MINISTRY OF EDUCATION AND TRAINING

THE UNIVERSITY OF DANANG

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RESEARCH MIXTURE FORMATION AND COMBUSTION OF DUAL FUEL ENGINE (BIOGAS-DIESEL)

Specialty: Heat Engine Engineering

Code: 62.52.34.01

ABSTRACT OF TECHNICAL THESIS

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The work has finished at

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The thesis is going to be defended at the Council for Evaluation PhD thesis Technical meeting at The University of Da Nang on 05 Month 11 year 2016

This thesis can be lookup at:

- Learning Information - Resource Center, the University of Danang.
- Learning Resource Center, the University of Danang.

INTRODUCTION

THE REASON FOR CHOOSING: Saving energy and reducing environmental pollution are the objectives of automobile industry and car (automotive industry). Biogas is a renewable energy source derived from solar power, so using it does not increase the concentration of CO_2 in the atmosphere. Biogas has been thriving not only in the developing countries but also in the developed countries. To meet the diverse needs of the application of biogas in internal combustion engines, technology solutions converting the traditional engine to biogas are necessary. In order to predict the size of the converter transforming from each kind diesel engine into dual fuel diesel-biogas engine works with many different sources of biogas, we must conduct simulation researches and evaluate the results with experimental data in a number of specific cases [16].

For the above reasons, the topic ***"Research mixture formation and combustion of dual fuel engine (biogas-diesel)"*** is very urgent; it not only contributes to diversify fuel sources for heat when the engine is running out of oil, but also contributes to more efficient use of biogas fuel source for internal combustion engines.

PURPOSE OF STUDY: Perform the basic research on combustion and fuel supply for dual fuel biogas-diesel engine outside the purpose of reducing environmental pollution, increasing the availability of fuel for internal combustion engines; the thesis also aims at using this biofuel alternative source widely to combustion engines in an effective way.

SUBJECTS AND SCOPE OF THE STUDY

Subjects of study: The combustion in Vikyno EV2600-NB dual fuel engines using biogas-diesel fuel is selected as the thesis research object.

Scope of the study: Due to the complexity of the research problem, this thesis is limited and focused on the mixture formation and combustion in EV2600-NB dual fuel engines using biogas-diesel fuel by modeling and experimental research.

RESEARCH METHODS: Thesis uses theoretical research, modeling combined with empirical research methods.

Theoretical research and modeling: Research the mixture formation of the Vikyno EV2600-NB dual fuel engine (biogas-diesel) by means of suction through the throat Venturi by GATEC-20 to establish the curve of the rate coefficient of dynamic equivalent load muscle; research modeling biogas combustion-air mixture ignited by jet bait to predict economic features and technology of the engine to the operating modes and different fuel components. Modeling results help reducing experimental costs.

Experimental study: Experimental measurements of pressure changes in the combustion chamber of the Vikyno EV2600-NB dual fuel engine (biogas-diesel) fuel uses diesel and biogas fuels with different components ignition CH_4 by priming jet; Experimental studies mixture formation of the dual fuel engine to establish characteristic curves of coefficients equivalent rate under engine load; compare results by modeling and experimentation.

SCIENTIFIC MEANING AND REALITY OF THE STUDY:

Scientific significance: The thesis has contributed to basic research and depth of dual fuel engines (biogas-diesel) in Vietnam.

Reality significance: The thesis will identify the efficiency of using biogas fuel for internal combustion engines and reduce environmental pollution.

THESIS CONTENT STRUCTURE

The layout of the thesis beyond the introduction, conclusion and direction of development of the subject, the content is presented in four chapters with the following structure:

Chapter 1: Overview

Chapter 2: Simulation research mixture formation and combustion of dual fuel engine (biogas-diesel)

Chapter 3: Experiments study

Chapter 4: Comparison of the results given by simulation and experimental dual fuel engine biogas-diesel

CONTRIBUTION NEW SCIENTIFIC ASPECTS OF THE THESIS:

The thesis has some new contributions in science as follows:

① Thesis experimentally determined characteristic lines of equivalent coefficient ratio according to load and engine speed, the results were compared with the model was calculated previously.

② The thesis has developed computational models mixture formation and combustion of dual fuel engine (biogas-diesel) thereby orientating during testing to evaluate the usability of mobile this muscle.

③ The thesis points out the characteristics of the combustion of fuel biogas methane corresponding components in different fuels, thereby allowing analysis accurately assess the parameters affecting engine features dual fuel (biogas-diesel).

Chapter 1
OVERVIEW

1.1. ISSUES OF ENERGY AND ENVIRONMENT TODAY

1.2. CHARACTERISTICS OF BIOGAS USED FOR INTERNAL COMBUSTION ENGINES

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. APPLIED RESEARCH BIOGAS FOR COMBUSTION ENGINES

1.3.1. Research and application of biogas in the world

Internal combustion engines using biogas as fuel can be used engines or fuel gas converted from the engine using traditional liquid fuels. Engines using biogas fuel from the engine renovated using traditional liquid fuels can be the engine ignition cramp or dual fuel engine. Dual fuel injection engine is about 10% to 20% of diesel fuel primer widely used in small power range because of the highly efficient power generation. However, it emits the higher contamination levels. On the other hand, this approach has the advantage that without biogas, the engine can still run entirely by diesel [8], [21], [22], [24].

Clark (1985) [38] said that when switching engine uses natural gas to biogas, power run down about 5 ÷ 20% compared with the natural gas. Jewell et al. (1986) [59] suggest that running biogas with 60% CH_4 reduces engine capacity from 15 ÷ 20%. Derus (1983) [43] proposed composition of methane in biogas minimum for 4-stroke engine with a calorific value of 35% 14,89MJ/m^3.

