CFD Analysis of Combusition Parameters of Methane-Air Mixture

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***Abstract*—— Combustion plays a vital role in generation of power. The heat liberated, maximum temperature and emissions are highly depending upon the air fuel mixture ratio, type of fuel used. In the present days, percentage of the oxygen content is changing in the atmosphere due to the higher emissions from the transport vehicles and different types of the pollutions. This change in oxygen content will effect the combustion process. In this study effect of the oxygen content in the atmosphere, inlet temperature of the air and inlet velocity of the air are studied on the maximum temperature in the combustion chamber, CO_2 emissions and Turbulence kinetic energy for methane air mixture. Ansys fluent software is used for analyzing the combustion process. It is observed that higher oxygen content give the maximum temperature and CO_2 emissions. Higher velocity and temperature of the air decreases the temperature and CO_2 emissions.**

Keywords—Ansys Fluent, K-ε equation,Combustion,Secomd order upwind, Turbulence kinetic energy

I. INTRODUCTION

In most of the combustion chambers, furnaces that are used in industries, combustion is the common process. The heat liberated and the peak temperatures attained depend on the combustion process. Typically these in-turns depend on the type of fuel used, velocities, temperature & pressure of both the fuel and air. In addition to these parameters the amount of oxygen present in atmospheric air also influences the combustion process and outputs. An effective combustion process will minimize the un-burnt fuel and thereby increase the heat output.

K.M.Pandey et al [1] observed the maximum temperature in the combustion process by the injection of H2 & air at Mach 2 speed in a scram jet engine having wall injector. Sk.Magbul hussain et al [2] observed the effect of the biogas-diesel dual fuel combustion process using Ansys fluent software on turbulent kinetic energy, turbulent dissipation rate, combustion flame velocity and NOX formation for five different compression ratios. Fraser et al [3] studied the natural gas in combustion with diesel was tried and studied experimentally to obtain the ignition delay data as a function of engine cylinder pressure and temperature. K.V. Chaudhari et al [4] observed the temperature distribution at the center line of liner, at the liner wall and at exit of combustion chamber in annular combustion chamber with kerosene as fuel.

II. PROBLEM MODELLING

To analyze the combustion process 2-D combustion chamber is modeled in Ansys workbench as shown in Fig 1. The fuel chosen for the combustion process is methane. The effect of oxygen content in the air, temperature of the air and velocity of the air on the maximum temperature in the combustion chamber, CO2 emissions at the outlet and turbulence kinetic energy were studied. To analyze the process Ansys Fluent is used as a simulation tool.

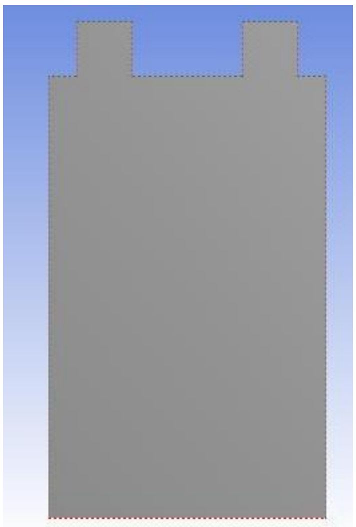

Fig 1: Combustion Camber

A. Input Parameters

Oxygen content %: 20, 21, 22, 23, 24 in the air

Temperature of the inlet air (K):300,320,340,360,380,400

Velocity of the inlet air (m/s):15, 20, 25, 30

Velocity and temperature for methane is 10m/s and 300 K for all the cases.

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B. Meshing, Loads & Boundary conditions

Finer mesh is performed on the combustion chamber to get better accurate results. The combustion chamber contains two inlets and one outlet. Out of two inlets one is for fuel (Inlet-1) and other is for air (Inlet-2). Room temperature 300K is assigned for inlet-1 and inlet-2 for cases of oxygen content and velocity of the air. Inlet velocity of 10 m/s is assigned for cases of Oxygen content and temperature of the inlet air.

