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ORIGINAL CONTRIBUTION

The Design of Motorcycle's Combustion Exhaust Gas Powered Tyre Pump

Riana Magdalena [1*], Stefani Prima Dias Kristiana [2], Lukas Ambarita Saragih [3]

[1, 2, 3] Industrial Engineering Department, Faculty of Engineering, Atma Jaya Catholic University of Indonesia, Jakarta, Indonesia

***Abstract*— This research is motivated by observations and experiences of the researchers that a motorcyclist wants comfort while driving, but on a motorcycle, there can be many factors that cause problems. For example, experiencing a lack of air pressure on tyres (deflated) or a flat tyre becomes a serious problem when driving on a quiet road so that the driver feels disturbed. It is necessary to make a tool that can be used to pump tyres easily and efficiently. In making and designing tools, product specification design methods were used, ranging from task translation to detailed design. The Product Design Specification (PDS) method focuses on the criteria for being achieved in ideas and concepts. The value of pressure from the theoretical calculation is different from the calculation of the tool; the results of the theoretical calculation of the tool obtained air pressure of 38.8 Psi, while the tool testing can directly reach a pressure of 30 Psi. Although figure 30 Psi has been able to fill the front and rear tyres of a motorcycle, the difference in numbers is certainly caused by observable factors. With a variety of factors that affect the performance of the tool but still can meet enough criteria to be able to pump motorcycle tyres and also the design of this tool is made for use in emergency conditions, so that when a motorcycle experiences a flat tyre and the condition is not in the immediate vicinity with a tyre pump workshop, the tool can be used.**

***Index Terms*— Motorcycle Tyre Pumps, Product Design, Product Specifications Design**

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I. INTRODUCTION

The automotive industry in Indonesia is undergoing a very rapid development marked by many new products offered with various types. One type of automotive industry that is in demand in Indonesia is named as motorbikes. The development of motorbikes as transportation is very helpful for humans in doing any job [1]. The number of motorcycle production in Indonesia in 2016 was 105,150,082 units [2].

Fig. 1. Motorcycle ownership in Indonesia from the year 2007-2016

*Corresponding author: Riana Magdalena
†Email: riana.magdalena@atmajaya.ac.id

Motorcycles are two-wheeled vehicle that is most in-demand in Indonesia by users from various groups including the lower class, middle class and even the upper class [3]. Motorbikes with relatively low prices and flexibility offered private vehicles, becoming the choice of many people with income middle-low to meet needs movement [4, 5, 6]. Motorbikes have become a means of transportation favored by the majority of the Indonesian people with a model that is not so wide and not so large that it makes it easy to use so that it will be easy to drive plus the emergence of motorbikes with automatic/automatic engines. Not only in terms of form, but the price offered from this motorcycle is also cheap enough so that the small and middle-class people can afford to buy this type of motorcycle.

Motorbikes are vehicles that are joined by many components, both the main component and supporting components, one of the most important components of the many components that are the mainstay of a motorcycle is a tyre. Motorcycle tyres are round rubber objects that are installed circularly on wheels (bicycles, cars, etc.). Tyres have a very important role in driving because of their diverse functions, namely; the tyre serves to hold the load, maintain the stability of the vehicle's speed, control the suspension system, control the direction of the vehicle, and to reduce vibration.

As a component that has a very important role, tyres have challenges that are not easy when used. If the tyre does not function properly, it will certainly disrupt the performance of the motorcycle itself. Problems that often occur in tyres are flat tyres and leaking tyres. Road conditions in Indonesia, which are mostly damage, are also one of the causes of frequent tyre leaks on motorcycles. In general, there variety factor that caused by road damaged, such as the age of the road that has been passed, puddles on the road surface cannot flow due to poor drainage, and overloaded [7]. Damages to road pavements or asphalt cover must be prioritized repair, because in areas with high rainfall such as Indonesia, pavement can be damaged more quickly if the road structure work is not accordance with the provisions [8]. Under any conditions when the tyre lacks wind pressure, it will certainly be an obstacle in the use of the tyre itself, both flat and tyre leaks. When you experience a flat tyre on the road, of course we will try to find a way to solve the problem, based on the results of observations made to motorists, it is known that there are 3 choices of ways or things that will likely be done if there are events such as flat tyres or leaking tyres on the road. Shown in Fig. 1, the 75 respondents consisting of Atma Jaya Catholic University of Indonesia students and people in the neighborhood around the researchers, 94.7% said they would look for the nearest tyre pump shop. Based on these data it can be concluded that the majority of motorists who were respondents in this study wanted the vehicle to be repaired immediately.

