Avrupa Bilim ve Teknoloji Dergisi
Sayı 51, S. 282-293, Ağustos 2023
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Araştırma Makalesi

www.ejosat.com ISSN:2148-2683

European Journal of Science and Technology
No. 51, pp. 282-293, August 2023
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Research Article

Experimental Investigation of Acoustic Forcing on the Combustion Effect of Propane - Methane Mixtures

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(İlk Geliş Tarihi 9 Temmuz 2023 ve Kabul Tarihi 25 Ağustos 2023)

(**DOI:** 10.31590/ejosat.1324879)

ATIF/REFERENCE: Erol, İ. & Balaban Ökten, B. (2023). Salgın Hastalık Süreçlerinde Sağlık Hizmetlerine Yönelik Mekansal İhtiyaçların Belirlenmesi. *Avrupa Bilim ve Teknoloji Dergisi*, (51), 282-293.

Abstract

Today, the ever-increasing energy resource needs are of great importance for all countries in the global sense. Countries have recently been developing important policies to meet their energy needs and to use existing energy resources efficiently. In addition, in order to minimize the emissions that harm the nature as a result of the burning of energy sources, they have turned to alternative energy sources that are less harmful to the environment. In order to be an alternative energy source, in this study, the effect of enriching propane gas with methane gas on combustion in a Tubitak supported combustor was experimentally investigated. The enrichment of methane gas was determined at the rates of 10%, 20% and 30%, and the effects of acoustic stress on combustion, emission values and the effects on the flame were investigated. The thermal power was 7 kW and the equivalence ratio (Φ) was 1.2, and the experiment was carried out with a constant eddy value (1.0). When the experiment was carried out without acoustic stress, it was determined that the temperature, flame brightness and light intensity increased as the methane ratio increased, the dynamic pressure value almost did not change, the NOx value was negligibly small, and the CO value decreased depending on the oxygen amount as the methane ratio increased. In the experiments carried out under 90 Hz, 185 Hz and 330 Hz acoustic stress, as the forcing value increases, the temperature and flame brightness increase; It was observed that the NOx value was negligibly small, and the CO value decreased compared to the experiment performed without acoustic stress.

Keywords: Acoustic forcing, emission, methane, propane, combustion.

Akustik Zorlamanın Propan - Metan Karışımlarının Yanma Etkisine Deneysel Araştırılması

Öz

Günümüzde giderek artan enerji kaynağı ihtiyaçları küresel anlamda tüm ülkeler için büyük bir öneme sahiptir. Ülkeler son zamanlarda enerji ihtiyacının karşılanması ve mevcut enerji kaynaklarının tasarruflu kullanılması için önemli politikalar geliştirmektedir. Bunun yanı sıra enerji kaynaklarının yanması sonucu doğaya zarar veren emisyonları minimuma indirmek için çevreye daha az zarar veren alternatif enerji kaynaklarına yönelmişlerdir. Alternatif enerji kaynağı olması adına bu çalışmada propan gazını metan gazı ile zenginleştirilerek Tubitak destekli bir yakıcıda yanma üzerine etkisinin deneysel olarak incelemesi yapılmıştır. Metan gazı zenginleştirmesi %10, %20 ve %30 oranlarında belirlenmiş olup akustik zorlamanın yanma üzerine etkileri, emisyon değerleri ve alev üzerine olan etkileri incelenmiştir. Isıl güç 7 kW ve eş değerlik oranı (Φ)1,2 olup girdap değeri sabit (1.0) olarak deney gerçekleştirilmiştir. Deney akustik zorlamasız olarak gerçekleştirildiğinde metan oranı arttıkça açığa çıkan sıcaklık, alev

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parlaklığı ve ışık şiddetinin arttığı, dinamik basınç değerinin neredeyse değişmediği ve NO_x değerinin ihmal edilebilecek kadar küçük olduğu, CO değerinin ise metan oranı arttıkça oksijen miktarına bağlı olarak azaldığı belirlenmiştir. 90 Hz, 185 Hz ve 330 Hz akustik zorlama altında yapılan deneylerde, zorlama değeri arttıkça sıcaklık ve alev parlaklığı artarken; NO_x değerinin ihmal edilebilecek kadar küçük olduğu, CO değerinin ise akustik zorlamasız olarak gerçekleştirilen deneylere göre azaldığı görülmüştür.

Anahtar Kelimeler: Akustik zorlama, emisyon, metan, propan, yanma.

1. Introduction

Today, with rapidly developing technologies, the demands for energy needs are increasing. As well as finding the energy source, the studies carried out to obtain that energy source are realized through projects and works that have very large production stages, production costs. At the same time, our energy resources are decreasing day by day and global warming is increasing and serious effects are seen on the world. For this reason, it is very important for us and future generations to use our energy resources effectively and to pollute the nature less.

Pollutant emissions from combustion processes have become a source of great concern due to their impact on health and the environment. The last decade has witnessed rapid changes in both the regulations for controlling gas turbine emissions and the technologies used to meet these regulations. During this period, the fuel consumption of civil aviation increased to the extent that air transport is now perceived as one of the fastest growing energy use sectors in the World (Seaton et al., 1995).

