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Design and Implementation of Secondary Air Brake System Using Engine Exhaust Gas

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ABSTRACT

In many automobiles the engine exhaust is probably wasted and it mixes with the atmosphere. The waste heat recovered from the exhaust gas released by the internal combustion (IC) engines are used as used as an assisting system to perform several functions. In this project the exhaust gas is used to assist the air braking system. The components like turbine, compressor, solenoid valve and braking assembly are modelled by using the solidworks after the found the design requirements. The structural setup of the project contains a turbine placed in the path of exhaust followed by a connection to store the energy generated by the rotation of the turbine. The generated electric power from the turbine used to compress the air in the DC compressor then supplied the pneumatic power to the air braking system. The exhaust gas was effectively utilized to perform the air braking system in addition to the conventional braking system and found the improvement in the braking performance.

Keywords: Exhaust gas, Solidworks, Turbine, DC Compressor.

1. INTRODUCTION

A brake is a mechanical device used in automobile to stop or decelerate the vehicle by means of friction. Here the kinetic energy of the moving vehicle is converted into heat or other forms of energy.

1.1 Regenerative Braking System

In the modern Regenerative Braking system, at the time of braking the power supplied to the motor is cut. The mechanical energy generated by the rotating wheels is converted into electrical energy which is stored in the battery.

1.2 Heat Recovery of Exhaust Gas

Many researches and studies have recognized that the engine exhaust recovered can be made highly effective in terms of its usage by decreasing the fuel consumption and emission. The latest technology and advancements have made this possible in an efficient way. A number of irreversible processes within the capability of the engine to realize a highly balanced efficiency. It was stated that the waste heat produced from the thermal combustion process generated by gasoline engines could get as high as 30–40 percent which is lost to the environment through an exhaust pipe. In addition, 12–25 percent of the available energy in a fuel will be used to drive the wheels and other accessories with technical descriptions. It was analyzed that only 10.4 percent of fuel energy was converted to useful work and also 27.7 percent found the thermal energy lost through exhaust gas. In the given second law states that only 9.7 percent of fuel energy is converted to brake power. And 8.4 percent wasted in exhaust. In total combustion energy around 18.6 percent sent through exhaust and various forms of losses which occur in an engine and exhaust thermal loss tops in that list.

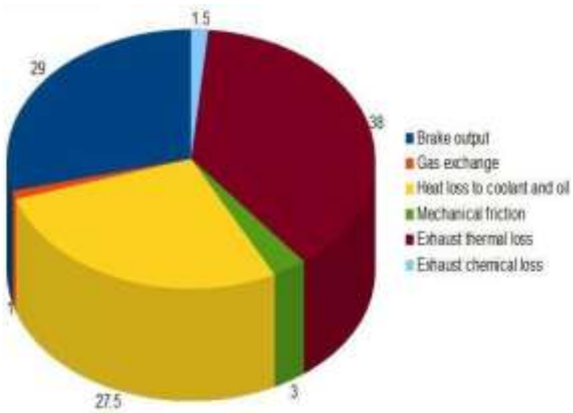

Fig.1 Exhaust Gas Energy distribution

2. METHODOLOGY

A petrol powered two stroke engine produces exhaust gas as a result of combustion which is made to flow through the exhaust pipe. A turbine is placed in the path of flow of the exhaust gas. Based upon the flow of the gas, the turbine rotates. The turbine is connected to the dynamo which converts the rotating force into equal electrical power, which is finally stored in the battery after rectification.