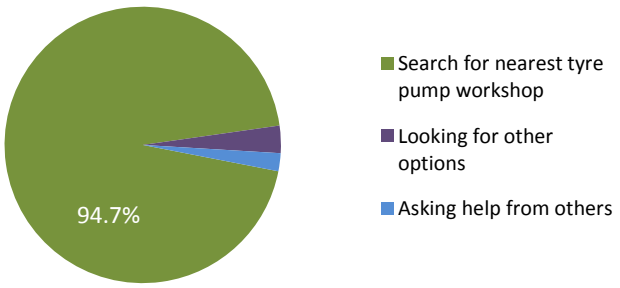


Fig. 2. Actions done when experiencing a flat tyre on the road

But on the same occasion, the question was also asked about how easy it was for motorcyclists to find a tyre pump shop, amounting to 50.7% of respondents answered quite difficult which is shown in Fig. 2.

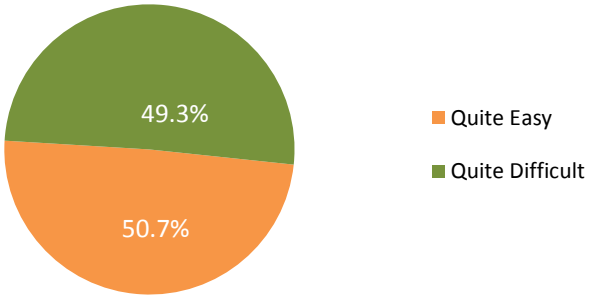


Fig. 3. How easy is it to find a tyre pump shop?

This explains that although the majority of motorists want to directly repair their vehicles, the fact in the field states that it is not easy to find a motorcycle tyre, especially when at night where many public facilities are closed.

Viewed in terms of the problems above, the researchers tried to find a new solution where when someone experiences a flat tyre no longer needs to look for a tyre patch but can do their own repairs on the tyre of the motor using existing tools and easy to use. Of course this is a good solution and is expected by many people, of course this is supported by the results of observations made that of 75 respondents who are motorcycle riders, as many as 94.6% stated that they really need a tyre pump that can be used in emergency times as shown in Fig. 3.

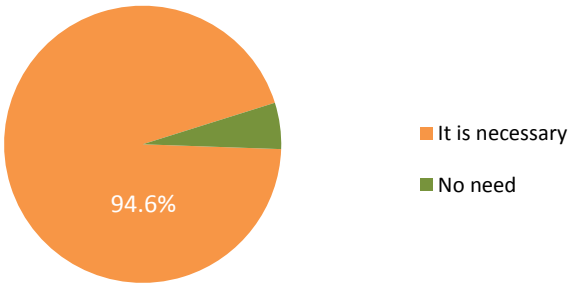


Fig. 4. Need for a tyre pump that can be used in emergency times

Based upon the results above, the researchers tried to design a device that could be used to fill the motorcycle tyre pressure independently, without having to go to the workshop and be used easily and easily carried around.

One of the opportunities that can be exploited is by making a motorbike tyre pump whose source of pressure is derived from the combustion gas from the motor itself, where the gas is discharged through the exhaust of the motorbike. The muffler is an instrument or tool that is used to deliver exhaust gas produced from the combustion residue of the engine with a protruding pipeline for disposal access. Exhaust gas is the combustion residue produced by combustion in a motor vehicle engine. The function of the exhaust gas system is; to deliver exhaust gas from combustion to the atmosphere, increase engine power; reduce heat; muffle engine noise. Exhaust gas from motorbike consists of non-toxic substances such as Nitrogen (N_2) at 72%, Carbon dioxide (CO_2) at 18,1% and water vapor (H_2O) at 8,2%, and toxic substances such as Carbon monoxide (CO), Hydrocarbons (HC), etc [9]. So based on the composition, it is possible to make tyre pump from combustion gas of motorbike.

Designing a tool or product cannot be arbitrary as it needs to be studied more deeply and attention to be paid to many aspects, because the product becomes a crucial point of a manufacturing industry [10]. In addition, the product is also defined as everything offered by producers to pay attention to, be asked, sought, bought, used/consumed by the market as

fulfilling the needs/desires of the relevant market [11], so that it is possible to mass production, by paying attention to aspects of consumers. Another thing that is of concern to researchers is that motor vehicle exhaust emissions are increasingly alarming to be able to be reused to be able to pump motorcycle tyres. So that the goal so that the tool becomes easy and efficient can be applied in real terms.