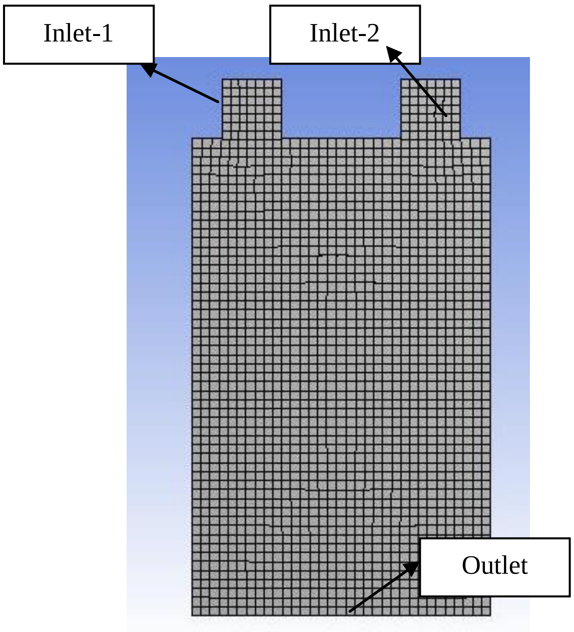

Fig 2: Meshed view

C. Fluent control settings

K-ε equation with energy dissipation is chosen. To get the accurate results second order upwind is chosen for solution methods.

III. RESULTS & DISCUSSIONS

D. Contours

Fig 3 shows the typical diagram of temperature distribution in combustion chamber for case of 23% oxygen content with loads of 300K temperature and velocity of 10m\s at inlet 1&2. It can be observed that maximum temperature of 1792K is existed at the inlet 2 side.

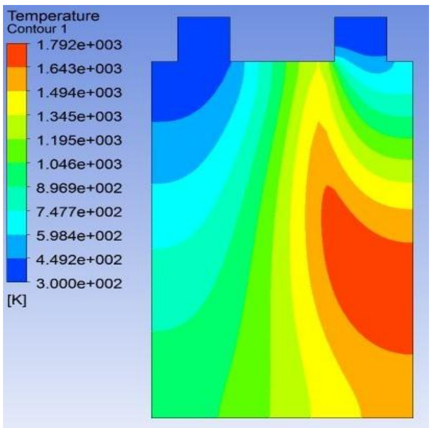

Fig 3: Contour of maximum temperature for the case of oxygen content 23%

Fig 4 shows the typical diagram of CO2 emissions at outlet of combustion chamber for case of 23% oxygen content with loads of 300K temperature and velocity of 10m/s at inlet 1&2. It can be observed that maximum emissions are located at inlet 2 side.

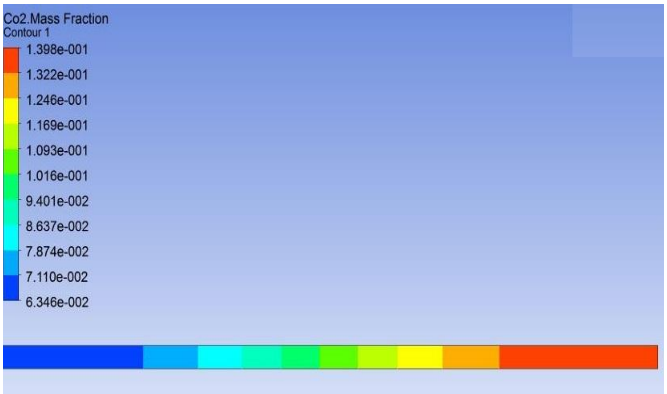

Fig 4: Contour of CO_2 emissions at the outlet for case of 23% oxygen content

Fig 5 shows the typical diagram of Turbulence kinetic energy distribution in combustion chamber for case of 23% oxygen content with loads of 300K temperature and velocity of 10m/s at inlet 1&2. It can be observed that maximum value of T.K.E is located at inlet 2.

