Re-engineering of Gold Precious Metal Production Process in Mining Companies

Achmad Gunawan Wibisono
Department of Industrial Engineering, Faculty of Engineering
Universitas Indonesia
Depok, Indonesia
achmad.gunawan11@ui.ac.id

Gold is a precious metal commodity used in many industries. Developing research institutions assess gold as a safe haven for investors during severe market pressure. In Indonesia, there are 15 gold producers, with one of the largest being PT Antam, Tbk. ("ANTAM"). The Precious Metal Processing and Refining Business Unit is part of ANTAM's operations and is responsible for gold processing and refining facilities. To respond to the growing demand for precious metal products, the Precious Metal Factory is expected to optimize its production capacity and product quality. Currently, the lack of recording and standardization, as well as the absence of digitization in the production process, results in significant loss and high cycle time. The aim of this study is to conduct a process reengineering analysis to reduce cycle time and increase production in the production of Antam's Precious Metal. This involves identifying waste in the production process using Value Stream Mapping (VSM) and optimizing the layout and facilities to meet the production capacity of Antam's Precious Metal

Keyword
Process Business, Gold Manufacturing, cycle time and VSM.

1. Introduction

Gold is a precious commodity used in many industries. Building up gold reserves, for example, is fundamental to establishing central bank monetary policy. Significant changes in gold prices affect economic growth (Bildirici and Gokmenoglu, 2020). Many investors include commodity investments in their portfolios, emphasizing that additional effects come from the relationship among commodity markets. In fact, it can lead to risk shocks on one commodity market spreading to other commodity markets and causing financial losses (Walid Mensi et al. 2021).

Gold has a long and unique history as a financial asset over the past 6,000 years. Growing research assesses gold as a safe haven for investors in times of severe market stress. Since the 2008 financial crisis, the price of gold has risen from $252 in July 1999 to $1,600 per ounce in 2012, and many Exchange Traded Funds (ETFs) have been established to facilitate small investors in buying gold (Zhen He et al. 2018). For decades, investment and trading in precious metal gold have attracted the attention of traders, portfolio managers, and investors. Hedging, diversification, and safe-haven properties of precious metals, especially gold, have offered significant motivation as one of the alternative investment instruments (Baur and Lucey 2010).

Fluctuations in COVID-19 cases result in uncertainty effects that are subsequently transferred to the monetary market (Baek and Lee, 2021). After COVID-19, financial market volatility has significantly increased, resulting in huge losses for market participants. In contrast, commodity prices are highly fluctuating with the decline in crude oil prices due to reduced demand. However, gold prices reached an all-time high with expectations of economic recovery. As a result, during the pandemic, financial markets became more volatile (Su Yuandong et al. 2022).

The initial stage of the COVID-19 pandemic in the US instantly had adverse effects on US Treasuries, international markets, and prompted investors to invest in precious metal gold (Semeyutin and Downing 2022). Retail investors' attention currently focuses on the current gold price trend and projects its future (Piccoli Pedro et al 2021).

Based on USGS Table 1 data, the total world gold reserves are estimated to be 54,000 tons of gold. Countries with the largest gold reserves include Australia, South Africa, and Russia. Indonesia has gold reserves of 2,500 tons. Gold consumption, according to Metal Focus data, is used in various sectors such as jewelry, technology materials, investment, and central bank needs. From this data, the largest gold consumption is for jewelry, followed by the investment sector. In 2018-2019, the investment sector's demand increased by 9% (Figure 1).

Table 1. Reserves Gold in The Word
Source: (Ober, 2017)

No	Country	Reserves (Ton Au)
1	United States	3,000
2	Australia	9,800
3	Brazil	2,400
4	Canada	2,200
5	China	2,000
6	Ghana	1,000
7	Indonesia	2,500
8	Kazakhstan	1,000
9	Mexico	1,400
10	Papua New Guinea	1,300
11	Peru	2,300
12	Russia	5,500
13	South Africa	6,000
14	Uzbekistan	1,800
15	Other Countries	12,000
	World Total	**54.000**