II. Methodology

A product, is a complex character, either touchable or untouchable, including packaging, color, price, company prestige, entrepreneur service, and retailers which customers receive in order to satisfy their wants and needs [12].

In product development, there are steps needed in order to guide the process of planning and implementation. There are six steps in the development process [13] which are planning, concept development system level designing, detail level design, testing and repair, and prototype production. Product design is part of the process and development in a system that is integrated with many other scientific fields. There are steps in applying the PDS method, as follows [14].

A. Job Description

At this stage, gather information about the conditions expected to be fulfilled by the final solution. This information becomes a reference for compiling a list of specifications and also identifying what obstacles are faced to achieve the optimal solution.

B. Concept Design

This stage identifies the problem through the creation of a function structure, the search for the principle of an appropriate solution by combining the principles of the solution into a variant or alternative concept, which will then be evaluated.

C. Design Form

A design form is an illustration of a tool designed, made as with technical drawings, and is usually made using AutoCAD software or Solid Work.

D. Design Details

The detailed design contains mathematical calculations, where calculations are carried out in accordance with a tool designed by using formulas or equations in accordance with the design concept of the tool. There are several equations used in designing the tool, namely:

Calculating the speed of air flow: This calculation is done to find out how much wind speed there is when exiting from the exhaust. Here's the calculation [15].

$$Din = 2.\sqrt{\frac{CC.Ntq}{US.94.2}} \tag{1}$$

Din = Diameter of area exhaust runner(mm)
CC = Volume of one cylinder (Cubic CM/CC)
Ntq = Engine speed (RPM) when peak torque occurs, or maximum engine speed is divided by 1.25
US = The velocity of the air flow on the exhaust runner.

Calculating the air volume: This calculation is to find the air volume when the air flowing flows from a larger hose that is smaller and smaller.

$$\begin{aligned} Q1 &= Q2 \\ A_1V_1 &= A_2V_2 \end{aligned} \tag{2}$$

A = Area of Section (Circle)
v = Velocity of air flow

Look for cross-sectional area in this case a circular cross-section.

$$\begin{aligned} A &= circle\ area \\ A &= \pi r^2 \end{aligned} \tag{3}$$

Calculating the wind pressure produced: To calculate the ability of the wind pressure produced, use the formula:

$$P = \frac{1}{2}\rho v^2 + \rho gh \tag{4}$$

P = Air pressure (Pascal/Pa)
v = velocity of air flow (m/s)
ρ = density of
g = 9.87
h = length of hose

III.Results and Analysis

The following is the result of processing data in accordance with existing steps according to the PDS method .

A. Translation of Tasks

In the process of designing a gas-powered tyre pump, the rest of the combustion of a motorcycle has two important parts that are interconnected, namely the input and parts output. The part input is when the air from the exhaust goes into the tool that is channeled through the exhaust hole. And what is meant by output is when the air entering from the exhaust is processed inside the tool and then released through the other end of the side and then inserted into the motorcycle tyre.

In designing this tool the measurement is adjusted to the real conditions of each motorcycle component that is directly related to this tool when operating, such as the exhaust and also the motor wheels. The diameter of the exhaust hole is measured and recorded according to the type of motor, as well as the distance of the wheel from the exhaust hole; of course it will be different between one motor and another.

The ease in operating the tool is important to see the purpose of this tool that is used when in emergency. So it needs to be designed in such a way that when operated everyone can understand how to use it easily.

Likewise with security, this one thing needs to be designed considering that during the operation of the tool there is a time when the motorbike's exhaust is still hot because the new motor is used. It also avoids turning the rear wheel. Then the distance between the operator and potentially dangerous parts must be limited.

In accordance with the elaboration of the above tasks, the next is made a list of specifications with regard to several requirements with the intention that the specifications are clear and structured. There are two types of requirements, namely:

- Absolute requirements or demand (D): is an absolute requirement that must be fulfilled in a design; if this condition is not met, the tool will not function as expected or fail.
- Expected requirements or wishes (W): are things that need to be considered and can be fulfilled if possible; if these conditions do not exist, the tool can still function properly.

The following is a list of design specifications with absolute terms (Demand) and expected conditions (wishes).