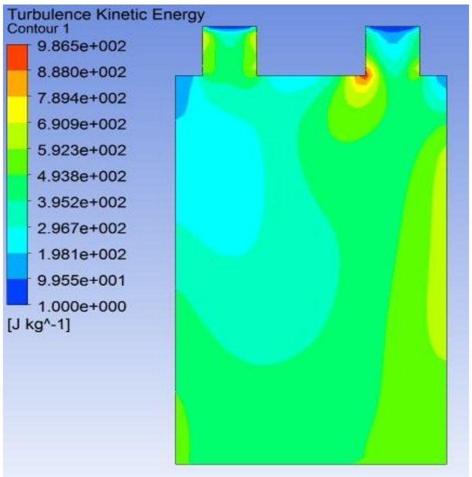

Fig 5: contour of Turbulence kinetic energy for the case of 23% oxygen content

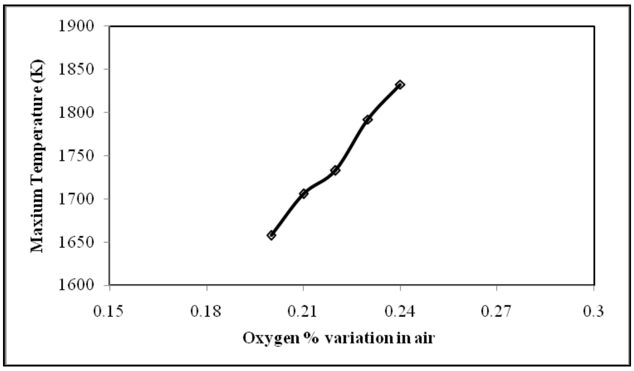

Fig 6: Variation of Temeprature in combustion chamber w.r.t oxygen content(0.20 to 0.24)

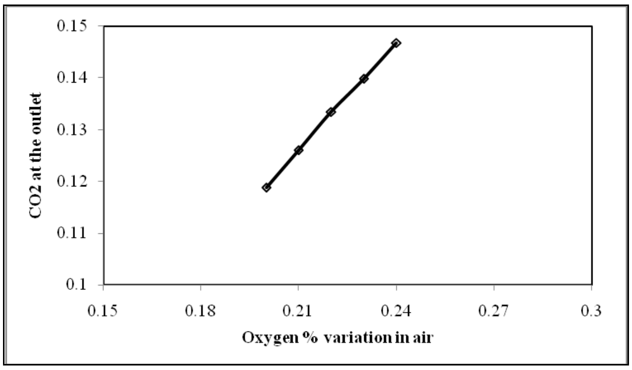

Fig 7: Variation of CO_2 emissions at the outlet w.r.t oxygen content(0.20 to 0.24)

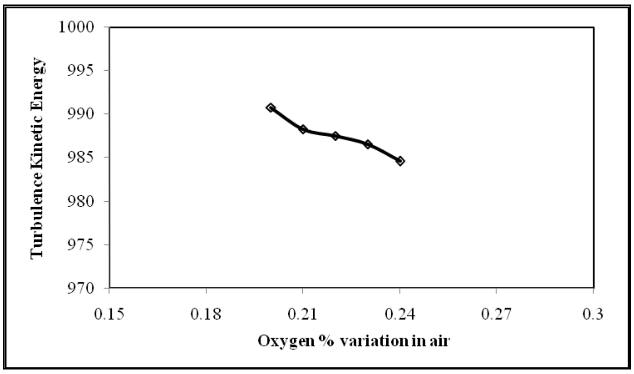

Fig 8: Variation of T.K.E in combustion chamber w.r.t oxygen conten(0.20 to 0.24)

It can observed that from Fig 6 to 8 as the oxygen content is increasing, maximum temperature in the combustion chamber and CO_2 emissions are increasing. But the turbelence kinetic enrgy is decreasing.

