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Report from The Organizing Committee

It is indeed my great pleasure and honor to welcome you all to Soedirman's International Conference on Mathematics and Applied Sciences (SICoMAS) 2019. The conference running this year is the first SICoMAS series hosted by Faculty of Mathematics and Natural Sciences Jenderal Soedirman University. As the development of technology and management of world resources for our future based on the innovation in Mathematics and Sciences, this conference takes issue "Innovation in Mathematics and Applied Sciences for better future".

SICoMAS 2019 aims to provide a platform for researchers, lecturers, teachers, students, practitioners, and industrial professionals to share knowledge, exchange ideas, collaborate, and present research results in the fields of Mathematics, Chemistry, Physics, and their applications. Hence, my sincere gratitude goes to our four keynote speakers (Prof. Dr. Hadi Nur from University Teknologi Malaysia, Prof. Dr. Hirokazu Saito from Tokyo University of Science, Dr. Devi Putra, ST, M.Sc. from Pertamina Research and Technology, and Uyi Sulaeman, Ph.D. from Jenderal Soedirman University), and our six invited speakers (Prof. Dr. Youtoh Imai from Nishogakusha University, Prof. Riyanto, Ph.D. from Universitas Islam Indonesia, Dr. Moh. Adhib Ulil Absor from Gadjah Mada University, Bambang Hendriya Guswanto, Ph.D, Dadan Hermawan, Ph.D. and Dr. Eng. Mukhtar Effendi, M. Eng. from Jenderal Soedirman University) for sharing their expertise in this conference. My deepest appreciation also goes to our 80 presenters and 7 non presenters for their commitment to participate in this conference.

As the output of this conference, some selected papers in the field of chemistry will be published in Jurnal Molekul which is accredited Sinta 1; and other selected papers in the fields of Mathematics, Physics, Physical Chemistry, and Innovative Chemistry Education will be published in IOP Conference Series Journal. So, I greatly thank Jenderal Soedirman University, all our contributors, and all the members of the committee for the invaluable support that makes this conference a reality.

Finally, I would like to apologize for any short comings found in this conference; and hopefully this two-day conference will be engraved in your memory.

The chair of SICoMAS 2019

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Table of contents

Volume 1494

2020

◀ Previous issue Next issue ▶

**Soedirman's International Conference on Mathematics and Applied Sciences (SICoMAS) 2019
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Accepted papers received: 03 April 2020

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Preface

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Preface

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Metaheuristic algorithm approach to solve non-linear equations system with complex roots

A Kamsyakawuni, M P Sari, A Riski and K A Santoso

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Model identification for prediction of dengue fever disease spreading using Bat Algorithm and backpropagation

A Damayanti, N L Hidayati and A B Pratiwi

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The proof of properties of dihedral group and its commutative elements

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H M Muhammad, E Susnowati and Fatmawati



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012004

Petri Net Model and Max-Plus Algebra on Queue in Clinic UNS Medical Center

T. Sulistyaningsih, Siswanto and Pangadi

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012005

Cat swarm optimization and Levenberg-Marquardt for model identification and prediction tuberculosis disease spreading

A Nuari, A Damayanti and A B Pratiwi

[+ Open abstract](#)[View article](#)[PDF](#)**OPEN ACCESS**

012006

Numerical comparisons based on new NCP-functions

I Nurhidayat and L C Han

[+ Open abstract](#)[View article](#)[PDF](#)**OPEN ACCESS**

012007

Ant System Algorithm in Renewing Pheromone for Completing Quadratic Assignment Problem

F M Utami, Renny and S R Nurshiami

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012008

Clustering of fish freshness using discrete wavelet transform and Kohonen self organizing map

J Anvy, A Damayanti and A B Pratiwi

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012009

Annihilator graph of semiring of matrices over Boolean semiring

R Yudatama, V Y Kurniawan and S B Wiyono

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012010

Interval min-plus algebraic structure and matrices over interval min-plus algebra

A R Awallia, Siswanto and V Y Kurniawan

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012011



On Cartesian product of intuitionistic Q-fuzzy ideal on ordered semigroup

N Hidayat, I Yanti, Z Fitriah, D Miftah, S Anam, S I Rahman and F Hidayat

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012012

Implementation of Bayesian Mixture Models in identifying subpopulation of breast cancer patients based on blood test measurements

N Dwimantara, S Abdullah, A Bustamam and A Rachman

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012013

Determining soil fertility using principal componen regression analysis of oil palm plantation in West Sulawesi, Indonesia

