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NATIONAL INSTITUTE FOR LASER, PLASMA and RADIATION PHYSICS

MAGURELE, ROMANIA

NUMERICAL INVESTIGATION OF THE EFFECTS OF FLAME STRUCTURE ON ENGINE CHARACTERISTICS

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INTRODUCTION

The effects of technological advances are also seen in the automotive world. Experimental research on internal combustion engines, one of the most important research areas of the automotive field, requires high costs and time-consuming. The importance of numerical modeling studies for internal combustion engine is increasing day by day and numerical modeling studies save time and reduce costs.

The effect of many parameters on engine performance and exhaust emissions can be examined ultimately with the modeling software. Examples of these parameters are: flame properties, loading conditions, compression ratio, combustion mechanisms, alternative fuel additives, alternative fuel usage, combustion chamber geometry, etc.

Engine modeling studies are carried out through 1-D modeling and 3-D modeling methods. In this context, many software are used such as Ricardo-Wave and STAR-CD/es-ice, AVL-Fire, GT-Power etc. Through the studies carried out in these software, many results can be obtained about the actual engine behavior.

As can be seen in the literature, it was conducted several studies on the engine modelling and flame propagation by this time. Chen et al. [1], determined to the critical flame radius is larger than the flame thickness and the minimum ignition energy is a function of the critical flame radius. Yontar et al. [2] investigated the effects of ignition advance on flame propagation, engine characteristics and they observed that the optimum ignition advance was 50 CAD from the top dead center in terms of engine performance and exhaust emissions. Huang et al. [3] determined to the flame radius increases with time but the increasing rate decreases with flame expansion for lean mixture combustion in their works. Pischinger and Heywood [4], investigated about the Kernel flame propagation model for a spark-ignition engine and conluded that Kernel grows more slowly with higher heat losses about up to 1.5 mm Kernel flame radius.

In this study; The effects of flame structures on engine characteristics and flame development have been numerically investigated at a sequential ignition engine.

MATERIALS AND METHODS

This work focuses on determined optimum flame radius via numerical simulation of flame propagation in a cylinder with STAR-CD/es-ice software. In the 3-D cylinder model was built including the entire cylinder from the beginning of the intake port to the end of the exhaust port.

A single cylinder of the Honda L13A4 i-DSI (Intelligent-Dual Sequential Ignition) engine (intake-exhaust manifold connections, intake-exhaust valves, cylinder, cylinder head, piston, spark-plugs etc.) was modeled in STAR-CD/es-ice software (Figure 1) for the gasoline usage taking into account all components related to the combustion chamber.

In the numerically modeled engine, there are two spark plugs located in different zones in each cylinder.

