Safe Eco Exhaust, Air and Sound Free Pollution-Free Innovation with Cooler Safety Material Based on Silica Aerogel Made from Ash Bagasse Waste

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Abstract. *Indonesia's demographic bonus has an important role in realizing Indonesia's future success. The total population of Indonesia recorded in 2010 amounted to 238.5 million people and is estimated to increase to 305.6 million in 2035. The higher the population growth, it is also in line with the needs that must be met One of the very important needs is the need for transportation access. At present, the number of vehicles in Indonesia has reached 138,556,669 units with 81.58% of which are motorcycles. Each vehicle has a standard of eligibility to operate, this is functioned to reduce the impact that can be caused such as air pollution, noise pollution, and safety of the vehicle. Muffler (exhaust) becomes a part that plays a very important role, the resulting gas emissions such as carbon monoxide, nitrogen oxides, carbon dioxide, etc. can endanger human health. To overcome this, the idea of Safe Eco Exhaust was sparked as a smart solution to reduce air pollution, noise pollution, and also reduce the heat generated by the vehicle exhaust. The Safe Eco Exhaust design is projected to reduce CO exhaust emissions below the threshold by utilizing activated carbon. It is also able to reduce noise and reduce the heat generated by the exhaust by utilizing silica aerogel silica bagasse aerogel. So that Safe Eco Exhaust is expected to be able to minimize environmental degradation towards an independent Indonesia.*

Keywords: *Gas Emissions, Safe Eco Exhaust, Silica Aerogel*

1. INTRODUCTION

Indonesia's demographic bonus has an important role in realizing Indonesia's success in the future. This is in line with the large quantity of Human Resources owned by Indonesia, Indonesia's population recorded in 2010 amounted to 238.5 million people and is expected to increase to 305.6 million in 2035 (National Development Planning Agency,
2013). The higher the amount of population growth is also in line with the needs that must be met (Hardini, 2011). One very important requirement is the need for transportation access. The recorded value of economic consumption in the commodity trade in transportation vehicles, especially motorbikes and cars in the second quarter of 2018 was able to reach Rp 676,506.00 Billion and an increase of 5.1% over the previous period (Ministry of VAT, 2018). At present, the number of vehicles in Indonesia has reached
138,556,669 units with 81.58% of which are motorcycles (BPS, 2017). The ease of transportation obtained must be balanced by the adverse effects that can occur.

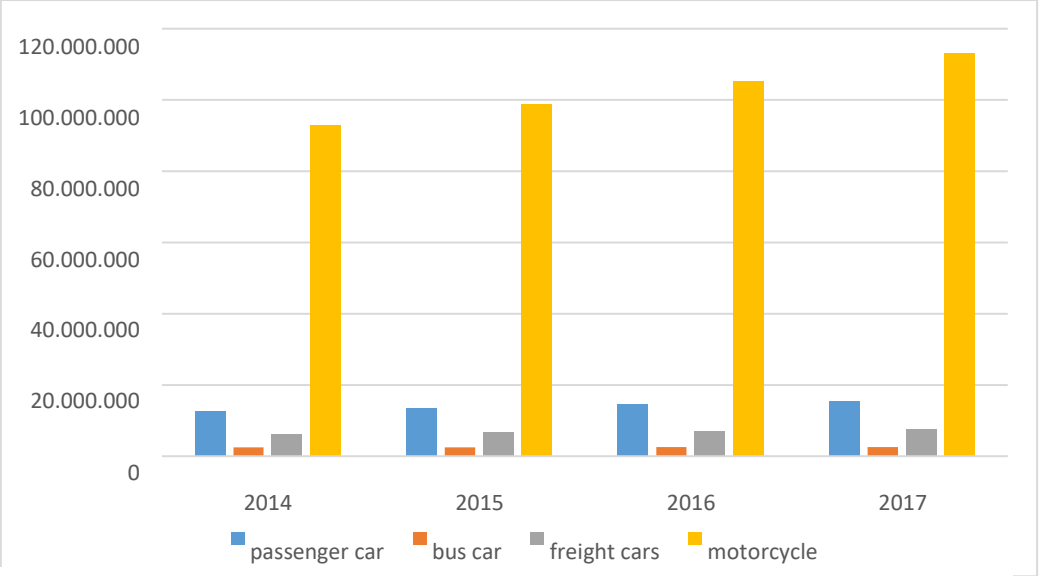
Each vehicle has a standard of eligibility to operate, this is functioned to reduce the impact that can be caused such as air pollution, noise pollution, and safety of the vehicle. Muffler (exhaust) is a part that plays a very important role, the resulting gas emissions such as carbon monoxide, nitrogen oxides, carbon dioxide, etc., can trigger health problems and become a major source of air pollution in urban areas (Mia. AP et al , 2016). Not only that, the noise that occurs can cause health problems, such as: hearing damage, hypertension and other disorders (Van, et al, 2002; Finkelstein et al, 2004). The government has tried to minimize this by creating regulations in the MenLHK Law No.7 of 2009 related to noise limits on motorized vehicles.