U S Pasaribu, N Nurhayati, N F F Ilmi and K N Sari

[+ Open abstract](#)[View article](#)[PDF](#)

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012014

Half-space model problem for a compressible fluid model of Korteweg type with slip boundary condition

Suma Inna, Sri Maryani and Hirokazu Saito

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012015

The metric dimension of k -subdivision graphs

L Susilowati, S Zahidah, R D Nastiti and M I Utoyo

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012016

Jacobson graph construction of ring \mathbb{Z}_3^n , for $n > 1$

A Novictor, L Susilowati and Fatmawati

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012017

Betweenness centrality in corona product of K_n and C_m graph

T I Haryadi and L Susilowati

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012018

Algorithm and computer program to determine metric dimension of graph

F Muhammad and L Susilowati

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012019

An Adams type inequality of fractional integral operator on hypergroups

I Sihwaningrum, A Wardayani and Y Dasril

[+ Open abstract](#)[View article](#)[PDF](#)

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012020

Regular rings and their properties

A Wardayani, I Kharismawati and I Sihwaningrum

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012021

The validity of the properties of real numbers set to hyperreal numbers Set

R Masithoh, B H Guswanto and S Maryani

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012022

Removal of rhodamine b using 4-hydroxy-3-methoxyphenylcalix[4]resorcinarene

S N Handayani, Irmanto and N N Indriyani

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012023

Adsorption of Gold(III), Copper(II), Nickel(II) on Amino Silica Hybrid Coated Magnetite

M T Thahir, N Nuryono and S J Santosa

[+ Open abstract](#)[View article](#)[PDF](#)

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012024

Kinetics Adsorption of Strontium(II) by Silica Xerogel from Fly Ash

N A Kundari, K Megasari and C Yusephin

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012025

Triterpenoid and Steroid from the Rind of *Chisocheton macrophyllus* (Meliaceae)

V M Sari, Nurlelarsi, D Harneti, R maharani, N Indrayati, M N Azmi and U Supratman

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012026

Introducing Colorimetric Analysis with Document Scanner for High School Students

A Fatoni, Supiani, D W Dwiasi and M D Anggraeni

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012027

The pH dependence of Ag₃PO₄ synthesis on visible light photocatalytic activities

I Futihah, A Riapanitra, S Yin and U Sulaeman

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OPEN ACCESS

012028

Improved reuse and affinity of enzyme using immobilized amylase on alginate matrix

Zusfahair, D R Ningsih, D Kartika, M Kurniasih, R Nofiani and A Fatoni

[+ Open abstract](#)[View article](#)[PDF](#)

OPEN ACCESS

012029

Effect of ultraviolet and visible lights on degradation of congo red dye using Fe²⁺/H₂O₂

J Tama, K Riyani and T Setyaningtyas

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012030

Introducing Iron Analysis with Smartphone Camera for High School Students

A Fatoni, Zusfahair and M D Anggraeni

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012031

Quantitative Structure Activity Relationship Analysis of 1,3,4-Thiadiazole Derivatives as Anti-Inflammatory using Parameterized Model 3 Method

Ponco Iswanto, Maylani Permata Saputri, Vaulina Y.D. Eva and Sari Paramita

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012032

Application of High Performance Liquid Chromatography Method for Triadimenol Analysis in Water Sample

D Hermawan, Cacu, Suwandri, A Fatoni, Mudasir and H Y Aboul-Enein

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012033

The Effect of Multiplanes Graphene Flakes Coating on Ag Nanowire Transparent Conductive

Nur Fiqalbi, Ratih Dwi Cahyaningrum, Bambang Prihandoko and Harsojo

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012034

Mapping of gold mineralization using 3D inversion magnetic data at Zone X, West Java

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012035

Hydrocarbon Reservoir Characterization of 'Y' Field in Kutai Basin East Kalimantan Using Artificial Neural Network Method

Y R Hendryan, M S Rosid and Haryono

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012036

Study of Thin Film Cu Nanowire and Reduced Graphene Oxide as A Gas Sensor

Noviana Candra Wijayanti, Ratih Dwi Cahyaningrum and Harsojo

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012037

Study of Transparent Conductive of Ag Nanowire Under Ambient Environment

Ratih Dwi Cahyaningrum and Harsojo

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012038

Estimation of Potential of Iron Sand in The Eastern Coastal Area of Cilacap Regency Based on The Local Magnetic Anomalies Data