SEKTOR	2018	2019	YEAR-ON-YEAR % CHANGE
Jewerelly (ton)	2.243,6	2.118,6	▼ - 6
Technology (ton)	334,8	326,6	▼ - 2
Investment (ton)	1.167,2	1.274,9	▲ 9
Central Bank & other inst. (ton)	656,2	648,2	▼ - 1
Gold Demand (ton)	**4.401,9**	**4.368,3**	▼ - 1
LBMA Gold Price, (US$/oz)	1.268,5	1.392,6	▲ 10

Figure 1. Data Consumption Gold in The Word
Source: Metal Focus though ESDM

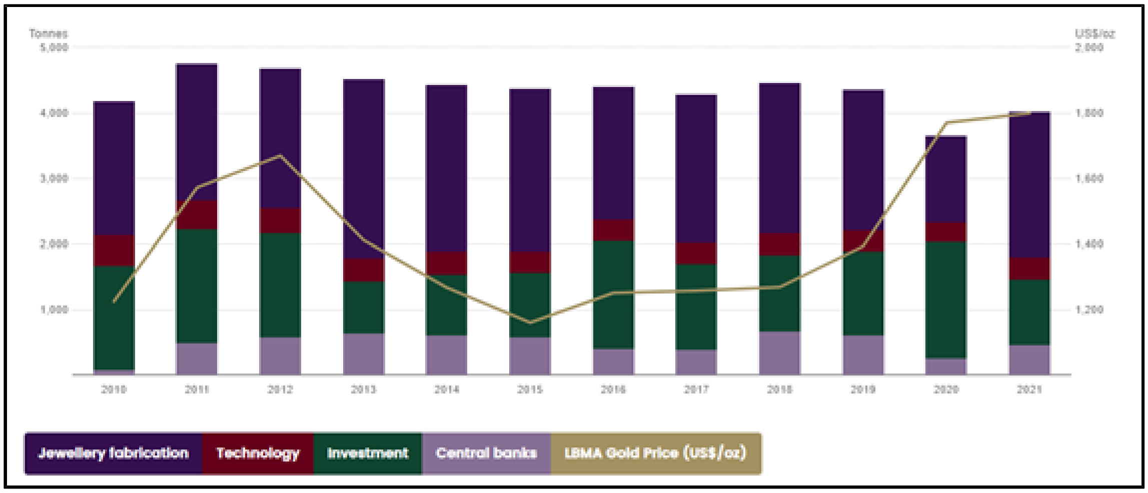

Figure 2. World Gold Demand
Source: Metal Focus & World Gold Council, 2021

World gold demand (Figure 2) based on Metal Focus & World Gold Council data from 2010 to 2021 is fluctuating and tends to increase from 2015 to 2021. This proves that gold is one of the materials that is highly needed in various industrial sectors. From a pricing perspective, based on this data, there has been a significant increase in price from 2019 until now. In Indonesia, there are 15 Gold Producers. One of the largest producers is PT Antam, Tbk. ("ANTAM"). ANTAM is a diversified and vertically integrated mining company with operating assets spread across several regions in Indonesia. ANTAM's activities include exploration, mining, processing and refining, as well as marketing of various commodities. One of the main commodities marketed by ANTAM is Precious Metals such as gold and silver.

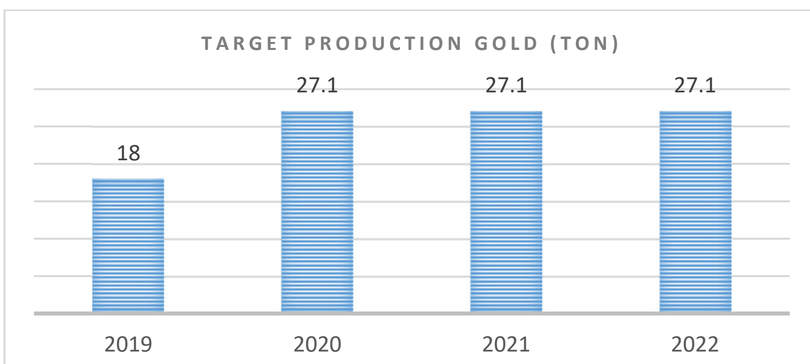

Figure 3 Target Production Gold ANTAM
Source (Production ANTAM)