1.3.2. Research and application of biogas in VietNam

In 2007 the team of Prof. Dr. Bui Van Ga has conducted research on the use of biogas engines [7]. And they tested to run on biogas with the 110cc motorcycle accessories GA5. Besides, the research team has published studies provide biogas systems for traction motor generator system presents 2HP offers complete biogas for combustion engines clusters - generator [8]. In 2008, Prof. Bui Van Ga and his colleagues published the research on biogas systems offer dual-fuel engines for biogas-diesel [8]. In 2009, Prof. Bui Van Ga and his colleagues continued to study system providing multiple cylinder engines sized two fuels [6].

In 2013, Nguyen Van Dong has successfully applied research biogas fuel used for motorcycle [25]. Also in 2013, Le Xuan Thach has researched and published the results in transforming diesel into biogas engine ignition forced to run biogas [22]. Le Minh Tien (2013) at the University of Da Nang has studied the design and manufacture of motor fuel used two biogas / diesel on the basis of a cylinder engine [21].

However, the aforementioned study was not conducted measurements of exhaust gas emissions engine. When converting diesel engines to run biogas, authors have just compared the features of this engine with the original diesel through the engine's power and special-use simulation software. In order to assess more accurately, we need to measure the pressure gauge indicating the engine combustion chamber. In the course of providing fuel mixture biogas/diesel, we should determine their density in experiments.

1.4. CONCLUSION

The overview research results of the use of biogas for internal combustion engine allows drawing the following conclusions:

- Studies in production and application of renewable energy sources have been widely deployed. One of them is research using biogas used as fuel for internal combustion engines in stationary purposes and motor vehicles. Solutions using biogas as a fuel for internal combustion engines achieves all 3 objectives: saving fossil fuels, limiting emissions of greenhouse gases and protecting the environment in the production and activities.

- Biogas is a renewable energy derived from solar energy; the use does not increase the concentration of greenhouse gases in the atmosphere. The presence of CO_2 in biogas reduces fuel heating value and fire rate. However, it increases resistance to detonation of fuel, allows increasing compression ratio of the engine.

So "Research mixture formation and combustion of dual fuel engine (biogas-diesel)" has scientific and practical significant. The results will partly contribute to the process of solving the above problems; especially to create a premise and a solid basis for the production of next-generation dual fuel engine (biogas-diesel) work with high efficiency and capacity; low fuel consumption rate brings economic efficiency for the country.

Chapter 2

RESEARCH AND SIMULATION PROCESS OF FORMATION OF MIXED AND FIRE DUAL FUEL ENGINE (BIOGAS-DIESEL)

2.1. THEORY OF INJECTION DIESEL DEVELOPMENT IN COMBUSTION CHAMBER DUAL FUEL ENGINES (BIOGAS - DIESEL)

2.1.1. Equations of Motion for Particles

2.1.2. Stochastic Particle Tracking in Turbulent Flow.

2.1.3. Droplet Vaporization

2.2. THE DEVELOPMENT OF JET DIESEL IN THE BIOGAS-AIR MIXED.

Diesel includes stable molecules such as $C_{12}H_{22}$, $C_{13}H_{24}$ and $C_{12}H_{24}$. Normally, people use the average chemical composition of diesel $C_{12}H_{23}$. Diesel spontaneously burn at combustion temperature 210^0C.

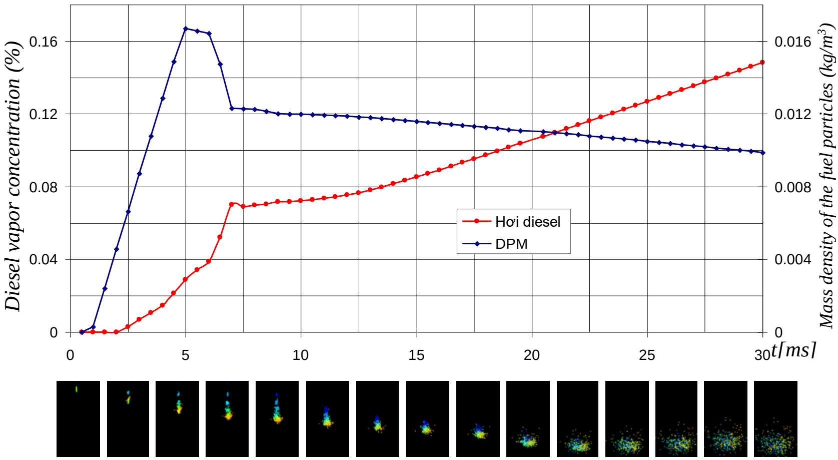


Figure 2.3: The development of Jet diesel in the biogas-air mixed (p=3[bar])

We can easily find out that after the end of injection at the time of 5ms, jet started strongly decaying into particle fuel cloud, going away from the nozzle mouth. When cloud particles volume expansion, fuel particles accelerated evaporation, decreasing the amount of grain and fuel vapor concentration in the combustion chamber increases.

2.3. DEVELOPMENT JET DIESEL ENGINE COMBUSTION CHAMBER BIOGAS FUEL USING WITH DIFFERENT INGREDIENTS CH_4

2.3.1. Component mixture

2.3.2. Conditions jet Diesel

Combustion chamber used in simulation calculations Cylinder, diameter 140 mm, height 300 mm, volume 4.62 liters. Airflow can be used to burn completely 0.4 g diesel.

2.3.3. Effects of combustion chamber pressure

Just as case of the fuel injection in the atmosphere or environment containing air and CH_4, we find that in the same conditions, when the pressure in the combustion chamber is increased, the fuel vapor concentration in the combustion chamber reduces.

2.3.4. Effect of temperature on the development mixture of jet

Just as in the case of diesel injection air environment containing CH_4, biogas-air mixtures when temperatures rise, the diesel fuel vapor concentration in the mixture also increased due to rapid evaporation of fuel at high temperatures.

2.3.5. Effect of biogas fuel

When components CH_4 biogas increases not only in improved combustion but also improved the condition of the jet diesel evaporation leads to improved quality spark jet primer.

