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Design Improvement of Energy-Saving and Eco-Friendly Car as Transportation Facility

Zainal Arifin⁽¹⁾, HerminartoSofyan⁽²⁾, Moch. Solikin⁽³⁾, Kir Haryana⁽⁴⁾

Automotive Engineering Education, Faculty of Engineering, Yogyakarta State University, Indonesia

E-mail :

[^{\(1\)}zainal_arifin@uny.ac.id](mailto:zainal_arifin@uny.ac.id)[^{\(2\)}herminarto_sofyan@uny.ac.id](mailto:herminarto_sofyan@uny.ac.id)[^{\(3\)}solikin@uny.ac.id](mailto:solikin@uny.ac.id)[^{\(4\)}kir_haryana@uny.ac.id](mailto:kir_haryana@uny.ac.id)

Abstract. The increase of transportation facility needs raises a problems, especially pollution caused by motor vehicle exhaust that directly affects the decline of air function. Consequently, it is needed an effort to build alternative technologies and eco-friendly vehicles as transportation, in order to reduce the negative impact of exhaust emissions from fossil-fueled vehicles. This research was conducted to design and improve energy-saving and eco-friendly product that can be utilized as transportation. Accordingly, to improve the design of energy-saving and environmentally friendly vehicles, this research is conducted using research and development, for 5 years, starting in 2017 until 2021. Based on a survey towards 327 people that spread across major cities in Indonesia, the result reveals that the design of energy-saving and environmentally friendly vehicles required is a multi-purpose vehicle (multi-purpose vehicle / MPV). By considering the aspect of energy consumption and its impact on the environment, then the concept to improve is city car vehicle concept with 2 seats capacity plus baggage which is able to carry load of 60 kg. The selected vehicle specifications includes 2200 mm long dimension, 1800 mm width, 1700 mm height, 160 mm clearance ground, 1000 cc engine capacity, and 2 x 3000 W motor capacity.

1. Introduction

The growth of transportation facility needs, particularly from the number of vehicles, brings benefits to the financial life of society. However, other problems arise, for instance air pollution that affects the decrease of air quality caused by motor vehicle exhaust in many places as a result of the rapidly increase of vehicles number. Based on data from the Central Bureau of Statistics (BPS), the number of motor vehicles in 2014 reached 114,209,266 units, up to 9.69% from the previous year. The number was dominated by motorcycles amounting to 92,976,240 units and followed by passenger cars whose total was 12,599,138 units. While the growth of road length and width is only about 2% (source: www.bps.go.id). It indicates that the growth of the road area could not be balanced with the growth of the vehicle. Hence, this is extremely crucial to consider vehicle dimensions that is relevant to the road conditions.

Besides considering energy-efficient considerations and environmentally friendly, the other important factor is that the existence of small cars (mini car) has become a necessity. Therefore, it is important to



develop vehicles (cars) with a small size and in accordance with the needs of society, mainly urban communities. Small cars are very effective to reduce road density in urban areas.

This study aims to (1) Realize Strategic Plan and Research Master Plan (RIP) of Yogyakarta State University on the development of environmentally friendly technology; (2) Produce prototype of energy-saving and environmentally friendly cars in accordance with the needs of the community and the extent of urban roads.

This research is highly essential as the consumption of fuel oil for the transportation sector, continues to increase. High fuel consumption gives impact on environmental pollution, as the consequence, an environmentally friendly vehicle is required. Furthermore, the growth rate of roads is not able to offset the growth of vehicle population, so it is very important to develop a small vehicle (mini car) that is representative towards urban transportation needs. Energy-saving-and-environmentally-friendly-cars with urban hybrid concept are important to develop to overcome the problem of decent transportation needs.

2. Literature Review

Motor vehicles as a means of transportation have much better characteristics than non-motorized vehicles. Motor vehicles can transport people and goods much more even at speeds much faster than non-motorized vehicles. The role and function of the motor vehicle demands excellent capability in the form of engine power that can overcome the load of goods and human as well as the force of resistance from road surface and speed of movement (Sutantra, 2001). However, behind the role and function of motor vehicles that are prime, there are negative impacts behind that must be solved more quickly and precisely, especially related to air and sound pollution that should not exceed the threshold.