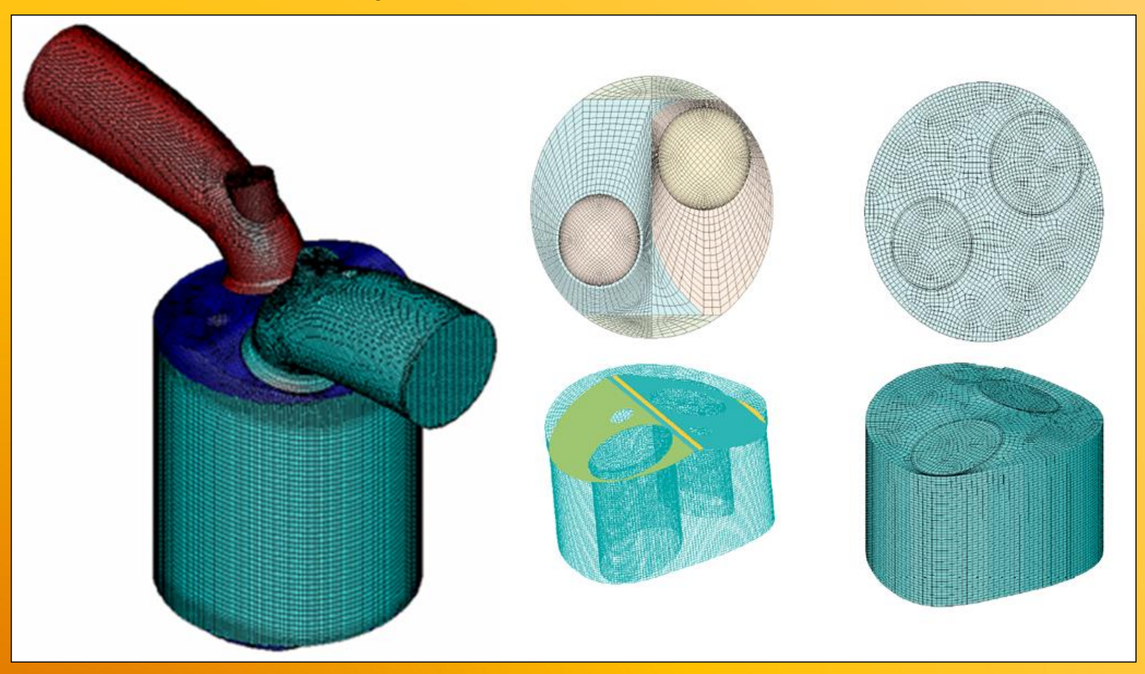

Figure 1 : 3-D cylinder model and mesh structure

With sequential ignition made at different times, it is possible to increase the combustion efficiency, reduce the HC emission and reduce the fuel consumption by providing more efficient reaching of the flame in-cylinder. The ignition difference between the two spark plugs is determined by the electronic control unit (ECU) of the engine between 2-5 CAD depending on the number of revolutions. In the analysis, engine speed is 3000 rpm, compression ratio is 10.8: 1, air-fuel ratio is 1.2, ignition advance at 30-25 CAD, were kept constant.

The optimum flame radius value was determined in these conditions and k-ε RNG turbulence model, Angelberger wall interaction and G-equation combustion model were used. The effect on flame engine characteristics is the function of flame radius and flame thickness. Prior to the numerical studies, the number of mesh and cold flow studies were performed. In the study, three different analysis were carried out to determine the effect of the flame radius.

In simulations, the flame radius was changed to 0.0005 m, 0.0010 m and 0.0020 m, respectively.

RESULTS AND DISCUSSIONS

As a result of the study, images of flame formation and development were obtained for the time period up to the top dead center at the time of sequential ignition and 3-D model results are shown in Figure 2.

It was determined that the net work area was obtained from the highest power and pressure-volume graph when the flame radius was 0.0010 m for the specified operating conditions.

For 0.0020 m flame radius, 13% reduction was observed on the power due to the premature completion of combustion.

For the flame radius was 0.0005 m, the maximum pressure and temperature formation occurs at the middle of the expansion time as a result of the slow progress of the flame in the cylinder. Therefore the power drops by about 15%.

The small radii cause the temperature to be low, causing the amount of NO_x to decrease but not the whole of the mixture to enter the reaction. Large-radius flame formation allows the flame to penetrate the entire mixture. Since the high temperatures in the cylinder occur, the amount of NO_x increases.