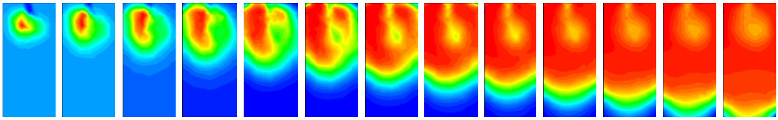
2.3.6. Effect of flow injection

The calculation results show that when traffic jet increases, diesel fuel vapor concentration at a given time after spraying has also increased. Growth rate of the fuel vapor concentration is greater when higher jet flow rate of fuel vapor concentrations increase speed while jet little. Due to the mixture which evaporates quickly, enabling the combustion takes place completely we should increase traffic jet but decrease time jet to ensure fuel supply cycle does not change.

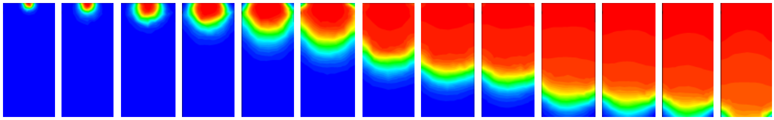
2.4. STUDY COMBUSTION OF MIXED BIOGAS -AIR SPARK JET PRIMER DIESEL

2.4.1. Equivalent coefficients ϕ and mixture compositions f

In this section, we study the combustion of biogas-air mixture in the combustion chamber isometric cylinder diameter of 140mm and a height of 300mm.



a.



b.

Figure 2.32: Simulation combustion of biogas-air mixture ignited by primers jet diesel (a) and forced ignition by sparks (b)

We clearly see the difference of 2 ignition cases. In the case of ignited by sparks, the membrane-shaped pompoms fire spreads from ignition candle farthest regions of the combustion chamber. In the case of diesel spark jet primers, combustion starts from the top jet in random shapes, when the fire moved away membranes, jet

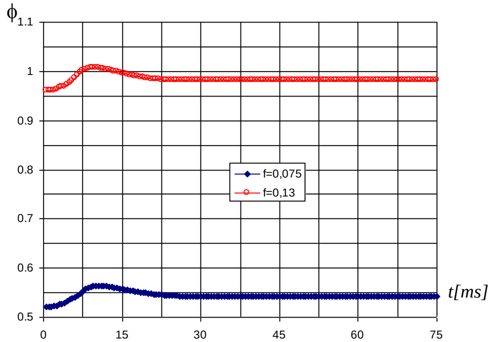


Figure 2:33: The variation coefficient of equivalent ϕ-time (M6C4, p=3[bar], T=750[K], Q=0,01[kg/s], t_{jet}=4[ms])

area remained slightly lower temperature than the temperature in the combustion chamber of the mixture.

Equivalent coefficient rose in diesel fuel injection period and then stabilized during the fire. Shape of the curve barely changed when changing the mixture ratio

2.4.2. Varying pressure and temperature in the combustion chamber mixed

We recognize that initial component mixture increases the pressure and temperature of the mixture is increased. When the mixture starts making bold, f increases pressure and decreases temperature due to incomplete combustion mixture.

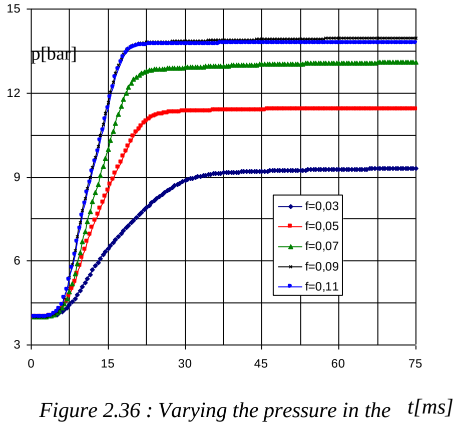


Figure 2.36 : Varying the pressure in the combustion chamber (M8C2, p=3[bar], T=750[K], Q=0,01[kg/s], t_{jet}=4[ms])

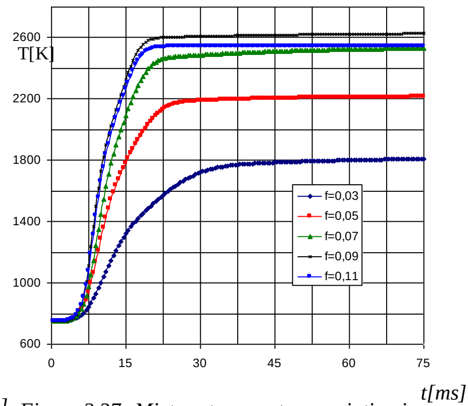


Figure 2.37: Mixture temperature variation in the combustion chamber (M8C2, p=3[bar], T=750[K], Q=0,01[kg/s], t_{jet}=4[ms])

2.4.3. The influence of various factors on the efficiency of combustion

2.4.3.1. The influence of the amount of diesel fuel injection

In the poor mixed conditions, the amount of diesel jet significantly increased the pressure in the combustion chamber with M6C4. When using fuel M8C2, the degree of difference of pressure jet spray primers and primers is not large.

2.4.3.2. The influence of mixture components

We see in all cases, the growth pressure when f little is lower than large f.

2.4.3.3. The influence of fuel

We found that when using a poverty of mixture, the impact of variable fuel to pressure is trivial. However, when using the wealthy mixture, level pressure difference when using fuel M8C2 and M6C4 changed significantly.

2.5. CONCLUSION

From the above results, we draw the following conclusions:

- Evaporation of the diesel jet in air environment close to the environment of CO_2 in the combustion chamber pressure conditions close to the environment of low and CH_4 in conditions of high pressure combustion chamber. The effect of air-biogas mixture combustion chamber depends on the rate of CH_4 /CO_2 in the fuel.

- In the same condition and component jet solvent mixture, diesel beam evaporation of the combustion chamber when the pressure decreased but increased sharply increases with increasing temperature of the mixture in the combustion chamber. Diesel fuel vapor concentrations decreased 2 to 3 times when the pressure increased from 3[bar] to 5[bar] in the same temperature conditions.