Based on the data in Figure 3, the target production of Antam's Precious Metals in 2019 was set to reach 18 tons per year, while in 2020-2022 the target increased to 27.1 tons per year. If we analyze it monthly, based on the Target vs. Realization Production of Antam's Gold data, the realization result was below the target, with a gap of -6% to -44%. This could potentially become a problem in the following year if Antam doesn't take any improvement and innovation actions related to meeting the set production target. Reorganizing and redesigning traditional business processes is an essential factor for manufacturing organizations. Business Process Reengineering (BPR) is one of the best methods that should be applied to achieve this goal (Bhaskar 2018). The main objective of this method is to improve overall manufacturing quality (Ghanadbashi and Ramsin 2016). BPR provides a roadmap on how to efficiently achieve operational goals in terms of increasing flexibility and productivity, reducing costs, and improving the quality of product services.

In the process of producing Precious Metals, there is no recording at each stage, and there is no standardization and digitalization, which results in loss time and a significant impact on cycle time. This is evident from the monthly target and realization data, which shows a significant gap. Monthly targets are set in the Work Plan and Budget (RKAP). In the process of producing Precious Metals, operators play an important role, so if there is an error in the operator's work, it can cause a mismatch in the resulting product.

1.1 Objectives
Based on the background described above, the research problem of this study is how to redesign the production process of ANTAM's Precious Metal Gold to increase production and reduce cycle time in the production process using Business Process Improvement (BPI) method. In improving business processes, BPI is a system used to help organizations make significant progress in their business processes.

2. Literature Review
According to Walter (1994), BPR is a general term that encompasses various perspectives to influence organizational change. BPR enables managers to see their business as a set of processes driven by customers. The basis of BPR is to identify gaps not only in customer service, but also along the supply chain and external environment. Ultimately, BPR acts as an analytical and implementation tool. The productivity benefits of BPR ensure that organizations are responsive to customer needs, efficient in their use of time, human resources, and finances, and competitive in the liberal global economy.

Business Process Reengineering (BPR) is a process of radically and dramatically changing business processes to make them more effective and efficient without changing the organizational structure and function of the business processes themselves. BPR was first written and published by Hammer (1990), Davenport & Short (1990), and Hammer & Champy (1994), "Re-engineering is the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service, and speed." Hammer and Champy (1994, p32) state that Business Process Reengineering (BPR) is a completely new approach to the ideas and models used in business improvement. Davenport & Short (1990) view Business Process Reengineering as an extension of "industrial engineering".

VSM is a method that has been known worldwide for over 50 years, under the name "Material and Information Flow Mapping" at Toyota in Japan. This industrial engineering technique maps the value flow in all processes, from material entry into production to actual material delivery to customers. By using this method, processes that add value or do not add value can be investigated and monitored in production, logistics, administration, and service processes. The purpose of VSM is not only to monitor material flow but also to ensure that information flows according to standard procedures in individual process representations.

Mapping the value flow is not just a map of the current state but also a map of the future value flow. All processes that change raw materials into final products form the value stream. Value is a crucial element for customers, and it is calculated as the ratio of product performance to cost. When mapping the value stream and creating current and future state maps, it is appropriate to implement and utilize all changes in production plans, such as changing new products into production processes, modifying the manufacturing process, changing the production layout, or modifying the process or technology.

The main output of mapping is a visual representation of the state of the value stream and a comprehensive view of the selected production representative. Mapping provides a credible view of congestion, potential reasons for loss, and inefficient production or storage systems. By using the VSM method, it is possible to achieve several benefits for systematic production as well as for the entire company, such as optimizing the value stream of materials, identifying potential for improvement, understanding process capacity, reducing goods in process and warehouses, mapping production status, visualizing data, reducing production lead time, and identifying bottlenecks.