There have been many muffler innovations developed to date, one of which was done by Mahendra et al (2017: 1) designing filters to reduce exhaust emissions by utilizing coconut shell charcoal briquettes, a reduction in CO2 gas emissions by 32.28% in injection motors. However, this is considered still not effective, we need a more complex system to be able to overcome various problems at once. The author's innovation is designing Safe Eco Exhaust (SEE). SEE is projected to be a smart muffler innovation that can reduce air pollution and air pollution. This design is equipped with a cooler material system so that it can reduce the heat generated by exhaust gases. SEE's objectives can be achieved thanks to the Smart Design implementation and mature analysis testing in the design stage. Through this innovation, it is expected to help reduce pollution to the environment and create comfort for all parties.

2. LITERATURE REVIEW

2.1 Development of Motorized Vehicles in Indonesia

Today the use of motorized vehicles in Indonesia has increased very rapidly. The increasing number of motor vehicles is accompanied by increasingly advanced technology.



Picture 1. Diagram of an increase in the number of motorized vehicles

Source: BPS, 2017

Based on the above table in 2017 the number of motorized vehicles in Indonesia has reached 138,556,699 units consisting of 15,493,068 passenger cars, 2,509,258 bus cars, 7,523,550 freight cars and 113,030,793 motorbikes. The increase in the number of motorized vehicles in Indonesia averaged 14.5% per year higher than the average increase in the population in Indonesia by 1.36% (BPS, 2017). If the population in Indonesia in 2017 is recorded at 262 million, the ownership of motor vehicles in Indonesia reaches more than 1890 vehicles per 1,000 people, in other words it has increased four times from 2014 as many as 453 motorized vehicles for every 1,000 people (BPS , 2014).

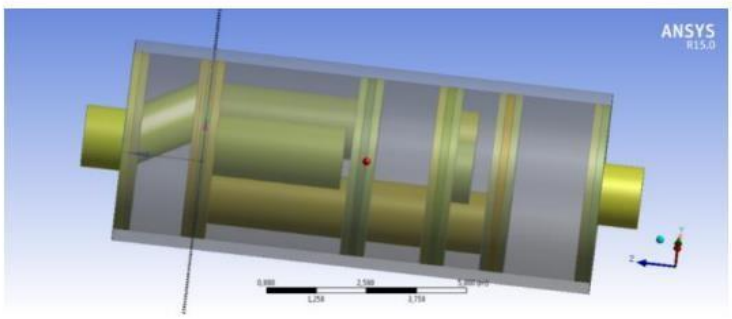
2.2 The Impact of Motor Vehicle Growth in Indonesia