- The same conditions, when the pressure in the combustion chamber is increased, the fuel vapor concentration in the combustion chamber reduces diesel. Biogas mixtures when temperatures rise, the air-vapor concentration in the mixture diesel fuel also increased.

- When ignited by flame bait, the ignition point appears at the top jet, screen fire randomly shaped. Compared with forced ignition, speed increased pressure in the combustion chamber when the spark higher spray primer

- The pressure in the combustion chamber reaches the maximum value when the equivalent ratio of general mixture at about 1.01

- In the same operating conditions, temperature, maximum pressure in the combustion mixture dual fuel engine combustion chamber increases the concentration of CH_4 in biogas increase. Combustion pressure increased by 3% while increasing component in biogas CH_4

from 60% to 80% when mixed with a coefficient equal to 0.5; this level of increase to 20% to the coefficient equivalent of 1.01.

Chapter 3
EXPERIMENTS STUDY

3.1. STUDY EQUIPMENT

3.1.1. Experiment engine

Experiment engine is a dual fuel engine biogas - diesel when converting EV2600-NB diesel engines to dual fuel biogas-diesel engine

3.1.2. Dynamometer engine power APA 204

APA dynamometer 204 (asynchron Pendelmaschinen Anlage) can measure the power and torque of the engine through sensors experiment is mounted by the dynamometer.

3.1.3. The system for measuring pressure combustion chamber of internal combustion engines - indiset 620

Pressure variation in the cylinder indicator was recorded by pressure sensors GU12P and the speed is determined by engine speed sensor Encoder 364C [34], [35], [36].

3.1.4. Equipment intake air flow measurement and biogas flow provides dual fuel engine

3.2. EXPERIMENTS AND EVALUATION OF RESULTS

3.2.1. Layout and process laboratory testing on a dynamometer engine

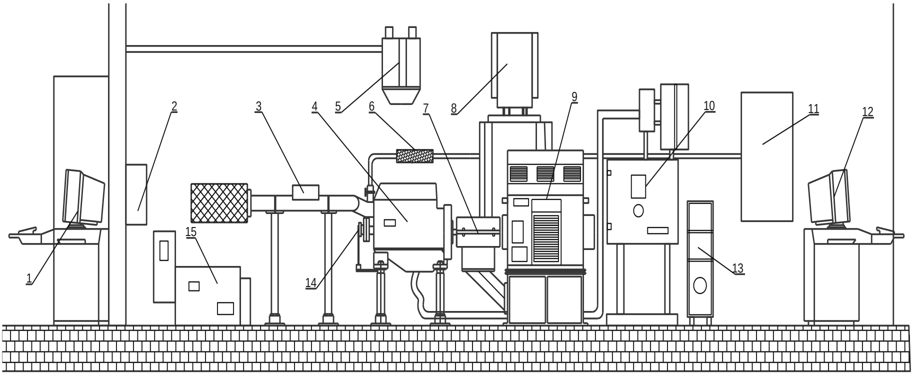


Figure 3.15: Laboratory layout dual fuel engine (biogas - diesel) on a dynamometer engine

3.2.2. Experimental results Analysis

3.2.2.1. Analysis the experimental results determined equivalent factor ϕ

From the simulation results and the results of running, we conduct experiments to identify the relative size of the delivery orifice with each biogas fuels with different components.

Table 3.4: The diameter of the hole in the fuel grade biogas

Biogas fuel	60%CH_4	70%CH_4	80% CH_4
Hole diameter main level [mm]	17,07	14,83	13,59

With supply biogas pipe diameter selected for CH_4 biogas containing various components, the relationship between the ratio equal and open the throttle does not differ much.

3.2.2.2. Experimental results Analysis combustion dual fuel engine

a. Features diesel and dual fuel engine (biogas - diesel)

In this study, early injection angle of the motor is fixed in value φ_s = 22,25° before DCT. Public cycle with 100% of the maximum injection is 1180.55J/cyc; while the cycle of the engine when the injection 50% of the maximum injection was 607.39J/cyc, ie only by 51.45% compared to the maximum spray. Public motor cycle when running through biogas containing 60%CH_4 in the above condition is 851,65J/cyc, by 72% to 100% of the diesel spray maxima (Figure 3.22).

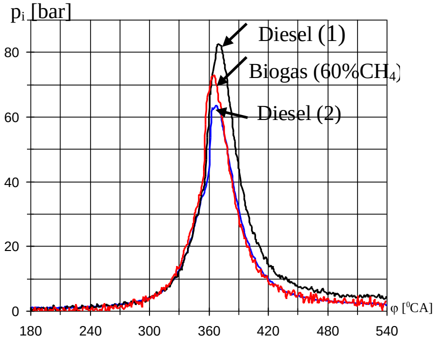


Figure 3.21: The pressure in the cylinder of the engine at speed n = 2000[rpm]when diesel to 100% of maximum injection (diesel (1)), 50% of the maximum injection (diesel (2)) and the powered by biogas containing 60% CH_4 with ϕ= 1

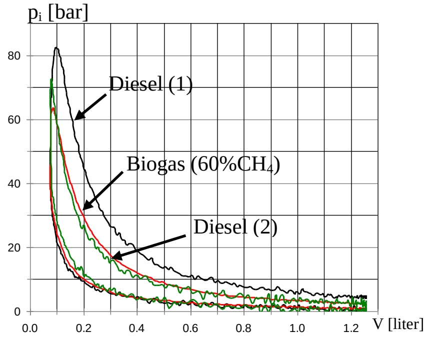


Figure 3.22: Graph of the motor at speed n=2000[rpm] when not fitted diesel mixtures (diesel (1)), when mounting the mixtures (diesel(2)) and when powered by biogas containing 60%CH_4 with ϕ = 1

b. The influence of the throttle to the pressure indicated in dual fuel engine cylinder

