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Pertamax Quantity Optimization by Controlling Losses Using Vapor Recovery Unit at Fuel Terminal Bandung

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Abstract

This research addressed Pertamax losses due to evaporation in fixed roof tanks at a fuel terminal, a storage and distribution facility. Evaporation leads to hydrocarbon vapor emissions, negatively impacting the environment. To mitigate this, a Vapor Recovery Unit (VRU) was proposed, capable of capturing up to 95% of hydrocarbon vapors and converting them back into liquid form. The study utilized breathing loss and working loss calculations to evaluate the VRU's efficiency in reducing emissions and controlling losses. The results demonstrated that the VRU significantly reduced environmental emissions and operational losses, making it a strategic solution to improve efficiency and sustainability at the terminal. Additionally, implementing the VRU aligns with environmental regulations and operational goals. This research serves as a foundation for further exploration of VRU technical installation, performance optimization, and broader application in the field to enhance environmental and operational outcomes in similar facilities..

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1. INTRODUCTION

The rapid economic growth in Indonesia has led to an increase in the need for energy, particularly fuel oil, which has become an essential requirement for society. The demand for gasoline is steadily increasing due to the growing transportation needs and population [1]. This necessitates a timely and suitable supply of fuel to ensure uninterrupted economic operations. Fuel terminals in the oil and gas industries serve the purpose of receiving, stocking, and distributing fuel oil, playing a crucial part in the economy. One of the significant challenges in oil storage is the devaluation of products like Pertamax caused by evaporation and leakage, resulting in adverse effects on the economy and the environment [2] [3] [4].

Pertamax is the popular choice among consumers in the oil and gas industry due to its commendable effectiveness in mitigating engine damage and enhancing operational efficiency. Pertamax, with its superior research octane number (RON) of 92 and enhanced engine performance design, is an optimal selection for oil and gas sector applications [5]. Managing fuel oil presents challenges in minimizing losses due to its inherent volatility. Oil losses refer to the financial losses that arise from the decrease in the value of oil, which can be caused by factors such as changes in its quality or volume during the computation of fuel quantity [6] [7].

Fuel losses in the oil and gas sectors pertain to the quantity of fuel that is wasted during the various stages of production, storage, and distribution [8] [7] [9]. Evaporation is the primary factor contributing to fuel losses. Evaporation is induced by fluctuations in temperature, pressure, and ambient conditions. This study employed the working loss and breathing loss techniques to detect the decline in fuel quality that takes place at the fuel terminal. In order to address the issue of fuel losses, effective solutions like controlled fuel storage and delivery technology and infrastructure are needed [10] [11].

This study employed Vapor Recovery Unit (VRU) technology to effectively manage losses control. The system captures and redirects fuel vapour released into the air back to the storage tank, thereby minimizing carbon emissions and offering economic benefits [12]. Additionally, the VRU successfully captured the volatile organic compounds (VOCs) present in the product stored in the tank. Furthermore, VRU technology employs a carbon adsorption technique to minimize the inhalation of fuel vapors when dispensing. This study utilizes activated carbon as an adsorbent to capture gasoline vapor from the tank and subsequently reintroduce the condensed fuel back into the tank [13]. The objective of this study was to optimize the amount of Pertamax fuel by managing losses through the use of a VRU at the fuel terminal [14].

.2. RESEARCH METHOD

Site and Time

This study was conducted at Fuel Terminal Ujung Berung located in Bandung, Indonesia. The duration of the study was 2 years, starting from January 2022 to December 2023.

Data Collection and Technical Operation

This study assessed the Pertamax loss, the effects of using VRU to control pertamax loss during storage, as well as the factors influencing this loss [15].

Vapor recovery unit operation

This study utilized the Vapor Control System (VCS), a specifically developed system that captures vapors or gases produced during the process of fuel loading or dispensing. The primary objective of utilizing VCS was to mitigate or diminish the release of pollutants from gasoline vapors, which can lead to air pollution or other environmental risks. A vapor recovery unit is a system consisting of interconnected pipes, tanks, and equipment that is utilized to transform oil vapor into a liquid state. Approximately 95% of hydrocarbon vapors emitted from low-pressure storage tanks were successfully caught.