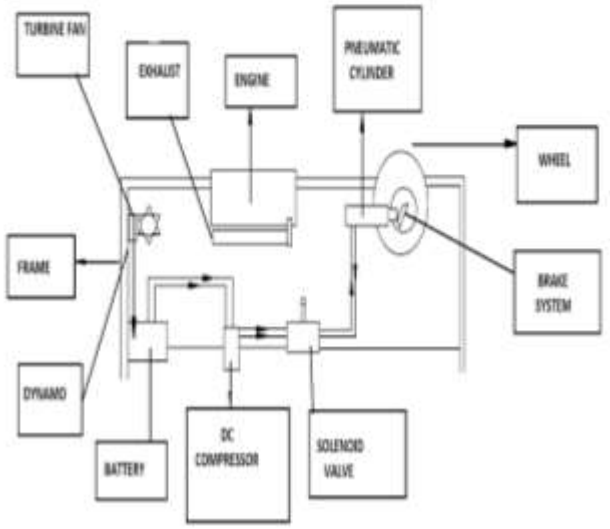

Fig. 2. Methodology of the experiments

The power from the battery runs the DC compressor. The DC compressor compresses the air and stores it in the air tank with pressure. A solenoid valve is used to actuate the pneumatic cylinder with the help of electrical signals. Solenoid valves are accompanied with a control timer circuit. The flow control valve is used for adjusting the braking speed. Solenoid valves are used to operate the pneumatic cylinder which actuates the brake lever of the wheels. The experimental flow chart is given in the figure.3

This project is working on pneumatic powered, the cylinder works on exhaust gas power utilization. The braking speed is varied by adjusting the valve is named "FLOW CONTROL VALVE".

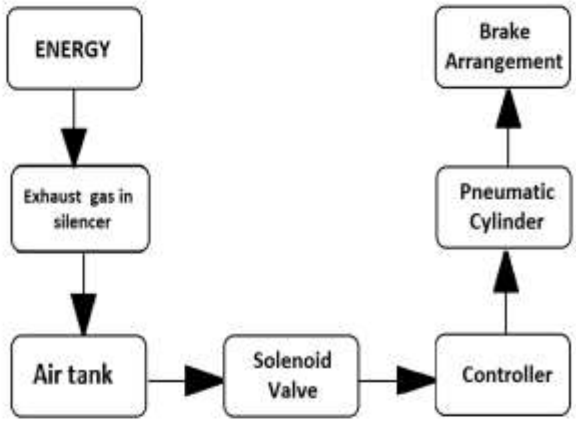

Fig.3 Experimental Flow chart

3. DESIGN OF COMPONENTS AND ITS CALCULATIONS

The development of pneumatic power using the velocity or flow of exhaust gas requires the various components to perform this of complete operation of the machine which is mentioned in the Table 1.

3.1 Engine

Fig. 4 Two stroke Engine

Table 2 shows various specifications of the TVS super XL – 69.9 cc engine and the values corresponding to the given specifications.

Table 1 List of materials

Sl. No	List of materials	Quantity
1	Engine	1
2	Fuel tank	1
3	Wheel	1
4	Chain and sprocket	1
5	Turbine	1
6	Battery	1
7	Compressor	1
8	Air tank	1
9	Solenoid valve	1
10	Flow control valve	1
11	Control unit	1
12	Pneumatic cylinder	1
13	Frame	4kg

Table 2 Engine specifications

Sl. No	Specifications	Values
1	Displacement	69.9 cc
2	No. of Cylinders	1
3	Max. Power	3.5 Bhp @ 5000 rpm
4	Max. Torque	5.0 Nm @ 3750 rpm
5	Engine Description	2 Stroke, Single Cylinder
6	Cooling	Air Cooling
7	Ignition	Fly Wheel Magneto 12V x 50W Electronic Ignition
8	Bore	46 mm
9	Stroke	42 mm
10	Fuel Type	Petrol
11	Clutch	Centrifugal Wet Type
12	Secondary Drive	Roller chain drive

3.2 Calculation of Braking Force

Vehicle Mass (m) = 350 kg

Vehicle velocity (v) = 10 m/s

Work done (W) = Kinetic energy

$= \frac{1}{2} mv^2$

$= \frac{1}{2} \times 350 \times 10 \times 10$

= 5401.12 J

Work done (W) = F (Brake Force in N) × s (Stopping distance in m)

Assume the vehicle is moving in uniform velocity so

s = 10 m

W= F x s (Nm)

F = W / s

= 5401.23 / 10

= 540.12 N

Therefore Force required to apply brake is **465 N**

Fig 4 shows the braking forced required for vehicle speed.