Pressure graph with ϕ=1 and ϕ=1.05 is almost identical and have the maximum pressure value. When the equivalent ratio is lower, the maximum peak pressure also decreased and shifted DCT

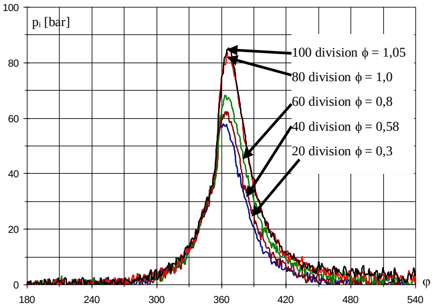


Figure 3.23: The influence of the throttle to the pressure in the cylinder (20, 40, 60, 80, 100% throttle; 80% CH_4; n = 1800rpm)

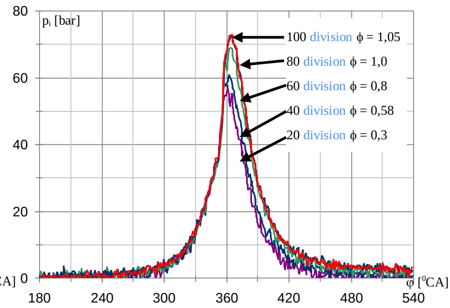


Figure 3.24: The influence of the throttle to the pressure in the cylinder (20, 40, 60, 80, 100% throttle; 80% CH_4; n=2000rpm)

c. The influence of the concentration of CH_4 in the biogas to the pressure in the cylinder dual fuel engine

The same operating conditions, the maximum pressure in the cylinder increases CH_4 content in the biogas. Peak pressure curve as far DCT translate the content of CH_4 in biogas reduction. This can be explained by the firing rate of the mixture decreases with increasing levels of CO_2 in biogas.

d. The influence of the motor speed to the pressure in the cylinder dual fuel engine

Results showed that when the engine speed increases, the maximum pressure of the cycle resulting in the reduction cycle indicator decreased. This can be explained by the mixture of biogas-air has low burn rate compared to traditional fuels, so when the engine speed increases, the time for combustion to decrease, leading to fire and not totally, reduces the engine directive.

e. Influence of ratio equivalent ϕ to the directive cycle dual fuel engine

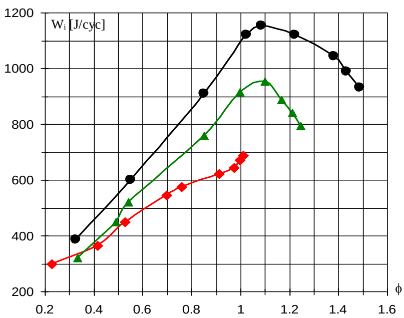


Figure 3.28: The relationship between the indicator cycles and equivalent ratio ϕ when running at speed up with n = 2000[rpm] with biogas contains 60%CH_4 (◆), 70%CH_4 (▲) và 80%CH_4 (●); D_b=18mm)

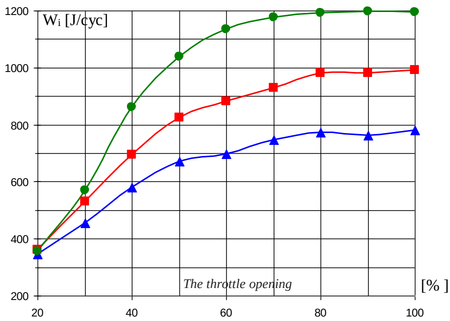


Figure 3.29: Effects of fuel to curve the indicator variable according throttle aperture (%) (n=1800[rpm]; biogas contains 80%CH_4(●), 70%CH_4(◆), 60%CH_4(▲); D_b change)

Figure 3.28 shows the cycle indicator reaches its maximum value when the mixture slightly rich, approximately ϕ=1.1. Public directive cycle equivalent reduces ratio when greater or smaller than this value.

Theoretically, when ϕ=1 the optimal mixture of fire and therefore also the position that the cycle reaches the maximum value. For biogas as fuel containing CO_2 fire so speed is slowed down. In the other hand, due to the inert gas content in the mixture increases should be locally incomplete combustion. Because of these reasons, we should provide the amount of fuel into the combustion chamber greater than the theoretical amount of fuel to ensure the highest performance engine.

Such characteristic lines outside of engine fuel biogas-diesel dual characteristic roads built with ϕ=1,1.

f. Effects of CH_4 in biogas components to the cycle indicator of the dual fuel engine according to the throttle opening

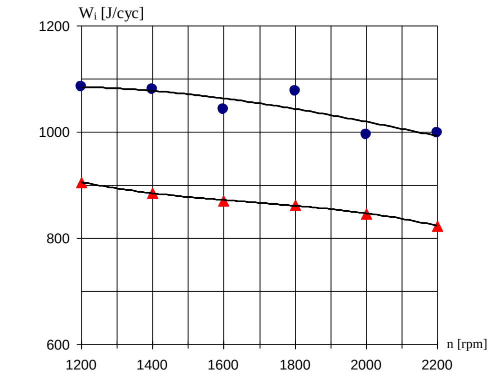


Figure 3.32: Effects of CH_4 in biogas components to the cycle varies according to engine speed (biogas contains 80% CH_4(●) and 60% CH_4(▲), ϕ=1,1)

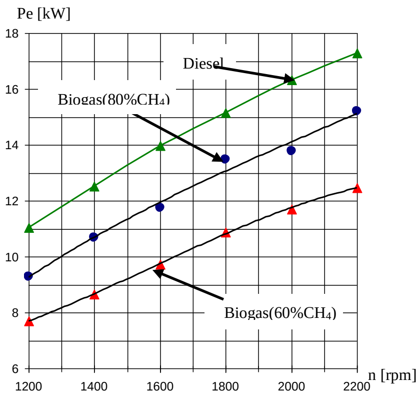


Figure 3.33: Compare outer curve of the diesel engine primitive and when powered by biogas containing 80%, 60% CH_4 with ϕ = 1.1

Along with the same throttle valve aperture, the directive increases the engine's components in biogas CH_4.

