Research Article

DESIGN AND ANALYSIS OF A BIOFUEL-POWERED MICRO GAS TURBINE COMBUSTION CHAMBER

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ABSTRACT

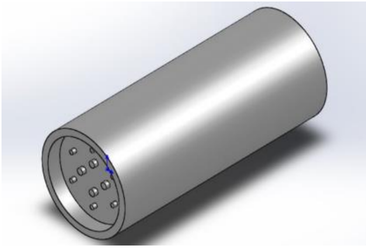
Small combustion turbines known as micro turbines provide power in the 20 kW to 500 kW range. Small jet engines, auxiliary power units (APUs) for aircraft, and turbochargers for cars and trucks are the origin of the Evolution. A relatively recent development in distributed generation, micro turbines are employed in stationary energy generation applications. In most cases, they are combustion turbines, which on a small scale generate heat as well as power. Radial inflow turbine, combustor, and centrifugal compressor are the three main components of a micro (gas) turbine engine. Along with turning the compressor, it also serves as a power output. For distributed electricity and cogeneration (combined heat and power) applications, micro turbines are becoming more and more common. The micro turbine and gas turbine cycles both run continuously. Studying a brief description of SOLIDWORKS modelling is necessary. With the aid of Solid works, several turbine components (includes the housing, connection, exit, rotor, nozzle, storage, inlet, and so on) are designed (software). They were then put together as one unit and attached to a generator to produce electricity. The axial intake and axial output of the turbine indicate its kind.

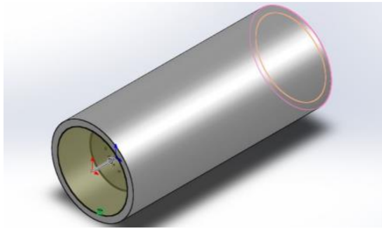
Introduction

Micro turbines are power plants with outputs between 15 and 300 kW. Although they have some common qualities, such as air bearings, low NOX emissions, high speed operation, variable speed, small size, easy operability, quick installation, cheap maintenance, and typically a remunerator, their fundamental design is inspired by open cycle gas turbines. **Gerhard Vellguth[1]** researched the effects of various vegetable oils on the efficiency of a single-cylinder direct-injection diesel engine. He claimed that there was no efficiency loss when oiling up with veggie directly as fuels in Diesel engines for a brief period of time. He noticed operational issues such carbon buildup and modifications to the lubricating oils characteristics, and a sticky ring issues when running an engine for an extended period of time with vegetable oils. a diesel engine with indirect injection and rapeseed oil was tested by **Nwafor et al.[2]** 50 CA BTDC and a 3.5 injection advance. The engine load, speed, and system temperature were said to have an impact on the delay time. With regular fuel injection timing, there was a noticeable rise in brake-specific fuel usage at 2400 rev/min. With enhanced timing, emissions of carbon monoxide and carbon dioxide were significantly reduced for the tested speeds. For operations at low engine speeds, a moderate injection advance was advised. Additionally, he stated that at high loads, heated and chilly oil activities used somewhat more fuel than diesel fuel operations. Compared to the unheated fuel, there was a decrease in delay due to the unheated oil. The findings of the overall test indicated that fuel heating was advantageous for operations with low speed and part-load. utilising jatropha oil and esterified jatropha oil an individual diesel cylinder engine was studied by **Varaprasad et al.[3]** When compared to diesel, they discovered that esterified jatropha oil had a greater brake thermal efficiency than raw jatropha oil. In comparison to esterified Jatropha and diesel fuel, they also found that neat jatropha oil produced significant levels of smoke and low levels of NOX emissions. **Parmanik[4**] investigated the characteristics and applications of diesel fuel and jatropha curcas oil mixtures in compression ignition engines. Because the vegetable oil diesel blends have less viscosity, a decrease in The temperature of exhaust gas has been measured. It was discovered that adding more jatropha curcas oil to the blends resulted in higher fuel usage. With blends comprising up to 50% by volume of acceptable thermal jatropha oil efficiencies within the engine were attained. **Herchel et al [5]**. discovered that even without engine changes, the test engine operated satisfactorily using virgin coconut oil and virgin coconut diesel mixes for a variety of engine load circumstances. Increasing the amount of diesel fuel containing coconut oil blends increased the amount of brake-specific fuel consumed while reducing smoke and NOX emissions. The outcomes a test on an engine using various Diesel fuel, mixes, and pure rapeseed oil were presented by **Rice et al [6].** The use of these alternate fuels did not cause any serious issues with engine running. According to the test results, the blend's thermal efficiency decreases as rapeseed oil content rises. Additionally, it was observed that when emissions increased, power output decreased. On a diesel engine running at a constant speed, **Kumar et al[7]**. discovered the methyl ester of jatropha oil had a greater a delayed start than in diesel fuel. Karanja oil and its diesel mixes were used in performance evaluation studies on a diesel engine by Bhatt, Murthy, and Dutta. It was found that there was no discernible varying power output, fuel use for brakes specifically, or varying brake thermal efficiency when karanja oil was blended up to 40% (by volume) in diesel. The compression ratio was raised from 16:1 to 20:1, which increased the performance of engines using karanja oil mixtures. In a diesel engine with direct injection, **Scholl and Sorenson[8]** investigated the burning of methyl ester of soy oil. When they used the identical engine parameters (load, speed, timing, and nozzle diameter) as diesel combustion, they discovered that the Most of the important soya bean oil methyl ester combustion parameters, like ignition delay, peak pressure, and rate of pressure rise, were similar to those in diesel combustion. The amount of the the two fuels' ignition timing delays was found to be equivalent, and diesel's ignition delay was shown to be more resistant to nozzle size than that of methyl ester of soy oil. carbon dioxide emissions decreased significantly, NOX for the two fuels were equivalent, and soya bean oil methyl ester produced somewhat lower carbon monoxide emissions and lower smoke numbers. **Amit et al [9]** created a test rig for bio diesel synthesis in accordance with hydrodynamic cavitation. Cavitation caused by hydrodynamics method for producing bio diesel has been discovered to be easy, effective, time-saving, environmentally beneficial, and commercially viable. In addition, experimented with Catullus diesel and bio diesel blends in a direct-injection, four-cylinder engine, water-cooled diesel engine. Designing the combustion chamber in relation to the swirling of the fuel and combination of air that must occur in the manner of the heat transfer and radiations that are worked to mark its efficiency level to be attained. The use of bio fuels has reduced emissions that will be discharged into the atmosphere as its principal benefit. Additionally, it is utilised in low-cost, low-scale industries.