Basically, there are several routes for gold purification processes at UBPP LM that are currently applied, which depend on the gold content in the dore to be processed. The dore to be processed is classified into dore with high gold content (>30%), medium (5-30%), and low (<5%) gold content. For dore with high gold content, after the smelting process, the dore is cast into ingots and sent to the dry chlorination unit. In the dry chlorination process, the dore is melted again where impurities such as Cu, Pb, and Zn will be volatilized in the form of their respective chloride gases, while silver will form AgCl which is separated from Au. Next, Au is cast into anodes and sent to the gold electrorefining unit. Meanwhile, silver chloride will be dissolved again and cemented with iron powder to produce crude silver, which is then cast into anodes and sent to the silver electrorefining unit.

For dore with medium gold content (Au content of 5-30%), after smelting, the dore is cast into ingots and melted again and granulated. The resulting granules are then subjected to the parting process in nitric acid (HNO3) solution. The parting process is carried out in a tumbler and aims to dissolve silver and separate the insoluble gold. The dissolved silver is then recovered by the electrowinning process, while the insoluble gold is separated, dried, and processed in the dry chlorination unit. For dore with low gold content (<5%), the dore is melted and cast into silver anodes. In the electrorefining process, the silver anodes are purified to produce pure silver crystals, which are then melted and granulated to produce pure silver granules.

During the electrorefining process, the gold in the silver anodes will accumulate in the anode slime. This gold-rich anode slime is then melted into gold anodes and processed in the gold electrorefining unit. Smelting is the earliest process in the series of dore purification processes, which aims to remove some impurities in the dore and determine the gold and silver content in the dore before being processed in the next stage of the process. The dore purification process begins with the weighing, smelting, and sampling of the dore melt. The smelting furnace at UBPP LM consists of 3 Morgan Furnaces and 4 Removable Crucible Gas Furnaces with a smelting capacity of 450 kg of material per batch. The initial heating is carried out for 1 hour to increase the furnace temperature to ±1100°C.

The dore smelting process is carried out for 3 hours before the sampling process is carried out using the dip sampling method using a long metallic sampler to determine the gold, silver, and impurities contained in the dore through analysis in the LM laboratory. In the dore smelting process, flux materials such as borax and dorslag are added. From the smelting process, molten metal, slag, and exhaust gas are produced. Molten metal is a gold-silver alloy and impurities that are then cast into ingots (for further dry chlorination and parting processes) or anodes (for silver electrorefining processes) based on the gold and silver content in the dore. The slag will be processed in the mineral processing unit to recover any precious metals still contained in it. The exhaust gas from the smelting process is directed to the gas cleaning system (scrubber system) before being released into the atmosphere through the stack.

Business Process (BP) enables workers and organizations to interact in a structured manner. BP is defined as a series of steps that lead to the achievement of a specific goal or the fulfillment of specific business needs. BP should collaborate with other processes to achieve common business objectives. The challenge is to provide flexibility while providing process support and constant improvement (Gomes et al., 2022). Value Stream Mapping (VSM) is a tool from quality management that can analyze the current state of a process by identifying opportunities for improvement and reducing waste. The general benefits of VSM are to improve business processes comprehensively and increase process efficiency and effectiveness. Some other advantages of VSM are to identify inventory accumulation points in business processes, to help visualize the overall current business process, to help design desired processes that are efficient, effective, and waste-free.

3. Methods

There some Method in this research:

a) The initial stage of this research is to discuss with the advisor to determine the background, formulate the problem, and set the objectives of the study.
b) Data Collection Stage: In this stage, literature related to the research is searched for. After obtaining the appropriate literature and journals, field observations are conducted to observe the existing production process. Then, discussions with experts are conducted to find the root cause of the case study.
c) As-Is Process Stage: This stage aims to analyze the existing production process of precious metals. The research uses the Business Process Re-engineering approach to identify waste in each process flow of the precious metals production. Brown paper is created in several aspects of the As-Is condition in this stage.
d) To-Be Process Stage: In this stage, the data collected is used to simulate the improvement process, comparing the As-Is condition with the proposed improvement (To-Be) condition.

4. Data Collection

This research was conducted at a precious metal processing company that focuses on process time control and improving product cycle time production. The manufacturing business process for precious metals still relies heavily on human labor, and limited space is one of the factors that will be further examined in this research. The following methods and data were used in this study:

1. Primary data collection. Primary data refers to data obtained through direct observation of the object being studied. In this research, primary data was collected through direct observation and interviews with respondents or conducting focus group discussions.
2. Secondary data collection. Literature studies from other research, journals, and books that support the research were used as secondary data.