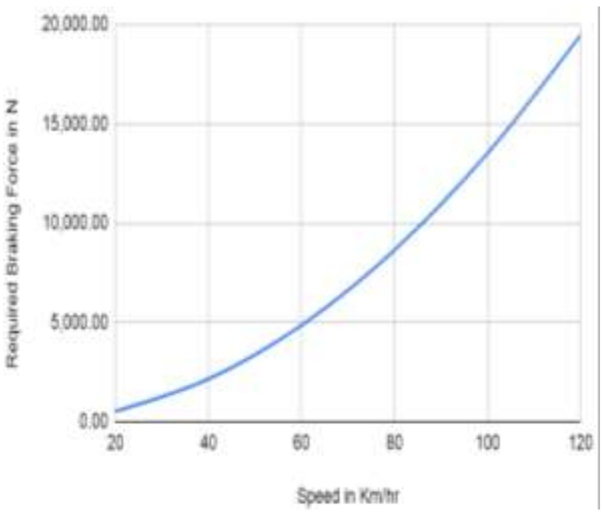

Fig. 4 The braking forced required Vs Speed

3.3 TURBINE

Total blades = 22

Diameter = 0.08m

Formula to be used:

Area of Swept, $A = \pi$ x (radius of turbine)

$2 = \pi \text{ x } (0.04)^2 = 0.005024$ metresq.

F or N = 105 rpm

Velocity of the Turbine,

$V = (\pi x D x N)/60 = (\pi x 0.08 x 105)/60 = 0.44$m/s

Where,

D=diameter of turbine,

N=number of revolution per minute

Power available at the turbine = 1/2 x density x area x $(\text{velocity})^3$ x Cp

$= 1/2 \text{ x } 1.23 \text{ x } 0.005024 \text{ x } (0.44)^3 \text{ x } 0.45$

Power available at the turbine = **1.18 Watt.**

Turbine is designed as per the requirements and model is developed through the solidworks is shown in fig.5.

Fig. 4 Turbine

3.4 Air Tank

Tank Diameter (d) = 0.20 m

Tank Length (l) = 0.05 m

Area of tank (A) $= \pi r^2$

$= \pi \times 0.12$

$A = 0.0314 \text{ m}^2$

Volume of the tank (V) $= A \times l$

$= 0.0314 \times 0.050$

$= 0.00157 \text{ m}^3$

Air tank is designed as per the requirements and model is developed through the solid works is shown in fig.6.

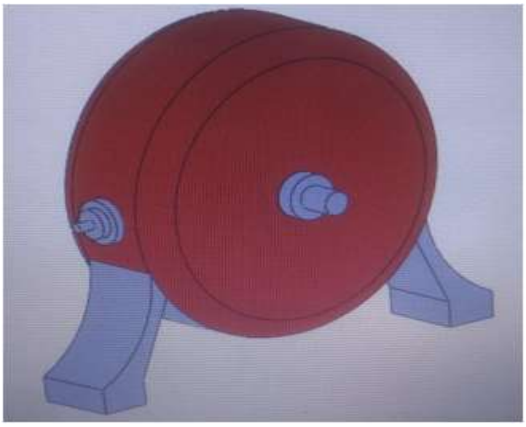

Fig.6. Air Tank

3.5 Compressor

Air compressors is designed in the solid works is shown in fig.7.

Fig.7 Air compressor

3.6 Solenoid Valve

Solenoid valve is designed in the solid works is shown in fig. 8.

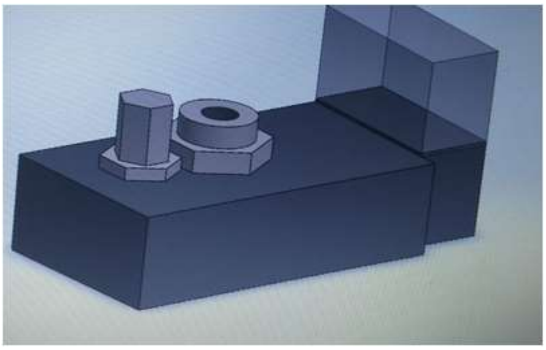

Fig.8 Solenoid valve

4. DEVELOPMENT OF DESIGN USING SOLIDWORKS

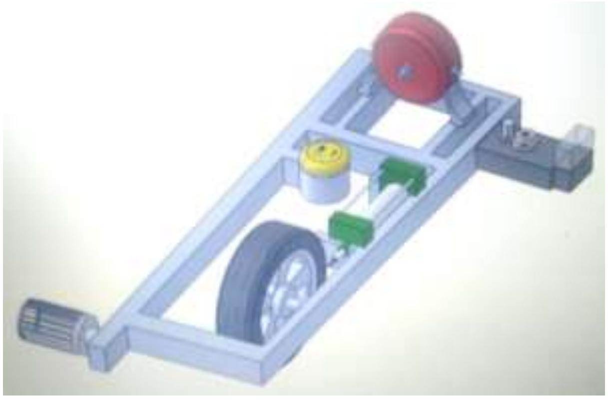

Fig.9 Development of Model

After designed all the components as per the requirement are assembled in solid works software shown in fig.9.