TABLE I
LIST OF SPECIFICATIONS

DESIGN SPECIFICATION LIST	
MOTORCYCLE'S COMBUSTION EXHAUST GAS POWERED TYRE PUMP	
D/W	TOOL SPECIFICATIONS
	GEOMETRY
	Dimension
D	Length : 55 cm
	Width : 12 cm
	Height : 6 cm
	ENERGY
D	Exhaust gas from the exhaust can flow into the tyre.
	STRUCTURE
D	Sturdy and strong
W	Components are light and flexible
	SAFETY
D	Safe when in use
W	Has a safety system
	MAINTENANCE
D	Easy to maintain
D	No special care is needed
D	Schedule of care doesn't have to be scheduled
	OPERATION
D	Easy to operate
D	In operation doesn't harm the operator
	FUNCTION
D	Can fill air into the tire until enough pressure
	ASSEMBLING
D	Easy to assemble and doesn't require many tools to install it.

B. Designing Concepts

Structure of function: The function structure of a motorcycle tyre pump with exhaust gas residual combustion can be seen in the explanation in Fig. 4 below where the image explains the relationship between input and output:

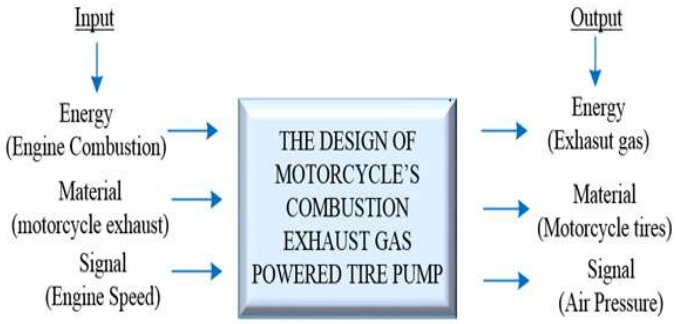


Fig. 5. Structure function

The overall function can be determined by alternative solutions in a simple and clear way from the combination of these sub-functions.

The following Fig. 5 shows the flow diagram of the sub-function of the motorcycle tyre pump exhaust gas residual combustion:

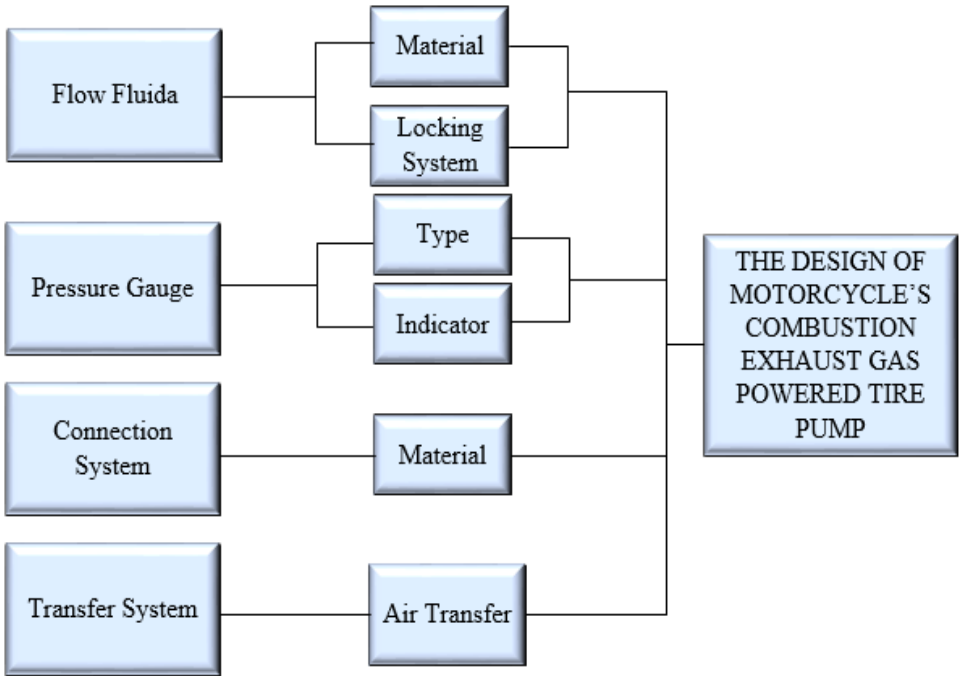
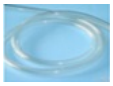
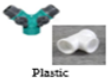


Fig. 6. Sub-function

Solution of principles: After making the function structure and sub-functions as a whole then the solution principles are sought, using a systematic combination method that is a method that combines all solutions which are in the form of a matrix.