Solid works Modelling

SOLIDWORKS is a 3D CAD programme that combines sophisticated design features with an easy-to-use user interface to expedite the design process and increase productivity right away.





Computational Analysis

Drag and drop fluid flow (fluent) to open a window in ANSYS Workbench. Now right-click on the geometry in the main window, and then select Geometry Import from External File (Micro Gas Turbine Combustion Chamber). Click create after that.

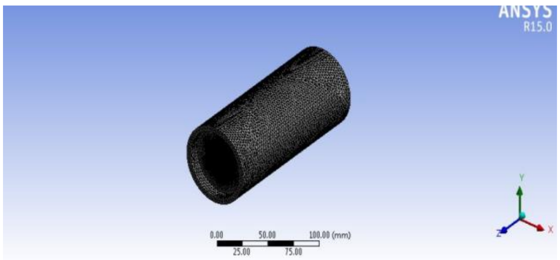
Now access the main ANSYS window, right-click the mesh, and select edit. The geometry properties are displayed in details view after you click geometry and choose a portion.

Right-click on a face or edge, select Create Named Selection, and then type in the name as seen in the figures below.

Now, from the Ansys Main window, select Setup. Double-click Setup, then select Double Precision, Series Processing, and then click OK.

General, type, and choose velocity formulation based on pressure, choose absolute. Select viscous K- Epsilon (2 Eqn) in Models -> Energy is On -> Click "OK".

Resources -> Select Solid, then select Create/Change. Include the content from the fluent database. Add the diffuser geometry-related items now. Conditions for the cell zone, fluid type selection, and operating conditions input.