Exhaust gases from an aircraft gas turbine consist of CO, carbon dioxide (CO2), water vapor (H2O), unburned hydrocarbons (UHC), particulate matter (mainly carbon), NOx, and atmospheric oxygen and nitrogen. CO2 and H2O have not always been considered pollutants as they are the natural result of the complete combustion of a hydrocarbon fuel. But both contribute to global warming and can be reduced by burning less fuel. Thus, improvements in motor thermal efficiency not only reduce direct operating costs, but also reduce pollution (Lefebvre & Ballal, 2010).

Gas derivatives are generally preferred as primary fuel in dual fuel combustion systems. Numerous fuels have been experimentally tested as the primary gaseous fuel for dual fuel combustion. These include mostly methane, ethylene, propane, butane and hydrogen, among other gases. Methane and propane are preferred as primary gaseous fuels as they are both widely available fuels and both exhibit fuel properties desired in dual fuel combustion. Methane makes up a large percentage of typical natural gas and has excellent resistance to knocking. (Evans, 2013), (Liu et al., 1995).According to Papagiannakis et al. showed a reduction in NO and soot emissions at high load and high natural gas-diesel ratios, while the problems associated with increased CO and THC were less noticeable. At partial load, high CO and THC levels due to incomplete combustion significantly affect engine efficiency and emissions (Papagiannakis et al., 2003), (Papagiannakis et al., 2010).

Propane is also a widely available fuel; However, it is also a more reactive fuel than methane and has poorer resistance to knocking (Stewart et al., 2007). The high reactivity of propane allows for less energy consumption under most loads, but limits high propane-to-diesel ratios under high load conditions (Jian et al., 2001). As with methane, high propane-diesel ratios at low load will result in significant THC and CO emissions due to complete combustion (Abd Alla et al., 2000). Both methane and propane are expected to produce minimal smoke emissions when used as the primary fuel for dual fuel combustion (Papagiannakis et al., 2010), (Shenghua et al., 2003).

Propane and methane is a hydrocarbon gas. Refining or other operating costs are much less than other petroleum-based fuels, it is seen that it will be cheaper when compared to energy sources. As a fuel, it burns more easily than most other fuels and has a higher combustion efficiency. The rate of harmful gases formed as a result of combustion is less than other fuels and it is thought that it will harm the nature less (Mokhatab et al., 2018).

In the combustion experiment conducted by Guerry et al., the dual-fuel combustion system, which is a strategy of reducing emission values and increasing combustion efficiency, which is thought to be very attractive for internal combustion engines in the future, was used. In this system, thanks to the modifications made to the premixed diesel engine, methane (CH4), which is preferred as a secondary fuel, is used. Changing injection values and pressure values were kept constant to measure NOX and CO values. A minimum of NOX emission was detected at an engine injection angle of 300° and above. It was determined that the injection angle should be close to 310° for the lowest HC and CO emissions (Guerry et al., 2016).

Raihan experimentally and numerically investigated the combustion of propane and methane in a single-cylinder diesel engine under different loads, the variation of combustion according to the amount of propane, the effects of injection pressure and turbo pressure on performance and emissions, and the effects of diesel injection time. And as a result of his experiments, he found that the most ideal propane ratio is 80%, the optimum injection pressure is 500 bar and the turbo pressure is 1.5 bar, and the diesel injection time is 355 KMA. One of the important effects was observed that soot and NOX emissions decreased as the propane ratio increased (Raihan, 2014).

Gibson, Folk et al. experimentally investigated the effects of propane and methane use on performance and emission values in a 4-cylinder turbodiesel engine under full and partial load. As a result of their research, they determined that the use of methane under high load can reach up to 90% and the value for propane under these conditions is 47.5%. When dual fuel system is selected as fuel, it is observed that brake shaft efficiency is similar to diesel fuel at high loads, while brake shaft efficiency decreases under low load. It was observed that while the NOX and soot ratio of exhaust emissions decreased, CO and HC emissions increased (Gibson et al., 2011).

Polk et al., in a 6-cylinder diesel engine with dual fuel combustion of low-speed and low-power propane-diesel fuel; investigated their effects on performance, combustion and emission values. In their results, they concluded that as the amount of propane increases, NOX and soot emissions approach zero, and on the other hand, the amount of propane used can be up to 93% by reducing the EGR ratio and increasing the inlet pressure(Polk et al., 2014).

In his study on dual fuel systems, Boretti carried out his experiment with the modifications he made in the diesel tractor engine to burn 95% LPG and 5% diesel fuel. In his study, he investigated the effect of LPG combustion on engine performance and emission values experimentally and numerically. And the results obtained have determined that LPG combustion causes a decrease in CO2 emissions, soot and NOX emissions, while it does not cause a change in engine performance (Boretti, 2013).

