MINISTRY OF EDUCATION AND TRAINING

THE UNIVERSITY OF DANANG

A RESEARCH INTO THE APPLICATION OF COMPRESSED BIOGAS FOR MOTORCYCLES

Specialty: Heat Engine Engineering
Code: 62.52.34.01

ABSTRACT OF TECHNICAL THESIS

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The work has finished at

The university of danang

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This thesis can be lookup at the university of DaNang:

- The Learning Resource and Infomation Centre
- The Learning Resource Centre

INTRODUCTION

URGENT NECCESSITY OF THE RESEARCH : Different from many developed countries, the major means of transportation in most of the cities in Vietnam is motorbike. Currently, there are over 30 million motorbikes in use and the figure is reported to be upwards with considerably fast speed in the following years. Air pollution caused by motorbike emissions is getting worse in many of the big cities.

Therefore, the thesis **"A research into the application of compressed Biogas for motorcycles"** is really meaningful and urgent.

RESEARCH OBJECTIVES: Apart from the purpose to eliminate environmental pollution and diverse fuel resources for internal conbustion engine, the thesis also aims to source more widely used biofuel alternatives in an efficient manner.

SUBJECTS OF SUTDY: According to the above analysis, the object of study of the thesis is the for the Honda wave α 110cc engine using biogas fuel.

SCOPE OF THE STUDY: Due to the complex nature of research problems, this dissertation research is limited to the following issues:

- Research the biogas purification and storage technology as a fuel provided to motorcycle Honda wave 110cc α;

- Research fuel delivery process and burning process of motorcycle Honda wave 110cc α engine using compressed biogas by modeling and experimentation method;

RESEARCH METHOD: thesis uses the methods of theoretical study and modeling combined with empirical research.

Theoretical and emulating study method: Research into the process of delivring compressed Biogas for the Honda wave α 110cc engine using extracting method through venturi by the group of 3 functional valves to

establish characteristic line of equal scale fator according to the engine load; emulating study the process of burning admixture of biogas and air in the the Honda wave α 110cc engine based on the comparison of emulation and experiment.

Experimental research: through experiment, behaviour of the pressure in the chambre of the the Honda wave α 110cc engine using petrol RON92 and compressed biogas 85% CH_4 is measured. Based on that, the research forms the conforming theory to establish emulation for the burning process.

SCIENTIFIC MEANING AND REALITY OF THE STUDY

Up to now, there have been no researches related to delivery systems and burning process of motorbike engine using compressed biogas. Thus, the thesis has acheived not only scientific significance but also practical reality in the situation of natural resouce crisis, running out of oil and worse global warming all over the world.

In the thesis organization, apart from introduction, conclusion and further development of the research, the main content can be divided into following 5 chapters:

Chapter 1: Overview on the research and application of biogas fuel for internal combustion engines.

Chapter 2: Theoretical study of using biogas as fuel for the motorcycle Honda Wave α 110cc .

Chapter 3: Research calculus and numerical simulation of combustion process in motorcycle engine 110cc Honda wave α using biogas fuel.

Chapter 4: Experimental studies.

Chapter 5: Comparison of simulation results with experimental motorcycle engine 110cc Honda wave α using compressed biogas.

Chapter 1
OVERVIEW ON THE RESEARCH AND APPLICATION OF BIOGAS FUEL FOR INTERNAL COMBUSTION ENGINES

1.1. The issue of energy and the environment

Facing fossil fuels are in crisis because of depletion and environmental pollution problems are becoming more serious, to reduce the concentration of pollutants from engine exhaust of vehicles, thesis proposed solution uses fuel "cleaner" for the motorcycle: biogas .

1.2. Characteristics of Biogas

Biogas is produced from the anaerobic degradation of organic compounds. Essential components of are methane (CH_4) and carbon dioxide (CO_2). Organic waste from different sources can be used to produce biogas.

1.3. Researching and Application regime of using biogas as fuel for internal combustion engine

1.3.1. Research and Application regime of biogas in the world

Producing Biogas as fuel for engines are being developed completely, including the following stages: improving biogas to meet the motor fuel standard, transporting with the networks of compressing, storing and supplying – stated in Figure 1.10

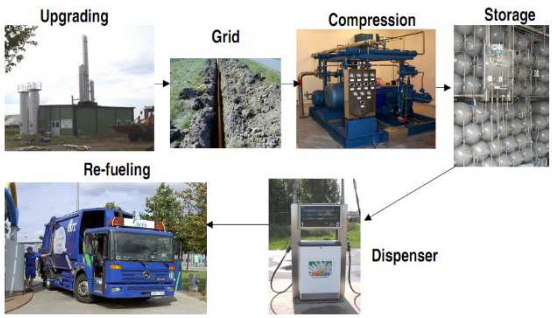


Figure 1.10: The process of producing and utilizing Biogas inSweden

Studies on the influence of the technical features of using biogas as an alternative fuel such as compression ratio, optimized ignition angle, the firing rate of biogas mixture - air levels pollutant emissions, assess the capacity of the engine to improve fuel use biogas ...

Biogas speed of fire membrane spread is lower than other gas fuels. Therefore, the ignition angle must increase to ensure the perfect combustion takes place, improving the performance and capacity of the engine. Jewell (1986) stated that the optimum ignition angle of the engine-powered 25 kW biogas containing 60% methane in the range of 33^0-45^0 before top dead center. According to Walsh (1986), 55 kW motors that use biogas has the optimum ignition angle is 45^0 before the top death center.

