Air purifier bike design and prototype as a short distance transportation plus an effort to downgrade the level of air pollution concentration in towns

B Iskandriawan\textsuperscript{1*} and J Jatmiko\textsuperscript{2}
\textsuperscript{1}Department of Industrial Design, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia
\textsuperscript{2}Department of Architecture Interior, Universitas Ciputra, Surabaya, Indonesia

*Email: bisk@prodes.its.ac.id

Abstract. In line to the economics growth rate which is improved hence economics level of the family also more prosperous. It is followed by the number of vehicle more increase. Jamming problem come to be in serious situation. Not to mention the pollution problem which is caused by the exhaust gas of motor vehicle where their number always increase every year. One of the problem solutions is within the operating of bicycle as the alternative of transportation. Based on the research experience before concerning to the applied heat transfer and bicycle design also the serious reality above so the author intend to air purifier bike design. The existence of them is expected will diminish the intensity of urban air pollution in a straightaway. Secondary manner it will give suggestion and stimulus for city inhabitant in order to strive their region is more environments friendly. Repeating manufacture even design are could not be avoided when some failure are occurred in the testing phase. Follow up the problem statement of urban air pollution, limited space, city inhabitant taste likewise production competence furthermore it is answered within bring into practicality the design and prototype of air purifier bike (APB).

1. Introduction
Author implemented the research within the topic of air purifier bike is considering more the high of air pollution in the town as the result of industry activities besides the number of motor vehicle which are raised. The existence of air purifier bike is expected directly could reduce of the intensity of air pollution. In an indirectly manner it could give the influence to the people concerning to the importance of seek their place of residence in order to more environmentally friendly, as shown in Figure 1. With an intense prophecy appearing in the background analysis therefore it is created critical problem statement in line to the need and constraint, as displayed in Figure 2.

In order to increase the number of the sliding tandem bike features hence eight new designs of the main frame have been designed while checking the structure [1]. Bicycle design is very unique depending on the needs of its users for example for patients with spastic cerebral palsy [2]. Bike is used not only for single but it could be possible in pair. They could increase relationship quality between couple even amongst people in the social community. Secondarily manner the using of tandem bike enormously possibly will reduce the concentration of air pollution [3, 4]. Previously, the alternative of bike design is manifested based on the purpose of design, even though several of them still in the concept [5, 6]. However, APB is not only a means of transportation but also as an air filter.
Figure 1. Background of the bicycle design to diminish air pollution in an urban area.

Figure 2. Determining of problem statement along with the clarification of bike which is required within need and design constraint.

2. Method

Step by step of the air purifier bike prototyping could be viewed at Figure 3. There are a lot of approaches how to do product design [7]. This work combines design theory and team’s experiences to do concept and every design decision. Material selection is not only considering the engineering aspects but also design attribute especially the appearance perspective [8].

Figure 3. Design and construction flow chart of air purifier bike prototyping.
Remaining but not least, the important aspect to complete this work is exploited ergonomic consideration to the design of air purifier bike [9].

3. Result and discussion
The implementation of science and engineering approach in this work are not only in design but furthermore in the fabrication and assembly phase [10, 11]. Stability and stiffness are the key prerequisite for air purifier bike as the transportation device.

Exploration idea of air purifier bike was presented throughout design sketching, as shown in Figure 4 and Figure 5. It is not only for the whole bike but also for each component in detail. Work drawing was generated to attain the bike dimension perfectly. When the work drawing was finish therefore material selection could be started. Furthermore, construction of jig and fixture for air purifier bike frame fabrication was completed. Discussing amongst team member exploited technical and 3D drawings. Parallel work process were done, they are pipe bending trial, bike frame development along with jig operating evaluation for fabrication simplicity, as exposed in Figure 6. Due to the pipe wall thickness is very thin therefore bending work needs more extraordinary consideration otherwise shrinkage even crack will occur.

Figure 4. Idea exploration and realization throughout design sketching, work drawing, material selection then the construction of jig and fixture for air purifier bike frame fabrication.

Figure 5. Technical drawing production, design and manufacture exploration utilise 3D software in addition detailing of bike frame component.

Figure 6. Parallel work process: pipe bending trial, bike frame development along with jig operating evaluation for fabrication simplicity.

Figure 7. Air velocity measuring simulation as the function of wheel angular velocity parallel to construction of the connector between elbow cup and enter air area to the wheel blade.

Although the jig was already established but it is still need some modification for simplicity of frame fabrication. Whereas the frame of air purifier bike is still in progress, the team implemented
simulation of air velocity measurement with another bike, as presented in Figure 7. It is also examined the effect of blade number to the air velocity magnitude. Construction work of the connector between elbow cup and enter air area to the wheel blade is done at the same time. Five blades proficient to accelerate air velocity enter to the wheel compare to them with three blades as it can be seen at Figure 8. The body air purifier bike has built successfully and it ready for trial but the head cup was still under construction, as shown in Figure 9. The weight of air purifier bike is not too heavy that’s why it could be lifted by only one people. There is an electronic equipment inside the head cup where it is planned could measure the quality of air before and after throw air filter.