Elnajjar et al. observed the combustion of LPG fuel and diesel fuel containing different ratios of butane-propane in terms of performance values under 26 different loads at variable compression ratios, variable injection angles and variable speeds. As a result of their observations, they concluded that the change in the propane-butane ratios in the LPG content affects the engine efficiency very little, while it is quite effective on the combustion noise .(Elnajjar et al., 2013)

Prabhakar et al. burned propane and dimethyl ether in a diesel engine burner in their combustion experiment on the dual-fuel combustion system and evaluated the performance. As a result of the results they obtained, they got the best performance from 30% propane, 20% dimethyl ether and 50% diesel fuel mixtures. In addition, by providing 24% less fuel consumption, they reached the best efficiency values and increased the maximum pressure value by 6 bar (Prabhakar et al., 2015).

In his work on combustion experiments, Koca modified a diesel engine and carried out a transformation that can burn diesel/LPG fuels with a dual-fuel combustion system. In the new engine system that Koca made, LPG was used at 10%, 20%, and 25% levels and preferred as a secondary fuel. Koca examined the effect of LPG on combustion performance and exhaust emissions. As a result of the results obtained, the torque values and power of the engine increased up to 25% LPG, and a decrease in fuel consumption was observed. Although the NOX value in terms of exhaust emissions is lower than the diesel engine combustion situation, it first decreased and then increased as the amount of LPG increased (Koca, 2013).

The increasing energy crises in the current century and the struggles of the great states for energy resources show how important energy resources are. Increasing energy source needs and minimizing the combustion products that harm the environment as a result of the burning of these sources is very important to leave a clean nature for future generations. For this purpose, we conducted an alternative fuel and combustion experiment, which is thought to be less harmful to nature than petroleum derivatives fuels. In this study, propane gas, a hydrocarbon gas thought to be beneficial for the search for alternative fuels, was enriched with 10%, 20% and 30% methane gas, allowing it to burn in a premixed burner under different acoustic stresses. Thus, in our study, the effect of adding methane gas to propane gas at different rates on combustion instability under acoustic stress and its effect on flue gas emission were investigated.

2. Material and Methods

The experimental setup includes the fuel cylinders where the fuels are contained and stored, the compressor and dry air cylinder where the air is supplied and transferred, the mass flow controllers where the air and fuel are adjusted and transmitted, the pre-mixer where the fuel and air are mixed without entering the combustion chamber, as shown in Figure 1. In addition, it includes the acoustic combustion chamber with vortex generator where combustion takes place and the chimney sections where the burning gases are discharged.