1.3.2. Research and Application regime of biogas in Vietnam

Prof. Dr. Bui Van Ga and colleagues at University of Danang have studied conversion engine using gasoline fuel, used oil into biogas. Tranditional gasoline engine can be converted to run on biogas through the fuel conversion kit has brought economic efficiency - technical and environmental protection.

1.3.3. Research and Application regime of biogas to motorbikes

Use compressed biogas motorcycle deals with problems of the high pressure fuel. In case of storing in the liquid state, it is also difficult due to deep cooling to very low temperatures (-161.5^0 C and at a pressure of 1 atm for pure CH_4) and so the container must be made the double cover costs very high vacuum. Prof. Dr. Bui Van Ga and the group UD GATEC were also very successful with GATEC kits providing biogas for stationary engines and motor vehicles.

The author Nguyen Ngoc Dung, Tran Dang Long, Huynh Thanh Cong and colleagues at the Polytechnic University of Ho Chi Minh City has studied methods on biogas fuel injection intake and assessment features of the motorcycle engine machine on the dynamometer..

As stated above, the research and application of biogas as fuel for the motorcycle engine has not been studied thoroughly, or just stop in the preliminary assessment of the decline of the engine power when using the fuel in the laboratory.

In order to solve the above problems, the thesis contributes handle three important issues to be able to use biogas as a fuel for motor vehicles, which are (1) the compressed biogas pressure vessels, (2) compressed biogas to provide motorcycle parking operations to ensure optimal operating conditions, (3) simulations of combustion in the combustion chamber and compare the indicators given by the model and the real experience of motorcycle engines 110cc Honda wave using biogas.

1.4. Conclusion

Results of overview study on the use of biogas for combustion engines are allowed to draw the following conclusions:

- The use of motorcycles has contributed greatly to the overall economic development of our country's social conditions. Therefore, the search for and application of new alternative fuel source material of fossil origin is a matter of primary concern.

- The biogas fuel is renewable energy sources with large reserves and is produced in manufacturing operations and human activities. However, to use this energy efficiently, it is necessary to improve the biogas production, filtration and storage technology..

Therefore, the thesis "**A research into the application of compressed Biogas for motorcycles** " has meaningful scientific and high practical nature. The results will contribute to the subject solved the above problems.

Chapter 2

THEORETICAL STUDY OF USING BIOGAS AS FUEL FOR THE MOTORCYCLE HONDA WAVE A 110cc

2.1. Quality requirement of Biogas as fuel for internal combustion engine

It is possible to improve Biogas into natural gas (H_2S < 4ppm, CH_4 > 95%, CO_2 < 2% volume, H_2O < 10^{-4}kg/mm^3, eliminating pollutants, siloxanes) to apply to engines of motor vehicles.

2.2. Technology of processing contaminants in biogas

The biogas upgrading methods including chemical absorption or absorbed by the fluid physics. Methods of gas-liquid absorption can be enriched to 98% CH_4, while the method of high-pressure adsorption on a solid phase biogas can be enriched up to 96% CH_4.

2.3. Research result of experiment to ascertain the effect of processing contaminants in Biogas

1- water pump, 2- Valve, 3- Pools; 4- Flow Measurement Equipment; 5- The gas meter input; 6- Bag contains the following biogas purification; 7- The biogas measured after filtering; 8- Sprinkler; 9- gauges; 10- measuring l priority water; 11- Body filtration column; 12- material buffer; 13 - inlet nozzle;

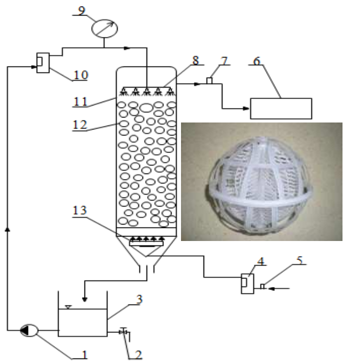
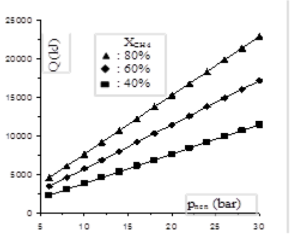


Figure 2.3: Diagram of biogas purification system water tower with cushioning material

Results of experiment with elevated tank with buffering materials has shown that with input Biogas flow of 1,5 m^3/h, after filtering processed, clean Biogas is collected with CH_4 concentration up to 96,7%, only 1,87%, of CO_2 concentration is left, other gases make up 1,43% and H_2S is almost absorbed entirely.

2.4. Biogas storing technology supplied for motor vehicles

Figure 2.6 illustrates changes in stored Biogas in the 30 litre container according to compressed pressure in proportion of CH_4 in Biogas fluctuating from 40% to 80%.



Figrue 2.6: Changes of stored energy in Biogas according to compressed pressure

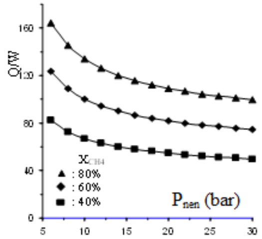


Figure 2.7 : Effect of used energy from compressed Biogas

For Biogas with X_{CH4} = 80%, limited of Q/W is about 100, (figure 2.7). Therefore, economical effect of using compressed Biogas for motor vehicles is clearly improved..

2.4.2. Emulating process of compressing biogas and absorbing CO_2

Figure 2.8 illustrates the diagram of new process of compressing and absorbing CO_2 proposed in the thesis.