The VRU consisted of two vessel units that were utilized for the purposes of adsorption and regeneration procedures. During operation, one vessel unit functioned as an adsorption unit while the other vessel unit functioned as a regeneration unit. The absorber column functioned to facilitate the absorption process, in which the fuel vapor would come into contact with the liquid absorbent, causing it to transition into a liquid state. An air compressor was utilized to reclaim carbon. The product pump was responsible for transporting the absorbent material to the absorber column and transferring the recovery outcomes to the product storage tank. The vent served as an air exhaust duct. The fuel vapor that entered the vessel was impure, as it was often mixed with free air that had a diverse composition. Consequently, the vent will eliminate the free air throughout the adsorption process. The seal fluid cooler or separator functioned to separate condensate and other particles from the fuel vapor. This component also served as a decanter, facilitating the separation of water. Pipelines are utilized to transport both the fuel vapor and the recovered fuel product.

Carbon adsorption

The VRU utilized the carbon adsorption technology for implementation, which effectively minimizes the exposure to fuel vapor throughout the distribution process. Activated carbon functions as an adsorbent, capturing fuel vapor from the tank and subsequently releasing the condensed gasoline back into the tank. The objective of this method was to minimize losses and mitigate the risk of hazards. Hence, the most optimal technique to be implemented in the VRU was the carbon adsorption method [13]. The operational procedure of the VRU is illustrated in Figure 1.