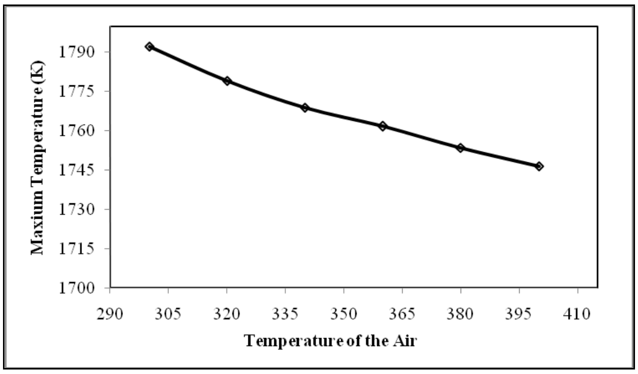

Fig 9: Variation of temeprature in combustion chamber w.r.t inlet temperature of the air

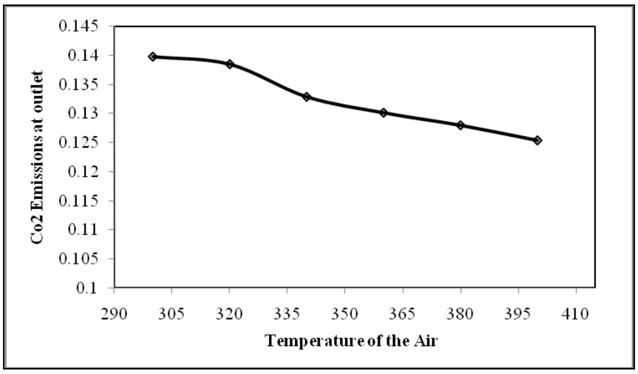

Fig 10: Variation CO_2 emissions at the outlet w.r.t inlet temperature of the air

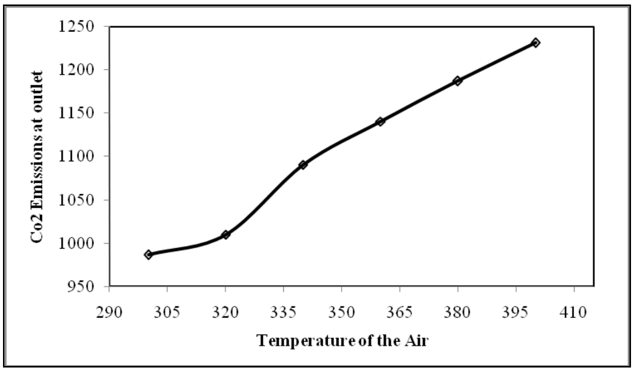

Fig 11: Variation T.K.E in combustion chamber w.r.t inlet temperature of the air

It can observed that from Fig 9 to 11 as the inlet air temperature is increasing, maximum temperature in the combustion chamber and CO_2 emmisions are decreasimng. But the T.K.E is increasing.

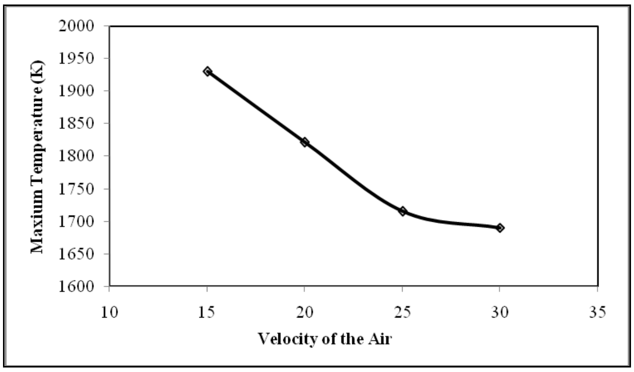

Fig 12: Variation of temeprature in combustion chamber w.r.t velocity of air at inlet