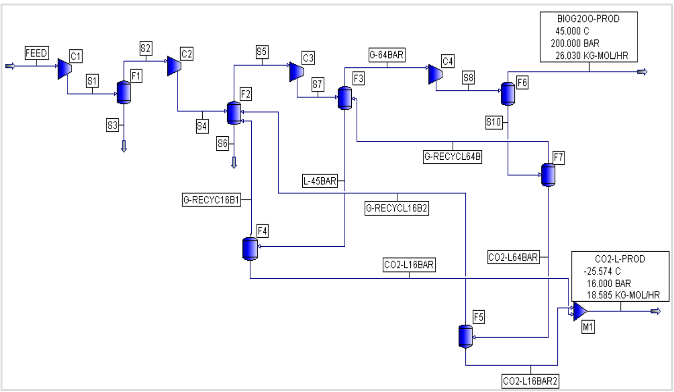


Figure 2.8 Diagram of process of compressing, absorbing CO_2 from Biogas

The result has shown high content of CH_4 (96,4%), the content of CO_2 < 2%, H_2S ~ 0, collecting efficiency of CH_4 is up to 94,7%.

2.4.3. Biogas storage type of absorption

Using carbon nanotube materials for biogas storage allowing storage capacity to increase from 2.8 to 3 times in the same condition 35 bar compressed pressure.

2.5. Research on the compressed biogas delivery process for Honda Wave α 110cc Engine

2.5.1. The compressed biogas delivery system for Honda Wave α 110cc Engine

Fuel supply system consists of the main clusters such as compressed biogas tank (1), pressure relief valve (5), three function vacuum valve (7, 14, 15) are arranged as shown in Figure 2.9.

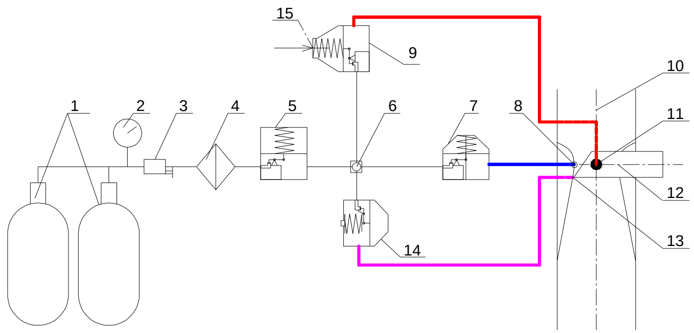


Figure 2.9. Diagram of biogas delivery system with vacuum triple function valve for Honda Wave α 110cc

1- Compressed Biogas container; 2 Container pressure meter; 3- Flow lock; 4- Filter; 5- Depressurizing valve manifold; 6- Spliting kit; 7- Capacity valve; 8- Main supply pass through venturi head; 9- Accelerant valve; 10- Venturi drafting head; 11- Accelerant circuit supply hole; 12- Gas core; 13- Idle pass; 14- Idle valve; 15- Accelerant valve constrained serving mechanism;

2.5.2. Establishing calculating and simulation model for compressed Biogas supply network with triple function valve for Honda wave α 110cc

By establishing equations of resaved capacity in V_i capacity, equations of capacity for expansion elements, combining with hypothesis and boundary condition, we establish set of differential equations of pressures in capacities the following::

$$\begin{cases} \dfrac{dp_3}{dt} = \left(Q_{1,3} - Q_{3,5} - Q_{3,9} - Q_{3,13}\right)\dfrac{k.R.T_{0\_3}}{V_3}\rho_3 \\ \dfrac{dp_5}{dt} = \left(Q_{3,5} - Q_{5,7}\right)A_5 \\ \dfrac{dp_9}{dt} = \left(Q_{3,9} - Q_{9,11}\right)A_9 \\ \dfrac{dp_{13}}{dt} = \left(Q_{3,13} - Q_{13,15}\right)A_{13} \end{cases} \quad \begin{cases} A_5 = \dfrac{4^2.C_5.k.R.T_{0\_5}.T_5.\rho_5}{\left(4^2.C_5.V_5.T_5 + kT_{0\_5}.p_5.(\pi D_5^2)^2\right)} \\ A_9 = \dfrac{4^2.C_9.k.R.T_{0\_9}.T_9.\rho_9}{\left(4^2.C_9.V_9.T_9 + kT_{0\_9}.p_9.(\pi D_9^2)^2\right)} \\ A_{13} = \dfrac{4^2.C_{13}.k.R.T_{0\_13}.T_{13}.\rho_{13}}{\left(4^2.C_{13}.V_{13}.T_{13} + kT_{0\_13}.p_{13}.(\pi D_{13}^2)^2\right)} \end{cases} \qquad (2.47)$$

And set of differential equations of average flow speed through expansion elements is set as following:

$$\begin{cases} \dfrac{dv_{1,3}}{dt} = \dfrac{k.R.T_1}{l_{1,3}(k-1)}\left(1-\left(\dfrac{p_3}{p_1}\right)^{\frac{k-1}{k}}\right) - \xi_{\Sigma 1,3}\dfrac{v_{1,3}^2}{2l_{1,3}} \\ \dfrac{dv_{3,5}}{dt} = \dfrac{k.R.T_3}{l_{3,5}(k-1)}\left(1-\left(\dfrac{p_5}{p_3}\right)^{\frac{k-1}{k}}\right) - \xi_{\Sigma 3,5}\dfrac{v_{3,5}^2}{2l_{3,5}} \\ \dfrac{dv_{5,7}}{dt} = \dfrac{k.R.T_5}{l_{5,7}(k-1)}\left(1-\left(\dfrac{p_h}{p_5}\right)^{\frac{k-1}{k}}\right) - \xi_{\Sigma 5,7}\dfrac{v_{5,7}^2}{2l_{5,7}} \\ \dfrac{dv_{3,9}}{dt} = \dfrac{k.R.T_3}{l_{3,9}(k-1)}\left(1-\left(\dfrac{p_9}{p_3}\right)^{\frac{k-1}{k}}\right) - \xi_{\Sigma 3,9}\dfrac{v_{3,9}^2}{2l_{3,9}} \\ \dfrac{dv_{9,11}}{dt} = \dfrac{k.R.T_9}{l_{9,11}(k-1)}\left(1-\left(\dfrac{p_{kt}}{p_9}\right)^{\frac{k-1}{k}}\right) - \xi_{\Sigma 9,11}\dfrac{v_{9,11}^2}{2l_{9,11}} \\ \dfrac{dv_{3,13}}{dt} = \dfrac{k.R.T_3}{l_{3,13}(k-1)}\left(1-\left(\dfrac{p_{13}}{p_3}\right)^{\frac{k-1}{k}}\right) - \xi_{\Sigma 3,13}\dfrac{v_{3,13}^2}{2l_{3,13}} \\ \dfrac{dv_{13,15}}{dt} = \dfrac{k.R.T_{13}}{l_{13,15}(k-1)}\left(1-\left(\dfrac{p_h}{p_{13}}\right)^{\frac{k-1}{k}}\right) - \xi_{\Sigma 13,15}\dfrac{v_{13,15}^2}{2l_{13,15}} \end{cases} \qquad (2.48)$$

2.6. Simulating the process of supplying compressed Biogas with triple function valve for Honda wave α 110cc engine

2.6.1. Identifying of initial data

The following calculation is conducted with Honda wave α 110cc engine with cylinder diameter D_{xl} = 50mm, suction stroke S = 49,5mm and compressed ratio ε = 9:1. The engine can operate at highest speed with n = 8000 rpm when using Biogas with 85% CH_4.

2.6.2. Simulation results

By solving sets of diffential equations (2.47) and (2.48) identifying relation between equivelant ϕ scale of admixture and loading display of engine is found (figure 2.14).

Figure 2.14 shows the three characteristics of the mixture for motorcycle engines using biogas compression was calculated to simulate with the vacuum three functions valve which is working and effective.

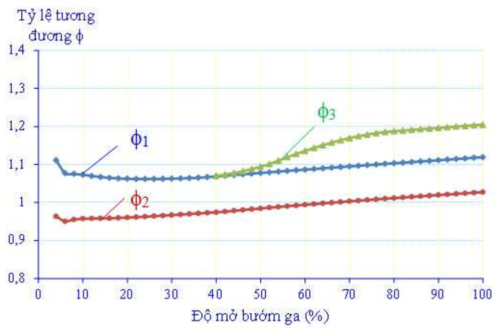


Figure 2.14: The relation between equivalent scale of admixture and engine load of triple function valve supplying compressed Biogas for Honda wave α 110cc

The symbol % is calculated according to the value (%) of throttle position, ϕ_1 is the rate coefficient values by the idle load circuit and main circuit and have curves in figure 2.14 with values equivalent rate $\phi \approx 1$ (ϕ_1 = 1.06 to 1.12), while Characteristics ϕ_2 is related to the case of adjusting advance throtte major circuit screw to reach the value of $\phi < 1$ in small loading area for energy saving purpose (the value of ϕ_2 = 0,95 to 1,03). Meanwhile, ϕ_3 curves corresponding to the main circuit characteristics ϕ_1 (no adjustment screw idle providing for primary circuit) when accelerated circuit operates. Accelerated circuit is adjusted to accelerated valve providing additional fuel, and starts working on throttle position at 40% or higher. Accordingly, the properties are equivalent rate coefficient a significantly greater (equivalent rate coefficient ϕ can reach 1.21).

2.7. Conclusion

Biogas is one of the renewable energy sources with large reserves and production in human life. To use this energy efficiently, they must filter and storage technology biogas reasonable. The study results allow to draw the following conclusions:

- Vietnam has high intensity solar radiation, evenly distributed throughout the year, creating favorable conditions for decomposition of waste from agriculture and animal husbandry. The quality of biogas depends on the concentration of CH_4 (up from 50% - 70% volume) in the biogas. CO_2 is the impurity concentration of the largest accounting, the presence of impurities reduces the heating value of the fuel. H_2S is the main harmful impurities present in biogas because it causes corrosion of metal parts and causing environmental pollution.

- The removal of H_2S and CO_2 depends on the method of filtration, filter material ... Method tower filtration buffer material using solvent with water for reliable results (corresponding to the input gas flow 1.5 m3 / h to 96.7% resulting CH_4, 1.87% CO_2, other components accounted for 1.43% of the H_2S is absorbed almost completely) and facilitate the processes used.

- The biogas storage in the natural gas container is very convenient for use on motor vehicles. The energy required to compress biogas to 135 bar pressure accounted for about 8% of the energy contained in biogas (80% CH_4). Simulations also indicate the process of separating CO2 is compressed biogas and energy consumption accounts for about 9% compared with compressed biogas energy.

- The results of simulations show that the feature provides the biogas fuel mixture to the engine compression motorcycle Honda wave α 110cc with vacuum three functions valve and equivalent rate coefficient $\phi \approx 1$. This again confirms the correctness of the application of vacuum valve provides three functions to compress biogas for motorcycles. This has enormous significance in directing the empirical adjustments to supply biogas motorcycle to reach the largest possible capacity.