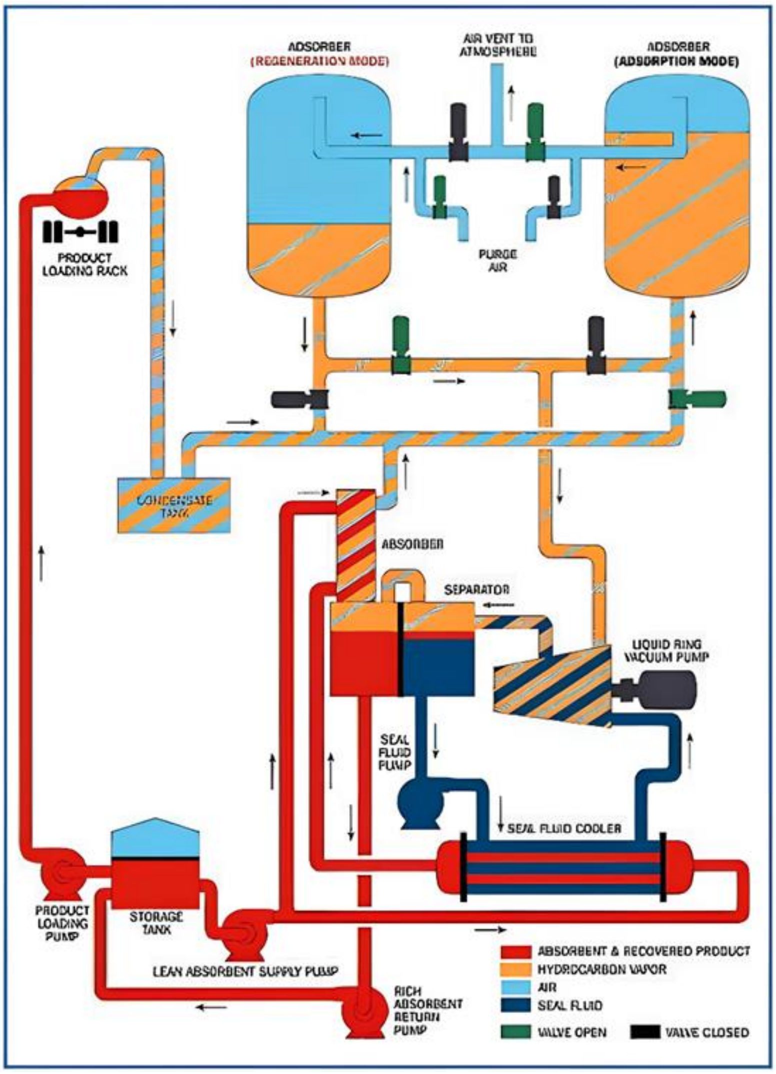

Figure 1. Vapor Recovery Unit Operating Procedure

The VRU was equipped with two adsorber columns filled with activated carbon. One adsorber column was supplied with vapor as an input (on stream), while the second adsorber column was subjected to a desorption or regeneration process (off stream). The adsorber column captured the fuel oil vapor by utilizing activated carbon. At this stage, the fuel vapor was transported through the activated carbon and discharged through the ventilation system between the adsorber columns. Both columns were equipped with valves that served to regulate the ongoing activity. If there was no pressure or fuel vapor input, the VRU would promptly disengage, and it would be automatically engaged when a pressure differential was caused by the presence of fuel vapor. The fuel vapor that had been absorbed by the activated carbon during the regeneration process exited the adsorber column and entered the vertical absorber column. The fuel product stream acted as an absorbent, causing the fuel vapor in the vertical absorber column to condense from the gas phase to liquid.

Formula of evaporative losses

A methodology was employed to calculate the breathing loss and working loss in order to ascertain the magnitude of losses incurred at the gasoline terminal. This computation introduced a novel approach to compute evaporative losses in order to limit the depletion of evaporative fuels. The calculating formulas were outlined in the subsequent equations.

Breathing loss in fixed roof tanks was calculated using the following equation:

$$\mathrm{Ly} = \mathrm{Kc}\left(\frac{24}{1000}\right)\left(\frac{\mathrm{P}}{14{,}7-\mathrm{P}}\right)^{0.68} \mathrm{D}^{1.73}\mathrm{H}^{0{,}51}\mathrm{T}^{0{,}50}\ \mathrm{F_P}\ \mathrm{C} \qquad (1)$$

where Ly = Breathing Loss (BBL/yr)
Kc = Product Factors
P = True Vapor Pressure at liquid temperature (psia)
D = Diameter of Tank (ft)
H = Ullage Height including roof volume correction (ft). The volume of a cone roof is equivalent to a cylinder having the same diameter and one-third the height of the cone.
T = Daily average ambient temperature change (°F)
Fp = Tank paint factor, determined from field test results or estimated based on tank paint factor tables.
C = Adjustment factor for small diameter tanks

Working loss on fixed roof tanks was calculated using the following formula:

$$L_W = 0{,}0010\ M_V\ P_{VA}\ Q\ K_N\ K_P \qquad (2)$$

where Lw = Total working loss in one year (lb/yr)
MV = Molecular weight of vapour (lb/lb-mole)
PVA = Vapour pressure at daily average liquid surface temperature (psia)
Q = Total annual net utilisation (bbl/yr)
KN = Product working loss factor. For Crude Oils KP = 0.75, other Organic Liquids KP = 1
KP = Turnover working loss factor (saturation factor)
For turnovers > 36, KN = (180 + N)/6N
For turnovers ≤ 36, KN = 1
N = Number of turnovers per year, dimensionless
N = Q/VLX, where VLX = Maximum liquid volume in the tank.

The relationship between RVP with vapor molecular weight (Mv), and liquid density (ML) with True Vapour Pressure, PVA (psia) at various temperature changes (ºF) is presented in Table 1.

3. RESULTS AND DISCUSSION

The data acquired through the utilization of VRU effectively accomplished the predetermined objectives. The data was computed utilizing mathematical methods and verified through conclusive testing. The storage tank at the fuel terminal was equipped with a fixed roof, resulting in evaporative losses. These losses were analyzed using the methodologies of breathing loss and working loss to assess the evaporation of Pertamax over the periods of 2022 and 2023.

Breathing Loss

Breathing loss was occured naturally due to temperature factors inside and outside the tank. Breathing loss of Pertamax products for the period of 2022 resulting from calculations using the formula produces different volumes of lost Pertamax (Table 2).