The research model used is by applying the concept of Business Process Re-engineering and value stream mapping (VSM) to achieve better conditions than before. In this study, the time required and the savings after improvements in the production process will be calculated. The focus of this research is on products produced by the APM/API manufacturing process. In this research, observations were conducted on Senior Operations Manager, Manufacturing Manager, Assistant Manager, Supervisor, and Operator.

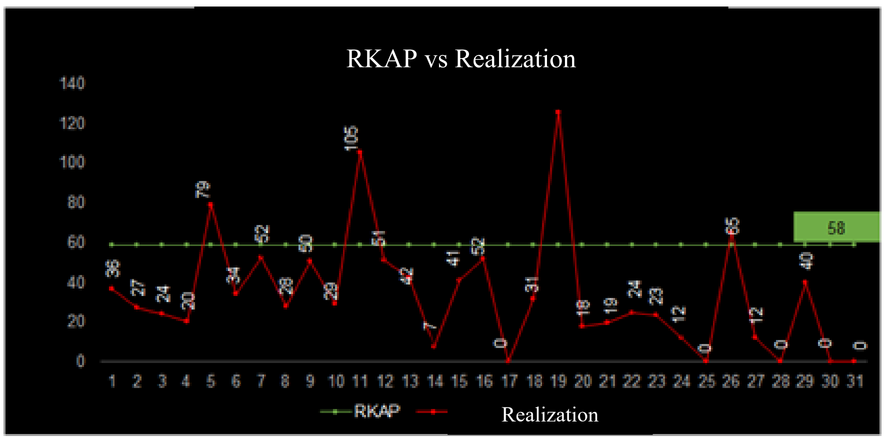

Figure 4 Target Production Gold ANTAM
Source (Production ANTAM)

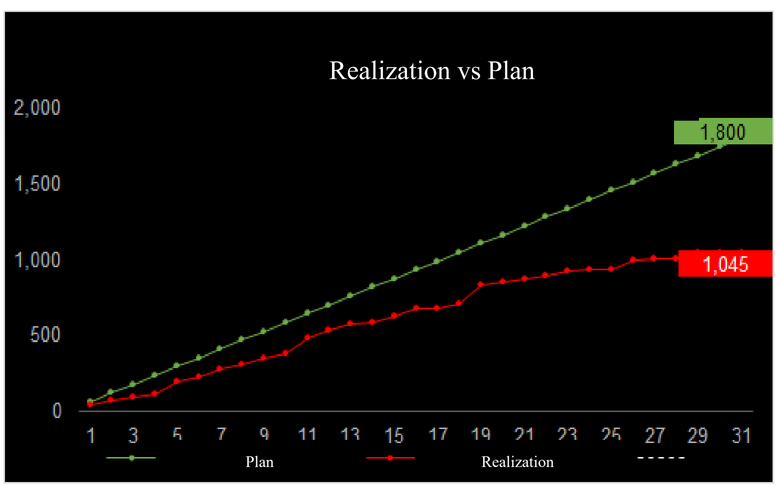

Figure 5 Cumulative Daily Gold Production Graph of UBPP LM in December 2022
Source (Production ANTAM)