Chapter 3

RESEARCH CALCULUS AND NUMERICAL SIMULATION OF COMBUSTION PROCESS IN MOTORCYCLE ENGINE 110CC HONDA WAVE A USING BIOGAS FUEL

3.1. Characteristics of the combusting process of Biogas and air admixture

The equivalent ration of fuel – air (*or called admixture density)* is one the influential data to the combusting process and is established as follow:

$$\phi = \frac{(F/A)_{tt}}{(F/A)_{lt}} \qquad (3.1)$$

We can ascertain the density of admixture according to air capacity, biogas capacity supplied to the engine.

$$\phi = \frac{m_{CH_4}}{0,23 m_{O_2}} \qquad (3.2)$$

When improving the carburetor, we should notice the air-fuel scale to ensure the optimum of engine features.

Combustion of biogas fuel mixture air is premixed outside from combustion chamber, it can be seen as a combustion of a uniform mixture. Nevertheless, biogas contains some impurities mainly CO_2 molecule mosaic of CH_4 and air, prevent the spread of fire membrane, making the membrane is not continuous fire, combined with the increasingly turbulent makes distributed concentration of CH_4 in the mixture is not homogeneous, it can be seen as pre-mixed combustion locally.

3.2. Combustion Theory premixture homogeneous

Rate of fire spread disorder in the combustion chamber membrane ignition engines forced a very important parameter deciding mixture consumption rate. Damkohler expression suggest relationship between membrane spreading velocity laminar and turbulent flames as follows:

$$f_f = \frac{S_t}{S_u} = \sqrt{\frac{\varepsilon}{\nu}} \qquad (3.13)$$

In which S_t, S_u respectively membranes fire spreading speed in the case and laminar turbulence; ε is a total mess diffusion; ν is the kinematic viscosity of the unburned gas mixture.

3.3. Theory of premixed combustion air locally

Su laminar burning speed is the fundamental parameter in modeling the combustion process can be calculated if you know in detail the rate of chemical reactions taking place in the combustion process.

R.Stone, A.Clarke, and B.Beckwith has conducted experimental determination of laminar burning speed fuel mixture is contaminated by CH_4 and CO_2. Iijima and Takeno suggest the following expression::

$$S_u = S_{u,o} T^{\alpha} (1 + \beta \log_{10} P) \qquad (3.30)$$

With β= -0,42-0,31(ϕ-1)

In the following simulations, the speed of the film laminar flame burning fuel mixture CH_4, CO_2 and air were calculated based on the expression of 3.30 and experiments of R.Stone, A.Clarke.

3.4. Establishing calculation simulation of combusting process of Honda wave α 110cc engine

3.4.1. Establishing the calculation simulation

The Honda wave α 110cc engine has sphere -frustum – shape chamber, with cylinder diametre of 50mm, suction stroke of 49,5 mm (Figure 3.3). The compress ratio is ε = 9:1.

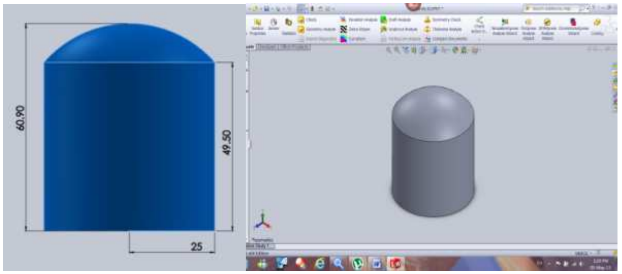


Figure 3.3. Calculating space of Honda 110cc combustion chamber

The technology of dynamics net-division is applied to show the motion of suction in cylinder and is conducted on Workbench of ANSYS (Figure 3.5).

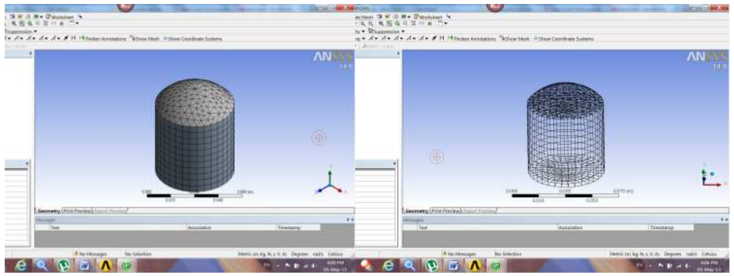


Figure 3.5: The process of net-division in chamber space

3.4.2. Emulation result by Fluent software

Figure 3.6 introduces changes of CH_4 content, temperature and space of admixture in the chamber in proportion with biogas admixture calculated M85C15 with air.

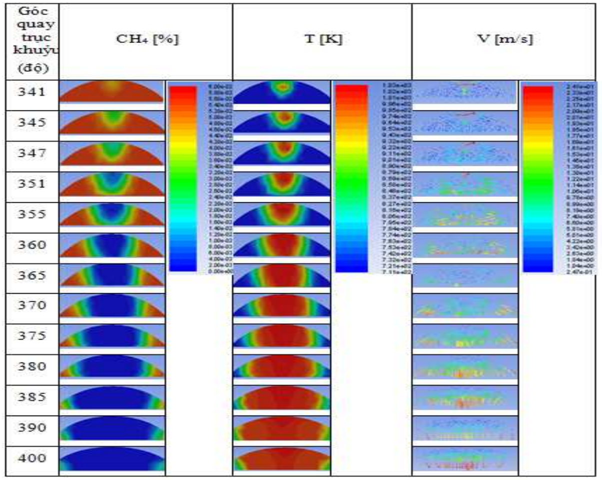


Figure 3.6: Changes of average CH4 content, temperature and space of admixture in engine chamber in proportion with fuel M85C15 (85% CH_4 and 15% CO_2) and crank speed n= 3000 rpm

3.5. Conclusion

The above research findings allow us to come to the following conclusions:

- The simulation is developed base on the foundation of the combusting simulation of gasoline engine in addition to changes in density of admixture and basic combusting speed.