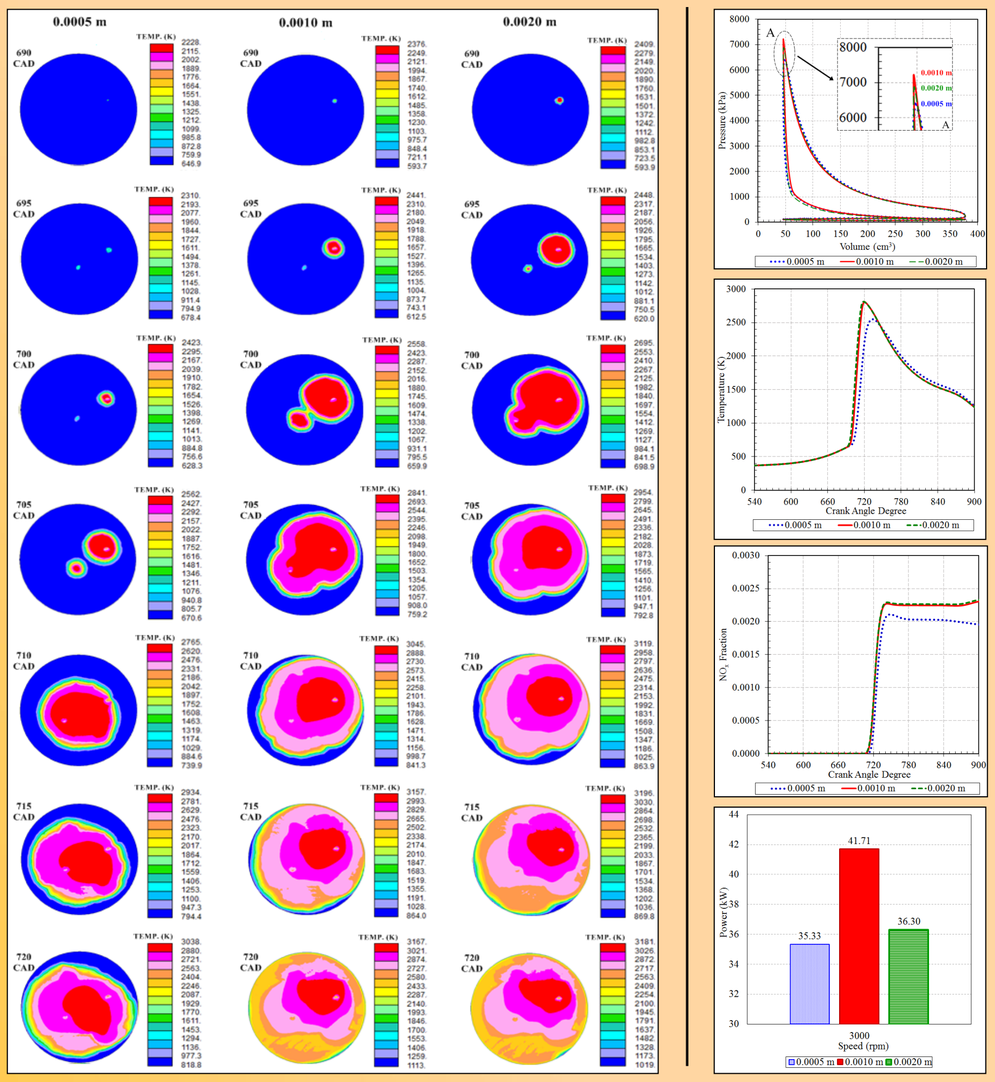

Figure 2 : The effects of flame radii on engine characteristics

REFERENCES

[1] Chen, Z., Michael P. B., and Yiguang, J. "On the Critical Flame Radius and Minimum Ignition Energy for Spherical Flame Initiation." Proceedings of the Combustion Institute 33.1, 1219-1226, 2011.

[2] Yontar, A. A., Kantaroğlu, E., and Doğu, Y., “Ateşleme Avansının Motor Performansına ve Egzoz Emisyonlarına Etkilerinin Sayısal Olarak Incelenmesi.”, 13. Uluslararası Yanma Sempozyumu,Türkiye, 2015.

[3] Huang, Z., Zhang, Y., Zeng, K., Liu, B., Wang, Q., and Jiang, D. “Measurements of Laminar Burning Velocities for Natural Gas–Hydrogen–Air Mixtures.” Combustion and Flame, 146(1), 302-311, 2006.

[4] Pischinger, S., and Heywood, J. B. “A Model for Flame Kernel Development in a Spark-Ignition Engine.” Proceedings of The Combustion Institute, Vol. 23, No. 1, pp. 1033-1040, 1991.

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Subject: **Letter of Acknowledge**
LASER IGNITION SUMMER SCHOOL 2017, 19-22 July 2017, Brasov, Romania
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TO WHOM IT MAY CONCERN

This is to prove that **Dr. Ahmet Alper YONTAR** of Kirikkale University, Faculty of Engineering, Department of Mechanical Engineering, Science of Automotive, Ankara Yolu, Kirikkale 71450, Turkey has attended the **LASER IGNITION SUMMER SCHOOL 2017**, held 19-22 July 2017 at Classic Inn Hotel, Brasov, Romania and that he was awarded with:

"The Prize for the Best Poster"

for his poster presentation: "P26, Numerical Investigation of the Effects of Flame Structure on Engine Characteristics" that was presented in the poster session of this School, Thursday 20 July, 16:15-18:00.

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The Committee that evaluated the poster presentations appreciated the quality of the work give by **Dr. Ahmet Alper YONTAR**.

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