5. EXPERIMENTAL SETUP

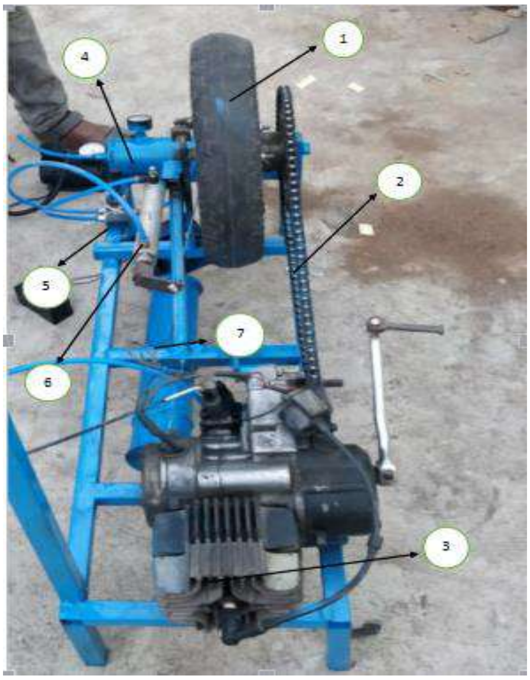

Fig. 10. Experimental setup

1. Wheel
2. Chain
3. Engine
4. Air compressor
5. Solenoid valve
6. Pneumatic cylinder
7. Air tank

From the graph shown in fig. 11. Pressure Vs speed, it can be seen that the required brake pressure in the brake master cylinder and pressure developed in the air braking system. With the above experimental setup the load of the master cylinder can be reduced by the addition of a secondary pneumatic braking system.

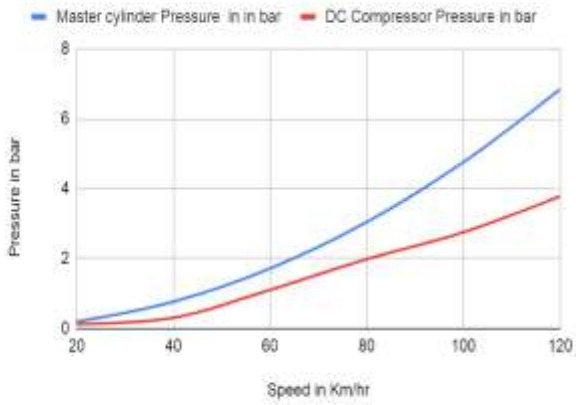

Fig. 11 Pressure Vs speed

6. CONCLUSIONS

From this project, it is possible to recover energy that is being discharged from the engine exhaust system and used to assist the air braking system. Exhaust gases have the large potential of energy, and they are saved before released to the atmosphere. The structural setup of the project contains a turbine placed in the path of exhaust followed by a connection to store the energy generated by the rotation of the turbine. The generated electric power from the turbine used to compress the air in the DC compressor then supplied the pneumatic power to the air braking system in addition to the conventional braking system and found the improvement in the braking performance.

REFERENCES

[1] A. Fazlizan, Design and experimental analysis of an exhaust air energy recovery wind turbine generator, *Energies*. 2015, 6566-6584.

[2] S. Kumar, Generation of electricity by using exhaust from bike, *International Journal of innovative research in Science, Engineering and Technology*. 4 (6), 2015, 1877-1882.

[3] V. Nivethan, Fabrication of air brake system using engine exhaust gas, *Ijariie-issn (o)* 2 (3), 2016, 305-308.

[4] S. Rajoo, Analytical and experimental study of micro gas turbine as range extender for electric vehicles in Asian cities. *Energy Procedia* 143 2017, 53-60.

[5] R. Saidur, Technologies to recover exhaust heat from internal combustion engines, *Renewable and Sustainable Energy Reviews* 16, 2012, 5649-5659.

[6] J. Yang, A comparative study on turbocharging approaches based on IC engine exhaust gas energy recovery, *Applied Energy* 113, 2013, 248-257.