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3rd PART

APPLIED AND NATURAL SCIENCES

MATHEMATICS, COMPUTING TECHNOLOGY AND INFORMATICS

ENGINEERING

PHYSICS

BEHAVIOR OF FLAME PROPAGATION IN LPG PREMIXED COMBUSTION WITH CARBON DIOXIDE INHIBITOR

Nasrul Ilminnafik[1], Nurcholis Hamidi[2], ING Wardana[2]

[1]Doctoral Program at Mechanical Engineering, University of Brawijaya,
[2]Mechanical Engineering, University of Brawijaya, Malang (**INDONESIA**)
E-mails: nasrul.ilminnafik@gmail.com, nurkholishamidi@yahoo.com, wardana_ing@yahoo.com

ABSTRACT

This study was focused on the influence of carbon dioxide on the behavior of LPG premixed flame propagation in cylindrical combustion chamber. The combustion chamber was made of transparency acrylic cylinder so that behavior of flame propagation from the ignition source could be recorded with high speed camera at various mixture concentrations. Ion sensor made of aluminum foil having dimension: 20 cm long, 2 cm wide were installed on the two sides of the chambers wall for detecting the behavior of ion during flame propagation. The results showed that the carbon dioxide decreases velocity of LPG flame propagation. The ion concentration in the flame with carbon dioxide was also shown the different behavior. These indicated that carbon dioxide reduced reaction rate of LPG premixed combustion.

Key words: LPG, Carbon Dioxide, Premixed Combustion, Ion Sensor.

1. INTRODUCTION

Fire and explosion were the main danger in industry which used fuel. Fire was more often occurred than explosion, but explosion had great potential damage. Some of them were caused by performing forced wave for being damaged. Explosion effect was bigger than fire because fire was a slowly process, but explosion was occurred very fast anyway. Because of great effect of explosion, there was needed an effort to crush and decrease the damaged effect. The explosion was caused by flammable material. To anticipate explosion could be carried out by increasing inert material which be able to extinguish or decrease reaction velocity before there was occurred big damage.

Collision theory qualitatively explains how chemical reactions occur and why reaction rates differ for different reactions. For a reaction to occur the reactant particles must collide. Only a certain fraction of the total collisions cause chemical change; these are called successful collisions. The successful collisions have sufficient energy (activation energy) at the moment of impact to break the existing bonds and form new bonds, resulting in the products of the reaction.

In opposite, reaction had to be anticipated with avoiding collision in the correct direction so that was safeguarded from breaking and form new bonds. It was done by entering non flammable molecules so that would prevent reaction. The molecules were named as inhibitor which had opposite character with the catalyst which increasing reaction velocity. In refrigerant field, the manner of decreasing flammability was by increasing inhibitor at hydrocarbon refrigerant such as R1234a as inhibitor which was used to decrease flammability of R290 [1]. To get easy application at refrigeration system, inhibitor was selected from natural refrigerant such as carbon dioxide which was as the future refrigerant [2]. Carbon dioxide was as material which was able as effective inhibitor [3]. This study was carried out by observing occurred fire flame. It was intended to know the effect of carbon dioxide at fire flame behavior from LPG premixed combustion. Fire flame produced ion and could be observed from ion behavior. Mehres had used spark plug as ion sensor to catch the move of ion behavior [4].

2. MATERIALS AND METHODS

The material used in this study was LPG which was produced by Pertamina Indonesia and carbon dioxide was used as inhibitor. This study was carried out by using experimental standard of DIN 51649 as combustion vessel of transparency acrylic cylinder with 300 mm of height dimension and 30 mm of diameters. Two electrodes were installed as igniter which was put with 5 mm distance of the two extreme points. Combustion vessel was made transparency so the flame behavior could be recorded visually by using high speed camera of 420 fps. At kind of this combustion vessel, it was developed ion sensor type which the two sides of combustion vessel was installed ion sensor connecting to sound card of PC. If there was flame, it meant that at the same time there was ion move and it was appeared voltage which was read in monitor. Scheme of study was as Figure 1.