Provide biogas pipe diameter is determined with equivalent coefficient ϕ = 1.1 when the engine works at rated speed mode with the lowest CH_4 biogas composition.

g. Effects of CH_4 in biogas components to the cycle indicator of the dual fuel engine according to engine speed

As engine speed increases the time for combustion to reduce fuel consumption in combustion process also leads to the reduction of the engine cycle is reduced.

h. Compare outer curve and motor performance of dual fuel engine

At rated speed mode n=2200rpm, the power of dual fuel engine run with biogas containing 80% CH_4 reduction of 12% compared with the diesel. When running on biogas containing 60% CH_4, the extent of this reduction of up to 25% (Figure 3.33).

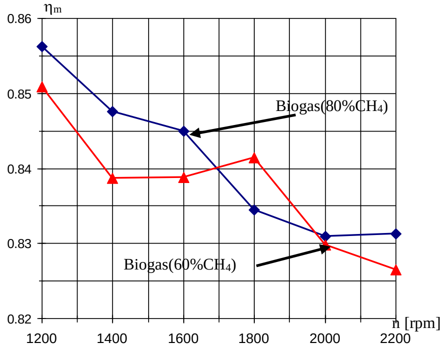


Figure 3.34: Motorized performance variation of the dual fuel engine according to engine speed when running on biogas containing 60%CH_4 and 80%CH_4

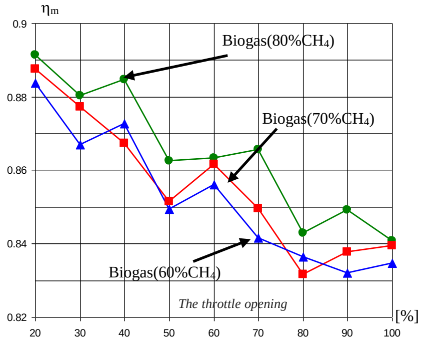


Figure 3.35: Motorized performance variation of the dual fuel engine according to the throttle when running on biogas containing 60% CH_4, 70% CH_4 and 80%CH_4

However, capacity reduction of switching to diesel-powered small biogas than capacity reductions when transferring gasoline engine to run on biogas (this reduction may be up to 40%). This is an outstanding advantage when transferring diesel to run on biogas.

Motorized performance is determined $\eta_m = P_e/P_i$. This is an important parameter to predict the useful capacity of the calculation engine combustion simulation. This result shows a slight decrease Motorized performance according to engine speed. This may explain the increased engine speed; friction losses increase with so useful power of the engine is reduced. In the working level of the engine from 1800[rpm] to 2200[rpm], Motorized performance from 0.82 to 0.86 change (Figure 3.34). Figure 3.35 shows the performance ranged from 0,82 to 0,89. Expanding the throttle, the pressure in the cylinder increases the friction leads to reduced Motorized performance of the engine.

3.3. COMPARISON OF THE RESULTS GIVEN BY SIMULATION AND EXPERIMENTAL DUAL FUEL ENGINE BIOGAS -DIESEL

3.3.1. Comparison of pressure directive variations combustion engine and the cycle directive of dual fuel engines.

Figure 3.36, Figure 3.37 shows the pressure in the engine cylinder for by higher pressure simulation experimental for grubs in combustion and expansion.

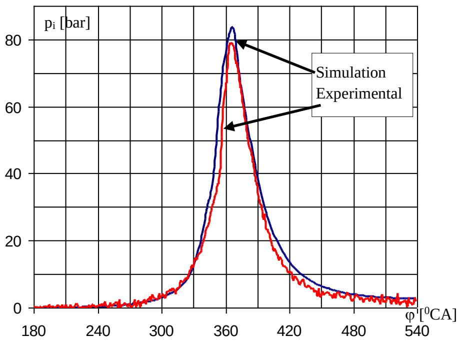


Figure 3.36: Pressure variations in engine cylinder dual fuel biogas-diesel as biogas containing run by 80%CH_4 at speed 1600rpm

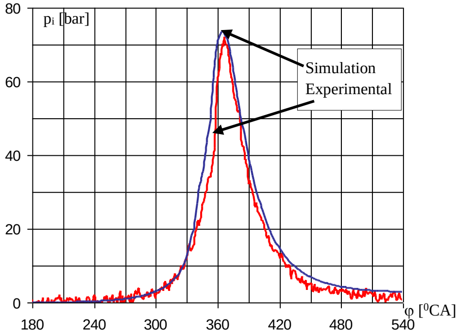


Figure 3.37: Pressure variations in engine cylinder dual fuel biogas-diesel as biogas containing run by 70%CH_4 at speed 1600rpm

The maximum pressure given by higher simulation experimental maximal pressure of between 3% and 10%. The difference between the two results as high the content of CH_4 in biogas as little. The differential pressure values given by simulations and experimental can be explained by the reasons:

(1) Simulation of fire spreading speed monitors biogas composition according to the actual higher models due to the presence of CO_2 in the combustion mixture burning speed affects larger than expected

(2) Simulation ignition (cylinder heat source) in model calculations differ with reality takes place in dual fuel engine combustor (Fire diffusion jet);

(3) Heat transfer between the refrigerant and the cylinder work in the model does not include detailed component combustion radiation diffusion priming jet

During compression, the higher the pressure simulation pressure reduces the experimental simulation directive. Conversely pressure on road expansion simulate higher pressure increases the experimental simulation directive. Public cycle directives given by the simulation higher experimental value by about 10% with 60% biogas containing CH_4 and 3% with biogas containing 80% CH_4.