Sehah, M A Kurniawan, I Andriyanto, B Arismawan, A Risyad, A M Wibowo, S A Raharjo and Sugito

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012039

Estimation of Ideal Configuration and Dimension of Pico Hydropower using Euler-Lagrange Equation and Runge-Kutta Method

J. Aminuddin, Nurhayati, A. Widiyani, P. Razi, Wihantoro, A.N. Aziz, R.F. Abdullatif and A. Arifin

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012040

CO oxidation through the formation of carboxyl intermediate on Pt(111) surface: A first principles study

S Zulaehah, W T Cahyanto, I N Fitriani, F Abdullatif, W Widanarto and M Effendi

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012041

Designing of Muffler Part for Car Exhaust System with Low Emission and Noise using Conjugate Gradient Method

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012042

The effects of milling time on structure, magnetic properties and microwave absorption capability of strontium lanthanum ferrite compounds

Mukhtar Effendi, Endra Nugraha, Wahyu Tri Cahyanto and Wahyu Widanarto

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012043

Magnetic and microwave absorption properties of Mn^{4+} doped barium-natural ferrites prepared by the modified solid-state reaction method

H. R. Luthfianti, W. Widanarto, S. K. Ghoshal, M. Effendi and W. T. Cahyanto

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012044

Cimandiri Fault Identification Using Earthquake Tomography Double-Difference Method

R G Simanjorang, M S Rosid, A S Sembiring, Daryono and N Heryandoko

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012045

Effect of Carbon Active Addition to Electrochemical Performance of $Li_4Ti_5O_{12}/SnO_2$ Composite Anode on Lithiumion Battery

Ebsan Simamora, Jeffrey Riady, Bambang Priyono and Anne Zulfia Syahrial

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Shan Chang-ji, Yuan Jun, Jiang Hang et al.



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Designing of Muffler Part for Car Exhaust System with Low Emission and Noise using Conjugate Gradient Method

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Abstract. The exhaust is an important spare part of the car for reducing noise and emission. The Noise is an unexpected sound from the roar of the engine that caused a hearing problem. The emission is originated from the combustion of an engine that causes air pollution. In this study, we enhance an exhaust performance for decreasing noise and emission by optimizing of the muffler part. Through the conjugate gradient method, we estimate an ideal dimension of the muffler part for circulating thermal energy at around 26 kcal/mole for 13.39 seconds in the closed system. From the results of the conjugate gradient estimation, we develop the muffler plus a re-heater with 58 and 14 cm of length and diameter, respectively. Furthermore, the muffler's performance is evaluated by doing a measurement of both noise and emission. The measurements are conducted by comparing the muffler without and with re-heater. From the measurement process of sound intensity level, we seek that the noise is decreased by approximately 3.79 and 3.00 % in the lower and faster rotation of the engine, respectively. Besides, the test result shows that utilizing re-heater can reduce of CO, CO₂, and HC of 0.35, 14.6, and 76.29 % compare to the muffler without re-heater. The results indicate that the muffler with re-heater designed in this study is effective in reducing noise and emission from the roar and combustion of the engine, respectively.

1. Introduction

An Exhaust system is the main part of a car that is consisted of the exhaust, muffler, and sub muffler (Figure 1). The exhaust system is a car's spare part for reducing the noise from the engine. The noise is unexpected sound originated from the roar of car engine due. The noise of the ineffective design from the exhaust system kept the people in the world came through a hear problem [1,2]. Furthermore, the exhaust also functions for canalizing gases emission from the combustion of the engine [3,4]. The gases emission consist of CO, CO₂, and HC. That condition causes air pollution approximately 70-85% [5,6]. An investigation in Indonesia proves that the big cars, the truck, bus, and minibus are the highest producer of emission [7]. Therefore, this study is intended for designing the exhaust of the big car such as the truck, bus, and minibus.

A solution to the problem is the optimation of the muffler part. The part is indispensable for reducing pollution and noise originated from the car's exhaust system. The muffler is the highest part of the exhaust system so that several treatments for optimizing the exhaust system are focused on the part. The treatment in the previous study is related to the material which is filled in the exhaust system as a catalyst [8,9]. Although the way has a significant



contribution to reduce both noise and emission the material cost is expensive. Therefore, the treatment for improving the muffler is focused on design.