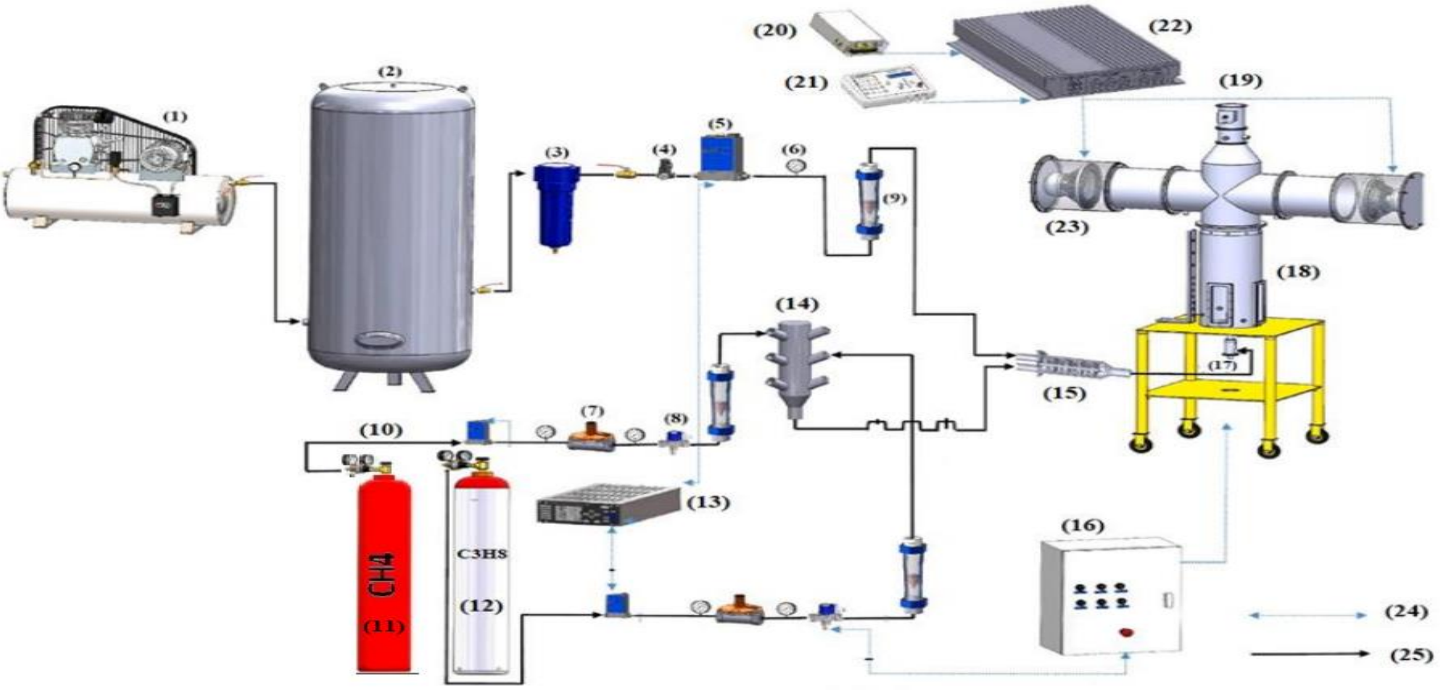

Figure 1. Schematic view of the experimental system, 1.Air Compressor (5.5 Hp and 510 lt) 2.External Air Tank 3.Filter 4.Pressure Regulator 5.Electronic Flow Meter 6.Manometer 7.Pressure Regulator 8.Solenoid Valve 9.Floating Type Flow Meter 10.Pressure Regulator 11.CH4 Tank 12.C3H8 Tank 13.Control Station 14.Gas Collector H2 Tank 15.Air/Fuel Premixer 16.Control Panel 17. Burner 18.Combustion Chamber 19.Chimney 20.Power Supply 21 .Signal Generator 22.Amplifier 23.Speaker 24.Electrical Connections 25.Gas Supply Lines

2.1. Equipment in the Test System

In our study, a combustion test was carried out by enriching propane gas, which is thought to be an alternative fuel, with methane gas, in order to minimize the increasing energy source needs and the combustion products that harm the environment as a result of the combustion of these sources. The important reasons why propane and methane gases are preferred are the high price/performance values and low exhaust emissions compared to other petroleum-derived fuels such as gasoline and diesel. The enrichment of methane gas was determined at the rates of 10%, 20% and 30%, and the effects of acoustic stress on combustion, emission values and the effects on the flame were investigated. The thermal power was 7 kW and the equivalence ratio (Φ) was 1.2, and the experiment was carried out with a constant eddy value (1.0). In our experience; The combustion instability of propane and methane, the effect of acoustic stress on combustion, the effects of mass propane-methane ratios on exhaust emissions, flame brightness, combustion efficiency and flue gas temperature were investigated by analyzing flame images.

2.2. Combustion Chamber

The front view of the combustion chamber is shown in Figure 2. The combustion chamber is completely made of stainless steel. It is 175.5 cm long, 32 cm inner diameter and 210 cm arm width. All parts are produced separately and combined with many fasteners. Thus, in case of any malfunction or deterioration, the partitions can be easily disassembled and reassembled, allowing the system to be reactivated quickly. In order to evaluate the experiments, around the combustion chamber and in the chimney; There are access ports where pressure, temperature and exhaust emission values are examined.

In addition, there are 30 cm long and 10 cm wide quartz glasses on the front and sides of the combustion chamber, which can be quickly disassembled and installed, in which conditions such as flame brightness and flame extinction are examined. Thanks to its easy disassembly and assembly, the swirl blades attached to the burner can be easily replaced and the combustion chamber and combustion chamber components can be easily accessed. A fan is mounted behind the combustion chamber, which is used to cool parts of the combustion chamber. A cylindrical air flow channel is placed around the combustion chamber. The low temperature air collected by the cooling fan circulates in these parts, absorbing the high temperature of the combustion chamber.