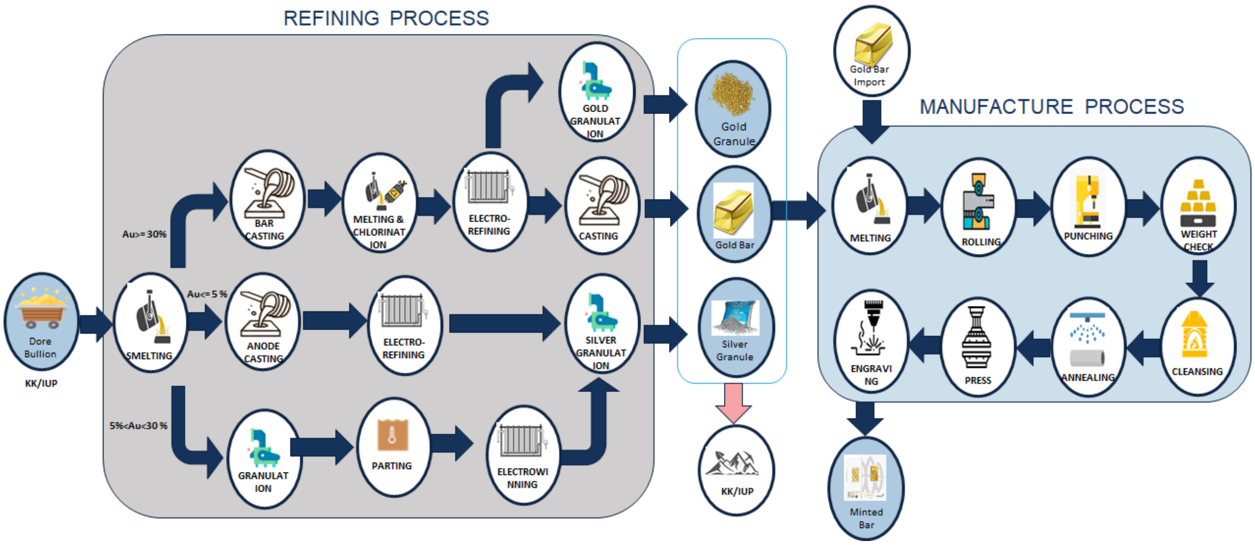

Figure 6. Flow Process Production Gold
Source : PT Antam, Tbk

The initial stage of this research begins with observation and in-depth interviews with practitioners to map the current business process (As-Is) and then followed by collecting scientific literature. After that, recording samples were taken for each process. As shown in Figure 6, the gold production process in each stage lacks recording of the processing time, which makes it difficult to determine the Service Level Agreement (SLA) in making 1 gold coin. Currently, only daily targets are instructed by the Manufacturing Manager to the operator and supervised by the supervisor and Assistant Manager. The lack of real-time monitoring recording in each process will certainly lead to potential Loss Time during the production process. Therefore, improvements are needed in the process stages of the manufacturing process. Adding control functions in the process stages and a plan to use digitalization systems in the production of precious metals, especially gold, is something to be discussed in this research. This is to ensure that all recording processes are done at each stage and analysis can be performed if there are any bottlenecks that arise in each process. Based on the data taken in December 2022 (Figure 4), only 12.9% of precious metal gold production exceeded the daily RKAP target set. And if the data from December 2022 is taken cumulatively, gold manufacturing production has only realized 58% of the RKAP target (Figure 5). Therefore, the researcher will collect data related to each process stage and conduct further analysis on each process stage.

5. Results and Discussion

Figure 7 shows the current state mapping whereas Figure 8 shows the future state mapping. Besides Figure 9 represents data time study whereas Table 2 shows the date time study by process and specification.