- The simulation allows us to predict the influence of major factors (the density of admixture and early ignition angle, angle speed of the engine and fuel buil-up) to changes in average CH_4 content, tempeature and space of admixture in the engine chamber of Honda wave 110cc.

Chapter 4
EXPERIMENTAL RESEARCH

4.1. Research facilities

4.1.1. Experimental motorbike

The experimental motorbike is installed with compressed biogas supply network with container including air compressed valve, depressurizing valve and Gatec 25 kit and put into slip proof Chassis Dynamometer 20’’.

4.1.2. Chassis Dynamometer 20”

Chassis Dynamometer 20” can identify a number of technical parameters such as vehicle speed, acceleration and pulling power of the vehicles.

4.2. Indicating pressure measurement system in the engine chamber

The variation of indicative pressure in the cylinder are recognized by GU12P pressure sensor and engine speed is determined by the speed sensor 364C Encoder as diagrams 4.4.

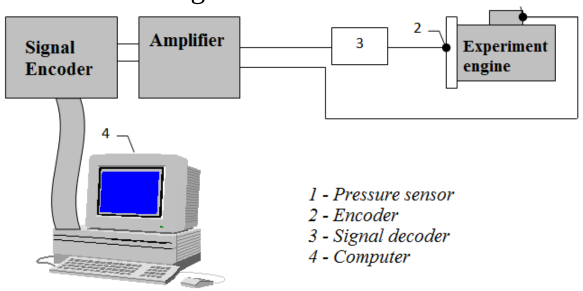


Figure 4.4: Layout of the experimental combustion engine 110cc Honda wave α

4.3. Experiment and analyzing findings

Findings from experiment have expressed the relationship between indicating pressure pi in the cylinder based on crank angle speed of the engine (deriving from pressure sensor and speed sensor) in Figure 4.11.

The performance of changes in pressure in the Honda wave α 110cc engine chamber when using the gasoline RON92 is quite good and reach the maximum value $p_{max} \approx$ 58 bar after the dead point at about 10 degree of the crank rotating angle. Meanwhile, when using Biogas 85% CH_4, the maximum value is only $p_{max} \approx$ 34,5 bar and last after the dead point at about 19 degree of the crank rotating angle.

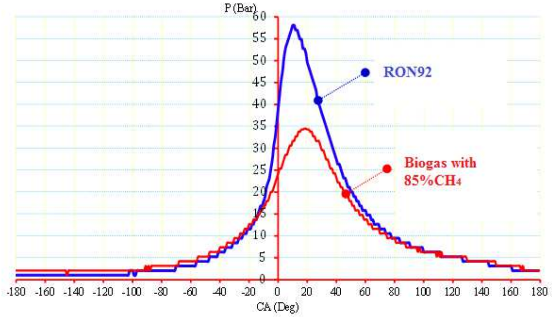


Figure 4.11 : Pressure performance according to crank rotating angle of the Honda wave α 110cc

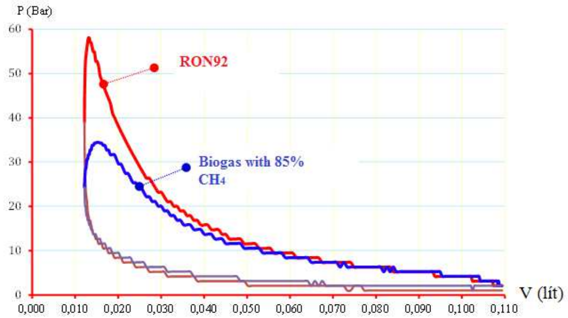
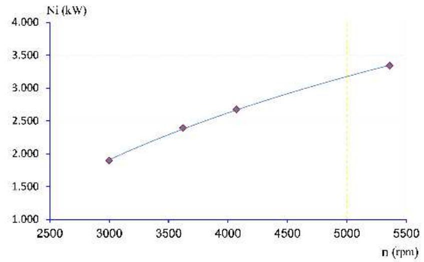


Figure 4.12: The graph of indicating work of Honda wave α 110cc engine circle

The life cycle in the combustion chamber engine motorcycle Honda wave 110cc α using RON92 petrol is 106.369 Jun /cyc, while the

fuel cycle using compressed biogas with 85% CH_4 indicates that 75.842 Jun /cyc (Figure 4:12).



Calculations determine the power of motorcycle engines 110cc Honda wave α when using biogas (85% CH_4) with speed n = 5360 rpm is 3,388 kW respectively (Figure 4.15), while power generated using RON92 petrol is 4.75 kW at the same speed.

Figure 4.15: Variability of power according to angular speed of the crankshaft empirical engine motorcycle Honda wave α 110cc

4.4. Testing motorbike using compressed Biogas on the road

Biogas 85% CH_4 is compressed in 2 containers with capacity of 3,5 litre each container at the pressure of 75 bar to be tested on the road. The real result has shown that the maximum speed is 55km/h. With this motorbike, when using gasoline, the maximum speed is 80km/h. The result matches the experiment on work test strip..

4.5. Conclusion

- The Biogas totally develops its effect in usage when being used for fuel for the internal combusting engine in general and particularly for the Honda wave α 110cc.