The number of motorized vehicles in Indonesia which from year to year is increasing starts to cause various kinds of negative impacts (Atqiya 2016). Start air pollution, noise pollution to booming access to land transportation. Based on a 2011 World Resources Institute study, Indonesia produced sixth largest motor vehicle exhaust emissions in the world with a total of 2,053 billion tons. From the air pollution can cause various kinds of damage to nature such as acid rain, ozone layer depletion and global warming (Amalia,
2016). The air pollution also impacts on human health so that many people are infected with various diseases such as cough, asthma, mild bronchitis, chronic bronchitis, risk of heart disease

even if inhaled by pregnant women can result in premature births (Detikhealth.com, 2019). In addition to disrupting nature and human health, the high rate of increase of motorized vehicles from year to year can also disrupt access to land transportation, causing congestion everywhere (Rozari, 2015). Besides noise pollution also needs to be considered its negative impact. According to MenLHK Law No. 7 of
2009 noise can be avoided due to motorized vehicles. Requirements can be said to be noisy if the sound has a pressure above 80 decibels (dB). Noise that occurs can cause various health problems, including: hearing damage, hypertension and other disorders (Van, et al, 2002: Finkelstein et al, 2004).

2.3 Exhaust Technology Development Innovation

Technological developments bring the latest innovations to overcome various problems that exist today. One of them is the issue of exhaust emissions caused by vehicles. Mahendra et al (2017: 1) designed a filter to reduce exhaust gas emissions by utilizing coconut shell charcoal briquettes, resulting in a reduction in CO2 gas emissions of 32.28% in the injection motor. This design combines pulp and activated coconut shell charcoal, this mixture is effective to be a CO and CO2 exhaust gas adsorbent at a thickness of 5 cm



Picture 2. MIFI Design
(Source: Saputra *et al*, 2017)

In the same year Saputra et al (2017: 28) designed the exhaust that is able to minimize vehicle emissions and air pollution with the design name "MIFI". This design implements activated charcoal from the processing of palm oil shells, this material was chosen because the amount is quite promising because of its production of 6% in each ton. This design successfully absorbed 66900 ppm CO gas, 135 ppm NO gas, and 142 ppm NOx gas. however, more complex innovations are still needed that are able to overcome not only noise pollution but noise pollution and are able to reduce the heat generated in order to create vehicle safety and comfort.

3. METHODOLOGY/RESEARCH METHODS

The method of designing the SEE (Safe Eco Exhaust) tool uses the ADDIE development model which consists of Analysis, Design, Development, Implementation, and Evaluate. This research method is suitable for producing certain products, and testing the effectiveness of these products.

3.1.Analysis

This stage the authors analyze the problems that occur in the current era that the exhaust system innovation in vehicles is not optimal, so it requires a more intelligent and sophisticated innovation through the SSE tool. At this stage the authors also conduct research and data collection, there are two things done, namely literature studies and field studies. Literature study is used to find concepts or theoretical foundations that strengthen the SSE (Safe Eco Exhaust) product.

3.2. Design

The author will design the SSE (Safe Eco Exhaust) system innovation concept on the vehicle. The next step is to design a prototype to be tested on the field. If the system on the prototype is successful, the SSE is ready to be designed and installed on the vehicle exhaust, in designing the SSE on the vehicle, actually planning needs to be made which includes:

3.2.1. The goal is to provide an intelligent exhaust innovation system as an effort to find out exhaust emissions that are harmful to health and discomfort with the conditions produced by the exhaust.

3.2.2. The party who uses the product, that is, all the owners of all types of motorized vehicles.
3.2.3. Description and explanation of the components of the SEE system

3.3. Development

The design of the SEE (Safe Eco Exhaust) system when completed, the next stage is the product development stage of the SSE (Safe Eco Exhaust) system. This stage the authors do the initial product development, through initial trials, if there are errors on the product, continue to the stage of the revision process. The final step is the development of the final product SEE (Safe Eco Exhaust) system.

3.4. Implementation

The author will implement the SEE (Safe Eco Exhaust) system directly to the people of Indonesia after getting cooperation from various parties, such as the Government, the Minister of Public Works and Public Housing, Transportation Agency, Private Parties and the Community. Before implementing, the authors conducted a dissemination stage to the community, namely socialization related to the concept of developing SEE (Safe Eco Exhaust), the workings of the SEE (Safe Eco Exhaust) system, the benefits of the SEE (Safe Eco Exhaust) system in buildings.