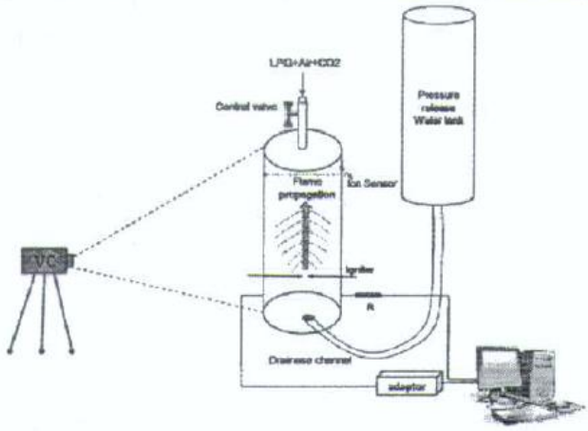

Fig. 1. Scheme of Study

The steps of analyses were as follows:

- To analyze the velocity of fire flame at the mix without carbon dioxide
- To analyze the velocity of fire flame at the mix with carbon dioxide
- To analyze the move of ion behavior at the mix without carbon dioxide
- To analyze the move of ion behavior at the mix with carbon dioxide

3. RESULTS AND DISCUSSION

The effect of carbon dioxide added on flame propagation of LPG premixed combustion was described as figure 2 to figure 5, which t = time between two frames = 1/420 sec = 0,0024 sec = 2,4 msec. Increasing of carbon dioxide was able to decrease flame propagation of LPG at some variations of carbon dioxide. Carbon dioxide had ability as inhibitor so the combustion reaction was delay and the flame propagation was decreased at the higher number of carbon dioxide.

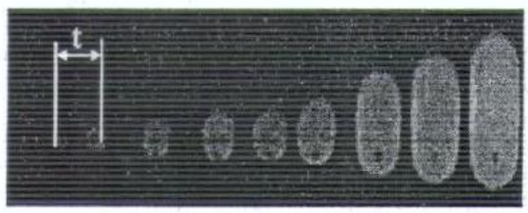

Fig. 2. Flame propagation of the rich mixture without CO2

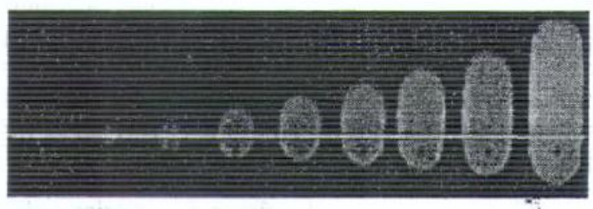

Fig. 3. Flame propagation of the rich mixture with 25% CO2

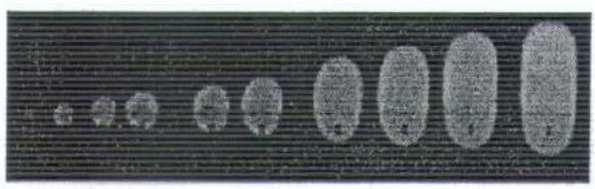

Fig. 4. Flame propagation of the rich mixture with 50% CO2

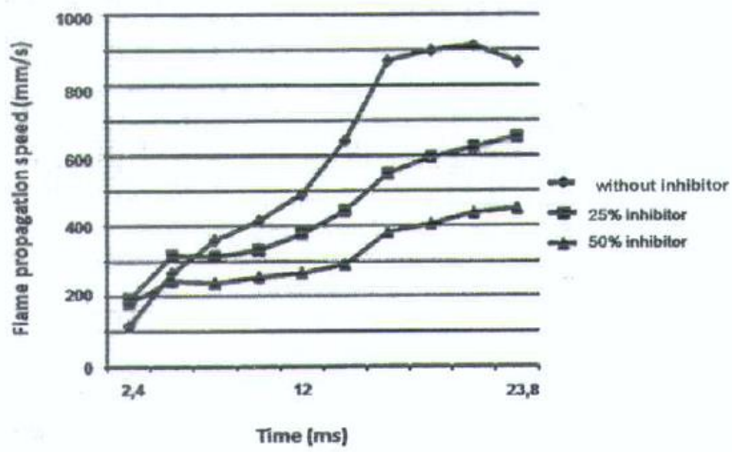

Fig. 5. Effect of Carbon Dioxide at LPG Premixed Combustion

Ion behavior at flame with carbon dioxide showed the different behavior too. It showed that carbon dioxide influenced the reaction rate of combustion. At the mixture without carbon dioxide (Figure 6 and 7), it was seemed that the voltage would decrease if it was through the top voltage. It showed that the flame was occurred very fast and would be missed directly because the reaction was very fast.

