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WATER CONDENSER BED TO REDUCE TRICHLOROETHYLENE GAS EMISSION AND AIR QUALITY

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ABSTRACT

Purpose: The purpose of this research is how to reduce trichloroethylene emissions using a condenser and the efficiency of reducing trichloroethylene emissions before and after using a condenser.

Theoretical Framework: Air quality is influenced by trichloroethylene emissions, condenser and efficiency, trichloroethylene emissions, and condenser.

Method: The research carried out was quantitative descriptive research. Data Source: Literature Study; Field observation; Trichlorethylene gas recovery process in existing systems in the field such as dryer units, carbon bed units and added condenser units. Sampling method with Trichlorethylene, Gas Emission, Concentration Measurement.

Results and Discussion: The efficiency value of reducing the trichloroethylene gas emission load before and after adding the condenser reached 68.16%. The emission load on the chimney before adding the condenser was an average of 223 kg/day and after adding the condenser an average of 71 kg/day.

Research Implications: The efficiency of reducing the trichloroethylene gas emission load is influenced by several supporting factors, namely the temperature of the condenser cooling water and the surface area of the cooling water tube pipe.

Originality/Value: The Electric Accumulator Component Industry with products in the form of sheet-shaped Electric Accumulator Separators made from polymer powder, silica powder, oil, and other supporting materials with the production capacity will affect the formation of the solution.

Keywords: Condenser Addition, Carbon Bed, Trichloroethylene Gas Emissions.

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CAMA CONDENSADORA DE ÁGUA PARA REDUZIR A EMISSÃO DE GÁS TRICLOORETILENO E A QUALIDADE DO AR

RESUMO

Objetivo: O objetivo desta pesquisa é como reduzir as emissões de tricloroetileno usando um condensador e a eficiência da redução das emissões de tricloroetileno antes e depois de usar um condensador.

Referencial Teórico: A qualidade do ar é influenciada pelas emissões de tricloroetileno, condensador e eficiência, emissões de tricloroetileno e condensador.

Método: A pesquisa realizada foi uma pesquisa quantitativa descritiva. Fonte dos dados: Estudo de Literatura; Observação de campo; Processo de recuperação de gás tricloroetileno em sistemas existentes no campo, como unidades de secagem, unidades de leito de carbono e unidades condensadoras adicionadas. Método de amostragem com Tricloroetileno, Emissão de Gases, Medição de Concentração.

Resultados e Discussão: O valor da eficiência de redução da carga de emissão do gás tricloroetileno antes e após a adição do condensador atingiu 68,16%. A carga de emissões na chaminé antes da adição do condensador foi em média de 223 kg/dia e após a adição do condensador foi em média de 71 kg/dia.

Implicações de pesquisa: A eficiência da redução da carga de emissão de gás tricloroetileno é influenciada por vários fatores de apoio, nomeadamente a temperatura da água de resfriamento do condensador e a área de superfície do tubo de água de resfriamento.

Originalidade/Valor: A Indústria de Componentes de Acumuladores Elétricos com produtos na forma de Separadores de Acumuladores Elétricos em forma de folha feitos de pó de polímero, pó de sílica, óleo e outros materiais de suporte com capacidade de produção afetará a formação da solução.

Palavras-chave: Adição de Condensador, Leito de Carbono, Emissões de Gás Tricloroetileno.

CAMA CONDENSADORA DE AGUA PARA REDUCIR LA EMISIÓN DE GAS TRICLORETILENO Y LA CALIDAD DEL AIRE

RESUMEN

Propósito: El propósito de esta investigación es cómo reducir las emisiones de tricloroetileno usando un condensador y la eficiencia de reducir las emisiones de tricloroetileno antes y después de usar un condensador.

Marco Teórico: La calidad del aire está influenciada por las emisiones de tricloroetileno, el condensador y la eficiencia, las emisiones de tricloroetileno y el condensador.

Método: La investigación realizada fue de tipo descriptiva cuantitativa. Fuente de datos: Estudio de literatura; Observación de campo; Proceso de recuperación de gas tricloroetileno en sistemas existentes en el campo como unidades secadoras, unidades de lecho de carbón y unidades condensadoras agregadas. Método de muestreo con Tricloroetileno, Emisión de Gases, Medición de Concentración.

Resultados y Discusión: El valor de eficiencia de reducción de la carga de emisión de gas tricloroetileno antes y después de agregar el condensador alcanzó el 68,16%. La carga de emisión en la chimenea antes de añadir el condensador fue una media de 223 kg/día y después de añadir el condensador una media de 71 kg/día.

Implicaciones de la investigación: La eficiencia de reducir la carga de emisión de gas tricloroetileno está influenciada por varios factores de apoyo, a saber, la temperatura del agua de refrigeración del condensador y el área de superficie de la tubería del tubo de agua de refrigeración.