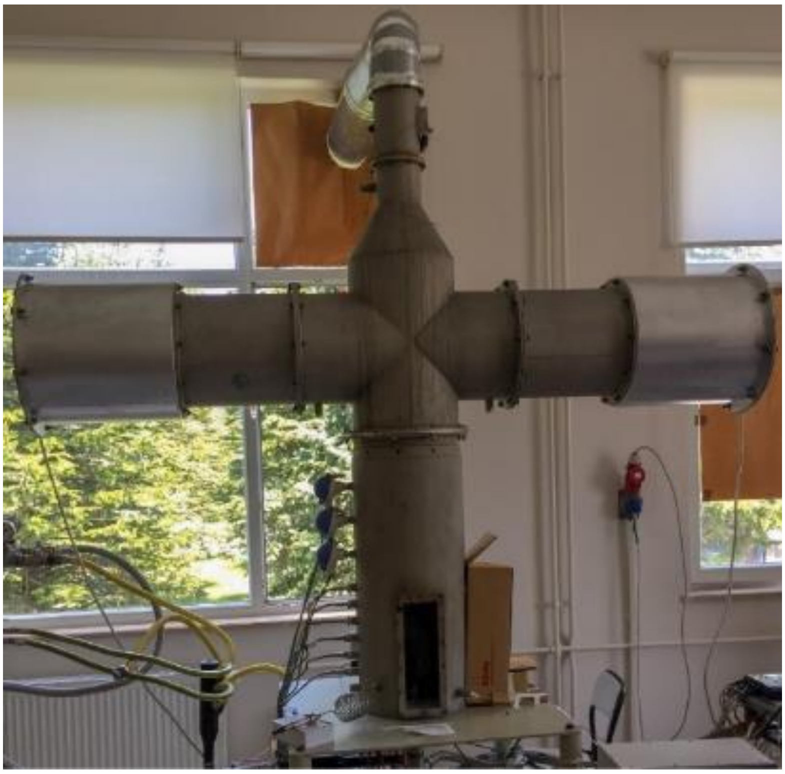

Figure 2. Acoustic Combustion Chamber

2.3. Vortex Generator Burner

The burner is very important for fuel efficiency and must be compatible with the fuel system. In addition, an ideal burner should reduce exhaust gas emissions by providing complete combustion with as little air as possible over its entire operating range. Finally, the flame diameter and size must be designed to provide an even distribution of heat within the burner. For these reasons, the burner and the burner system can produce up to 10 kW of thermal power, while in our trial it is set to 7 kW. The generator with swirl number (1.0) was used as the swirl generator. The swirl generators allow the air and fuel to mix and burn better before combustion, thanks to the swirl (rotation movement) before they enter the combustion chamber. The significant effect of vortex generators on the dynamic flame response is preferred in many combustion tests, as it has a positive effect on the combustion stability and therefore contributes positively to the combustion system (YILMAZ et al.).

Figure 3. Burner (Brulor)

2.4. Temperature Sensors (Thermocouple)

Temperature, which is one of the important parameters in the examination of the combustion test, is measured by means of 2 types of heat sensors in our setup. These are type B and type K heat sensors. Type B temperature sensors are sensors that can measure higher temperatures (up to 1800 °C) closer to the combustion chamber. Type K, on the other hand, are heat sensors located further away from the combustion chamber, made of chromium-nickel alloy and capable of measuring temperature up to 1200 °C.

Figure 4. Type B and K Temperature Sensors

3. The Results and Discussion

3.1. Experiment Results Without Acoustic Forced

One of the important values affecting the combustion stability is the combustion temperature. In the experiment we carried out, temperature parameters were measured by means of heat sensors placed at different points of the combustion chamber. The heat sensors we use are B and K type, those close to the point where the combustion takes place are B type, sensors that can measure lower temperatures at a farther point are K type sensors. The temperature values we obtained from the 2B thermal sensors are 1134 K, 1139 K and 1162 K at 10%, 20% and 30% methane ratios, respectively. The increase in the temperature value as the methane ratio increases is explained by the fact that the specific heat of methane is higher than the specific heat of propane (Lefebvre & Ballal, 2010).

In Figure 5, the temperature values of propane-methane fuel containing 10%, 20% and 30% methane obtained from 2B thermal sensors are shown.

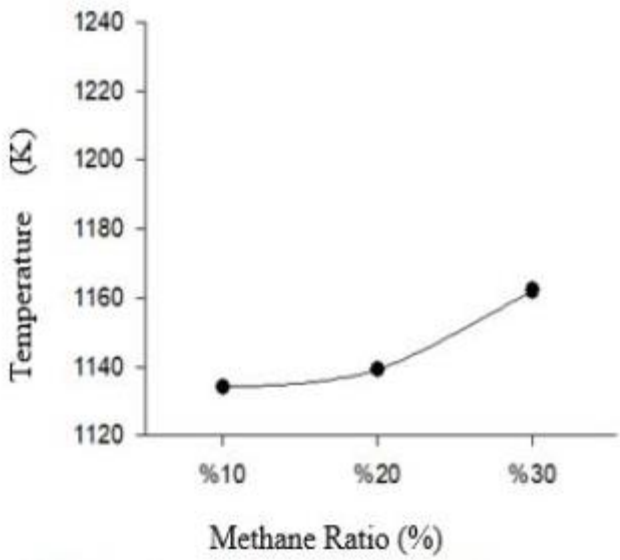

Figure 5. The effect of methane on temperature

In our experiment to meet the need for alternative fuel, we enriched it with methane by adding methane to propane gas. As a result of 3 different experiments shown in Figure 6, it was observed that the brightness and vitality of the flame increased with the increase of the methane ratio. In addition, it is noticed that the flame width and flame length increase when switching from 10% methane to 30% methane.

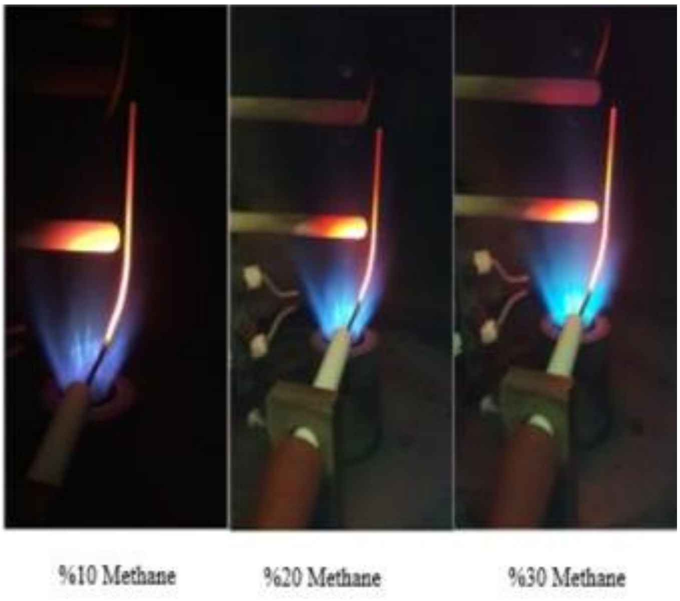

Figure 6. Effect of methane ratio on flame brightness

In the experiment, 10 ppm, 13 ppm and 9 ppm NOX were released, respectively. However, it has been determined that the NOX values that are released are too small to be taken into account, since NOVA Plus RCU measures at an error rate of +-10 ppm in the parameters. Table 1 shows the NOX values that vary according to the amount of oxygen.