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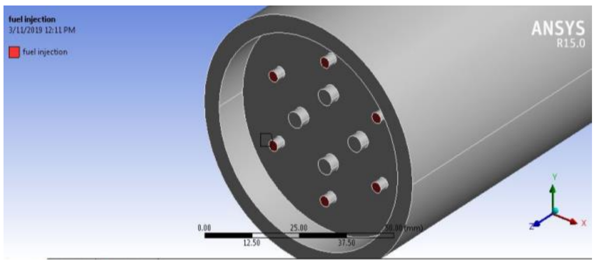

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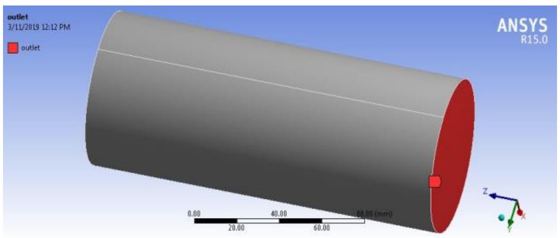

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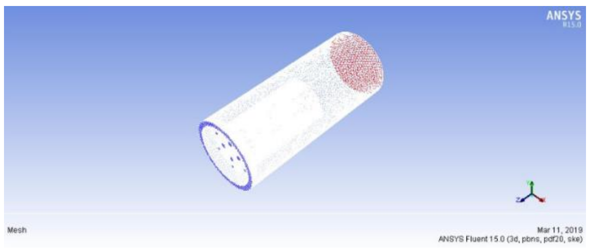

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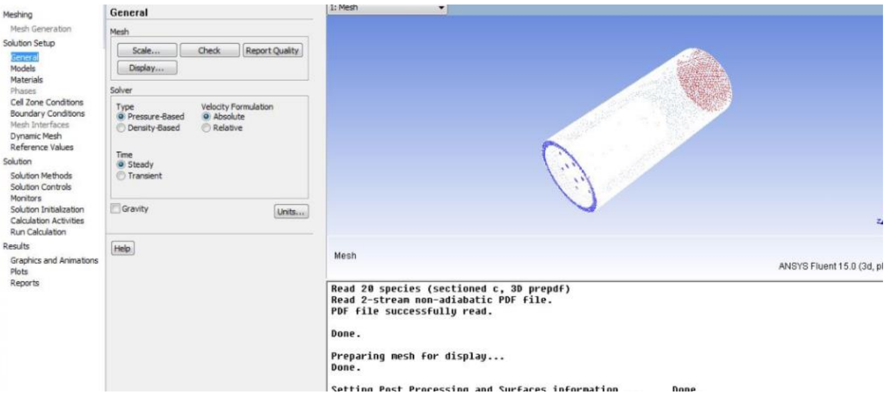

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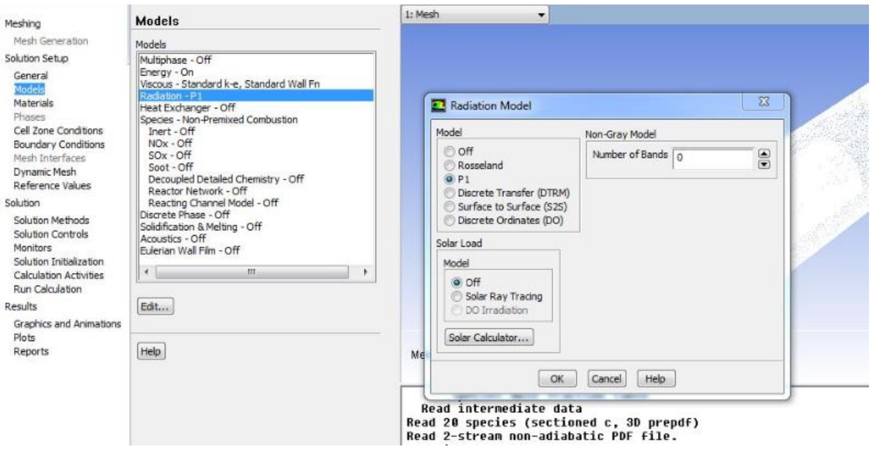


(f)

(a) Combustion chamber with fine meshing (b) Named Selection for gas turbine combustion chamber (Fuel Injection) (c) Named Selection for gas turbine combustion chamber (Outlet) (d) Geometry in Ansys Fluent (e) Solver type for geometry (f) Radiation model for gas turbine combustion chamber.