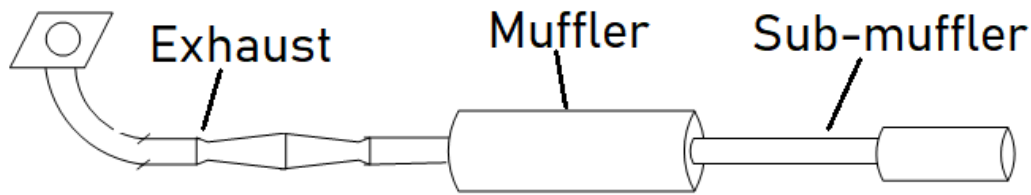


Figure 1. The exhaust system of the big car consist of the exhaust, muffler, and sub-muffler.

As a silencer, an exhaust system both the muffler and sub-muffler parts can be used as a resonator for reflecting sound waves from the roar of the engine. In physics principle, the longer the incoming, the more the reflecting of sound waves. As a result, the interference of both incoming and reflecting sound waves will generate loud to small sounds [10]. On the other hand, the higher size of the exhaust system for bringing down the noise can disrupt aesthetics. Therefore, a precise calculation is indispensable to obtain an ideal design of the exhaust system.

A scientific data related to a degradation process of gas emission is the magnitude of thermal energy which is circulated in the exhaust system. Based on the stoichiometric process we have come to know that to cut off chain carbon, for example, require thermal energy at around 26 kcal/mole for 13.39 second in the closed system. In this case, we need to compute a precise dimension of the muffler part for obtaining ideal thermal energy in the exhaust system [9]. To optimize the muffler part performance in canalization sound wave and circulating thermal energy, we employed a numerical calculation namely conjugate gradient method. The method can be used as optimization values without constraining by determining the local minimum of the target function [11,12].

2. Instruments and methods

The exhaust system in this study is designed by optimizing the muffler part. The muffler is developed by adding re-heater for reducing noise and emission from the roar and combustion of engines, respectively. Optimization is carried out based on the thermal conductivity principle in exhaust standards. Formulation of thermal conductivity is represented as:

$$Q = UA\Delta T, \quad (1)$$

Here Q is thermal conductivity, the diameter of the tube (D), and temperature difference (ΔT). Parameter A is obtained from

$$A = \pi DL, \quad (2)$$

and U is the representation of thermal coefficient conductivity between local and general within the area of interest [13,14]. The values of U can be calculated using the formula:

$$U = \frac{1}{\left\{ \left(\frac{1}{h_i} \right) \left(\frac{A_0}{A_i} \right) + \left(\frac{A_0 \ln \left(\frac{r_0}{r_i} \right)}{2\pi k L} \right) + \frac{1}{h_0} \right\}}. \quad (3)$$

In equation (3), the parameters of h_i , h_0 , A_i , A_0 , r_i , r_0 , k , and L are inside thermal coefficient, outside thermal coefficient, inside cross-sectional area, outside cross-sectional area, inside radius, outside radius, thermal conductivity coefficient, and length of the system. Furthermore, the coefficient of thermal expansion in the tube can be calculated using:

$$h_i = N_u \frac{k}{D} = 0.023 Re^{4/5} Pr^{0.3}. \quad (4)$$

Where N_u , D , Re , and Pr are Nusselt number, the diameter of *re-heater*, Reynold number dan Prandtl number, respectively. Both numbers have values at approximately 0,6–100. Furthermore, the Nusselt number (N_u) is determined by means of

$$Nu = 0.023 Re^{0.8} Pr^{0.3}. \quad (5)$$

In this case, the empiric formula is employed for the value of 0.3 so that the Reynold number is calculated using

$$Re = \frac{\rho v d}{\mu}. \quad (6)$$

Here, v is cooling speed rate which can be determined from the formula:

$$Rv = \frac{m_0}{\rho A}. \quad (7)$$

Where m_0 , ρ , and A are the cooler mass, the density of the material, and the cross-section area, respectively. Finally, condense number (C_0) in equation (3) is determined through

$$C_0 = h_0 \left[\frac{\mu^2}{k^3 \rho(\rho - \rho_v)g} \right]^{0.03}. \quad (8)$$

The new parameter here is μ dan ρv as a representation of the dynamic viscosity and density of steam. In the case of turbulent flow, we can use Kirbride formula as

$$C_0 = 0.0077 Re^{0.4}. \quad (9)$$

Although a gravity effect is small here acceleration of gravity (g) is considered [15].