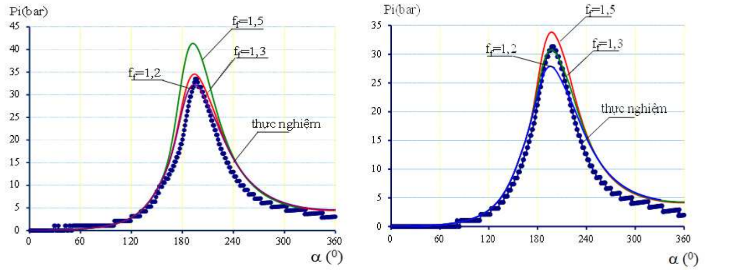
- When using biogas as a fuel for motor vehicles, must necessarily be filtered to achieve the purity required for combustion in an internal combustion engine that does not need to change any specifications public art. However, if not purified, it is necessary to change the ignition angle corresponding.

Chapter 5

COMPARING EMULATION RESULT WITH EXPERIMENT OF HONDA WAVE α 110cc ENGINE USING COMPRESSED BIOGAS

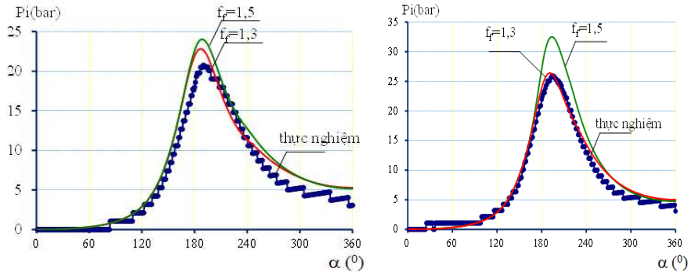
5.1. Comparing results from emulation and experiment

Figure 5.1a and 5.1b compare the results of indicating pressure performance from emulation and experiment at engine speed of 3000rpm and 3620 rpm. The selected speed scales of burning flame front are 1,2; 1,3 and 1,5..



a) n=3000 rpm b) n=3620 rpm

Figure 5.1: comparing results of indicating pressure changes from emulation and experiment (φ_s=270, 85% CH_4, ϕ=1) in proportion with engine crank angle speed of n = 3000 rpm and n =3620 rpm



a) n=4070 rpm b) n=5360 rpm

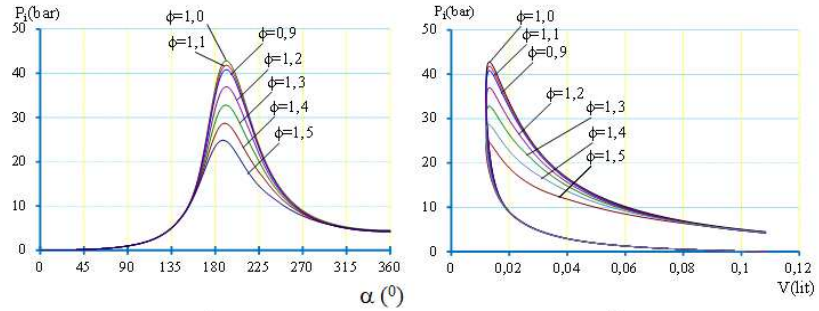
Figure 5.2: Comparing results of indicating pressure changes from emulation and experiment (φ_s=270, 85% CH_4, ϕ=1) in proportion with engine crank angle speed of n = 4070 rpm and n =5360 rpm

From the compared results, we come to the conclusion that in the scope of engine speed from 3000rpm to 6000rpm, flaming scale (f_f) in the Honda wave α 110cc chamber using compressed Biogas 85% CH_4 is about 1,3. Diviation between emulation and experimetn is about 10% at high speed areas.

Based on the above findings, we can erect emulating simulation proper to the experimental conditions.

5.2. Emulating the influence of fuel to the technical features of the Honda wave α 110cc engine

Figure 5.4a and 5.4b introduce the changes in indicating pressure graphs and indicating work graph according to the density of admixture ϕ.



a) b)

Figure 5.4: Influence of the admixture density on indicating pressure diagram and indicating work diagram (n=3000 rpm φ_s=30^0, 80% CH_4)

5.3. Emulating influence of composition and opertion data on techinical features of Honda wave α 110cc engine

5.3.1. Influence of the early ignition angle

When increasing the early ignition angle, the maximum pressure and temperature also rise. However, the engine indicating work does not increase to the maximum pressure or temperature. (Figure 5.17 and 5.18)

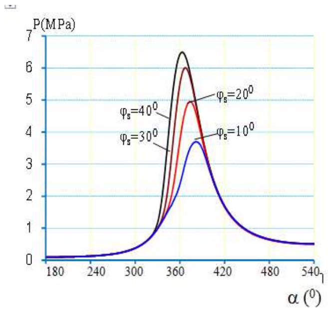


Figure 5.17: Influence of early ignition angle on indicating work diagram. (n=3000 rpm, ϕ=1,39)

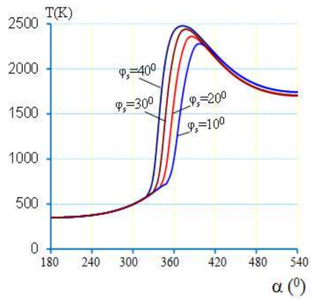


Figure 5.18: Influence of early ignition angle on circle indicating work. (n=3000 rpm, ϕ=1,39)

Early ignition angle is optimum with Honda wave α 110cc when using compressed biogas changing from 20 degree to 35 degree, when the engine speed changes from 3000rpm to 8000rpm (Figure 5.23).