Originalidad/Valor: La industria de componentes de acumuladores eléctricos con productos en forma de separadores de acumuladores eléctricos en forma de lámina hechos de polvo de polímero, polvo de sílice, aceite y otros materiales de soporte con capacidad de producción afectará la formación de la solución.

Palabras clave: Adición de Condensadores, Lecho de Carbón, Emisiones de Gas Tricloroetileno.

1 INTRODUCTION

The Electric Accumulator Component Industry with products in the form of sheet-shaped Electric Accumulator Separators which are made from polymer powder, silica powder, oil, and other supporting materials with a production capacity of each production line originally of 650,000 m2/month per year in 2022. In the production process, a solvent is needed in the form of a solvent with Trichloroethylene which functions as a solvent to dissolve the oil in the product through the Extraction process. In the form of liquids and solids, each molecule (Tom, 2022; Beim et al., 2023) is bound together due to the force of attraction between molecules, the force of attraction will affect the formation of the solution (Zhong et al., 2023; Li et al., 2023; Halder et al., 2022). If there is a solute in a solvent, the solute particles will spread throughout the solvent (Jahangiri et al., 2021; Kanth et al., 2019).

The Carbon Bed Unit installation used for the Trichloroethylene material recovery process has limited capacity and some activated carbon is saturated (Tai et al., 2017; Feng et al., 2016; Mofidi et al., 2013; Azara et al., 2022; Balicki & Bartela, 2014). The increase in industrial production capacity can cause an increase in the load of Trichloroethylene gas flow processed by the Carbon Bed. This can result in increased emissions of Trichloroethylene gas into the air. Based on the background description, we can formulate several problems, namely: how to reduce trichloroethylene emissions using a condenser and what is the efficiency of reducing trichloroethylene emissions before and after using a condenser?

2 THEORETICAL FRAMEWORK

In the Industrial production process after going through the extraction process, some of the Trichloroethylene solvent material will remain on the product sheet. Therefore, the product sheet will then go through a drying process (El Hajj et al., 2023; Kırkyol & Akköse, 2022; Arias et al., 2023) where the product sheet will be heated through a hot roll so that the Trichloroethylene in the product sheet will evaporate and change phase to gas. Trichloroethylene gas will then be processed by absorbing activated carbon through a carbon bed unit so that it can be reused as a solvent in the liquid phase. The planned increase in production capacity in the span of 2022 to 2023 in one of the industries from the original capacity of 650,000 m2 / month to 1,000,000 m2 / month causes an increase in the use of raw materials and supporting materials, one of which is Trichloroethylene.

The current condition of air pollution control equipment (existing) in the form of carbon bed with trichloroethylene gas concentration at the inlet of a maximum of 10000 ppm and at the outlet to the atmosphere a maximum of 15 ppm (Canales-gutiérrez & Canales-manchuria, 2022; Marisa et al., 2024). An increase in production capacity can cause excessive trichloroethylene gas load at the carbon bed inlet with an estimate of up to 17500 ppm. The design of the currently installed carbon bed is with a maximum trichloroethylene gas concentration inlet of 6500 ppm. The increase in the use of trichloroethylene results in an excessive load on the carbon bed, requiring an increase in the capacity of air pollution control equipment or the addition of air pollution control equipment units. In this study, an evaluation will be made of the effect of adding air pollution control equipment in the form of adding a condenser to the gas flow to the carbon bed to reduce trichloroethylene emissions which will be discharged into the ambient air through the chimney (Checkley et al., 2022; Ataee et al., 2017).

3 METHODOLOGY

The research conducted is quantitative descriptive research. This is because the research was carried out by analyzing existing problems, matching with theory, applying the theory, taking measurements, and concluding the results and data from the research.

3.1 DATA COLLECTION METHODS

Type of data in research primary data; primary data is obtained from informant sources, namely individuals or individuals (M. Gao et al., 2019; Prof. Dr. Ir. Raihan, 2019; Sato et al., 2018). According to Hasan primary data is data obtained or collected directly in the field by the person conducting the research or concerned who needs it. This primary data includes field observation results and direct measurement data. Secondary data is data obtained or collected by people who conduct research from existing sources. This data is used to support primary information that has been obtained, namely from library materials, literature, previous research, books, and so on. Data Source: 1) Literature Study; searching for literature in the form of references related to activities that will be complementary and comparative data with data obtained in the field; 2) Field Observation; direct observation in the field by looking directly at the condition of the Trichloroethylene gas recovery process in existing systems in the field such as dryer units, carbon bed units and condenser units that are added. The sampling method is a step-in measuring data in this study which will then be used as a basis for analysis (Bayat et al., 2018; Liu et al., 2016). Several types of sampling variables will be taken:

a. Measurement of Trichloroethylene Gas Emission Concentration. Measurement of the concentration of trichloroethylene gas emissions using a gas sampling device in the form of a sampling tube;
b. Cooling Water Temperature Measurement; measurement of cooling water temperature in the condenser using a water temperature measuring device in the form of a temperature sensor attached to a water cooler.