Table 1. Properties (Mv, WL, P_{VA}) of Selected Petroleum Liquids

Petroleum Liquid	Liquid Mole Weight	Molecular Weight of Vapour, Mv	Liquid Density (lb/gal 60F), Wl	Reid Vapour Pressure, Pva, (psia) at temperature (F) :						
	lb/lb-mole	lb/lb-mole	lb/USG	40	50	60	70	80	90	100
Pertamax	92	67	5.6	3.0618	3.7726	4.6111	5.5934	6.7365	8.0586	9.5786

Table 2. Receipt data pertamax

Periods	Volume (L)
2022	206.405.556
2023	202.655.476

The breathing loss in tanks 04 and 05 was calculated using the Pertamax intake data for the 2022–2023 period as a guide, enabling the calculation of the breathing loss %. In contrast, the following supporting data are used for calculations using the author's formula: tank diameter, tank height, average temperature, tank coating factor, and adjustment factor. These calculations yield the predicted results. Figure 2 depicts the rise in Pertamax breathing loss in tanks 04 and 05 over the course of 2022, while Table 3 displays the volume of Pertamax in liters that suffered breathing loss in tanks 04 and 05 as well as the overall volume.

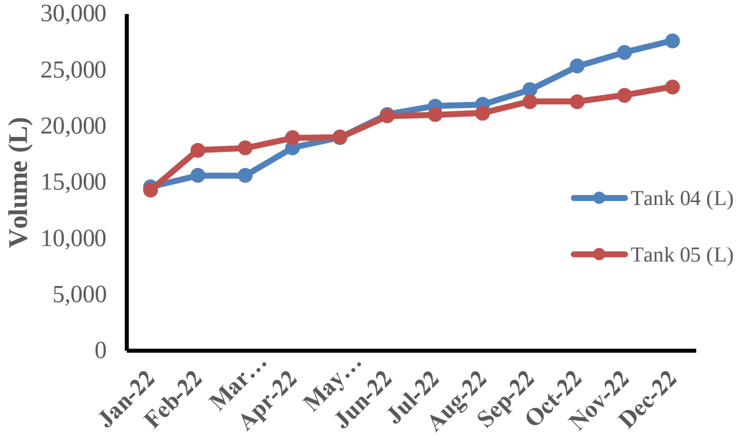

Figure 2. The pattern of Pertamax breathing loss during one year period in 2022. (data were calculated using calculated using the Pertamax intake data for the 2022 at Fuel Terminal Ujung Berung that located in Bandung, Indonesia)

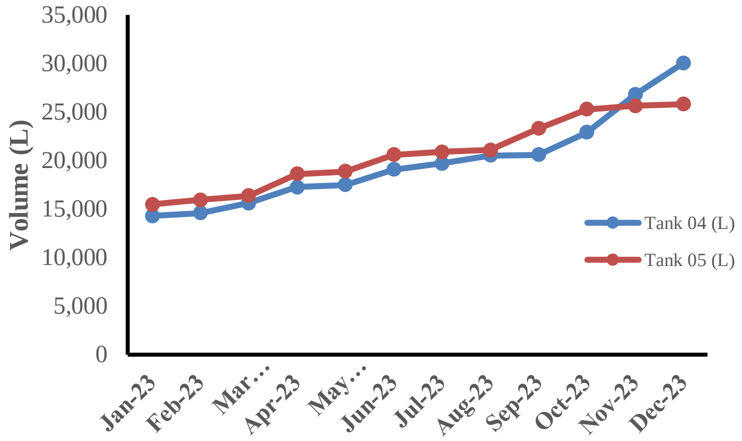

Figure 3. Breathing loss pertamax during the period 2023 (data were calculated using calculated using the Pertamax intake data for the 2023 at Fuel Terminal Ujung Berung that located in Bandung, Indonesia)

Table 3. Breathing loss pertamax during the period 2022 (data were calculated using calculated using the Pertamax intake data for the 2022 at Fuel Terminal Ujung Berung that located in Bandung, Indonesia)