One of the complexities of the construction phase was how to arrange electronic equipment inside the head cup. It needs extraordinary attention due to the limitation volume of head cup, as exposed in Figure 10. It is used Styrofoam as model study of the head cup.

Another activity is the elbow cup was still need to be evaluated, checking and dimension repeatedly. Also it is applied the duplication of elbow cup in line to the requirement of the bike, as shown in Figure 11. Each bike needs four elbow cups. Each elbow cup (result of duplication) needs to be checked to the conformity on the holder, as indicated in Figure 12. Also it was carried out the perfecting of ring at elbow cup then inspection of air tightness on connecting.
It was required the support to place tachometer and anemometer on the bike when it was carried out measuring of air velocity, $V$ (m/s) and wheel turning, $N$ (rpm). Figure 13 shows us the position of the supports. It could be noted the influence of wheel turning to the air velocity enter the bike pipe when air purifier bike was functioned, as displayed in Figure 14. The more the wheel turning the air velocity will increase gradually. This phenomenon proves that the centrifugal force of the wheel blade already works. They could drag the air flow into to the bike pipe with the certain speed. Figure 15 shows us the prototype of air purifier bike which was successfully realized.

**Figure 13.** Drive test and measuring of air velocity at the front wheel (a), production of tachometer and anemometer supports for air purifier bike trial setup (b).

**Figure 14.** Measuring process of enter air velocity and wheel turning when air purifier bike was operated.

**Figure 15.** Prototype of air purifier bicycle (APB) which is produced by author as initial step to analyse airflow inside pipe frame by means of numerical simulation.

4. Conclusion
Review to the problem statement, there are four aspects should be solved and considered: air pollution, appropriate for urban people, limited space and feasibility for production. It is expected that the existing of paper filter inside the head cup could transform dirty air turn into clean after the air throw the head cup. That means air pollution around the bike driver could be reduced. Unfortunately this paper is still not discussing the filter performance, as shown in Figure 16. The technical drawing of head cup can be
seen at Figure 17. In the role of one kind of personal transportation they very appropriate for urban people. There is a lot of traffic jam anywhere in the town so air purifier bike could be used while they deliver fresh air. The dimension of air purifier bike just similar to the others bike commonly adjusts to the limited space. It could be read above that the production process of air purifier bike is feasible. The small construction industry is proficient to manufacture them easily.

Deep discussion concerning to the airflow characteristic which is passing through frame pipe will be continued to the next paper along with a computational fluid dynamics analysis. It would be implemented some variable which are control the performance of the bike in the air filtering. Figure 18 illustrate us the air velocity counter inside the frame pipe of air purifier bike (APB).

Figure 16. Design of paper air filter which is installed on the head cup of air purifier bike

Figure 17. Design of paper air filter which is installed on the head cup of air purifier bike

Figure 18. Air velocity countour of air pass through head cup due to blades turning in the wheel

Acknowledgments
We would like to thank The Research and Technology Ministry specifically the division which manages Program Insinas Riset Pratama 2017. Title of funded research proposal: Design of Air Purifier Bike for Closed Distance Transportation, Social Communities and While an Initiative for Reducing Urban Air Pollution Levels.

References
[1] Bambang I, Jatmiko, Agus W and Ari D K 2018 Main Frame Structure Exploration of Sliding Tandem Bike as the Effort to Enhance Product Feature Journal of Engineering and Applied Science, ISSN: 1816-949X, pp 1872-1876
[2] Bambang I, Djoko K, and Elly F S 2018 Bicycle Design for Children with Spastic Cerebral Palsy to Enhance Interaction between Children and Parents Proceeding of Biomic, ISSN: 978-1-5386-7599-1, pp 68-72
[3] Bambang I, Jatmiko, Eri N U and Firman H 2017 Tandem Bike Design for Apartment Residents as an Idea to Reduces Air Pollution Matec Web of Conferences 101, 03017. SICEST 2016
[4] Bambang I and Jatmiko 2014 The Development of Bicycle into Tandem: The Bike Can be Used as Tandem or Single Depend of The Necessity AMM 607 pp 920-925
[5] Dudy W 2010 Desain Sepeda Indonesia Kepustakaan Populer Gramedia (KPG) Jakarta, ISBN: 978-979-91-0243-0
[6] Michael E foreword by Paul S photographer by Bernhard A 2011 Cyclepedia a Tour of Iconic Bicycle Designs Thames & Hudson, ISBN 978-0-500-51558-7
[7] Nigel C Engineering Design Methods, Strategies for Product Design 2000 Third Edition, John Wiley & Sons Ltd, Baffins Lane, Chichester, West Sussex, PO19, England
[8] Mike A and Kara J, 2007 Materials and Design, The Art and Science of Material Selection in Product Design, Butterworth Heinemann, Oxford, UK
[9] Henri C and Angus B 1998 Comfort on Bicycles and the Validity of a Commercial Bicycle Fitting System Applied Ergonomics, 29, 3, pp 201-211
[10] Chia H C, Ying H H and Tzyy Y S 2015 *The Effect of Bicycle Seat-Tube Angle on Lower Extremity* Journal of Science and Cycling, 4, 1, pp 28-32
[11] Robert L M 2009 *Machine Elements in Mechanical Design*, Volume 1 and 2 Publisher: Andi