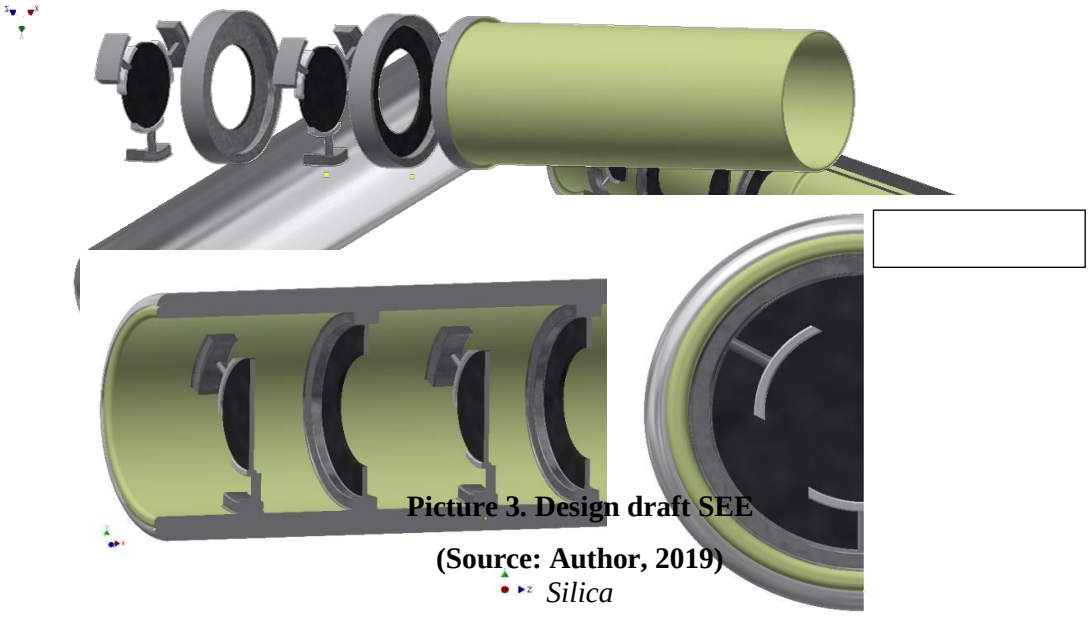
3.5. Evaluation

Evaluation is carried out after the concept of SEE (Safe Eco Exhaust) has been realized and is used by the public on the vehicle so that the shortcomings and weaknesses of the SEE (Safe Eco Exhaust) concept have been identified. So that in the future the concept of SEE (Safe Eco Exhaust) can be developed and further investigated, so that its function and use are more optimal in preventing pollution by exhaust gases.

4. RESULTS AND DISCUSSION

SEE is a muffler innovation in motor vehicles with the implementation of concepts in the use of material technology combined with mature design. Focusing on overcoming

three problems at once, including minimizing air pollution, minimizing noise pollution, and the cooler system on the exhaust. The SEE design is done digitally and in detail so that all three SEE functions can function optimally. The following design designs from SEE.



Picture 3. Design draft SEE

(Source: Author, 2019)

Silica

Picture 4. The design of the filter on the muffler
(Source: Author, 2019)

Minimizing Air Pollution, the design is done using 4 layers of filters on the SEE. The main material for SEE filters is to utilize activated charcoal layers. The choice is based on the nature of the charcoal as an absorber, molecular fuser, catalyst, and ion exchange. Activated charcoal becomes an adsorbent that has very small diameter pores that are able to absorb gases, so that harmful gases such as CO that pass through it will be bound and experience an attractive force with active charcoal pores (Maryanto, 2009). The filter is divided into two models, namely the middle filter and the edge filter which are placed alternately with the aim of getting maximum absorption and keeping the exhaust gas flow smoothly. The result of gas absorption can be increased by periodically changing filter material. Details of design design are in Figures 3, 4, and 5

Minimize sound pollution, the realization is done by utilizing the basic knowledge of fluid flow, the type of flow produced affects the noise and sound levels. Sound is interpreted when vibrations occur that can result in the shifting of particle matter in the air medium (sunitra, 2009). So, if the flow pattern (laminar) is getting smoother then there will be an increase in noise due to the absence of a medium that is able to hold the flow, while the turbulent flow pattern is able to dampen the results of the noise due to the medium that holds it. In line with the research results of putra et al., in 2013 which stated that the ability to reduce noise would be higher in line with high turbulence. The reduction in noise in the exhaust correlates to the design of the pollution filter design, namely the presence of 4 layers of filters plus the design of space on the exhaust inner wall. Details of the design design are in figures 3, 4, and 5. Through this design it is considered capable of reducing noise by increasing turbulence flow in the exhaust.