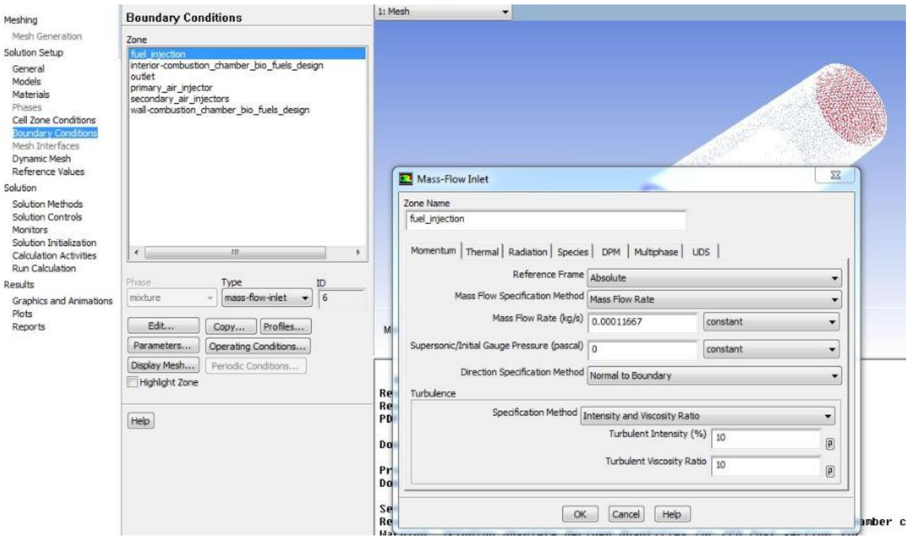
Boundary conditions

Input: Mass flow rate Input: Value of 0.000178 kg/s. Wall should be a solid wall; click edit; select the thermal tab; change the material; and enter the temperature.Keep the outlet set to Pressure outlet and use the default settings.Use default parameters for the interior component.Use default parameters for the wall part. Reference values, compute from, then choose an inlet.

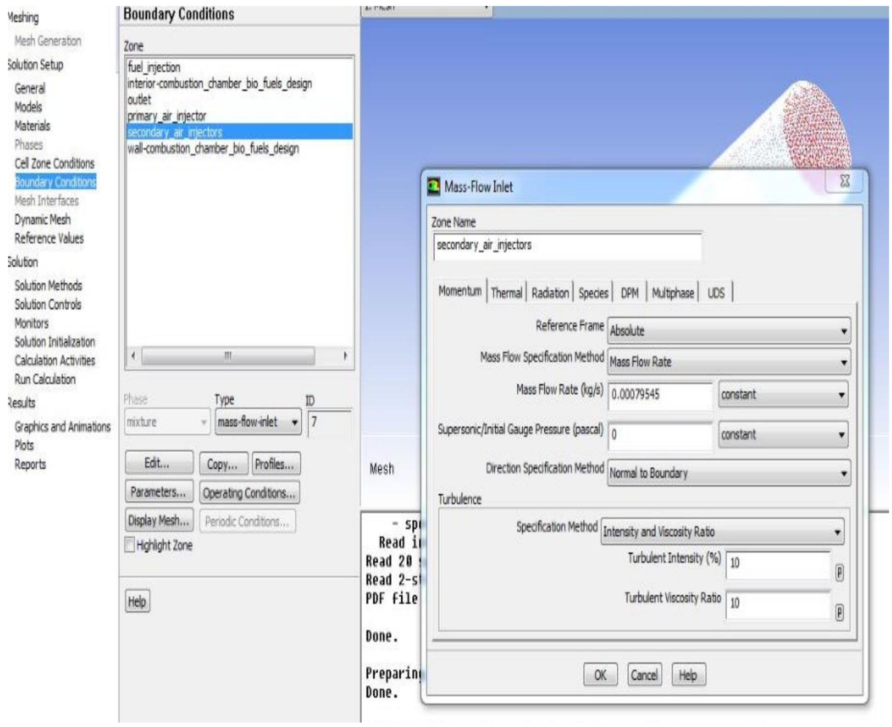
When this occurs, the reference values that you specified in the border circumstances show up. Second order upwind flow, modified, gradient, implicit, Roe-fds flux type, solution methods, formulation, and least square cell based first order upwind viscosity of the turbulence.