3.2 LOCATION AND SAMPLING DATA

This location is a point for sampling trichloroethylene gas emissions located at the location of the gas emission stream after the carbon bed or chimney unit. The sampling location is the location or point for taking samples from measuring the emission concentration of trichloroethylene gas which will then be analyzed:

3.2.1 Sampling location 1

This location is a sampling point for trichloroethylene gas emissions that evaporate from the drying process and is located between the location of the gas emission flow before the addition of the condenser to the SLA blower and carbon bed unit.

3.2.2 Sampling location 2

This location is a point for sampling of trichloroethylene gas emissions located at the location of the gas emission stream after the addition of a condenser to the SLA blower and carbon bed unit (Singh et al., 2020; Gupta, 2012; Q. Gao, 2015).

3.3 ANALYSIS METHOD

The analysis method is a step in analyzing the data that has been collected previously to get problem-solving. The method of analysis used in this study is to analyze the effect of the addition of condensers to reduce the Trichloroethylene gas load to be processed (recovery) on the carbon bed to reduce Trichloroethylene gas emissions into the air (Karami et al., 2023; Abbas et al., 2022). The following formula will be used as the basis for calculating the Trichloroethylene gas emission load that will be used in this study:

a. The formula for Converting Measurement Results. The measurement results from the Trichloroethylene gas emission measuring instrument have a unit of measurement of part per million (ppm) so it is necessary to convert it to milligrams per normal cubic meter (mg/Nm3) with the following formula:

$$C\left(\frac{mg}{Nm^3}\right) = C\,(ppm)\ \times 131{,}38\left(\frac{g}{mol}\right) \times 0{,}0409\ (Konstanta) \quad (1)$$

Descriptions:

C (mg/Nm^3) :Measurement results of trichloroethylene gas emission concentration converted from (ppm) into units (mg/Nm3)

C (ppm) : Measurement results of trichloroethylene gas emission concentration in units of one per one million (ppm)

131,38 : The trichloroethylene gas molecule’s weight

0,0409 : Constant value for converting the concentration value of a chemical substance in the air.

b. The formula for Determining Trichloroethylene Gas Emission Load. Emission load is a unit to determine the amount- of emissions in mass produced in units of time as follows:

$$E\left(\frac{kg}{hari}\right) = C\left(\frac{mg}{Nm^3}\right) \times Q\left(\frac{m^3}{detik}\right) \times\ 10^{-6}\left(\frac{kg}{mg}\right) \times 86400\left(\frac{detik}{Hari}\right) \quad (2)$$

Description:

E: Unit for the emission load generated in units of mass per time

C: Measurement results of trichloroethylene gas emission concentration converted from (ppm) into units (mg/Nm3)

Q: The flow of gas through a pipe or chimney in units of volume per time.

10^{-6}: Conversion result from milligram to kilogram
86400 : Conversion results from seconds to days

c. The formula for Determining the efficiency of reducing Trichloroethylene Gas Emissions (Jas et al., 2021). The efficiency of reducing trichloroethylene gas emissions is determined based on the calculation of the Emission Load before the addition of the condenser and the Emission Load after the addition of the condenser with the following formula:

$$Efisensi\ (\%) = \frac{E_0\left(\frac{kg}{hari}\right) - E_1\left(\frac{kg}{hari}\right)}{E_0\left(\frac{kg}{hari}\right)} \times 100\ \% \qquad (3)$$

Descriptions:

Efisensi (%) : Calculation results of trichloroethylene gas emission reduction efficiency
E_0: Emission load calculation results before condenser addition
E_1: Emission load calculation results after condenser addition

Data analysis was carried out to analyze the effect of the addition of a condenser on reducing the Trichloroethylene gas emission load and its efficiency with the following variables:

a. Temperature of Chilled Water in the Condenser;
b. Emission Load before Condenser;
c. Emission Load after Condenser;
d. Emission Load after Carbon Bed in Chimney.