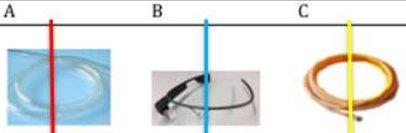
The principles of the solution must be more than one alternative, and each alternative will be analyzed to describe and adapt to the concept design to fit the objectives to be achieved. The following are the principles of the solution in the form of tables:

TABLE II
SOLUTION PRINCIPLES

No.	Sub-function	Solution Sub-function	A	B	C
1	Fluid Flow	Material			
2		Locking System			
3	Pressure Gauge	Type	 Pressure gauge	 Vacuum gauge	 Differential gauge
4		Indicator	 Analog	 Digital	
5	Conection System	Material	 Metal	 Plastic	
6	Transfer System	Air Transfer	 Direct	 Indirect	

It is known that there are 4 sub-functions and 6 sub-function solutions, in which there are several choices to be determined and analyzed from each alternative in accordance with the design and objectives to be achieved. The following table of principle solutions with 3 alternative pieces has been chosen:

TABLE III
PRINCIPLES OF SOLUTION WITH THREE ALTERNATIVES

No.	Sub-function	Solution Sub-function	A	B	C
1	Fluid Flow	Material			
2		Locking System			
3	Pressure Gauge	Type	Pressure gauge	Vacuum gauge	Differential gauge
4		Indicator	Analog	Digital	
5	Conection System	Material	Metal	Plastic	
6	Transfer System	Air Transfer	Direct	Indirect	

The above table illustrates three alternatives that in each alternative choose the best sub-function solution; a detailed explanation of the three alternatives is outlined below:

→ ***Alternative A:1A-2A-3B-4A-5B-6A:*** In the alternative, A for introducing fluids using hose material in the form of minimalism and also transparent and minimum thickness makes this one of the solutions to deliver fluid. And also to strengthen the hose handle on the connector, a clamp is needed, the clamp used in alternative A is considered easy to use because to open it/tighten it, simply rotate the pin without using a tool. Next go to the sub-function of the wind pressure gauge, using a vacuum gauge with analog indicators, while the connection system uses a connection made from plastic, with a light weight and of course a low price. Then the direct fluid transfer system is enough to use a hose.

→ ***Alternative B: 1B-2B-3A-4A-5A-6B:*** In alternative B the fluid conductor uses a transparent hose Janis with yarn fibers inside that are

able to strengthen the structure of the hose but still have good elasticity. Then for the locking system using the clamp with the Pull bolt system, where to tighten the bolt clamps must be rotated using a screwdriver. The pressure gauge system used is a pressure gauge with an analog indicator. The connection part is made of metal and the transfer system is indirect.

Alternative C: 1C-2C-3C-4B-5A-6B: In this third alternative using a Toy spray hose with a large pressure air flow capability, the locking system used is a clamp with a push bolt, and an angina pressure used gauge is with a digital indicator, the connection system is used as a connection made of metal and the transfer system is used indirectly.

Selection of the best alternative concept: Of the three alternatives available, the best alternative will be chosen according to the results of the selection made. Selection is made in the alternative determination table with several criteria in it, then it is determined whether each alternative meets the criteria or not so that ultimately a decision will be made for the best alternative. The following table determines the best alternative.

TABLE IV
DETERMINATION OF THE BEST ALTERNATIVE

Table Selecting the Best Alternative									
Selection Criteria:								Decision:	
(+) Yes								(+) Solution sought	
(-) Not								(-) Remove solution	
(?) Less information								(?) Gather information	
(!) Check Specifications								(!) See specifications for change	
Criteria	Meet the overall task	Fulfilling the will of	In principle can be realized	Time efficiency	In accordance with the	wishes of the designer	Care and safety	Cost is allowed	
	A	B	C	D	E	F	G	Information	
alternative 1	+	-	+	+	-	-	+	Not fulfilling the will of	-
alternative 2	+	+	+	+	+	+	+	Corresponding overall	+
alternative 3	-	-	-	+	-	+	-	Dominant does not fit the criteria	-

In the alternative determination table one of the best alternatives is alternative 2, this is seen from the value of the existing criteria. In the selected alternative, the second alternative gets the + value for all criteria, this means that from the seven criteria there is a second alternative that is able to fulfill all, which when compared to alternative one which only meets four criteria and alternative three is only able to meet 2 criteria.

C. Design Form

The following is the form of a gas-fired motorcycle tyre pump design, the rest of motorcycle combustion, a design form in the form of an image that resembles a prototype or original form of product design, a design drawing consisting of a whole device and design based on existing sub-functions. Fig. 7 is the design 3D of the overall look.