Nowadays, global demand has indicated the need of mitigation and adaptation to the impact of global warming due to the increase of greenhouse gas emissions that is obviously triggered by the increase of uncontrolled growth of motor vehicles. Knowledge of choosing a motor vehicle is particularly important with respect to the correlation of the type and the ability of the engine power to the load of the vehicle that would transported so that the exhaust emissions produced do not exceed the threshold limit. Thus it can be indicated that the greater the load carried by motor vehicles, the bigger the need for engine power comparing to basic ability, which in turn will result the greater exhaust gas.

Air pollution from motor vehicle exhaust emissions does increase, therefore, an effort to control vehicle emission gas emission is undoubtedly necessary. Such efforts should be reactively carried out since most of the motor vehicles operating in Indonesia are still using the era of conventional technology that has the potential to generate greater exhaust emissions. Currently, there are not only car engines with gasoline and diesel motor bases which exists. Momentarily, there are also transportation development, such as hybrid cars, electric cars, and car engines with fuel cell technology.

An electric car is a vehicle which consists of a battery that provides energy, an electric motor as a wheel drive and a controller that regulates the energy that flows into an electric motor (Leitman& Brant, 2009: 7). Battery has a big role in electric cars because it works as a storage of electrical energy required by electric motors. Electric cars require batteries with a large capacity to ensure the vehicle can be used for long distances. There are several types of batteries that can be used, where each type has its own characteristics, advantages, and weaknesses. Hodkinson & Fenton (2001: 29)

Hybrid technology is a vehicle propulsion technology which combines two types of driving machines (Toyota Motor Corporation, 2003: 2). Hybrid technology usually unites the internal combustion

engine with an electric motor, where the example is widely applied is a blend of gasoline engines with electric motors. Hybrid cars are created to cover the weaknesses of motor fuel and electric cars (Mi, Masrur& Gao, 2011: 22). Nevertheless, cars with gasoline or diesel engines have weaknesses in efficiency and pollution while electric cars have a disadvantage for mileage because of the limited energy that can be stored in batteries and it takes a long time to charge.

Through the use of hybrid technology, this becomes possible to improve the efficiency of energy use, since the motor fuel has a low efficiency and it also will be more wasteful with driving conditions in the middle of the city. Motor fuel either in the form of gasoline engine or diesel will still require energy during the engine life even if the vehicle stops. Unlike the electric motors that require energy only when the power is activated or needed. When the condition is in traffic jams or in stop and go driving then what is activated is the electric motor. Although hybrid vehicles use electric motors, but dissimilar with the electric car that, that is in the hybrid which does not require an external source of electricity.

The work combination between the two types of propulsion can be done with various combinations. Malloy & Lachapelle (2014: 14) divide hybrid technology types in vehicles into three types - Micro Hybrids, Mild Hybrids and Full Hybrid.

The simplest type of hybrid is a series model, which possess a working principle that is used for motor fuel only used to rotate the generator to supply the electricity needed to drive an electric motor directly connected to the wheels. In hybrid parallel model between motor fuel and electric motor, both can equally move the wheel. In other words, both of them can be combined with each other to rotate the wheel or be used independently. The latest type of hybrid car is the Plug-in Hybrid Electric Vehicle (PHEV) model. This technology provides cables that can be applied to facilitate the battery charging via household electricity (Mi, Masrur& Gao, 2011: 36). Usually this technology requires a larger battery capacity than a regular hybrid car, whose purpose is to save more electricity used to move the vehicle so that it can travel a longer distance and spend fuel more efficiently.

3. Method

This study aims to design and improve energy-savings-and-environmentally-friendly-car products that can be used as a facility of transportation. The attempt of improvement design of energy-saving and environment-friendly vehicles is oriented to technical aspects. To develop design and model of energy-saving and environmentally friendly vehicles, it is done by using research and development method or often abbreviated as R & D (research and development). The R & D method, in many ways, is regularly used to produce the product and test the effectiveness of the resulting product, thus this method is the most suitable method to conduct this research. In several cases, this R & D research is well-applied for the development of fields related to technology and industry.