Table 1. NOx values according to methane ratios

	%10 Methane	**%20 Methane**	**%30 Methane**
O_2	**4,7**	**4,9**	**3**
NO_X	**10**	**13**	**9**

In the experiment conducted by Kang et al., propane gas was preferred as the secondary fuel in a diesel engine with dual fuel combustion system. In the combustion test carried out, the amount of propane was increased from 80% to 95% in order to reduce the emission values and increase the pressure values, and it was observed that the NOX value decreased in terms of emission values (Kang et al., 2018).

In the experiment conducted by Ngan and Abbe, they designed an engine that could burn LPG and diesel fuel by converting a 4-cylinder diesel engine in a similar way. In this engine they designed, LPG-diesel mixture was burned in different ratios and the combustion performance and exhaust emissions were investigated. According to the results obtained, an increase in power, torque and efficiency values, and a decrease in NOX and HC emission values from exhaust emissions were determined (Ngan and Abbe, 2018).

When a combustion zone is in a fuel-rich mixture, large amounts of CO are formed due to a lack of oxygen as there is not enough oxygen to complete the reaction. However, if the combustion zone mixture is stoichiometric or fuel-poor, substantial amounts of CO will be released due to the decomposition of CO2 (Rink et al., 1986).

The more oxygen reacts with the carbons, the more complete combustion takes place and the less CO emissions are released. In our experiment, when we increase the methane ratio to 10%, 20% and 30%, the amounts of oxygen released as a result of combustion are 4.7 ppm, 4.9 ppm and 3 ppm, respectively. In other words, the less oxygen was produced in the emission values measured in the chimney as a result of combustion, the more oxygen participated in the reaction. As a result, 1620 ppm CO was released at the rate of 30% methane with 3ppm oxygen, 2560 ppm CO was released at the rate of 10% methane with 4.7 ppm oxygen, and 2700 ppm CO was released at the rate of 20% methane with 4.9 ppm oxygen, and the maximum amount of CO was detected at this rate. Figure 7 shows the CO values released as a result of combustion at 10%, 20% and 30% methane.

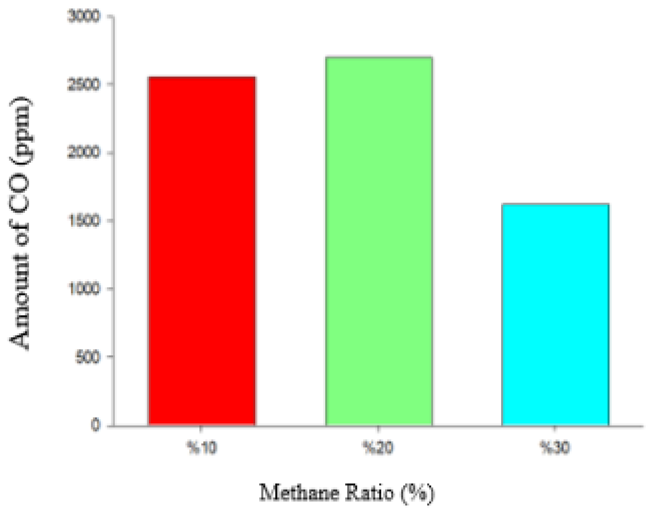

Figure 7. CO Values Based on Methane Ratio

Merlo et al. have studied the effect of enrichment with oxygen on the flame in premixed combustion. With the increase in the oxygen ratio, most of the CO2 emission was converted to CO2 gas and the amount of CO2 increased linearly (Merlo et al., 2013).

3.2 Test Results Under Acoustic Forcing

In the first phase of our experiment, propane fuel enriched with 10%, 20%, and 30% methane, which we burned unforced, was studied under varying conditions. In the second stage, emission values such as NOX and CO, which are formed by burning propane-methane blended fuel under acoustic stress, the effects of acoustic forcing on temperature and the effects of acoustic forcing on flame are investigated. We performed the acoustic forcing through speakers placed on both sides of the experimental setup.

By examining the sound frequency waves in the range of 30-400 Hz, which leave the function generator and go to the loudspeaker, 3 different frequency points where sudden pressure changes occur were determined. These frequency points are 90 Hz, 185 Hz and 330 Hz. In Figure 8, the frequency points with significant pressure changes on the Y axis enable us to find the frequency points where the acoustic force is determinant, while the normalized time value in the 0-1 interval on the X axis has been minimized at certain rates in order to clearly see the time interval in which the experiment takes place under acoustic force. It shows the elapsed time between 0-1.