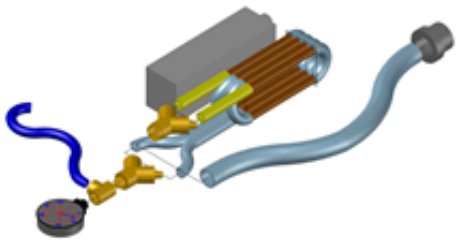


Fig. 7. 3D overall look

D. Design Details

In detailed design, mathematical calculations are made for the system of a design that was built. In the calculation below, the object that is the basis for retrieving the data needed for calculation is a Yamaha Jupiter MX 135cc duck type motorcycle, where the maximum RPM of the motor is 8500, and the exhaust hole diameter is 22.6 mm. The following is an example of the calculation performed:

Calculation of wind speed from the exhaust: This calculation is done to find out how much the air coming out of the exhaust. Next is the calculation:
CC = 135 CC
Ntq = 8500/1.25= 6800
Din = 22.6 mm = 0.0226 m

To find the US value/velocity of air when exiting from the exhaust using the formula equation 1 found in chapter two. So if the numbers are entered according to the data the calculation is obtained as follows:

$$0.0226 = 2\sqrt{\frac{135.6800}{US.94.2}}$$
$$\frac{0.0226}{2} = \sqrt{\frac{918000}{US.94.2}}$$
$$0.0113 = \sqrt{\frac{918000}{US.94.2}}$$
$$0.0113 = \frac{958,123}{\sqrt{US.9.7}}$$
$$\sqrt{US} = \frac{958,123}{0.109}$$
$$\sqrt{US} = 8790.12$$
$$US = 93.75m/s$$

Obtained are the results of the air velocity coming out of the exhaust for Yamaha Jupiter MX 135 motorcycles at 93.75 m/s.

Calculation of air velocity at large hoses which comes from the exhaust: Calculations for calculating air velocity when transferred from the exhaust to a large interval, the calculation uses equation 2, which is as follows:

$$A_1V_1 = A_2V_2$$

Where A is a circle, Calculates A/area of a circle using equation 3, where diameter $A_1 = 22.6mm$, and diameter $A_2 = 18.5mm$

$$A_1 = \pi.r_1^2$$
$$A_1 = 3.14.0.0113^2$$
$$A_1 = 0.0004m^2$$
$$A_2 = \pi.r_2^2$$
$$A_2 = 3.14.0.00925^2$$
$$A_2 = 0.000268m^2$$

After the cross-sectional area value is obtained again in the calculation of equation 2.

$$A_1V_1 = A_2V_2$$
$$0.0004 \times 93.75 = 0.000268 \times V_2$$
$$0.0375 = 0.000268.V_2$$
$$V_2 = \frac{0.0375}{0.000268}$$
$$V_2 = 139.9m/s$$

After the large hose then air flowed back toward the hose is small, so do come back pergitungan using equation 2, the following perhitunganya: $A_2V_2 = A_3V_3$

Looks for value A, where A is a circle, Calculates A/area of a circle using equation 3, where diameter $A_3 = 8.3mm$:

$$A_2 = 0.000268m^2$$
$$A_3 = \pi r_3^2$$
$$A_3 = 3.14 \times 0.00415^2$$
$$A_3 = 0.000054m^2$$

After the cross-sectional area value is obtained again in the calculation of equation 2

$$A_2V_2 = A_3V_3$$
$$0.000268 \times 139.9 = 0.000054 \times V_3$$
$$0.037 = 0.000054 \times V_3$$
$$V_2 = \frac{0.037}{0.000054}$$
$$V_3 = 685.185m/s$$

Calculation of wind pressure produced: To calculate the wind pressure generated, the equation 4 calculation formula is used, where in the calculation data is used from the results of previous calculations as well as observational data. It is known that the density of carbon monoxide is 1.14 kg/m^3, g = 9.87, h = 2 meters. Here's the calculation:

$$P = \frac{1}{2}1.14 \times 685,185^2 + 1.14 \times 9.87 \times 2$$
$$P = 267602.74 + 22.5$$
$$P = 267625.24Pa$$
$$267625.24Pa = 38.8Psi$$

From the above calculation results obtained the air pressure coming out of the designed tool sourced from Jupiter type MX type motor capacity 135 CC is 267625.24 Pascal or 38.8 Pounds per Square Inch.