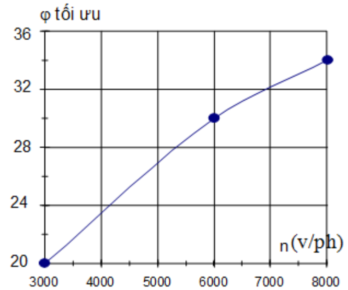


Figure 5.23: : Changes of early ignition angle being optimum to engine angle speed

5.3.2. Influence of engine speed

The difference in firing rate when changing engine speed at a given angle of ignition is evident in the graph variable pressure and average temperature in the combustion chamber of crankshaft rotation.

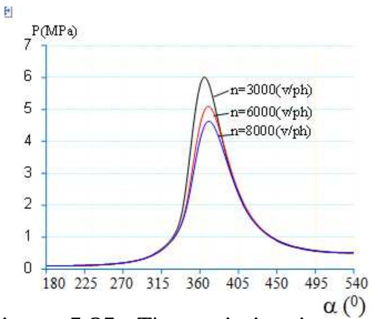


Figure 5.25: The variation in pressure indicates the crankshaft rotation with different speed of the engine (φ_s = 30^0)

5.4. Conclusion

- When converting motorcycle engine 110cc α wave to run on compressed biogas and improving combustion chamber turbulence coefficient by 1.3 f_f can choose for fuel containing 85% CH_4 and motor activity in average speed range from 3000rpm to 6000rpm..

- When the engine is running with biogas containing 85% methane volume, optimized ignition angle ranges from 20 to 35 degrees when the engine speed changes from 3000 rpm to 8000 rpm..

CONCLUSION AND DEVELOPMENT TREND

Using biogas as fuel for internal combusting engines is one of the solution to develop proper recyclable energy in Vietnam, where 80% of population are living in rural areas.

Using biogas is of more significance once we can supply motor vehicles, particularly for motorbike – the major means of transports in our country.

The research aims at solving 3 major issues to utilize Biogas as a fuel for motorbike, which are (1) compressing biogas into pressure container, (2) supplying compressed biogas for motorbikes and ensuring their optimum operation in any conditions and (3) ascertaining framing figure f_f in the engine chamber of Honda wave α 110cc using compressed biogas.

The results of the thesis allow us to draw the following conclusions:

General conclusion:

- Contaminant filtering in Biogas depends on demands and usage quantity of the gas. For small quantity, the simple filtering method using tower with purl material and hydro-solvent has delivered results adapting the standard of gas used for motor vehicles. When using NaOH 20% to filter, we can deaerate H_2S completely and raising CH_4 content in Biogas up to 97% CH_4. For large Biogas supply networks, we can deaerate H_2S by combining different methods : Adsorption filtering method, traditional absorption and CO_2 deaerating method by substracting and disposing at high pressure.

- Compressed Biogas supply network for motorbikes includes high pressure Biogas accumulator , relief valve, and admixture kit. We can use high pressure natural gas accumulator with capacity of 3,5 litre bearing 200 bar pressure to store Biogas used for motorbikes. On the other hand, we can adjust LPG supply kit for motorbikes including function valve (GATEC 25) : empty valve, major gas supply valve and accelerant valve to supply compressed Biogas to motorbikes. Experiment results have showed that if using two 3,5 litre compressed Biogas accumulators with 85% CH_4 at 75 bar compressed pressure, motorbikes can travel an independent distance of 20km at an average speed of 40km/h.
- The burning speed of Biogas is slower than the burning speed of tradiditional fuel. Thus, when motorbikes turn to use compressed Biogas, we should change the plug corner to ensure that the engine can operate properly at high speed. When the engine operates with Biogas with 85% volume of methane, the optimum plug corner fluctuate from 20 to 35 degree when the engine speed changes from 3000 rounds per minute to 8000 rounds per minute..
- When changing to use compressed Biogas, the maximum indicating pressure as well as the cycle work decreases

compared with when operated by petrol. Experiment has showed that when the engine is operated by petrol RON92, maximum pressure would reach $p_{max} \approx 58$ bar after the dead point of 10 degree crank rotation angle and the cycle work is 106,369 Jun/cyc; when the maximum indicating pressure reaches 34,5 bar, at the crank rotation angle of 19 degree after the above dead point with the cycle work of 75,842 Jun/cyc, approximately 71,3% compared with market petrol RON92.

- The combusting speed of the admixture biogas - air can use the experimental calculating structure of Iijima and Takeno. When changing the wave α 110cc engine into using compressed biogas without improving chamber, the flaming figure ff can operater at average limited speed of 3000rpm to 6000rpm. In this case, the calculating result in emulation by Fluent software match the experimental result in AVL motorbike test strip.

Development trend

In order to complete the theoretical and experimental background of motorbikes using compressed biogas, it is necessary to continue researches into the following issues:

- Develop Biogas filtering and compressing storing technology with materials having nano structures to absorb CH_4 in order to minimize the container size when installing to motorbikes for convinient usage.
- Study to relocate Biogas containers in proper and convinient places on the motorbike and ensure safety.
- Study about the influence of Biogas on the expectancy of the engines.

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1. Bùi Văn Ga, Nguyễn Văn Đông, Nguyễn Văn Anh, Trương Lê Bích Trâm (2009), “A research on compressed biogas delivery system for motocycle”, *The transport journal*, Vietnam ,12, pp. 79-82.
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