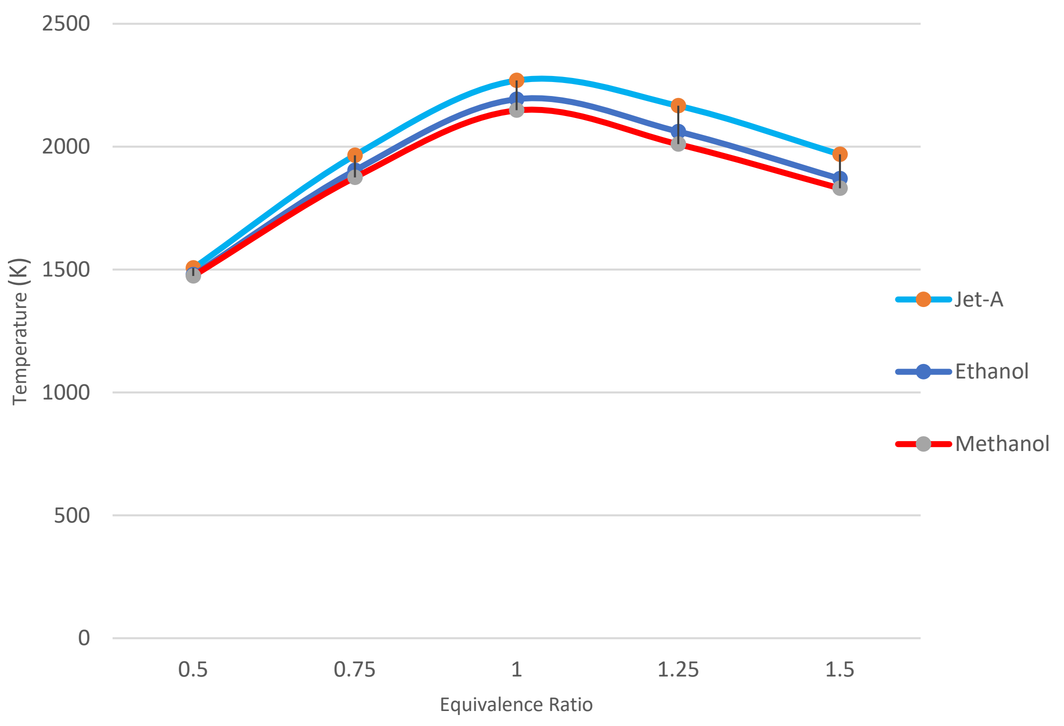
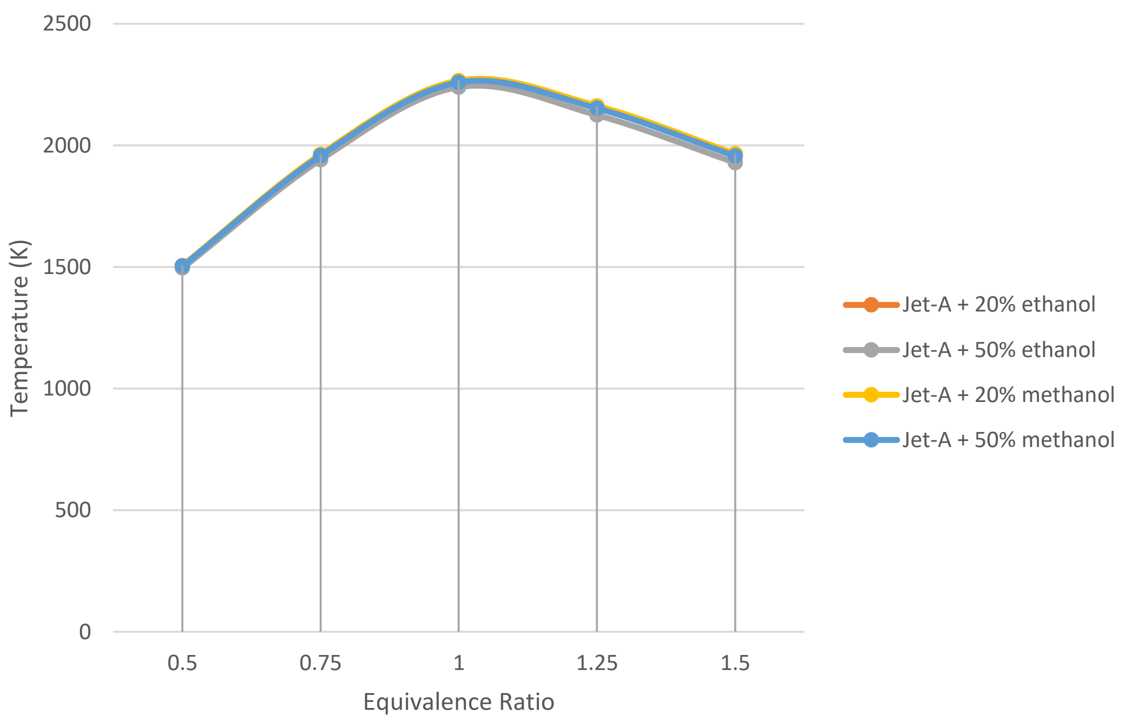
Flame Temperature vs Equivalence Ratio