There are several steps or steps to take in conducting R & D research, according to Borg and Gall (1989: 784 - 785) there are 10 (ten) steps in R & D research including: (1) research and information collecting, (2) planning, (3) development of product preliminary form of product, (4) preliminary field testing, (5) Main product revision, (6) Main field testing, (7) operational product revision, (8) operational field testing, (9) final product revision, (10) dissemination and implementation..



Figure 1. Research Procedure

The research and product development is conducted during 5 years, starting from 2017 until 2021. The research and development takes place at the Faculty of Engineering, Yogyakarta State University, Karangmalang Campus, Yogyakarta. A series of research and development processes with sequences of activities, methods, indicators of achievement and outcomes is done with steps annually.

Hybrid car that will be developed is Hybrid Car with Parallel Series System, thus, both electric motors and gasoline motors are used equally to move the wheels. The development of the car drive will begin with an electric drive and then the drive with a combustion engine and then a new arrangement is made to set the synchronization and job of the two s activator type used.

Through that variant, if the vehicle can be mass produced then the consumer can choose three variants of the car – the car with the motor drive gasoline, the car with electric motor drive and hybrid car (the combination of the electric motor and gasoline motor).

4. Results And Discussion

Survey is intended to explore and analyze the needs (need analysis) of the society with aims to gain information of how far the knowledge, needs and perceptions of the people who use the vehicle as facility of transportation. The survey results towards 327 people in all major cities across Indonesia, that comprises of 275 (84%) men and 52 (16%) women, ranging in age from 20 to 70 years, come from distinct professions - civil servants, entrepreneurs and others. Most of the respondents (community of vehicle users) indicated the public's need for transportation facilities is the multipurpose vehicle (multi-purpose vehicle) vehicles. Additionally, from the data of survey results, it can be understood that the needs of respondents representing most of the people of Indonesia is a vehicle that can be operated as a multi-function vehicle and family vehicles which can carry more passengers.

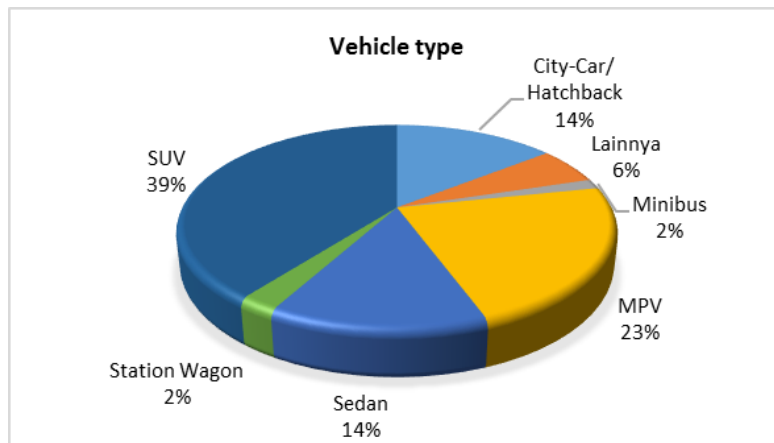


Figure 2. Type of Vehicle

Respondents more prefer multi-purpose vehicles that can accommodate many passengers, hence the choice of MPV 23% and 39% SUV is mostly chosen. This vehicle is a multi-function vehicle that has a basic form of engine compartment and passenger compartment that integrates with goods, so it can be used for various purposes.