If you want values that are more exact Press "OK" after selecting "Monitors," "Residuals," "Print," "Plot," "Give Values in order of 10-6," and then "Print."

Set the controls number to be less than 1 as a control. Initialize the solution by computing from the inlet and the reference frame: set the reference frame related to the cell zone.Run the calculations, set the iterations to more than 1,000, and then click Calculate.



(a)



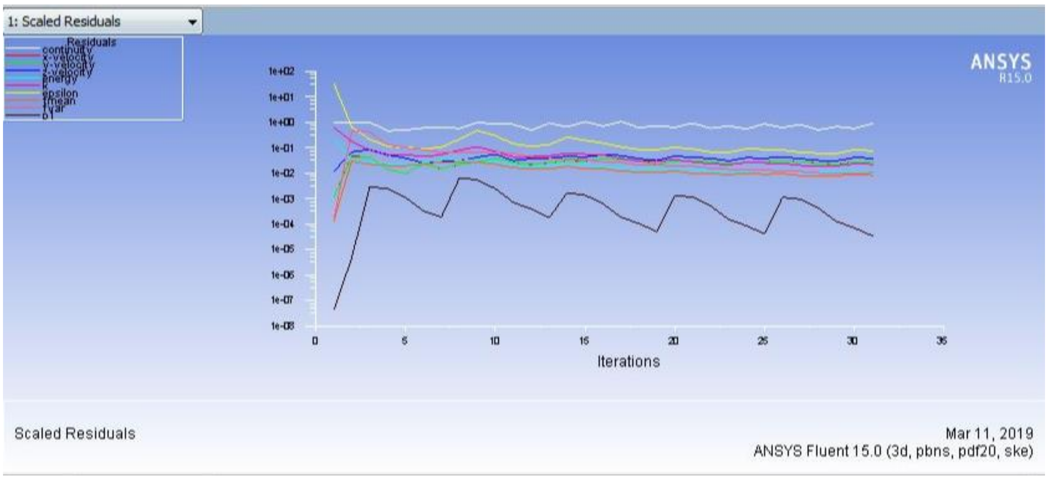
(b)

(a) Inlet Boundary Conditions (Fuel Injection) (b) Inlet Boundary Conditions (Secondary air fuel injector)

Results & Discussion

Post Processing of Standard Air Mixture

(a) Converging the solution (b) Mixture fraction of model (c) Pressure contour of mixture in gas turbine combustion chamber


1: Scaled Residuals
Residuals
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y-velocity
z-velocity
energy
k
epsilon
fmean
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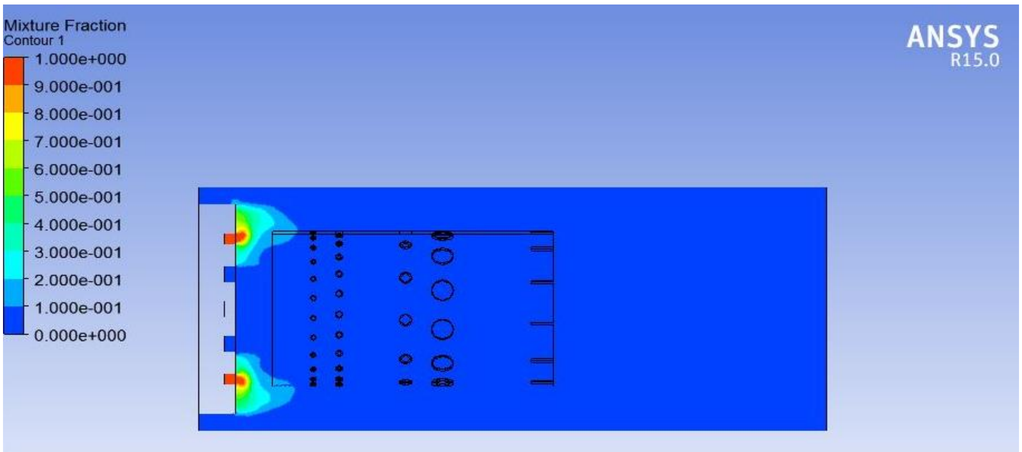
ANSYS Fluent 15.0 (3d, pbns, pdf20, ske)