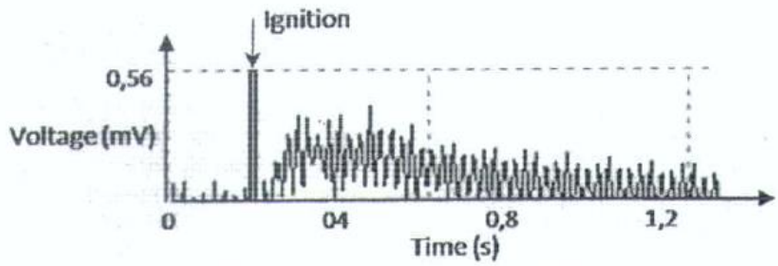

Fig. 6. Rich Mixture without CO2

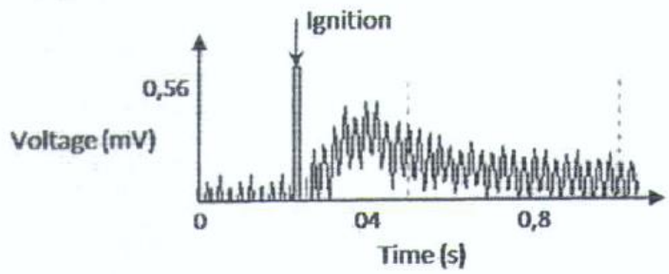

Fig. 7. Lean Mixture without CO2

In the mixture with carbon dioxide (Figure 8 and 9), the voltage was stable relatively and the voltage did not decrease during the reaction. It showed that carbon dioxide was able to act as inhibitor which prevented the collision among molecules of fuels and oxygen. So the combustion reaction was delay and the reaction was very slow.

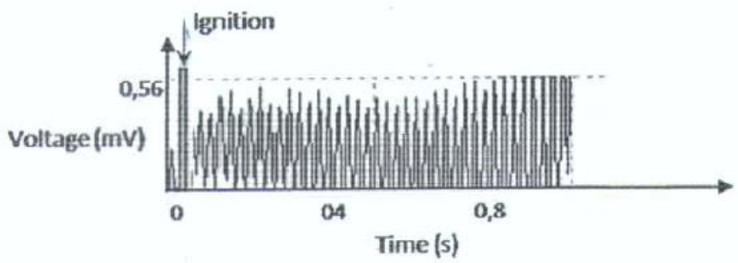

Fig. 8. Rich Mixture with 25 % CO2

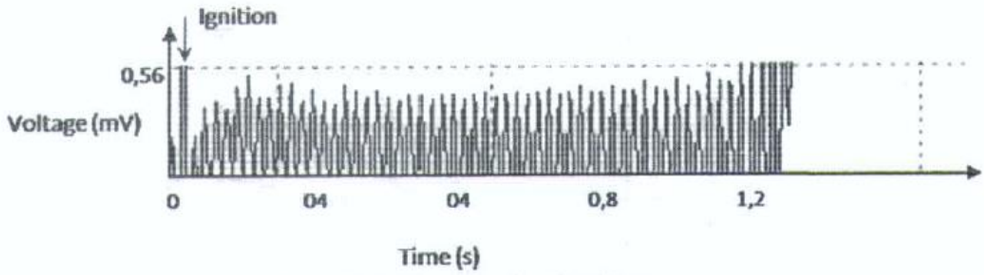

Fig. 9. Rich Mixture with 50% CO2

4. CONCLUSION

Carbon dioxide was able to act as inhibitor which would prevent the collision among the molecules of fuels and air which would delay the combustion, so the flame propagation would decrease and the reaction rate was occurred slower.

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