4 RESULTS AND DISCUSSIONS

4.1 REDUCING TRICHLOROETHYLENE GAS EMISSIONS USING A CONDENSER

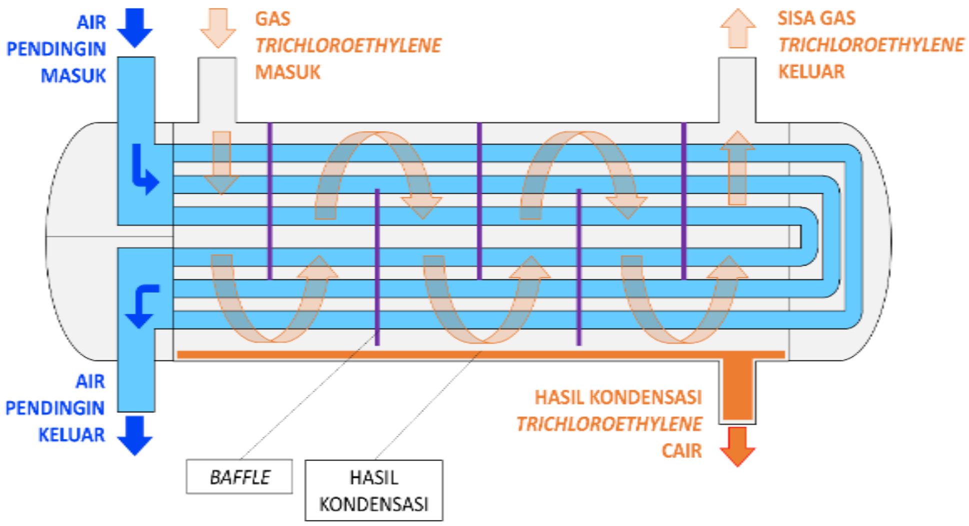
Trichloroethylene Gas Emission Control Conditions; increased production capacity affects the increased use of trichloroethylene materials used for the oil extraction process from the product. This of course also has an impact on increasing trichloroethylene gas emissions produced. The condition of the carbon bed unit which acts as air pollution control equipment with an unchanged capacity causes trichloroethylene gas emissions that exceed the design capacity of the carbon bed unit and cannot be controlled optimally or produce air pollution that exceeds quality standards. Addition of Condenser on *Trichloroethylene* Gas Emission flow (Curry et al., 2020; Fontes et al., 2020). T

he addition of a condenser to the *trichloroethylene* gas emission stream located in the position after the drying process and the position before the carbon bed unit is done with the consideration that the condensation results are maximized so that the amount of liquid *trichloroethylene* is more and reduces the risk of fugitive emissions due to leakage in the pipe or leakage in the expansion joints. Another consideration related to the addition of the condenser not in the position after the carbon bed unit is to prevent saturation of activated carbon due to the concentration of *trichloroethylene* gas emissions that exceed the design capacity.

The condenser operates with a condensation process so that *trichloroethylene* gas emissions can change from the gas phase to the liquid phase so that the concentration of *trichloroethylene* gas emissions at the output will decrease. The rest of the *trichloroethylene* gas emissions that do not undergo the condensation process in the condenser then come out through the condenser outlet pipe. The remaining emissions are then forwarded to the carbon bed unit for processing before being discharged into the ambient air through the chimney. The condensation of *trichloroethylene* gas into liquid *trichloroethylene* then exits through the drain pipe and continues to the liquid *trichloroethylene* raw material storage area so that it can be reused.

Figure 1

The condenser works to reduce trichloroethylene gas emissions.



Source: research data processing, 2023.

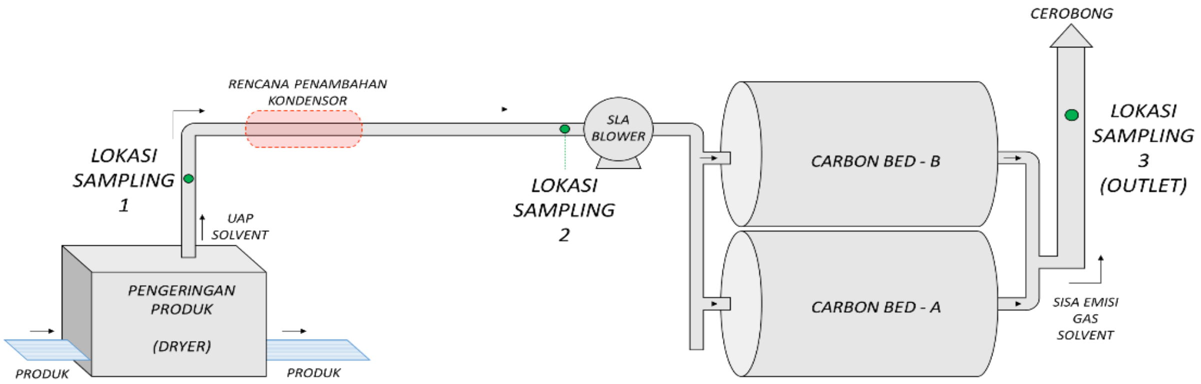
The remaining emissions of uncondensed *trichloroethylene* gas at the outlet of the condenser then have a lower concentration than the concentration of *trichloroethylene* gas at the condenser inlet. This has a good impact on the inlet of the carbon bed unit because it can control *trichloroethylene* gas emissions with lower concentrations or emission loads so that *trichloroethylene* gas emissions to be released through the chimney are lower

4.2 EFFICIENCY OF *TRICHLOROETHYLENE* GAS EMISSION REDUCTION USING CONDENSER

Measurement or sampling points of *trichloroethylene* gas emissions are in three different places where each of the places or sampling points can determine the effect of adding a condenser on reducing trichloroethylene gas emissions.