To obtain an ideal design of the muffler part, we employed the conjugate gradient method for determining an optimum thermal conductivity (Q) based on a random variation of diameter (D) and length (L). The formula for the optimization process is

$$Q(D, L) = \pi U D L \Delta T \quad (10)$$

Employing U in equation (3) as a constant where its value is obtained by using the procedure from equations (4) to (9), we develop conjugate gradient algorithm by considering the methods in ref [11,14]. Equation (10) can be represented in optimization target function as are thermal conductivity (Q) as a function of diameter (D) and length (L) of the muffler with re-heater:

$$\max \{Q(D, L)\} : D, L \in R^n \quad (11)$$

In this case, the target function is only for the real number.

Below are the conjugate gradient algorithm for solving equation (11) to determine the ideal dimension of the muffler with re-heater:

0. Choosing values of $D_0, L_0, \delta_0^D, \delta_0^L, g_0^{D,L}, d_0^D, d_0^L$ then calculating of:

$$1. D_n = D_{n-1} + \alpha_{n-1}^D d_{n-1}^D \text{ and } L_n = L_{n-1} + \alpha_{n-1}^L d_{n-1}^L$$

$$2. g_n^{D,L} = [\pi U \Delta T D_n \quad \pi U \Delta T L_n]$$

$$3. \beta_n^{D,L} = \frac{g_n^T g_n}{g_{n-1}^T g_{n-1}}$$

$$4. \delta_n^D = D_n - D_{n-1} \text{ and } \delta_n^L = L_n - L_{n-1}$$

$$5. d_n^D = D_n - D_{n-1} \text{ and } d_n^L = L_n - L_{n-1}$$

$$6. \alpha_n^D = \alpha_n^D \left\| \frac{d_{n-1}^D}{d_n^D} \right\| \text{ and } \alpha_n^L = \alpha_n^L \left\| \frac{d_{n-1}^L}{d_n^L} \right\|$$

$$7. \text{ Finally, estimating } Q_n(D_n, L_n) = \pi U D_n L_n \Delta T.$$

The target of the estimation in the conjugate gradient algorithm is to obtain the values of thermal energy at around 26 kcal/mole for 13.39 seconds in the muffler with re-heater [9]. The dimension and design of mufflers with re-heater are adjusted based on the car dimension.

The next steps are the realization and evaluation of the muffler with re-heater. The muffler is manufactured by using simple material but optimal dimension and design. Furthermore, the muffler's performance is evaluated by doing a measurement of CO, CO₂, and HC concentrations. The measurement is carried out by comparing the values of emission for muffler without and with re-heaters. An exhaust without re-heater is shown in Figure 2. The name of the instrument for retrieving the values of CO, CO₂, and HC concentrations is the emissions analyzer. Besides, the noise measurement is also

conducted in the same way (without and with re-heater) utilizing sound level meter. Both measurements are performed in both lower and faster rotation of engines, respectively.



Figure 2. Muffler without re-heater.

The text performance of the muffler designed in this study is carried out to Minibus produced in 1990, Kijang Type: SPR SH/KF40, MPNP/STATION WACO, and cylinder 1486CE. The measurement of emission is done by adjusting the emission analyzer at the end of the sub-muffler (Figure 3). Furthermore, utilizing of the sound level meter for retrieving noise parameters, measurement is adjusted at the exhaust, muffler, and sub-muffler parts (Figure 4).



Figure 3. Emission analyzer instrument.



Figure 4. Sound Level Meter.

3. Results and discussion

Figure 5 shows trajectories of thermal expansion which are projected to the length and diameter of the muffler with re-heater. The trajectories are obtained from the conjugate gradient algorithm which has been developed using equation (11). From the contour of thermal expansion, we retrieved both the length and diameter of the muffler with re-heater as 58 cm and 14 cm, respectively. Considering this estimation using the conjugate gradient method, we developed a muffler part with re-heater by considering the dimension of the car. By means of the dimension, the thermal energy at around 26 kcal/mole for 13.39 second in the closed system [9]. Besides, the interference of both incoming and reflecting sound waves will generate as a small sound [10].