(a)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9.000e-001
8.000e-001
7.000e-001
6.000e-001
5.000e-001
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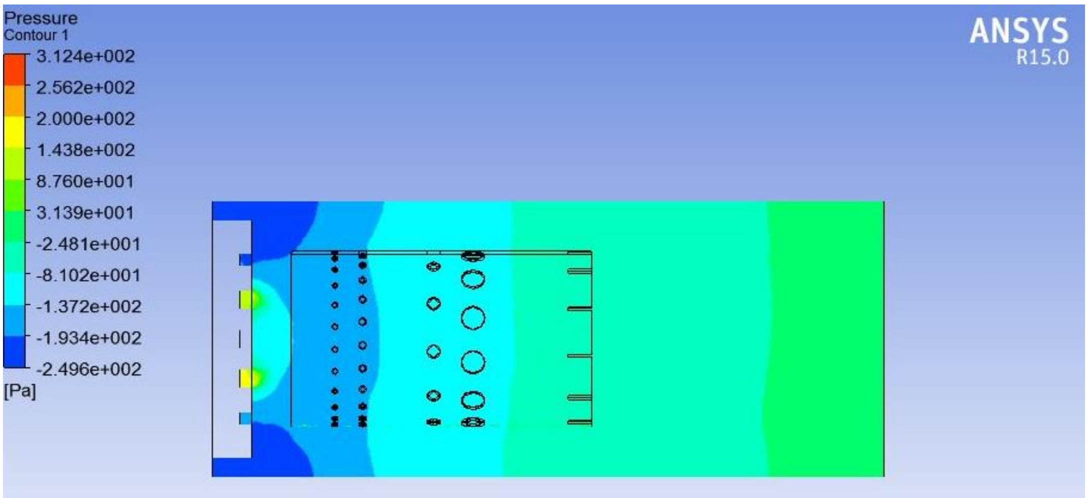
1.000e-001
0.000e+000
ANSYS
R15.0

(b)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3.139e+001
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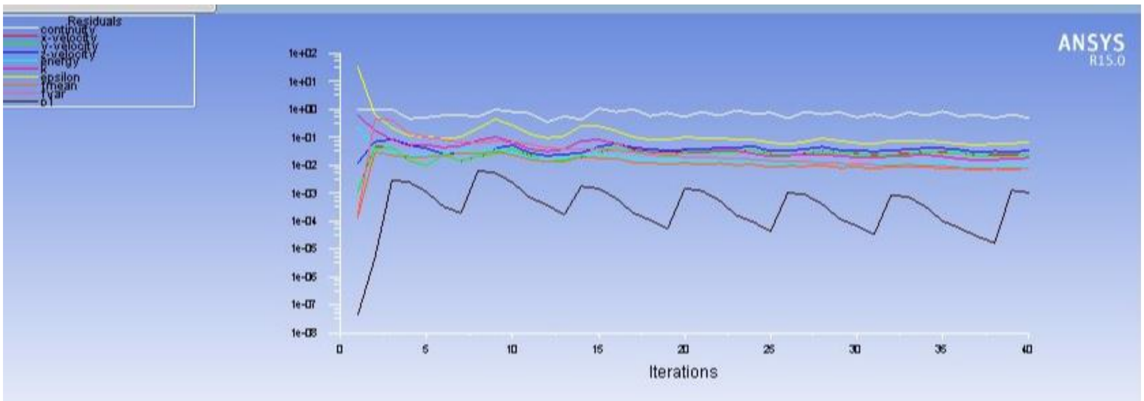
-8.102e+001
-1.372e+002
-1.934e+002
-2.496e+002
[Pa]
ANSYS
R15.0