Exhaust cooler system. The application of the cooler system is by utilizing the low thermal conductivity properties of the material. Similar to the exhaust in general, the design of cooler made from iron / stainless or carbon, but with an additional layer made from silica airgel. This concept utilizes the basic law of heat and mass transfer, the fourier law. The following formulation and calculation of temperature reduction that occurs:

There are several equations used:

$$= - \frac{KA}{\Delta X}(T_2 - T_1)$$

$$Q = \frac{\Delta T}{Rth}$$

$$Rth = \frac{\Delta X}{KA}$$

Information :
Q = Heat
K = Thermal Conductivity
A = Surface area
T = Temperature
X = Thick of amusement

The exhaust gas passes through the middle filter and the edge filter coated with activated charcoal, the absorption of harmful gases such as CO occurs, further attenuation of noise by the filter and the design of the chamber in the exhaust wall is added so that noise will be reduced with increased turbulence flow in the exhaust. The cooler system on the exhaust will absorb heat and reduce the exhaust temperature of the vehicle exhaust gases with an additional silica airgel layer.

The Cooler Material design applies the use of heat-resistant material. Materials using materials with low thermal conductivity are using silica airgel layers and reinforcement layers made from carbon.

Following Calculation of Heat Reduction:

Assessments are sourced from Thermtest.com and Resource.saylor.org

Known Technical Specifications:

Constant :

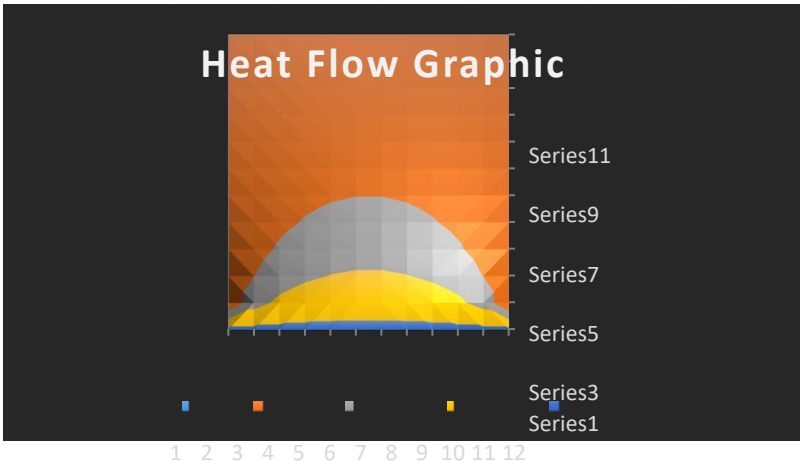
KA (Silica Aerogel) = 0,024W/m°C
KB (Carbon) = 1,7 W/m°C
Q = 735 W/h
T2 = 210°C
ΔX1 = ΔX2 = 0,005 m
T1 = ??

$$Q = \frac{T2 - T1}{\frac{\Delta X1}{KA} + \frac{\Delta X2}{KB}} \qquad 735 = \frac{210 - T1}{\frac{0,005}{0,024} + \frac{0,005}{1,7}} \qquad 735 = \frac{210 - T1}{0,2113}$$

$$T1 = 54,7°C$$

The following is a calculation of the heat distribution of material using the two dimensional nodal plate method.