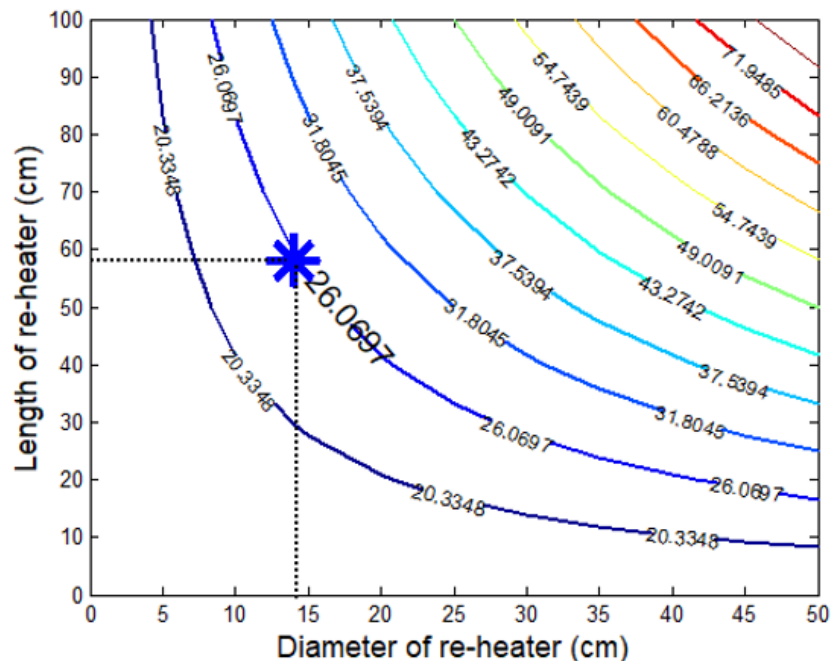


Figure 5. The thermal expansion derived from the conjugate gradient method with the optimal dimension of the muffler is marked by the asterisk.

Figures 6 and 7 are the design and real form of the muffler part developed based on the result in Figure 4. The muffler with re-heater is designed by improving the muffler without re-heater. Below are explanations of all parts in Figure 5:

- 1) Muffler standard consists of an empty tube with 34 and 14 cm of length and diameter, respectively. The muffler is completed by re-heater with 24 cm of length so that the total length is 58 cm.
- 2) The front-tube canal has 4.5 and 20 cm of diameter and length, respectively. The tube functionates for connecting the back part of the exhaust and the front part of the muffler.
- 3) The back-tube canal with 4.5 and 2 cm of diameter and length, respectively link the back part of the muffler and the front part of the sub-muffler.
- 4) The outside pipe canal with diameter 2 cm and length 54 cm is directly connected to the back part of exhaust through outside part of the muffler standard. Then, the pipe is connected to the inside part of the re-heater in the back part of the muffler standard.
- 5) The inside pipe of re-heater with diameter 2 cm and length 6 cm in the “U” form (up and down) is connected to the outside pipe canal in point 4).
- 6) The outside pipe canal with length 4 cm and diameter 2 cm from the end of the re-heater pipe is connected to the front part of the muffler standard.

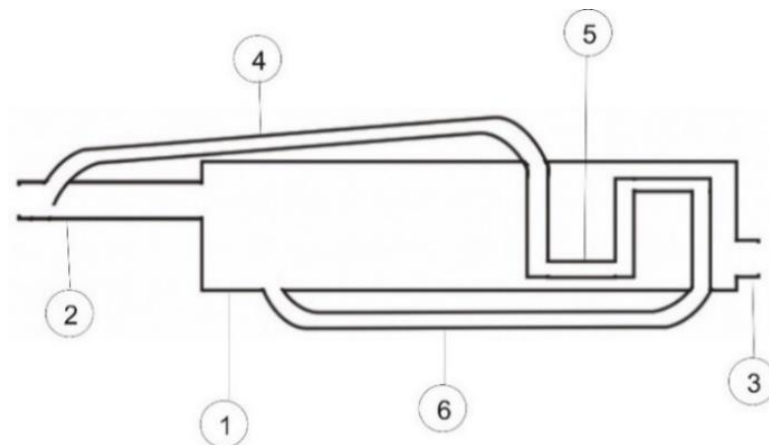


Figure 6. Design of muffler with re-heater.



Figure 7. Real form of the muffler with re-heater.