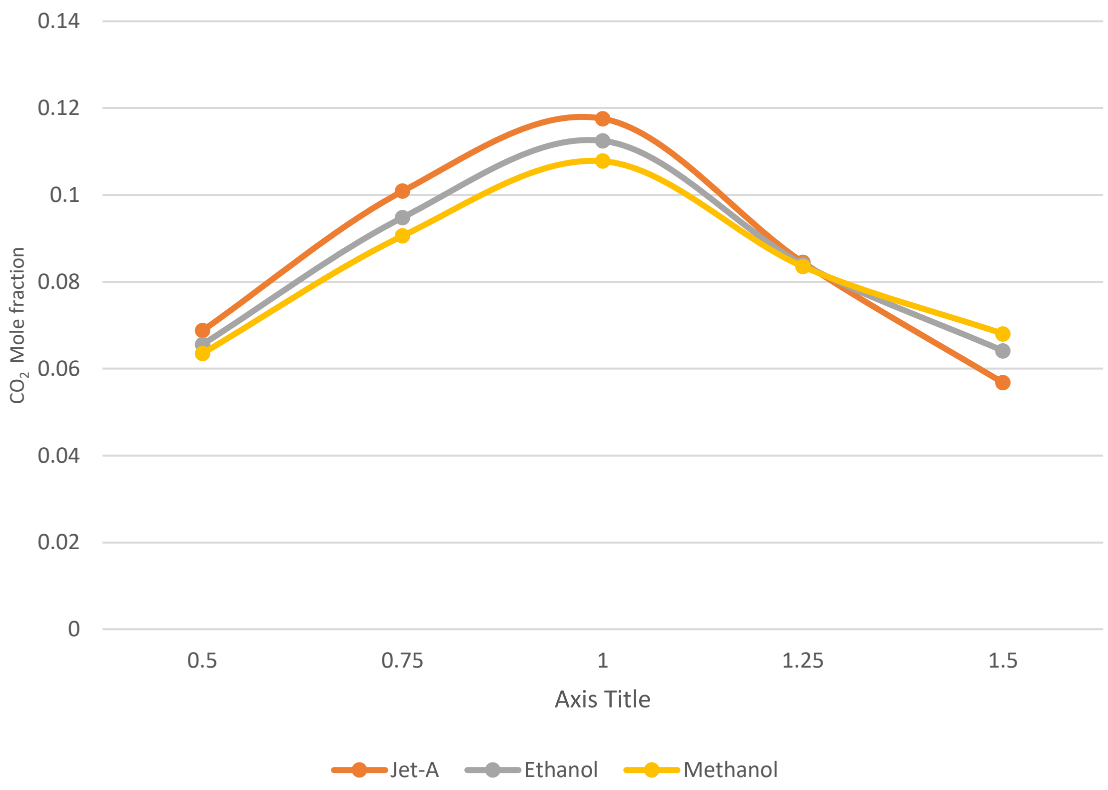


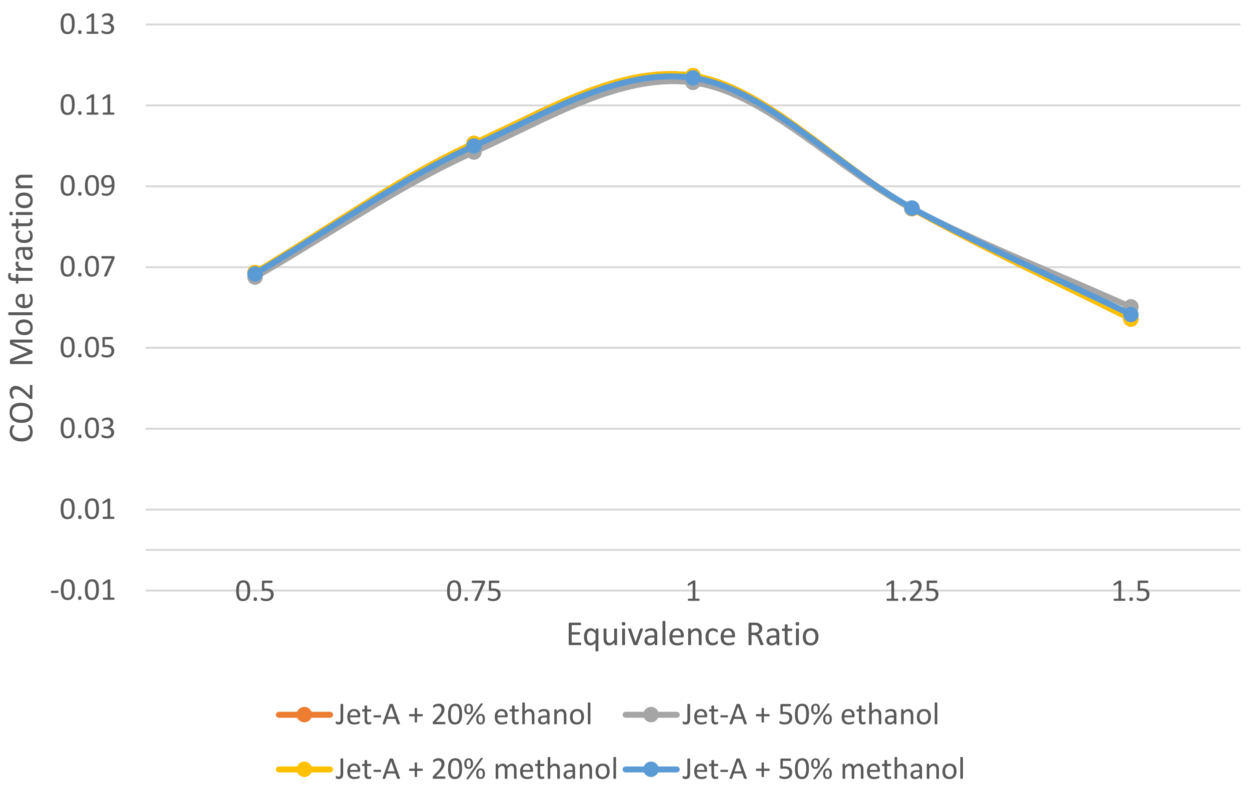


- From eq. ratio 0.5 to 1(lean mixture) flame temp. is increasing for all fuel.
- But from 1 to 1.5(rich mixture) flame temp. is decreasing for all fuel.
- At eq. ratio of 1(stoichiometry) we are getting maximum flame temp.
- Pure Jet-A fuel is giving maximum flame temp. at stoichiometry.

- From eq. ratio 0.5 to 1 (lean mixture) flame temp. is increasing for all fuel.
- But from 1 to 1.5 (rich mixture) flame temp. is decreasing for all fuel.
- At eq. ratio of 1(stoichiometry) we are getting maximum flame temp.
- Jet-A + 20% methanol combination is giving maximum flame temp. at stoichiometry.