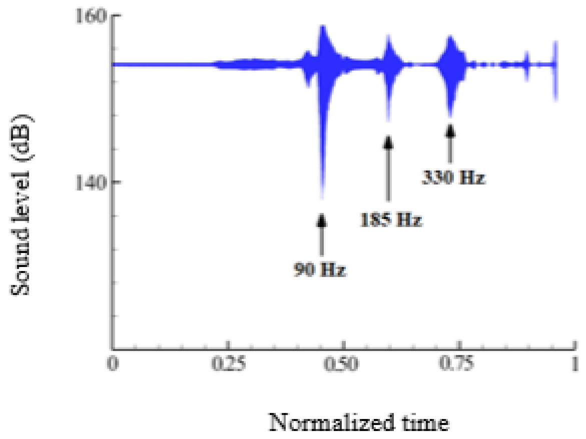

Figure 8. Acoustic Forcing Frequency Points

The average temperature values were recorded with the data obtained from the thermal sensors located in 2B close to the combustion chamber. According to the results obtained, it is seen that when the acoustic stress increases to 90Hz, 185Hz and 330Hz in the experiments performed with 10% and 20% methane, the temperature value increases in direct proportion depending on the forcing. Figure 9 and Figure 10 show the temperature values released at 10% and 20% methane. At the rate of 30% methane, it is seen that the amount of heat released does not change much depending on the acoustic forcing, and remains approximately the same. In Figure 11, the temperature values obtained as a result of the combustion carried out at the rate of 30% methane are shown.

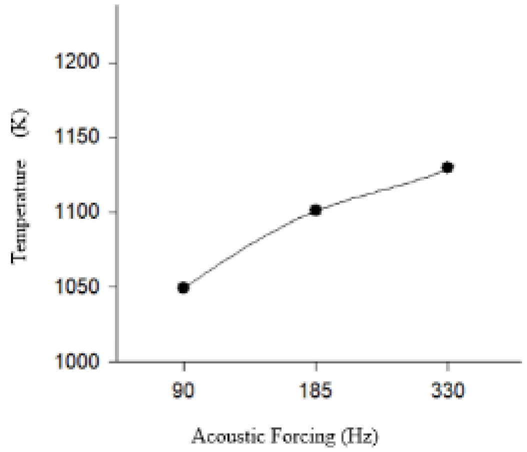

Figure 9. Changing Temperature Values Due to Acoustic Forcing at 10% Methane

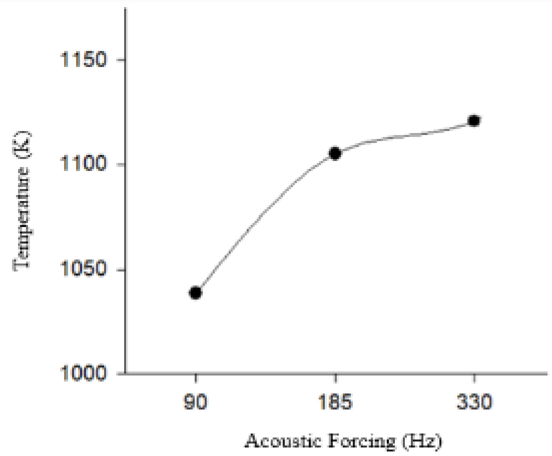

Figure 10. Changing Temperature Values Due to Acoustic Forcing at 20% Methane

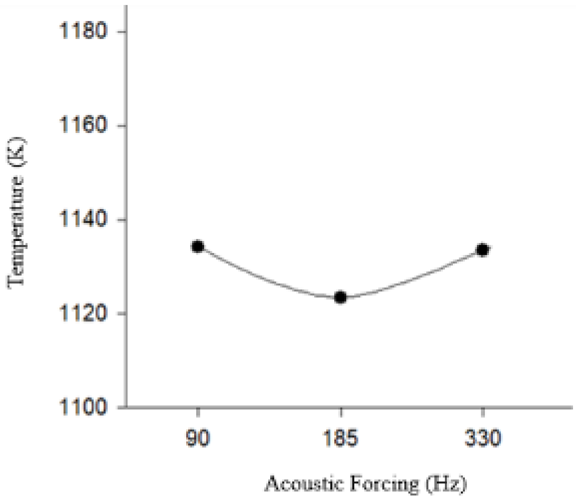

Figure 11. Changing Temperature Values Due to Acoustic Forcing at 30% Methane

As seen in the experiment performed without forcing in Figure 12, where the methane ratio is 10%, while the flame points coming out of the swirl generator are noticeable, it is seen that the brightness of the flame increases under 90 Hz acoustic stress and the flame points coming out of the swirl points disappear. Under 185 Hz and 330 Hz acoustic stress, it is seen that the flame center is suppressed and its intensity and density increase. The same results were seen in the experiments where the methane ratio was 20% and 30%.

