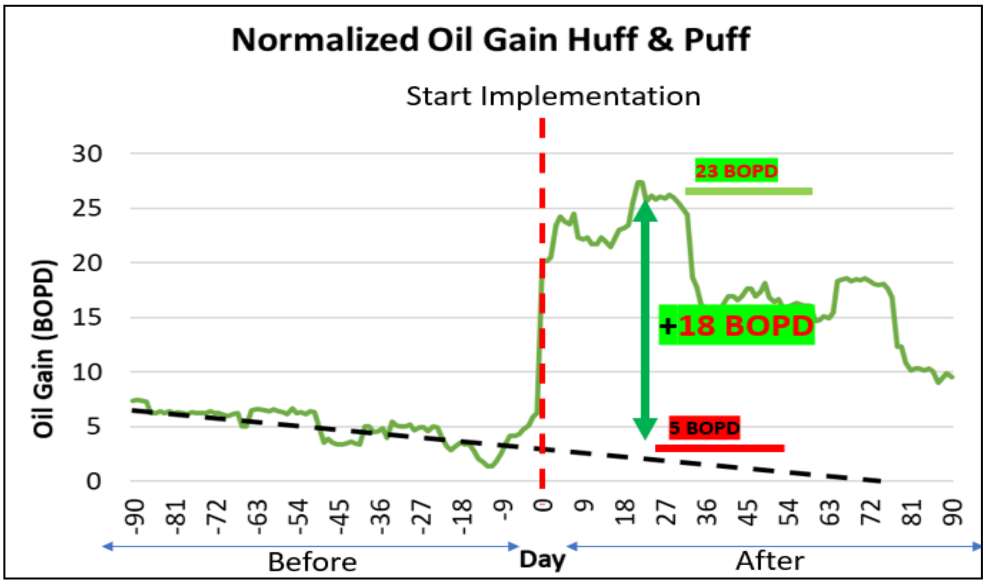

Figure 10. Oil production impact after improvement

E. Control Phase

The improvement process is monitored periodically through weekly well reviews to ensure all wells undergoing thermal stimulation with huff and puff demonstrate production performance on target. In these weekly meetings, the team discusses outstanding issues, weekly production trends, and wells requiring technical follow up. One of the main focuses is ensuring compliance with well tests after thermal stimulation to assess the well's production performance. Monitoring results indicate variations in well performance, so priorities and follow-up plans are compiled in the form of a table of findings, priorities, and remarks. These improvements are also evaluated through the Huff & Puff Monitoring dashboard, which displays stop soaking data, Put On Production dates, and production trends before and after the work. The graphical evaluation results show a significant increase in oil gain after the improvement method was applied to several wells. Monitoring is conducted weekly to ensure that the oil gain obtained remains in line with the forecast economic calculation and provides sustainable value creation.

V. CONCLUSIONS

This research discusses efforts to improve cost efficiency and enhance production in the New Steamflood Project in Area N, Dadali Field, through cycle time optimization of the Huff and Puff thermal stimulation process using the Lean Sigma approach. The main background of this research is the continuous decline in Dadali Field, and the limitations of thermal facilities. These conditions require a far more efficient thermal stimulation process to support new steamflood development in Area N. The conventional Huff and Puff process requires 20 day cycle time (13 days of steam injection and 7 days of soaking). This condition forces the well to be shut in during the entire activity, resulting in production loss and operational costs reaching USD 58,000 per job. With limited equipment availability where one unit can only serve one well at a time, the maximum number of jobs is restricted to just one well per month. Consequently, PT XYZ faces difficulties in meeting oil production targets and Opex reduction goals

Through the DMAIC phases of Lean Sigma, the researcher utilized SIPOC, process flow mapping, fishbone diagram, and FMEA. The analysis shows that the dominant root cause comes from method limitations means lack of a procedure capable of optimizing heat distribution in the reservoir, causing only a few wells to receive adequate heating. Based on the business solution analysis, an improved method for thermal stimulation using the Huff and Puff unit was identified, namely the application of parallel steam injection into two wells simultaneously combined with optimized cycle time. This improvement reduces Huff and Puff operational costs from USD 58,106 to USD 12,539 per well and shortens the thermal stimulation cycle time from 20 days to only 7 days for two wells at once. In addition, this improvement increases oil production, resulting in an oil gain of 18 BOPD per well. Therefore, the total value creation from this improvement amounts to USD 5,100,000. Implementation of this method provides several key benefits:

- Significant Opex savings due to reduced activity duration and equipment efficiency
- Increased production in Area N through faster reservoir heating
- Improved equipment utilization and job scheduling efficiency
- Stronger contribution toward achieving PT XYZ's KPIs and national production targets.

Through the Lean Sigma approach, this study demonstrates that optimizing cycle time and applying parallel injection is not only operationally feasible but also delivers significant economic impact. These findings are recommended for full implementation across all future new steamflood wells in Area N as a best practice to enhance thermal project efficiency at PT XYZ.

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