E. Testing

Testing tools are done in two methods, namely by theoretical calculations, as done in stages 4.2.4 detailed design and second by testing directly on the tool. Approval is also only done on one type of motorbike, namely a motorcycle type duck Yamaha brand Jupiter MX. The test results are attached to the table, the following details:

TABLE V
RESULTS OF CALCULATIONS AND MEASUREMENTS

Data Sheet Results Of Testing Tools Measurement Object: Duck Motorcycle Type (Jupiter Mx 135 Cc)			
No	Theoretical Calculation (Psi)	Measuring Tool (Psi)	Difference (Psi)
1	38.8	29	9.8
2	38.8	30.5	8.3
3	38.8	29	9.8
4	38.8	29.5	9.3
5	38.8	31.0	7.8
6	38.8	30	8.8
7	38.8	28.5	10.3
8	38.8	31.0	7.8
9	38.8	31.5	7.3
10	38.8	30.5	8.3
	Average	30.05	8.75

IV. Analysis

In this study the design of tools used to fill the wind on motorcycle tyres was carried out, the type of motor covered by the tool was a motorcycle and a type of sport motorcycle, and not can be used on an automatic motorcycle, this is because the automatic motorcycle rear wheels will continue to rotate when the machine is turned on, whereby a tool designed requires energy from the engine itself so that when the tyre is rotating certainly will not be able to do charging angina and only will be able to be fulfilled on type motorbikes *sport* and also duck types.

The first observation was measured on the diameter of the exhaust hole, where the size is needed to determine the size of the connecting connector between the tool and the exhaust hole. Then the measurements of the length of the motorcycle are carried out, where the size represents the distance between the exhaust hole and the front tyre of the motor, so that the tool can reach the front of the motor. From all measurement results, the maximum width of the exhaust hole is 29.8 millimeters and the width is at least 19.5 millimeters so that later, the connector to be selected is the one that can reach that size. As for the length of a motorcycle, the maximum length is 177 centimeters and a length of at least 162 centimeters; this means that the length of the distance from the tool to be designed must be able to reach the maximum length of a motorcycle.

The first process is transferring air from a large hose into a smaller hose; the air coming from inside the exhaust is not directly flowed into the motorbike tyres, but is divided into two in a smaller diameter hole, with the intention to narrow the incoming air space so that the push of air to come out becomes bigger.

The second process is the process of decreasing the temperature of the air, the air coming out of the exhaust is the combustion air that occurs in the engine, so that the air must have a high temperature, although the resulting high temperature can still be categorized as safe for tyres, but for more ensuring the level of security, the temperature needs to be lowered, the process of lowering the temperature is carried out by flowing air through copper pipes placed in bottles containing water coolant, where the water coolant will make the copper pipe have the water temperature and will affect the temperature of the copper pipe is equivalent to the temperature in a water coolant, or air cooling is carried out by conduction.

Furthermore, it enters the process of transferring air to a smaller hose again, the hose that comes from two branches is then put back together to flow into a smaller hose, the hose is also the last connecting directly to the motorcycle tyre, and on the small hose too input pressure gauge is used as a tool to measure the tyre produced, the pressure gauge is placed at the near end of the output because in that section the air pressure maximum is only produced and is the right place for feedback from the air inside the tyre, so that the pressure gauge will function properly and a measure of wind pressure is obtained.

This study used the PDS method. PDS is a development in a system that is integrated with many other scientific fields, with the intention that in carrying out the design it will involve many other branches of science as supporters to ensure the accuracy of the design results. PDS also focuses on ideas and concepts developed by the researchers themselves so that they are not dependent on others even though suggestions and input will still be an important part of the design.

In the PDS design there are criteria that are needed as the standard to be achieved from the product; not all criteria of PDS must exist because not all parts of the criteria can be fulfilled due to differences in the tools designed and the different objectives of the tool made.

A. Translation of the Task

The first action made was making a list of specifications in a table form. There are two types of wishes or requirements in the list of specifications, namely demand and wishes. In the design of a gas-fired motorcycle tyre pump, the rest of the motorcycle combustion has 8 criteria with 13 lists of wishes, 11 *requests* and 2 *wishes*.

B. Designing a Concept

Function structure: The first thing to do in designing a concept is to create a functional structure where the function structure aims to show the input and output of the tool.