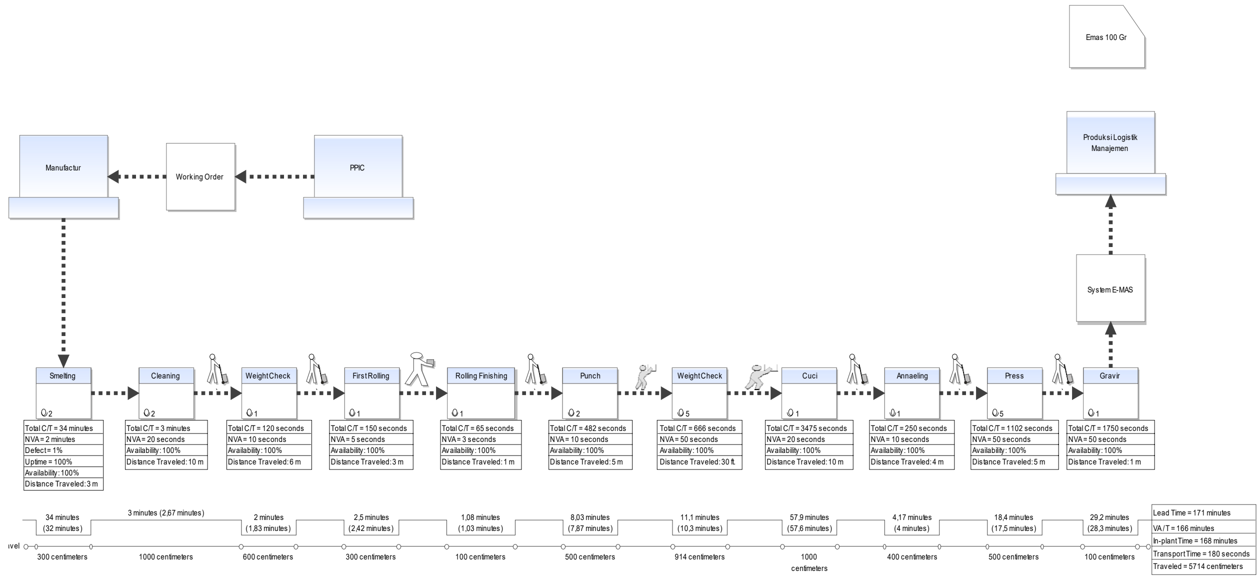

Figure 7. Current State Mapping

VSM as is onggris.igx

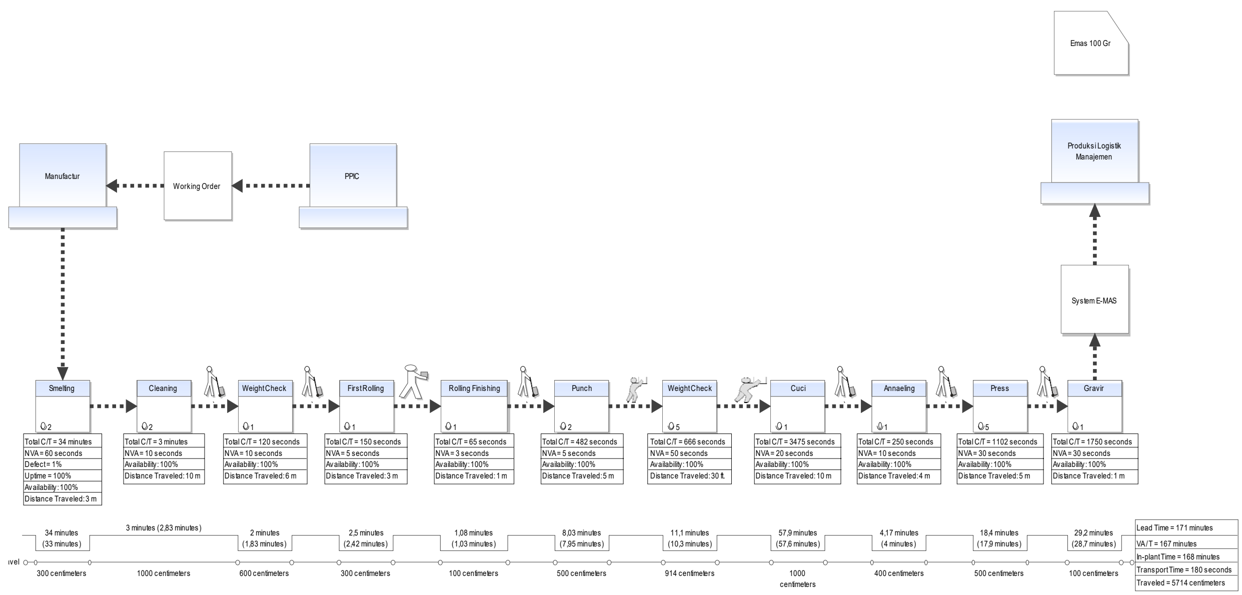

Figure 8. Future State Mappig

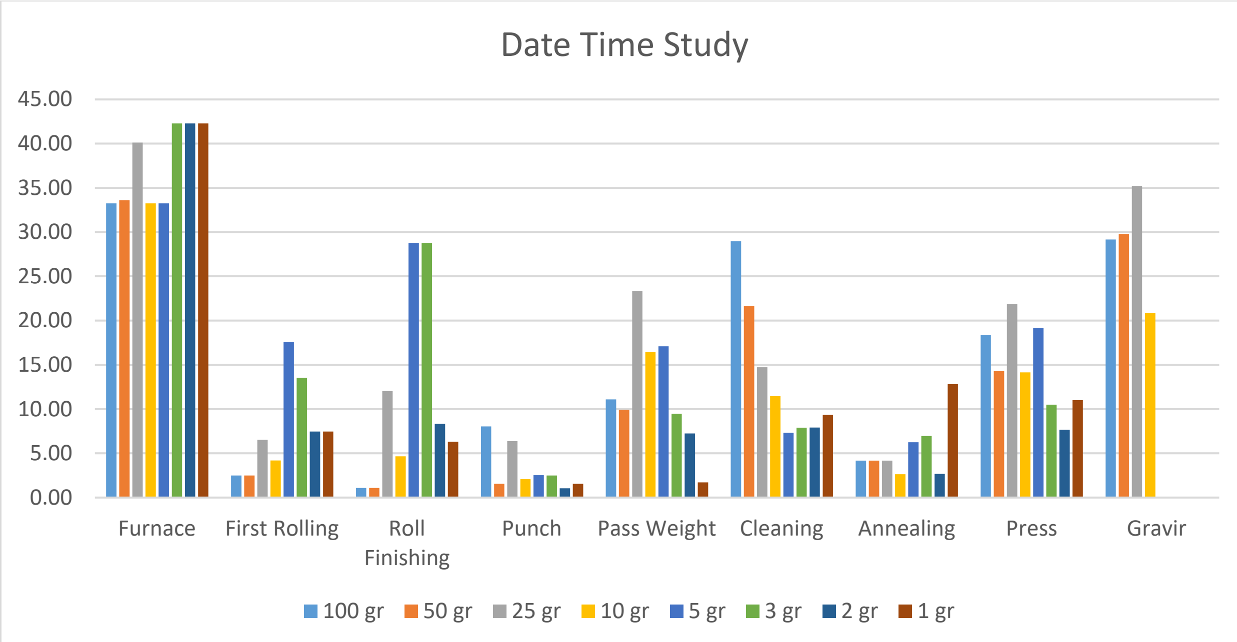

Figure 9. Date Time Study

Table 2. Date Time Study by Process and Specification

Activitiy	100 gr	50 gr	25 gr	10 gr	5 gr	3 gr	2 gr	1 gr
Furnace	33.25	33.60	40.10	33.25	33.25	42.28	42.28	42.28
First Rolling	2.50	2.50	6.52	4.18	17.58	13.53	7.47	7.47
Roll Finishing	1.08	1.08	12.03	4.67	28.78	28.78	8.33	6.30
Punch	8.04	1.56	6.38	2.08	2.53	2.50	1.04	1.56
Pass Weight	11.10	9.92	23.36	16.43	17.08	9.46	7.25	1.72
Cleaning	28.96	21.67	14.73	11.46	7.32	7.90	7.92	9.33
Annealing	4.17	4.17	4.17	2.64	6.25	6.95	2.68	12.81
Press	18.36	14.29	21.90	14.14	19.19	10.50	7.67	11.00
Gravir	29.17	29.79	35.21	20.83	0.00	0.00	0.00	0.00
Total (Minutes)	136.62	118.58	164.39	109.69	131.98	121.91	84.64	92.47
Total (Hours)	2.28	1.98	2.74	1.83	2.20	2.03	1.41	1.54

6. Conclusion

Through the use of BPR (Business Process Reengineering) and VSM (Value Stream Mapping) tools, we can understand the existing process in the gold manufacturing industry and improve it. By creating current state mapping and future state mapping, we can increase the production of precious metal gold. This can serve as a benchmark for other companies in the precious metal gold industry. However, there are still areas that need improvement, such as automation in every process. This is because many other industries are already implementing Industry 4.0.

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Biography

Achmad Gunawan Wibisono is bachelor's degree of Electrical Engineering at University of Indonesia. He is a student of master's degree in the Industrial Engineering at University of Indonesia, Jakarta, Indonesia. He is interested in the field of Project Management and Operation areas and has work as Base Metal Operation Excellence Division, PT Antam, Tbk.