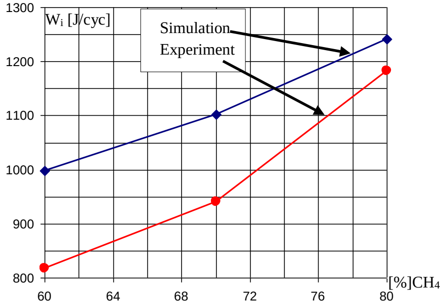


Figure 3.42: Compare of cycle directive for by simulation and experiment as dual fuel engines run on biogas contains various CH_4

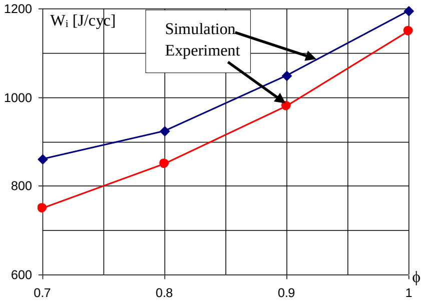


Figure 3.50: Variability of cycle directive for by simulation and experimental coefficient equivalent ϕ

Pressure difference between simulation and experiment takes place mainly on the road compression. When ϕ as little, the level difference between of directive given by the simulation and experimental greater. The level difference of 3% when $\phi = 1$ and 10% when $\phi = 0,6$.

The analysis results of pressure variations in the cylinder above shows the maximum difference between the indicator given by simulation and experiment than 10% in one of the variables: composition CH_4 in biogas, generation equivalent number and engine speed when the other parameters held constant.

3.3.2. Comparative features of dual fuel engine for by simulation and experimental

3.3.2.1. So compare useful variation capacity of dual fuel engines coefficient equivalent to by simulation and experiment

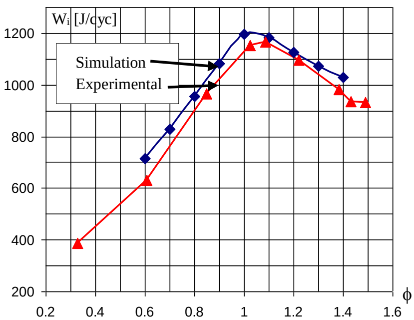


Figure 3.55: Variability of cycle directive equivalent coefficient when the engine runs at n=1300 [rpm] with Biogas 80%CH_4.

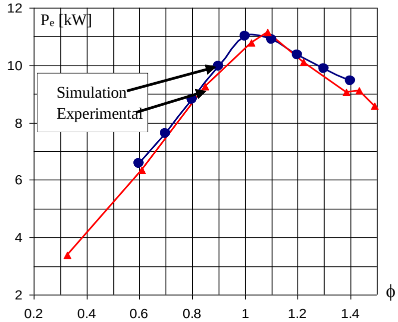


Figure 3.58: Variability of useful capacity of dual fuel engine coefficient equivalent to engine running at n = 1300 [rpm] with Biogas 80% CH_4.

Results compare on this form gives us our comments:

(1) The varying curve general rule is to have a value ϕ at which of cycle directive reached a maximum value;

(2) Simulation curve reaches maximum value with $\phi \approx 1$, whereas experiment curve reaches maximum value with $\phi \approx 1,1$;

(3) The difference between of directive given by simulations and experiment under 10% in all operating modes.

Useful simulation capacity is calculated from public directive cycle and Motorized performance. In experimental studies we have identified Motorized performance of dual fuel engine in the range of 0.82 to 0.86. In this calculation we choose Motorized performance values η_m = 0.85. Results comparisons shows the variation of the useful power a dual fuel engine for simulation by matching power by experiment useful for performance value motorized η_m = 0.85.

3.3.2.2. Compare outer curve of dual fuel engines for by simulations and experiments

The research results of directive variable cycle the engine experiment showed The cycle directive reached a maximum value to coefficient equivalent value of 1.1 slightly richer than stoichiometric values ϕ = 1 theory. So outside curve of dual fuel engine are built upon adjustment coefficient equivalent ϕ =1,1. According to the results study by the graph of pressure for simulation and experimentation above the cycle of directive given by the larger simulation of directive given by the experiment cycle of about 8%

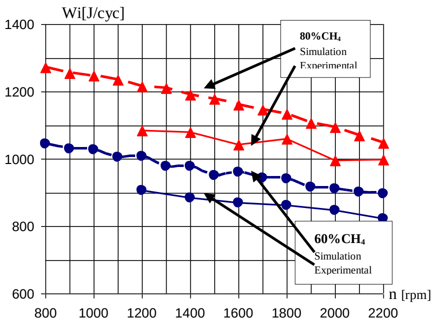


Figure 3.61: Variability of cycle directive according to the engine speed when running on biogas containing 60% and 80% CH4 for by simulations and experiment.

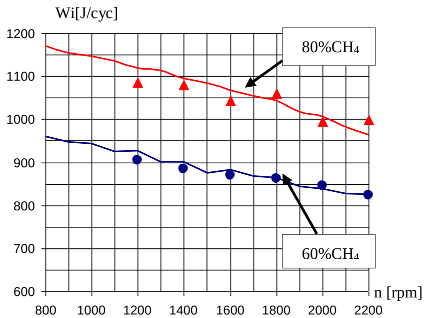


Figure 3.62: Variability of cycle directive according to the engine speed by simulating with coefficient of 0.92 is compatible with the directive given by the experiment

Capacity directive of of engine is proportional to the cycle directive and engine speed. Due to of cycle directive decreased when engine speed should increase power curve according to the speed directive nonlinear engine.

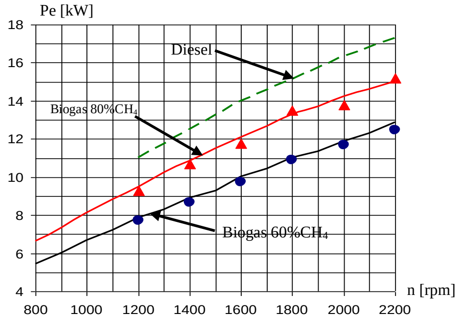


Figure 4.28: Compare outer curve of dual engine with biogas containing 60% fuelchay CH_4 and 80% CH_4 for by simulation and experiment, η_m = 0.85.