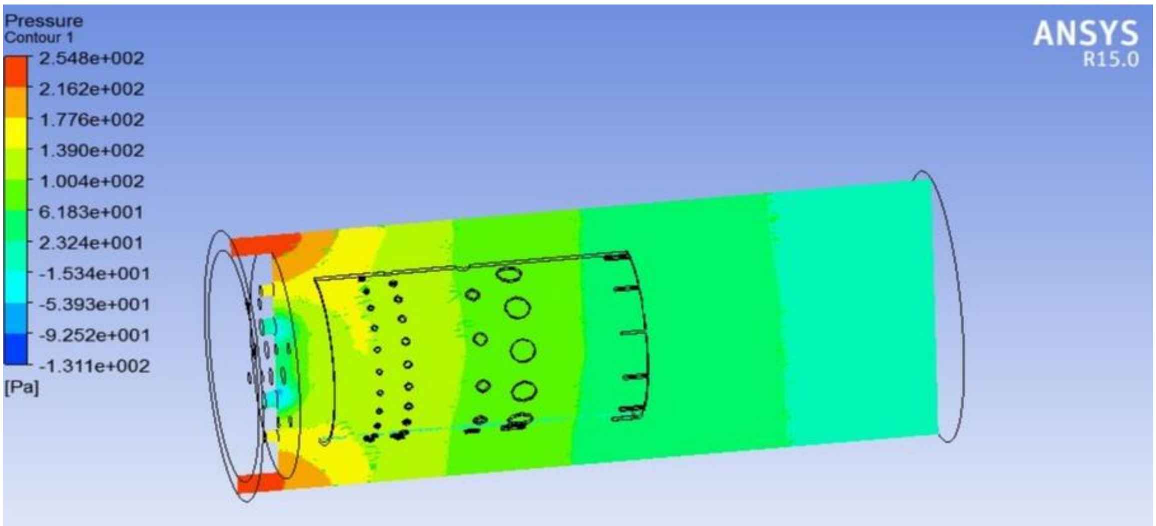
(c)

```
     Radiation Heat Transfer Rate                         (w)
-------------------------------- --------------------
                  fuel_injection          -0.074789904
                          outlet             285.10562
            primary_air_injector            -1.8305246
         secondary_air_injectors           -0.11268581
wall-combustion_chamber_bio_fuels_design             167.34836
                ---------------- --------------------
                             Net             450.43598
```

Post Processing of Ethene & Air Mixture



(a)



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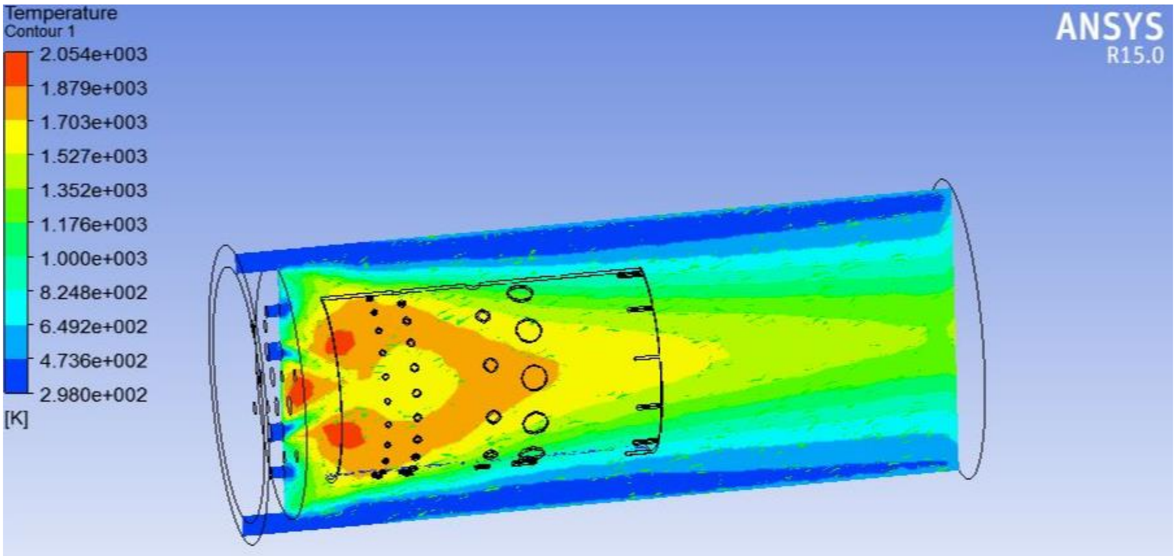
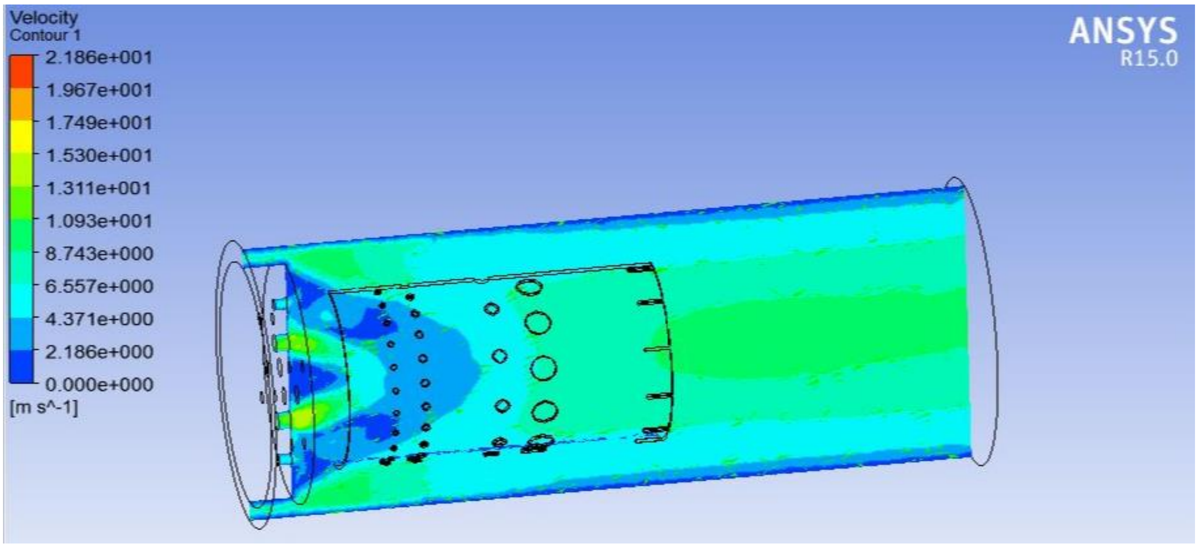