Periods	Tank 04 (L)	Tank 05 (L)
Jan-2022	25.34	21.17
Feb-2022	21.04	20.92
Mar-2022	27.62	21.02
Apr-2022	21.93	14.29
May-2022	15.60	18.96
Jun-2022	21.80	22.20
Jul-2022	19.00	22.75
Aug-2022	26.58	18.07
Sep-2022	14.60	17.86
Oct-2022	15.61	23.51
Nov-2022	23.24	22.18
Dec-2022	18.10	19.01
Total	**250.52**	**241.99**
Total 2 tanks	**492.52**	

Table 4. Total breathing loss pertamax during the period 2023 (data were calculated using the Pertamax intake data for the 2023 at Fuel Terminal Ujung Berung that located in Bandung, Indonesia)

Periods	Tank 04 (L)	Tank 05 (L)
Jan-2023	17.47	18.88
Feb-2023	14.29	20.57
Mar-2023	19.07	20.87
Apr-2023	26.78	16.35
May-2023	22.88	23.27
Jun-2023	20.51	21.08
Jul-2023	19.68	25.63
Aug-2023	20.57	25.26
Sep-2023	15.61	25.79
Oct-2023	14.60	18.60
Nov-2023	30.03	15.93
Dec-2023	17.27	15.48
Total	**238.82**	**247.78**
Total 2 Tanks	**486.60**	

Working Loss

According to ASTM D1250, the working loss calculation uses standard volume (Barrel 60oF). The data needed to calculate working loss for the period 2022-2023 is shown in Table 5 and Figure 4. Working loss for Pertamax products during the study occurred as a result of the receiving and distributing process.

Table 5. Total working loss of Pertamax during periods 2022 and 2023

Periods	Working Loss (L)
2022	417.16
2023	428.17
Total	845.34

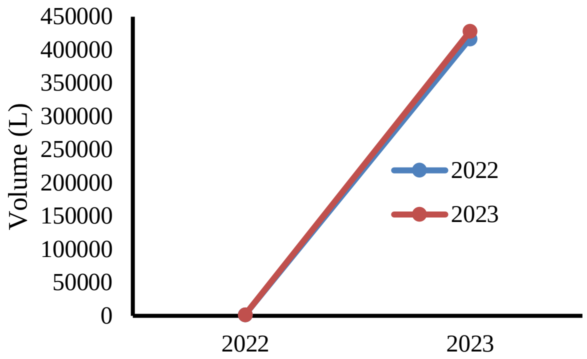

Figure 4. Pattern of Pertamax working loss during the period 2022 and 2023.

Upon employing the breathing loss and working loss methods, the fuel terminal encountered a decrease in Pertamax products caused by evaporation. This is showed in the table, which indicates that the breathing loss number surpasses the working loss figure. The disparity in the acquired figures is minimal, yet it poses a significant detriment to the fuel terminal if the underlying causes of the losses incurred during the fuel's reception, storage, and distribution, particularly Pertamax, are not identified. Evaporative losses at the fuel terminal result from various factors, including the use of a fixed roof tank and temperature fluctuations. When there is empty space (ullage) in the tank, Pertamax fuel evaporates to fill the ullage, leading to a decrease in the volume of Pertamax. Another contributing element to losses is the inherent nature of the product itself. Pertamax, with its unique characteristics, possesses a Reid Vapor Pressure (RVP) value ranging from 45 to 69 kPa, making it prone to evaporation. Conversely, inadequate attention to human or worker factors during sampling or dipping might have a significant impact..

Recovery Product

The VRU was installed in storage tanks 04 and 05, which have a maximum capacity of 11,544 KL and 11,878 KL, respectively. The VRU utilized the carbon adsorption method, which yielded optimal advantages due to its superior effectiveness, resulting in emissions that adhere to existing pollution regulations. The gasoline terminal derived a benefit from the deployment of VRU in the form of revenue generated from the sale of recovered products. The recovered product was determined by multiplying the VRU efficiency by the total volume of evaporative losses. The recovery product resulting from the adoption of VRU is displayed in Table 6.