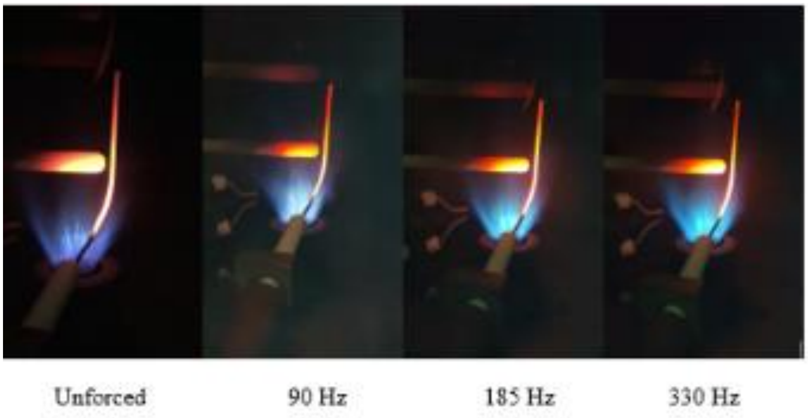

Figure 12. Effect of 10% Methane on Flame Brightness Under Acoustic Forcing

According to the study of Fujisawa et al., when acoustic forcing (dynamic pressure) increases; flame length, oscillation amplitude and flame brightness decrease. In this study, it was observed that the length of the flame shortened when the dynamic pressure applied on the flame increased (Fujisawa et al., 2019).

The effects of acoustic sound waves applied on the flame in the combustion mechanism on the emission values are noticed. Initially, the emission values were recorded without acoustic forcing and then under forced acoustic forcing frequency values of 90 Hz, 185 Hz and 330 Hz. At this point, the NOX emission values in Table 2 are almost non-existent. In our study, the tolerance range given for NOX in the results obtained with the NOVA Plus RCU branded emission measurement device is +-10 ppm. Therefore, since the values in Table 2 are very close to the tolerance value of +-10 ppm, it has been a reference for us to obtain that the values obtained in the combustion tests performed under acoustic stress are insignificantly small values.

Table 2. NOx Emission Values Under Acoustic Forcing

NO_x Emıssıon Table (ppm)	%10 Methane	%20 Methane	%30 Methane
Unforced	10	13	9
90 Hz	10	5	11
185 Hz	12	10	10
330 Hz	14	12	9

As a result, NOX values are almost non-existent in dynamic pressure values increasing with acoustic forcing. Acoustic forcing, which makes the fuel-air mixture ideal by creating vortices, is also an important factor contributing to combustion with low NOx formation.

In the experiment, which we started without acoustic stress, CO was released at 10%, 20% and 30% methane rates, respectively, at 2560 ppm, 2700 ppm and 1620 ppm. Afterwards, it is seen that these values, which are revealed in the experiments we apply under acoustic pressure, decrease as the frequency increases. In Table 3, the CO value released in the 30% methane-propane combustion, which was carried out without primary forced combustion, decreased to 1620 ppm and to 1540 ppm under 90 Hz acoustic stress. Afterwards, this value decreased to 1335 ppm at an acoustic forcing of 185 Hz and decreased to 1306 ppm under the last applied acoustic stress of 330 Hz, and the lowest amount of CO was released. Similarly, at 10% and 20% methane values, it is seen that the CO values released under acoustic stress are less than the CO values released as a result of non-acoustic forced combustion.

Table 3. CO Emission Values Under Acoustic Forcing

CO Emıssıon Table (ppm)	%10 Methane	%20 Methane	%30 Methane
Unforced	2560	2700	1620
90 Hz	2147	2050	1540
185 Hz	2290	2570	1335
330 Hz	2414	2620	1306

Increasing dynamic pressure as a result of acoustic forcing ensures a reduction in CO emissions. CO is released as a result of incomplete combustion, which occurs due to the inadequacy of the combustion chamber design and insufficient fuel-air mixtures (Keating, 1993),(Turns, 1996). In acoustically forced combustion, the air-fuel mixture can move freely and thus unburned air-fuel mixtures are released. Thanks to the dynamic pressure as a result of acoustic forcing, the unburned air-fuel mixtures are collected at the flame point and burned. Therefore, the CO gases released due to unburned fuels are destroyed by burning.

4. Conclusions

The results obtained in our experimental study are as follows:

In the experiments carried out at 10%, 20% and 30% methane rates without acoustic pressure;

1) As a result of the combustion of propane gas by enriching it with 10%, 20% and 30% methane, it was concluded that the temperature values increased as the methane ratio increased.

2) According to the results obtained from the acoustically forced combustion photographs, it was observed that the flame brightness, flame width and flame length increased as the methane content in the propane gas increased.

3) Depending on the methane ratio in the acoustically forced combustion test of the emission values, which is one of the important parameters; While it was observed that NOX values were negligibly low, it was noticed that the CO value decreased depending on the amount of oxygen in the system.

In experiments where acoustic forcing is applied as 90Hz, 185 Hz and 330 Hz at 10%, 20% and 30% methane ratios;

1) It has been observed that the temperature values increase as the acoustic forcing frequency values, hence the dynamic pressure, increase.

2) According to the results obtained from the combustion photographs, it has been observed that the brightness of the flame, the width of the flame and the length of the flame increase as the acoustic stress on the flame increases.

3) Emission values are; As there are negligibly small values for NOX, similarly insignificant amounts are released under acoustic stress. It was observed that the amount of CO decreased under acoustic stress compared to unforced combustion.

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Yılmaz, İ., Yılmaz, H., Çam, Ö. Sentetik Gaz Yakıtların Yanma Kararsızlıklarının Deneysel İncelenmesi”.