(c)



(d)

(a) Converging of gas turbine combustion chamber (Air ethane mixture) (b) Pressure Contour of gas turbine combustion chamber (Air ethane mixture) (c) Temperature Contour of gas turbine combustion chamber (Air ethane mixture) (d) Velocity Contour of gas turbine combustion chamber (Air ethane mixture).

Total Heat Transfer Rate	(w)
fuel_injection	-544.27063
outlet	1052.0292
primary_air_injector	16.490971
secondary_air_injectors	1.3796822
wall-combustion_chamber_bio_fuels_design	0
Net	525.6292

(a)

```
                 Mass Flow Rate              (kg/s)
-------------------------------- --------------------
                 fuel_injection          0.00011667
interior-combustion_chamber_bio_fuels_design         0.0071604056
                         outlet       -0.0099197021
            primary_air_injector        0.0094999922
         secondary_air_injectors       0.00079545024
wall-combustion_chamber_bio_fuels_design                   0
                ---------------- --------------------
                            Net        0.00049241041
```

(b)

```
          Radiation Heat Transfer Rate                  (w)
-------------------------------- --------------------
                  fuel_injection          -0.091152877
                          outlet            335.16003
            primary_air_injector           -2.2604649
         secondary_air_injectors          -0.13752344
wall-combustion_chamber_bio_fuels_design            432.13794
                ---------------- --------------------
                             Net            764.80883
```

(c)

(a) Total heat transfer rate of gas turbine combustion chamber (Air ethane mixture) (b) Mass flow rate of gas turbine combustion chamber (Air ethane mixture) (c) Radiation heat transfer rate of gas turbine combustion chamber (Air ethane mixture).

Results Table:

FUEL TYPE	TEMPARATURE(K)	MIXING RATIO	HEAT TRANSFER RATE(w)
STANDARD FUEL	1957	1.00	543.67
ETHANE –AIR	2054	.231	525.62
METHANE	2165	.461	528.17

Conclusion

In this investigation, we determined the standard, Ethane-air, and Methane combustion values. According to the data, the heat transfer rates and fuel mixing ratios for ethane-air and methane are lower than they are for regular fuel compositions, but when it comes to cost, biofuels are becoming less and less expensive. According to analysis, ethane, air, and methane have less efficiency than normal fuels.

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