Table 6. Total recovery product of Pertamax during the periods of 2022 and 2023

Periods	Evaporative Losses (Liter)	VRU Efficiency (%)	Recovered Product (Liter)
2022	909.68	95%	864.20
2023	914.78		869.04

Data in Table 6 shows the amount of Pertamax that can be collected and reintroduced to the product in liquid form was 864,201 liters in 2022 and 869,042 liters in 2023, in order to maximize the quantity of Pertamax with a VRU efficiency level of 95%. This study examined a critical matter in the storage and distribution of fuel: the evaporation-induced loss of Pertamax. The VRU is the primary solution that has been suggested. This device is capable of recapturing dissipated fuel, which not only mitigates environmental damage but also provides economic benefits. This study emphasizes the significance of technology such as VRU in mitigating these emissions, in line with wider worldwide endeavors to reduce air pollution and tackle climate change Integrating VRUs in fuel terminals exemplifies a pragmatic strategy to harmonize environmental obligations with commercial advantages. By reclaiming a substantial amount of evaporated Pertamax, fuel terminals can not only decrease their environmental impact but also recover commercial losses. Its twofold advantage underscores the possibility of wider use of the VRU in the oil and gas sector. Analyzing the regional environmental impacts of upstream oil and gas operations, [3] identified evaporation from storage tanks as a significant contributor to air pollution. This work enhances the existing knowledge by specifically addressing these environmental issues. The VRU system not only mitigates hydrocarbon emissions, but it also integrates with the environmental conservation measures promoted by [3] Their research focused on policy initiatives, but this study demonstrates a technology solution to supplement regulatory efforts.

The study revealed data indicating significant Pertamax losses in 2022 and 2023, with 492,520 liters attributed to breathing loss and 417,165 liters attributed to working loss in 2022. The implementation of the VRU yielded a recovery rate over 95%, resulting in the retrieval of 864,201 liters in 2022. These results demonstrate the VRU's capacity to greatly reduce losses. The quantitative efficacy of the VRU implementation in mitigating Pertamax loss substantiates the need for its extensive use. The potential cost reductions resulting from the recovery of such significant amounts of fuel might be considerable, rendering it a highly attractive investment for fuel storage owners, particularly in areas facing stringent environmental restrictions. The study conducted by [9] who investigated the management of fuel loss, with a specific emphasis on evaporation in storage infrastructure. Consistent with these results, their study emphasized the substantial losses caused by fluctuations in temperature and pressure. The present work extends the analysis by calculating the recovery potential of the VRU system. The research presented in this study provides actual data that extends beyond the detailed exploration of the 95% recovery efficiency in their previous work.

Although the technological aspects are clearly elucidated, future research should prioritize the optimization of the operational parameters of VRUs in order to further augment their efficiency. For example, acquiring knowledge about the optimal parameters for adsorption and regeneration cycles could result in even greater improvement in recovery rates or decreased operational expenses. The study conducted by [13] directly examined the efficacy of carbon adsorption techniques in mitigating vapor emissions from gasoline storage tanks. Their research is highly congruent with the technical methodology employed in this paper. The results of both investigations indicate that carbon-based adsorption methods are quite efficient in reducing vapor losses

The recovery of evaporated fuel offers a significant economic incentive that plays a vital role in driving the adoption of VRUs. The current aspect of the research pertains to overarching trends in the oil and gas industry, marked by the escalating rigor of environmental regulations and the efforts of companies to improve efficiency while reducing their environmental footprint. Ramdani et al. (2023) investigated the wider economic consequences of fuel volatilization in the Indonesian oil and gas industry. In contrast to their research finding, which emphasized the macroeconomic consequences of oil product losses, this current study adopts a more targeted technological strategy to alleviate these losses. Through the implementation of a VRU system, this study effectively connects economic research with technical solutions, providing a pragmatic solution to the concerns presented by [2].

4. CONCLUSION

This study demonstrates effectively the significance of employing Vapor Recovery Units to enhance fuel terminal operations through the reduction of Pertamax evaporation losses. It makes a strong case for the environmental and economic benefits of implementing VRU technology, providing valuable insights for fuel storage facilities facing similar challenges.

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