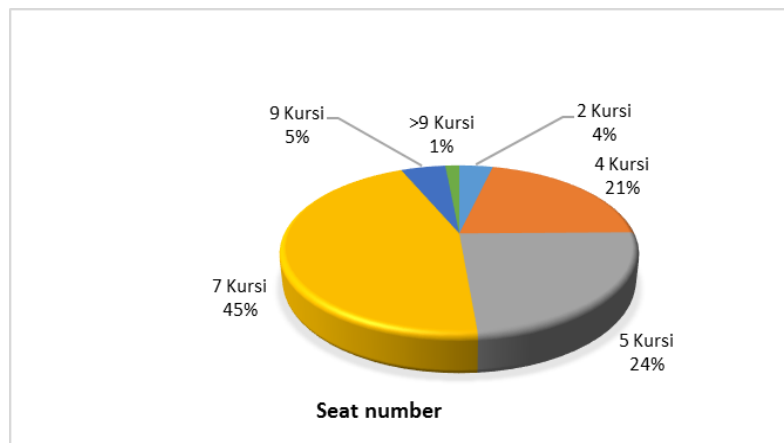


Figure 3. Choice of Number Seats

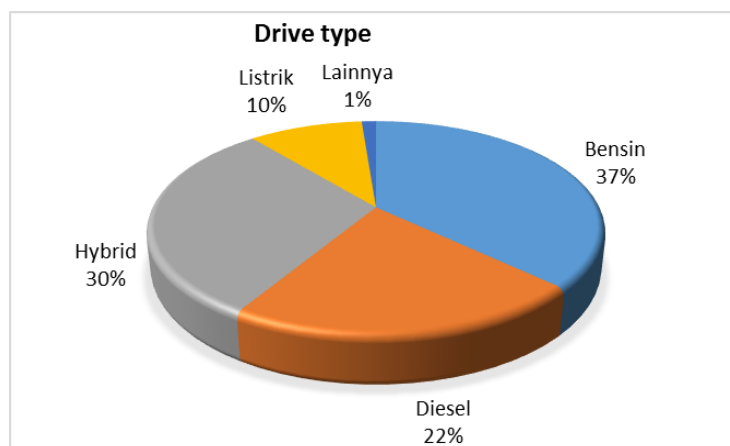


Figure 4. Choice of Drive Type

Meanwhile, based on the results of interviews and discussions with the staff of the Ministry of Communications and Transportation Office of Yogyakarta Province, it concludes that the target access of society related to mobility of society needs a special formulation since up to day the need for transportation modes is still quite high and will continue to increase as the impact of the increase of economic growth.

The initial design of an energy-saving and environmentally friendly car for two passengers can be seen in the figure below. This design will be well-completed and fixed after getting results data from need assessment and design test.

As the choice for respondents towards form design vehicle; there is urban car with 2 seats capacity and 60 - 100 kg of baggage capacity, it lies on concept that urban vehicle has a small enough space with a good enough maneuverability, as well as with gross vehicle weight (GVW) capacity of 700 kg which only requires 70-80 DK configures with 3-cylinder, DOHC VVT-i, Drive by wire, with electric motor power 2 x 3000 W, 48V.



Figure 5. Design of Urban Car Concept

Mobil urban Energy-saving and eco-friendly cars will be manufactured with the following specifications:

Table 1. Specification Concept

Section	Specification
General Specification:	
Length	2.200 mm
Width	1.800 mm
Height	1.700 mm
Distance to ground	160 mm

Capacity	2 passengers + baggage
Drive	
1. Gasoline Engine	4 stroke 1 cylinder 1.000 cc. Injection
2. Electric	2 x 3000 W, 48V
Suspension	
Front	Independent
Back	Independent
Power transfer	
Gasoline	Automatic Transmission of Rear Wheel
Electric	On Wheel, Front Wheel
Brake System	
Front wheel	Hydraulic discs
Rear wheel	Hydraulic discs
Steering	
	Rack and pinion

5. Conclusions

Based on the results of research and discussion that has been done in this first year, it can be concluded as follows.

- Based on survey towards 327 people live in various big cities in Indonesia, the result show that the design of energy-efficient vehicles and environmentally friendly required by the society is a multi-purpose vehicle (multi-purpose vehicle / MPV)
- By considering the aspect of energy consumption and its impact on the environment, thus, what is chosen to develop is the concept of city car with 2 seats capacity plus baggage that can carry 100 kg load.
- The selected vehicle specifications includes 2200 mm long dimension, 1800 mm width, 1700 mm height, 160 mm clearance ground, 1000 cc engine capacity, 2 x 3000 W motor capacity.

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