Figure 2

Measurement of trichloroethylene gas emissions.



Source: research data processing, 2023.

Sampling point 1, this place is a sampling point for *trichloroethylene* gas emissions that evaporate from the drying process and is located between the gas emission flow place before the addition of the condenser to the SLA blower and the carbon bed unit. Sampling point 2, this place is a point for sampling *trichloroethylene* gas emissions located at the place of gas emission flow after the addition of the condenser to the SLA blower and carbon bed unit. Sampling point 3, this place is a point for sampling *trichloroethylene* gas emissions located in the place of gas emission flow after the carbon bed or chimney unit.

Table 1

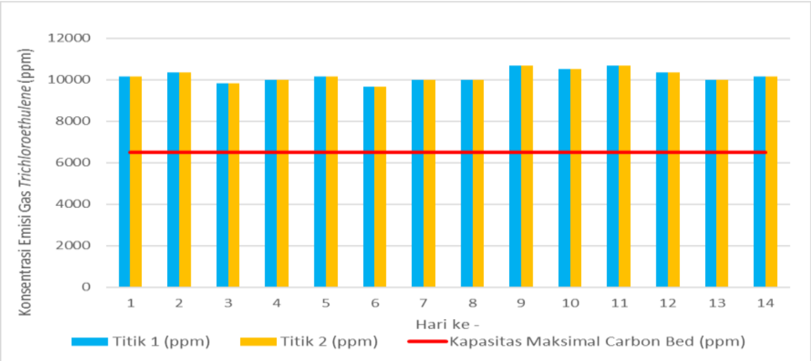
Results before condenser installation under normal production conditions.

Days to-	Average measurement results (ppm)		
	Point 1	Point 2	Point 3
1	10.167	10.167	24
2	10.333	10.333	26
3	9.833	9.833	23
4	10.000	10.000	24
5	10.167	10.167	24
6	9.667	9.667	22
7	10.000	10.000	23
8	10.000	10.000	24
9	10.667	10.667	28
10	10.500	10.500	27
11	10.667	10.667	28
12	10.333	10.333	26
13	10.000	10.000	24
14	10.167	10.167	25
Average	10.179	10.179	25

Emission measurement results before condenser installation under normal production conditions based on the measurement results in Table. 2 emission measurement results before condenser installation under normal production conditions above, it is known that the average measurement results at sampling point 1 are 10,179 ppm, point 2 is 10,179 ppm and point 3 is 25 ppm. The quality standard for *trichloroethylene* gas is 50 ppm, so this shows that under production conditions with normal capacity does not cause air pollution.

Figure 3

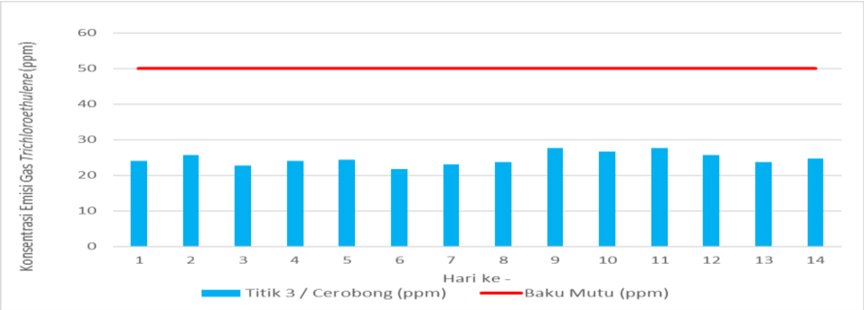
Emission Measurements at Points 1 and 2



Emission measurements at sampling points 1 and 2 before condenser installation under normal production conditions and in Figure 4. graph of emission measurements at sampling point 3 before installation under normal production conditions for the above, it is known that the measurement results of *trichloroethylene* gas emissions at sampling point 1 and sampling point 2 have exceeded the capacity of the carbon bed unit, while at sampling point 3 the measurement results of *trichloroethylene* gas emissions still meet the quality standards of the Minister of Manpower Regulation Number 5 of 2018 concerning Occupational Safety and Health Work Environment. Before condenser installation under normal production conditions:

Figure 4

Emission measurement chart at point 3 before installation under normal production conditions.



The results of emission measurements before condenser installation under conditions of increased production capacity above are known the average measurement results at sampling point 1 are 17,000 ppm, sampling point 2 is 17,000 ppm, and sampling point 3 is 120 ppm. The quality standard for *trichloroethylene* gas is 50 ppm, so this shows that under conditions of increased production capacity, it can cause air pollution.