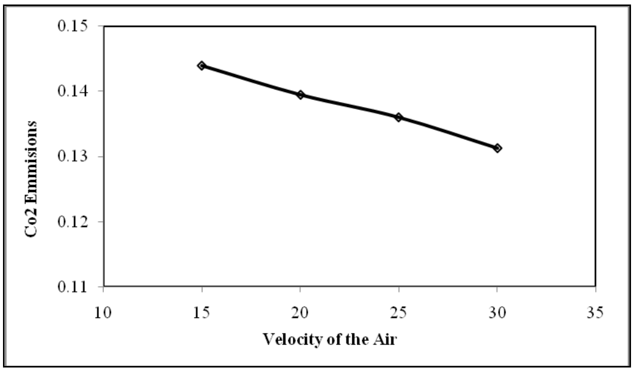

Fig 13: Variation of CO2 emissions at the outlet r w.r.t velocity of air at inlet

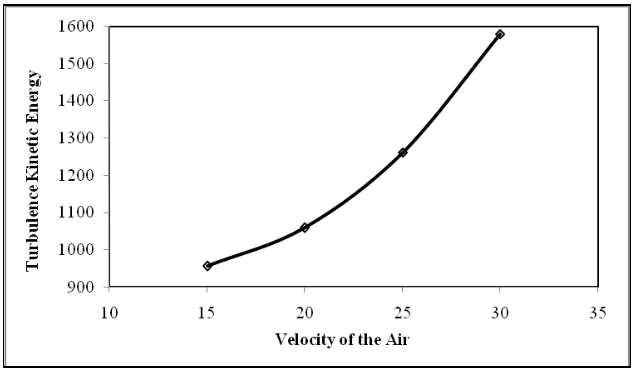

Fig 14: Variation T.K.E w.r.t velocity of air at inlet

It can observed that from Fig 12 to 14 as the velocity of inlet air is increasing, maximum temperature in the combustion chamber and CO2 emissions are decreasing. But the turbelence kinetic enrgy is increasing.

IV. CONCLUSIONS:

From the above observations it can be conclude that higher oxygen content give the maximum temperature and higher CO2 emissions. Temperature and velocity of the air, decreases the maximum temperature and CO2 emissions and increases the turbulence kinetic energy.

REFERENCES

(1) K.M.Pandey, P. Kalita, K. Barman, A. Rajkhowa and S.N.Saikia, “CFD analysis of wall injection with large sized cavity based scramjet combustion at Mach 2” international journal of engineering and technology, vol.3,Issue.02,April 2011.
(2) Sk.Magbul hussain, B.Sudheer prem kumar, K.Vijay kumar reddy, “CFD analysis of combustion and emmisions to study the effect of compression ratio and biogas substitution in a diesel engine with experimental verification”, International journal of engineering science & technology”, Vol.4, Issue-2, Feb 2012.
(3) Fraser, R.A,Siebers,D.L and Edwards, C.F, “Auto ignition of methane and natural gas in a simulated diesel environment”, Presented at SAE, paper SAE 2003-01-0755
(4) K.V. Chaudhari, D.B.Kulshreshtha, S.A.Channiwala, “ Design and CFD simulation of annular combustion chamber with kerosene as fuel for 20KW gas turbine engine”, international journal of engineering research and application, Vol.2,Issue 06, 2012, pp 1641-1645
(5) D.B.Kulshreshtha, S.A.Channiwala and Saurabh dikshit, “Numerical simulation of tubular type combusition chamber”, proceedings of ASME international mechanical engineering congress and exposition, Florida 2006.
(6) P.Sravan kumar, P.punna rao, “Design and analysis of gas turbine combustion chamber”, International journal of computational engineering research, Vol.3,issue 12, Dec.2013
(7) B.Varatharajan, M.Petrova, F.A.Williams and V. Tangirala, “Two-step chemical kinetic descriptions for hydro carbon-oxygen diluent ignition and detonation applications,proceedings of the combustion institute, 2005, pp. 1869-1877.
(8) A.R.Bhagat, Y.M.Jibhakate “Thermal analysis and optimization of I.C engine piston using finite element method” International journal of modern engineering research,vol.2,Issue.4,2012,pp.2919-2921