210	210	210	210	210	210	210	210	210	210	210	210
54,7	130,9317	160,1339	172,9119	178,8661	181,298	181,2979	178,866	172,9118	160,1337	130,9316	54,7
54,7	98,89279	126,6917	142,6475	151,2542	155,0277	155,0276	151,254	142,6472	126,6915	98,89264	54,7
54,7	83,24764	105,0926	119,7318	128,4753	132,5306	132,5305	128,475	119,7315	105,0923	83,24744	54,7
54,7	74,30501	90,6989	102,7116	110,3841	114,0887	114,0886	110,3838	102,7112	90,69856	74,30478	54,7
54,7	68,57331	80,68617	90,03116	96,26043	99,35099	99,3509	96,26017	90,03079	80,6858	68,57306	54,7
54,7	64,60187	73,44102	80,4661	85,27511	87,70359	87,7035	85,27486	80,46575	73,44067	64,60163	54,7
54,7	61,69296	68,00968	73,11679	76,66997	78,48441	78,48433	76,66974	73,11648	68,00937	61,69275	54,7
54,7	59,46013	63,78773	67,32112	69,80326	71,07945	71,07938	69,80308	67,32088	63,78749	59,45996	54,7
54,7	57,6597	60,35984	62,5765	64,14227	64,95052	64,95047	64,14215	62,57633	60,35967	57,65959	54,7
54,7	56,11876	57,41532	58,48263	59,23867	59,62974	59,62971	59,23861	58,48255	57,41523	56,11871	54,7
54,7	54,7	54,7	54,7	54,7	54,7	54,7	54,7	54,7	54,7	54,7	54,7



Picture 5. Distribution of heat in the material
(S: Author, 2019)

The reduction in air pollution uses activated charcoal to be able to reach even below the vehicle emission limit which is below 4.5% in line with research by Maryanto, D. et al in 2009.

Weight of Active Charcoal Addition	**Gas Emission Levels Before**	**After Gas Emission Levels**	**Percentage of Increase**	**Success**
50 Gram	5,49%	5,35%	2,55%	Failed
100 Gram	5,49%	4,33%	21,13%	Succes
150 Gram	5,49%	3,00%	45,35%	Succes

Whereas the Sound Noise Reduction is able to reach below the noise threshold (80 dB), but vehicle speed will always affect noise, in line with Welsa Putra's research in 2013:

Engine Speed (RPM)	**Test 1**	**Test 2**	**Test 3**	**amount**	**average**
1200	68	68	70	206	68,67
2000	72	72	75	219	73
3000	76	77	79	232	75,33
4000	80	82	84	246	82

While the reduction in temperature based on the above calculation formulation is able to reduce heat from 210 ° C to 54.7 ° C, or by 73.95%.

This concept can be realized if there is good cooperation with the Government, the Department of Transportation, the Institute for Assessment and Application of Technology, and the private sector. Safe Eco Exhaust is very possible to be perfected by designing more efficient designs and choosing the right and suitable material. The existence of Safe Exhaust is expected to be an effective innovation in reducing the risk and impact of increasing vehicles and being able to become a mover as a result of the utilization of science and technology in the framework of preparing to face the growing Industrial Revolution Era 4.0

CONCLUSION

SEE is a muffler innovation in motor vehicles. The SEE concept is an implementation of the use of material technology combined with mature design. The innovations applied to the SEE concept focus on addressing three types of problems at the same time in vehicle exhausts, including: Minimize Air Pollution, Minimize Sound Pollution, and Cooler Systems in Exhausts. The design of SEE is carried out in detail and digitally so that all three SEE functions can function optimally. This concept can be realized and implemented if there is good cooperation with the Government, the Department of Transportation, the Office of Assessment and Application of Technology, and the private sector. The Safe Eco Exhaust design is projected to be able to reduce CO exhaust emissions below the threshold with an increase in absorption of 21.13% on the addition of 100gram of activated charcoal and a reduction in sound noise at a value of 75.33 dB and able to reduce heat by 73.95%.

The existence of Smart Safe Exhaust is expected to be an effective innovation in reducing the risk and impact of increasing vehicles as well as being able to become a mover as a result of the utilization of science and technology in the framework of preparing to face the growing Industrial Revolution Era 4.0.

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