The muffler with re-heater is proved to decrease noise from the rear of the engine compared to the muffler without re-heater. From the measurement process of sound intensity level, we seek that the noise is decreased by approximately 3.79 and 3.00 % in the lower and faster rotation of the engine, respectively. Degradation of sound level intensity in dB is represented in Tables 3 and 4. When the measurement is carried out without re-heater (See Table 1), the sound level intensity is higher than with re-heater (See Table 2). As a silencer, the sound wave circulation process is started from the rear of the engine with different canalization of emission gases. The sound wave is canalized into two canals, the outside pipe and the inside tube of muffler parts. Here, we assumed that the magnitude of sound waves through the outside pipe and muffler standard is almost similar. The noise of the outside of the tube is canalized to the back part of the muffler, in the front part of the re-heater. In re-heater with the “U” form, the sound waves have experienced interference before propagating again into the front part of the muffler tube. In this process, we assumed that noise is decreased. The result is confirmed with the theoretical concept in ref [10].

Tabel 1. Noise without re-heater

Part	Sound Intensity Level	
	Lower (dB)	Faster (dB)
<i>Exhaust</i>	78.8	96.8
<i>Muffler</i>	75.9	90.1
<i>Sub Muffler</i>	82.5	90.7

Table 2. Noise with re-heater

Part	Sound Intensity Level	
	Lower (dB)	Faster (dB)
<i>Exhaust</i>	78.0	94.5
<i>Muffler</i>	70.1	87.1
<i>Sub Muffler</i>	80.1	87.9

The emission text to the muffler with re-heater by comparing the muffler without re-heater are represented in Table 3 and 4. The text result shows that utilizing re-heater can reduce CO, CO₂, and HC of 0.35, 14.6, and 76.29 %, respectively compared to the muffler without re-heater. The significant effect of the developed muffler can be seen in HC concentration. The exhaust system is operated by circulating thermal expansion and cutting the Carbon chain. The result of performance evaluation is confirmed to the stoichiometric principle in ref [9].

Table 3. Emission without *re-heater*

Time (minute)	Emission		
	CO (%)	CO ₂ (%)	HC (ppm)
5	10.53	12.64	5870
10	6.01	8.62	2990
15	4.71	8.60	5230
20	4.92	8.70	2970
25	5.00	8.60	4700
30	5.83	8.46	492
Total	37.00	55.62	22252
Average	6.17	9.27	3708.67

Table 4. Emission with *re-heater*

Time (minute)	Emission		
	CO (%)	CO ₂ (%)	HC (ppm)
5	9.93	8.40	864
10	7.78	8.78	1093
15	4.71	8.70	696
20	4.74	8.68	970
25	4.89	7.74	832
30	4.79	5.22	821
Total	36.87	47.52	5276
Average	6.15	7.92	879.33

The circulation process is started from the thermal energy produced by the combustion of the engine. The thermal is canalized to the outside pipe of the muffler parts. Almost emission flows to the outside of the tube, then continued to the back part of the muffler, in the front part of the re-heater. In the re-heater with the “U” form, the emission is heated before circulating again into the front part of the muffler tube. In this process, we assumed that emission is reduced before is discarded by the sub-muffler part out of the exhaust system. Besides the solution in refs [8,9] the muffler design that has been developed in this study can be an alternative for increasing the exhaust system performance.

4. Conclusion

Designing of the muffler part of the exhaust system for the big car has been conducted by employing the conjugate gradient method. The target of this study is to optimize the exhaust system in reducing noise and emission originated from the roar and combustion of the engine, respectively. In physics, controlling the sound wave propagation in the tube can reduce the noise due to the interference process. Then, from the stoichiometric concept, we have come to know that the carbon chain can be reduced by circulating the thermal energy at around 26 kcal/mole for 13.39 seconds in the closed system. This concept is applied by developing the muffler for decreasing noise and emission in the exhaust system.

From the results of the conjugate gradient estimation, we develop the muffler with a re-heater with 58 and 14 cm of length and diameter, respectively. To prove that the muffler's performance is efficient in reducing both noise and emission, measurement of sound level intensity and emission are conducted by comparing the muffler without and with re-heater. From the measurement, we seek that the noise is decreased by approximately 3.79 and 3.00 % in the lower and faster rotation of the engine, respectively. Besides, the test result shows that utilizing re-heater can reduce of CO, CO₂, and HC of 0.35, 14.6, and 76.29 % compare to the muffler without re-heater. The results indicate that the muffler with re-heater designed in this study is effective in reducing noise and emission from the roar and combustion of the engine.

Acknowledgments

We thank the Research Center of the Universitas Jenderal Soedirman (LPPM-UNSOED) for supporting this research. We also thank my peer group in Physics discipline for their discussion.

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