Figure 5

Graph of emission measurement at points 1 and 2 before installation under conditions of increased production capacity.

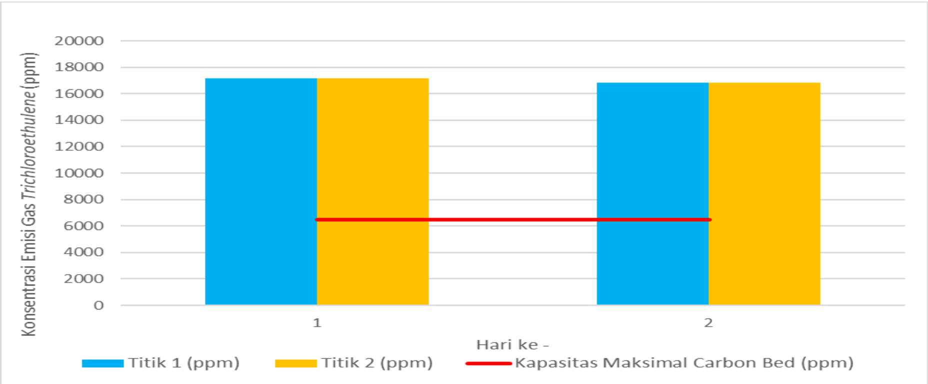
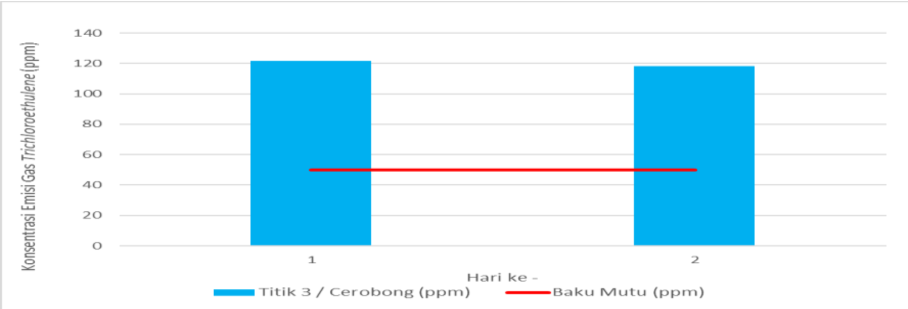


Figure 6

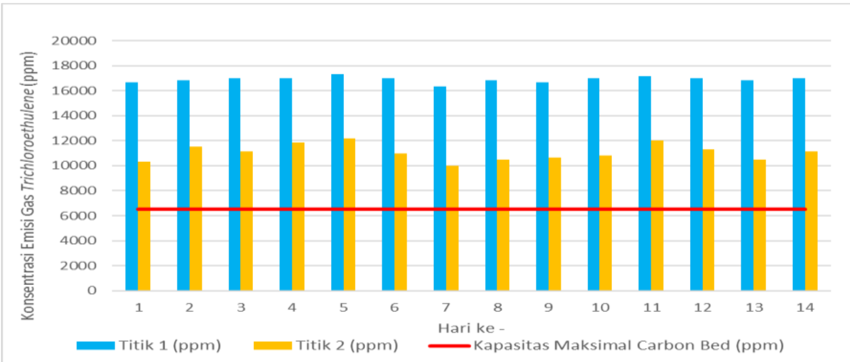
Emission measurement at point 3 before installation under production capacity increase condition.



The results of emission measurements after condenser installation under conditions of increased production capacity can be seen that the average measurement results at sampling point 1 are 16,905 ppm, sampling point 2 is 11,071 ppm and point 3 is 38 ppm. This shows that the addition of a condenser can reduce the concentration of *trichloroethylene* gas from sampling point 1 to sampling point 2. So the concentration of *trichloroethylene* gas treated with a carbon bed unit is lower and produces *trichloroethylene* gas emissions at sampling point 3 or chimney with a value below the quality standard.

Figure 7

Emission measurement at points 1 and 2 after installation in the conditions of increase in production capacity.



The emission measurement graph at sampling points 1 and 2 after installation under conditions of increased production capacity, it can be seen that there is a decrease in *trichloroethylene* gas emissions at sampling point 2 after going through the condenser, where sampling point 1 is the measurement location before going through the condenser. This shows that the condenser can reduce the concentration of *trichloroethylene* gas emissions.

Figure 8

Emission measurement chart at point 3 after installation under conditions of increased production capacity.