CO_2 Mole fraction vs Equivalence ratio

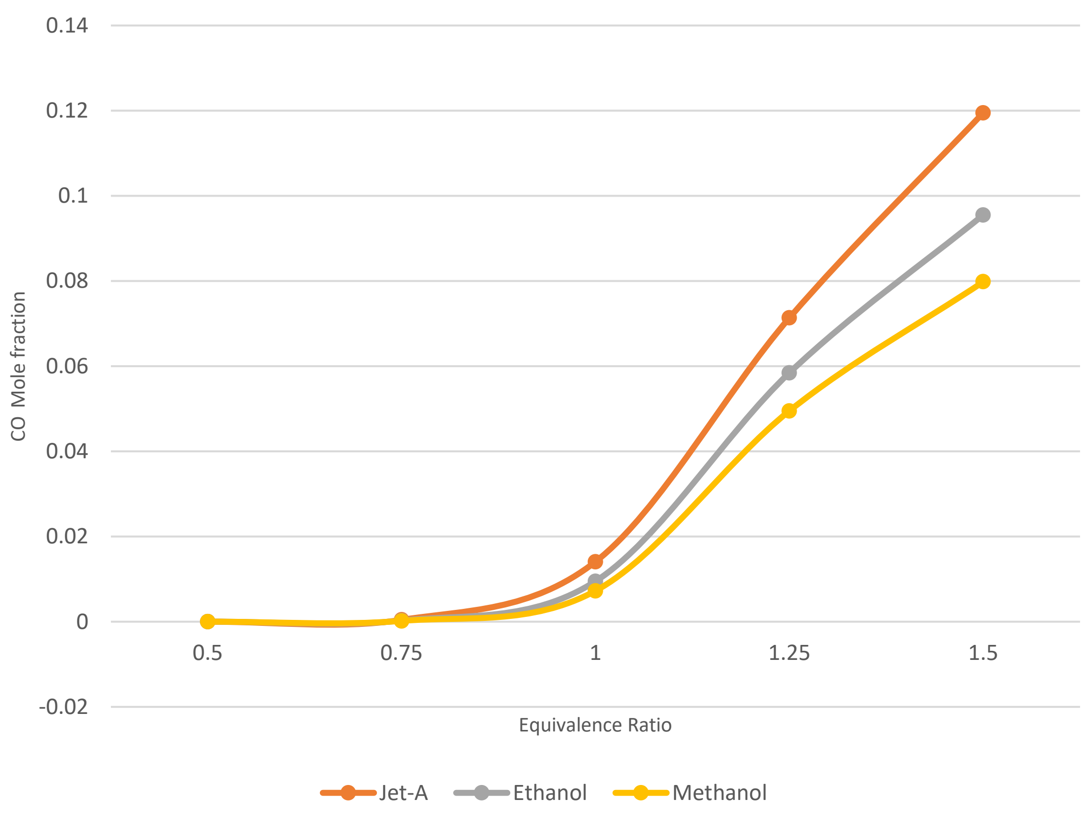


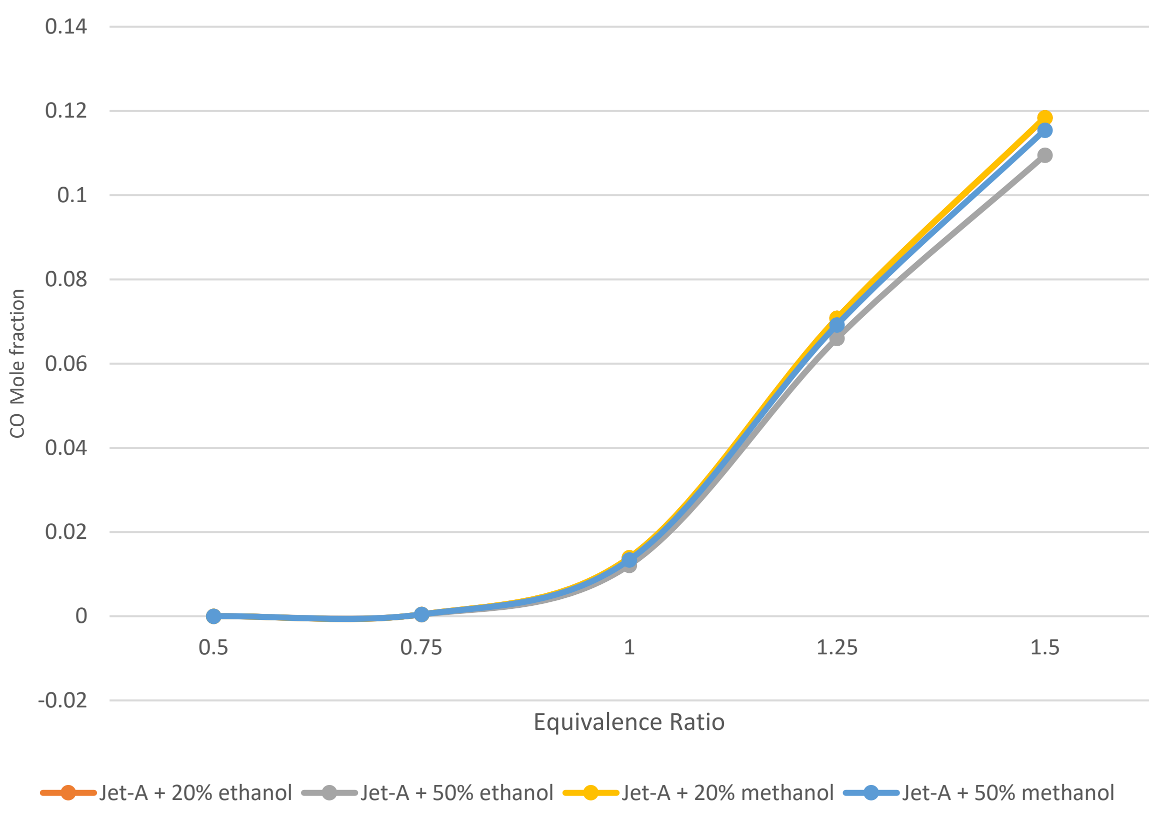


- From eq. ratio 0.5 to 1 CO2 Mole fraction is increasing for all fuel.
- But from eq. ratio of 1 to 1.25 CO_2 Mole fraction is decreasing for all fuel.
- At eq. ratio of 1(stoichiometry) we are getting maximum CO_2 Mole fraction.
- Pure Jet-A fuel is giving maximum CO2 Mole fraction