We see the results given by simulation is consistent with experiment results by. Compared with diesel power at speeds primitive norms in 2200rpm, dual fuel engine capacity less than about 12% when running on biogas containing 80% CH_4 and less than 25% when running on biogas contains 60% CH_4.

3.4. CONCLUSION

Research results above allow us to draw the following conclusions:

- The maximum pressure in the cylinder as well as the cycle indicator decreased while reducing component in biogas CH_4 and/or engine speed due to the presence of CO_2 in biogas reduces the burning speed. In these cases, increasing the spray angle early is necessary to guarantee engine features.

- Equivalent coefficient of mixtures varies considerably over the throttle but little change with engine speed. Public directive of engine cycles for simulations by achieving maximum value with $\phi = 1$ when the engine run at a given speed by biogas has given component. Public directive given by the experiment cycle reaches its maximum value with ϕ = 1,1. When the equivalent ratio is bigger or smaller than this value, the indicator of engine cycles are reduced.

- The maximum power EV2600-NB dual fuel biogas-diesel engine when running at rated speed 2200rpm when the power is lower than 12% diesel with biogas containing 80%CH_4 and 25% to with biogas containing 60%CH_4. In the same working conditions, the pressure in the cylinder, the cycle indicator and useful capacity of the engine increases CH_4 content in the biogas. At rated speed mode, the EV2600-NB engine cycle 10% discount when transferring from biogas containing 80% CH_4 down 60% CH_4.

- Motorized performance of dual fuel biogas-diesel engine is in the range of 0.82 to 0.89. Motorized performance decreases as the engine speed increases and / or when increasing the throttle opening.

- The presence of CO_2 in biogas as fuel reduction burning rate of the mixture. Therefore, to achieve high efficiency, we need to increase the injection angle soon when the component in biogas CH_4 decreased or when engine speed increases

- Can use simulation methods to predict the features the dual fuel engine work. Public directive of engine cycles for simulations by of directive larger experiment cycle about 8% when the engine speed range from 1000[rpm] and 2000[rpm].

CONCLUSION AND DEVELOPMENT TREND

The research results of the thesis allows us to draw the following conclusions:

1. CONCLUSION

1. Evaporation of the diesel jet in air environment near environment of CO_2 in the combustion chamber pressure conditions close to the environment of low and CH_4 in conditions of high pressure combustion chamber. Effects of air-biogas mixture combustion chamber depends on the rate of CH_4/CO_2 in the fuel. Under the same conditions injection and component solvent mixture, diesel beam evaporation of the combustion chamber decreased when the pressure increases but increased sharply with increasing temperature of the mixture in the combustion chamber. Diesel fuel vapor concentrations decreased 2 to 3 when the pressure increased from 3 [bar] to 5 [bar] in the same temperature conditions.

2. When ignited by flame bait, the ignition point appears at the top of jets, membranes randomly shaped fire. Speed increases the pressure in the combustion chamber when the spark primer spray higher when ignited by sparks. When the concentration of CH_4 in biogas increases, the temperature and the maximum pressure of the mixture in the combustion dual fuel engine increases. Combustion pressure increased by 3% while increasing component in biogas CH_4 from 60% to 80% when mixed with equal ratio ϕ= 0,5; This level of increase to 20% for equivalent coefficient ϕ= 1,01.

3. In the same working conditions, when the pressure in the combustion chamber increases, the diesel fuel vapor concentration in the combustion chamber decreased. When the temperature of air-biogas mixture increases the concentration of vapor in the mixture of diesel fuel also increased. The same amount of injection, when injection traffic increases over time, the evaporation rate of diesel fuel particles increases. Therefore to improve the process of evaporation and ignition of the dual fuel engine biogas-diesel we should shorten the time but increasing flow injection.

4. Diameter tubes provide biogas for EV2600-NB dual fuel biogas-diesel engine optimization vary by component CH_4 and valuable 17.07mm with biogas containing 60%CH_4, 14.83mm with biogas containing 70% CH_4 and 13.59mm with biogas containing 80% CH_4.

5. As calculated simulation the pressure in the combustor reaches at maximum value when the equivalent ratio of general mixture in the combustion chamber at about 1,01. In experimental public cycle indicator of the dual fuel biogas-diesel engine reaches the maximum value equivalent coefficients of about 1,1. When the equivalent ratio greater or smaller than this value, the indicator of engine cycles are reduced. Deviation of directives given by the model and experimentally decreased as ϕ approaching fire completely value theory.

6. The same working conditions, the pressure in the cylinder, the cycle indicator and useful power of the engine increases with the concentration of CH_4 biogas. At rated speed mode, the EV2600-NB engine cycle 10%

discount when transferring from biogas containing 80% CH_4 down 60% CH_4. Public directive of engine cycles for simulations by of directive larger experiment cycle about 8% when the engine speed range from 1000 rpm and 2000rpm.

7. So the maximum pressure in the cylinder as well as the cycle indicator decreased while reducing component in biogas CH_4 and/or engine speed. At conditions rated speed 2200rpm, useful capacity of a dual fuel engine capacity lower than diesel useful primitives 12% when running on biogas containing 80% CH_4 and 25% when running through biogas containing 60% CH_4. When converting diesel engines into dual fuel biogas-diesel engines should increase early injection angle to ensure the engine features.

8. Motorized performance of dual fuel engine biogas-diesel is in the range of 0.82 to 0.89. Motorized performance decreases as the engine speed increases and/or when increasing the throttle opening.

2. DEVELOPMENT TREND

This research project can be further developed in the following directions:

1. Experimental study the development of diesel-priming jet environment biogas-air mixture to compare simulation results.

2. Similar studies done on dual fuel engines using compressed biogas renovated from diesel engines for cars.

3. Research and development structure early injection angle adjustment according biogas fuel components provide stationary engines.

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