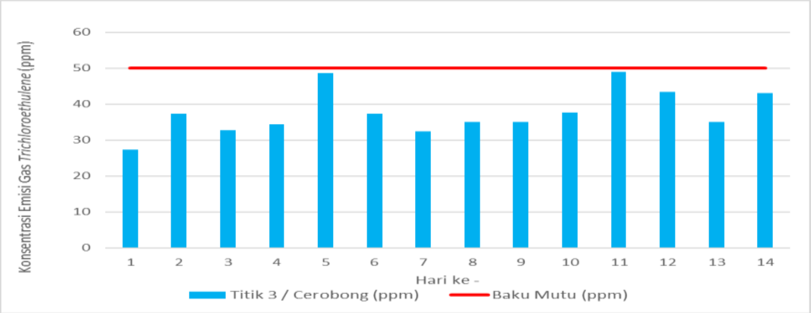
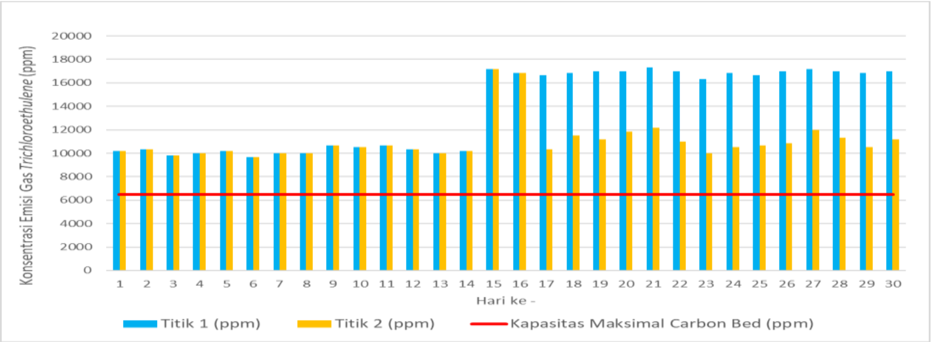


Figure 9

Graph of emission measurements at points 1 and 2 when before and after condenser installation.



Emission measurement graph at sampling point 3 after installation under conditions of increased production capacity, it is known that the measurement results of *trichloroethylene* gas emissions after the addition of a condenser at sampling point 3 can meet the quality standards of the Minister of Manpower Regulation Number 5 of 2018 concerning Occupational Safety and Health Work Environment. The addition of a condenser at sampling point 1 and sampling point 2 or before the flow of *trichloroethylene* gas enters through the inlet of the carbon bed unit, is known to affect reducing the concentration of *trichloroethylene* gas emissions so that the value of emissions contained in sampling point 3 or chimney can meet quality standards and does not cause air pollution that is harmful to the environment and human health.

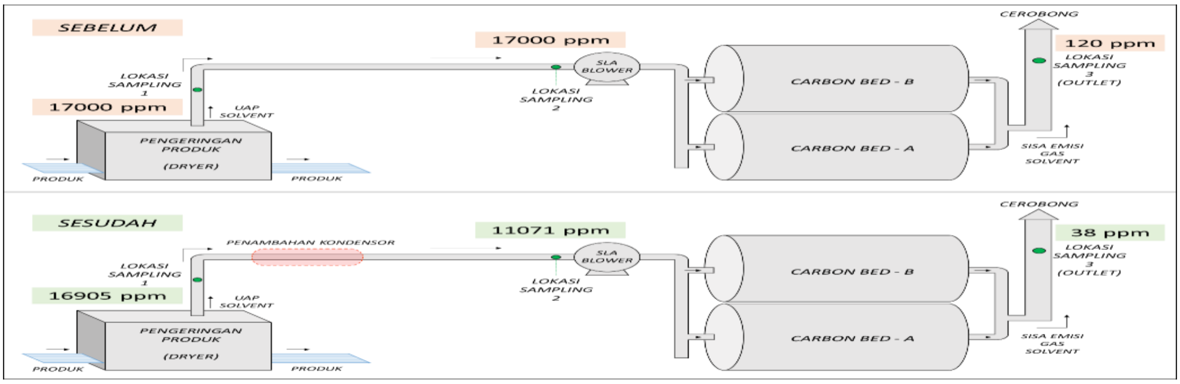
4.3 DECREASE IN *TRICHLOROETHYLENE* GAS EMISSIONS AFTER THE ADDITION OF CONDENSER

Determination for the placement of sampling points and installation of condensers on the inlet pipe flow of *trichloroethylene* gas emissions to the carbon bed unit or between sampling point 1 and sampling point 2 is by considering that the condenser functions as a pre-treatment or pre-treatment before the flow of gas emissions enters the carbon bed unit and so that the usage period of activated carbon in the carbon bed unit is longer and not easily saturated.

The measurement results before the addition of the condenser during conditions of increased production capacity at sampling point 2 are an average of 17,000 ppm and at sampling point 3 or chimney an average of 120 ppm. After the addition of the condenser, the results decreased *trichloroethylene* gas emissions at sampling point 2, which is an average of 11,071 ppm, and at sampling point 3 or chimney, which is an average of 38 ppm.