Sub functions: Then sub-functions are created, sub-functions are elaboration in more detail from the existing function structure into a system and the system itself will be explained in more detail to be able to describe the whole system. In the sub-function, 4 systems are created; the first is the fluid delivery system, the second system is the air pressure gauge, the third system is the connection system, 8 and the last system is the air transfer system, to determine the air flowed directly into the tyre or process first. Furthermore, it will be elaborated in more detail as well as sought the principle of the solution by using a combination method in the form of a matrix, where the principle of the solution must be more than one alternative in order to be able to compare one alternative with another.

Determination of the best alternative: To determine the best alternative decision, a table is made in which there are assessment criteria, Value is given by giving a value (+) if the criteria match the alternative concept and give value (-) if the criteria are not suitable or not in the alternative, then if the information needed is still not marked (?), and the sign! to re-check specifications. The chosen alternative is the alternative with the most (+) value with the meaning that the alternative that has the most value (+) is the concept that best meets the overall criteria. If you look at the alternative selection table, alternative A only fulfills the four criteria out of seven, namely the criteria to fulfill the task as a whole, in principle, can be realized, time efficiency and fees allowed. Next in alternative B fulfills the overall criteria, and alternative C only meets two criteria, namely time efficiency and care and safety. From the given value, it can be seen directly that for the best alternative concept, alternative B is the alternative cause, which has the most + value and also fulfills the whole of the existing criteria, with information as a whole, and then the chosen concept is alternative B.

C. Design Forms

In the form design are presented technical drawings that explain the shape of the design, the image of the tool is presented as a whole and also presented in each sub-function, with the intention that known the shape of each sub-function that exists.

D. Detail Design

The value of pressure from the theoretical calculation is different from the calculation of the tool, the results of the theoretical calculation of the tool obtained air pressure of 38.8 Psi, while the tool testing can directly reach a pressure of 30 Psi, with this difference the number reaches 8.8 Psi, although figure 30 Psi has been able to fill the front and rear tyres of a motorcycle, the difference in numbers is certainly caused by observable factors. The results of the observations obtained several factors that cause differences in the numbers calculated by the tool test.

The first factor is because there is a leak in the hose connection and the connection to the exhaust, this makes the air flowed not entyrely to the tyre and experiences a reduction in compressive power, thus impacting the air pressure produced.

The second factor is the narrowing of the air ducts (hoses), when accidentally operated hoses are bent so as to make the air flow become clogged and make the air pressure on the output become not optimal.

The third factor is the condition of the motorbike used. It is known that the motor used in testing the tool is 7 years old with a distance traveled of 92,000 kilometers, a motor that has been used for a long time will experience a decrease in performance, the energy released will also decrease, which in this case the energy to produce good combustion will be reduced.

With a variety of factors that affect the performance of the tool but still can meet enough criteria to be able to pump motorcycle tyres and also the design of this tool is made for use in emergency conditions, so that when a motorcycle experiences a flat tyre and the condition is not in the immediate vicinity with a tyre pump workshop, the tool can be used. With the fulfillment of sufficient criteria in the specification list, which causes this to be achieved or demand, the tool designed can be categorized as fulfilling the design specifications. Hose joins due to glue that does not stick perfectly, or may be caused by a hose that is bent so that it obstructs the flow of air passing. But the prototype was able to reach the goal of pumping motorcycle tyres to enough pressure. But it needs to be recognized that further development and improvement will be able to maximize the performance of the tool.

V. CONCLUSION AND IMPLICATIONS

From the criteria in the specification list, the rationale for how the tool will be designed is included, by determining the list of wants to be desired (demand/wishes). Each of these criteria represents the purpose of this tool is designed, as well as the use of exhaust gas combustion, components that are lightweight and flexible, easy to maintain, can be operated easily, easily in assembly, all of these in order to realize the results of easy design and efficient in use. By achieving the overall criteria in accordance with the list of their respective wishes, the design results have met the requirements to be an easy and efficient tool to use. In designing with the PDS method, in which there are four stages. Of the four stages, it is known where the direction of the idea and concept of the tool will be made, and

what criteria must be achieved as a requirement to design specifications, to determine the best alternative concept. After determining the best concept alternative, which has fulfilled the overall criteria, then the results of the design of the tool are obtained that meet the ideas and concepts using product design specifications. With a variety of factors that affect the performance of the tool but still can meet enough criteria to be able to pump motorcycle tyres and also the design of this tool is made for use in emergency conditions, so that when a motorcycle experiences a flat tyre and the condition is not in the immediate vicinity with a tyre pump workshop, the tool can be used.

Declaration of Competing Interest

We wish to confirm that there are no known conflicts of interest.

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