Figure 10

Illustration of conditions before and after the addition of condenser



Source: research data processing, 2023.

The addition of a condenser to the inlet pipe flow of *trichloroethylene* gas emissions to the carbon bed unit or between sampling point 1 and sampling point 2 affects reducing *trichloroethylene* gas emissions at the inlet of the carbon bed unit and reducing *trichloroethylene* gas emissions at sampling point 3 or chimney. The emission load processed by the carbon bed unit which initially increased due to an increase in production capacity can be reduced by the addition of a condenser so that the carbon bed unit can operate better to control *trichloroethylene* gas emissions before being discharged into ambient air through the chimney.

The emission load in the chimney before the addition of the condenser averaged 223 kg/day and after the addition of the condenser averaged 71 kg/day resulting in an efficiency value of reducing *trichloroethylene* gas emissions by 68.16%. The efficiency of reducing the *trichloroethylene* gas emission load is influenced by several supporting factors, namely the temperature of the condenser cooling water and the surface area of the cooling water tube pipe. The lower the temperature of the condenser cooling water and the more surface area of the cooling water tube pipe, the greater the efficiency of reducing the *trichloroethylene* gas emission load.

5 CONCLUSION

Conclusions can be drawn: the results showed that the reduction in *trichloroethylene* gas emissions was carried out by the condensation process in the condenser against *trichloroethylene* gas emissions which changed phase to liquid or condensate to leave the remaining *trichloroethylene* gas emissions with lower concentrations and meet the quality standards of the Minister of Manpower Regulation Number 5 of 2018 concerning Occupational Safety and Health Work Environment with a maximum concentration of 50 ppm or a maximum emission load of 92 kg/day. This study obtained a decrease in the average concentration of *trichloroethylene* gas emissions in the chimney from the original 120 ppm to 38 ppm. The efficiency value of reducing the *trichloroethylene* gas emission load to the conditions before and after the addition of the condenser reached 68.16%. The emission load in the chimney before the addition of the condenser averaged 223 kg/day and after the addition of the condenser averaged 71 kg/day. The efficiency of reducing the *trichloroethylene* gas emission load is influenced by several supporting factors, namely the temperature of the condenser cooling water and the surface area of the cooling water tube pipe.

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Canales-gutiérrez, A., & Canales-manchuria, G. (2022). *AIR QUALITY MONITORING : CO , CO 2 , H 2 S GASES 1 INTRODUCTION Currently , air quality is of great concern worldwide , due to the increase and higher intensity of pollution (Ganguly , Tzanis , Philippopoulos & Deliorgi , 2019). Air quality is affected and controlled by different factors , where several parameters interact , such as humidity , temperature , winds (Cortis & Oldenburg , 2009 ; Delgado & Aguirre , 2020), as well as industrial activities and vehicle fleet negatively affect air quality (Bedoya & Martínez 2009), being the use of older vehicles and two-stroke engines , which generate more environmental impacts (Shahid , Chishtie , Bulbul , Shahid , Shafique & Lodhi , 2019) and that cause environmental problems negatively affecting people ' s health (Ventura , Morales , & Gelabert , 2020), such as cardiopulmonary diseases , asthma , allergies that are related to exposure to air pollution (Ardusto et . al , 2019 ; Rodríguez , Sierra-Parada , R . & Blanco-Becerra , 2020). Carbon monoxide is a gas caused by incomplete combustion of hydrocarbons (Fleta , Arnauda , Ferrer & Olivares , 2005), it is present in the product of biomass , tobacco combustion , fossil fuels in 60 % and naturally in 40 % (Buchelli , Fernández , Rubinos , Martinez , Rodriguez & Casan , 2014), in the atmosphere its accumulation is less than 0 . 001 % but it is higher in urban areas (Clardy , Manaker & Perry , 2019). The main anthropogenic source is automobiles (Bolaños & Chacon , 2017) due to their CO emissions (Arias , Berenguer & Vázquez , 2018) and fuel consumption (Ávila & Pardo , 2016). It produces a negative impact on health (Rojas , Duẽas & Sidorovas , 2001), poisoning is caused by breathing this gas (Townsend & Maynard , 2002), being the most frequent cause of death by poisoning worldwide (Weaver , Hopkins , Chan , Churchill , Elliott , Clemmer , Orme , Thomas , Morris , 2002). 2 THEORETICAL REFERENCE Carbon dioxide is one of the gases related to the greenhouse effect (Hao , Geng , Wang & Ouyang , 2014), responsible for climate change (Ordoñez & Masera , 2001). It is monitored internationally (Monfort , Mezquita , Granel , Vaquer , Escrig , Miralles & Zaera , 2010), in only*. 1–13.

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