- At eq. ratio of 1.25 CO2 mole fraction is approximately same.

- From eq. ratio 0.5 to 1 CO2 Mole fraction is increasing for all fuel.
- But from 1 to 1.5 CO_2 Mole fraction is decreasing drastically for all fuel.
- At eq. ratio of 1(stoichiometry) we are getting maximum CO_2 Mole fraction.
- Jet-A + 20% ethanol fuel is giving maximum CO2 Mole fraction.

CO Mole fraction vs Equivalence Ratio

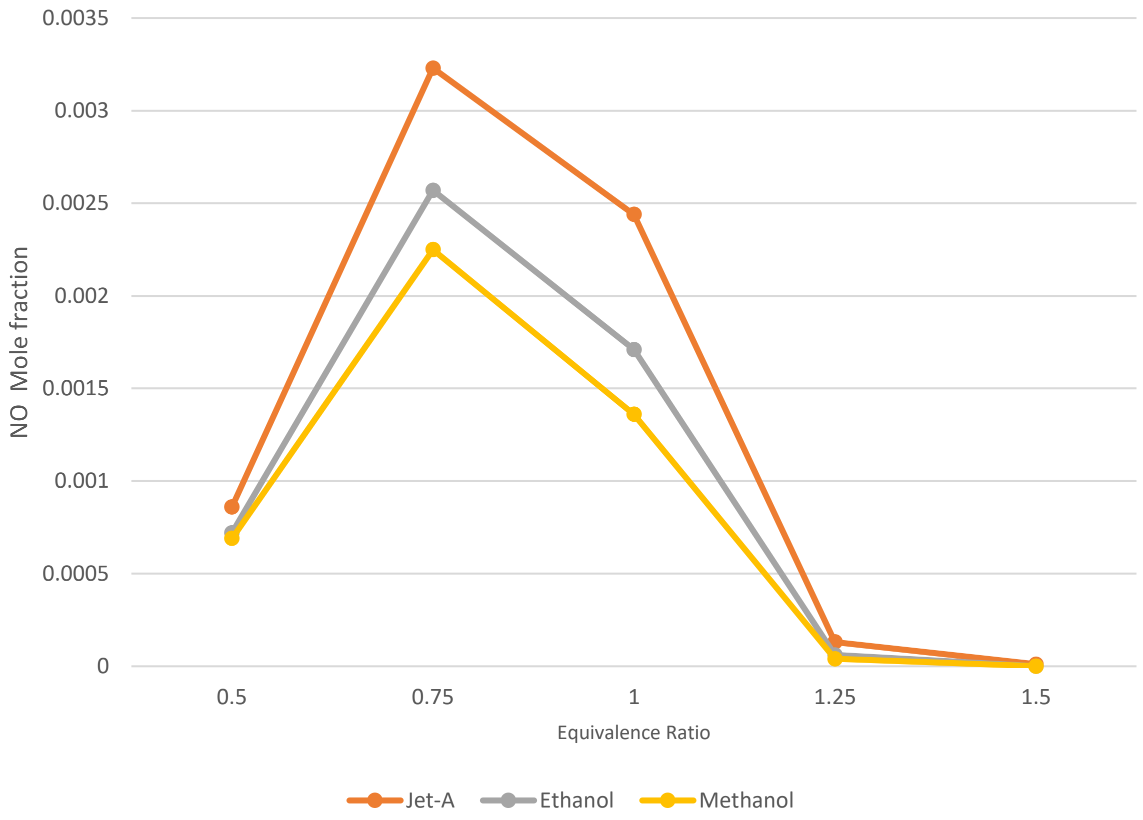


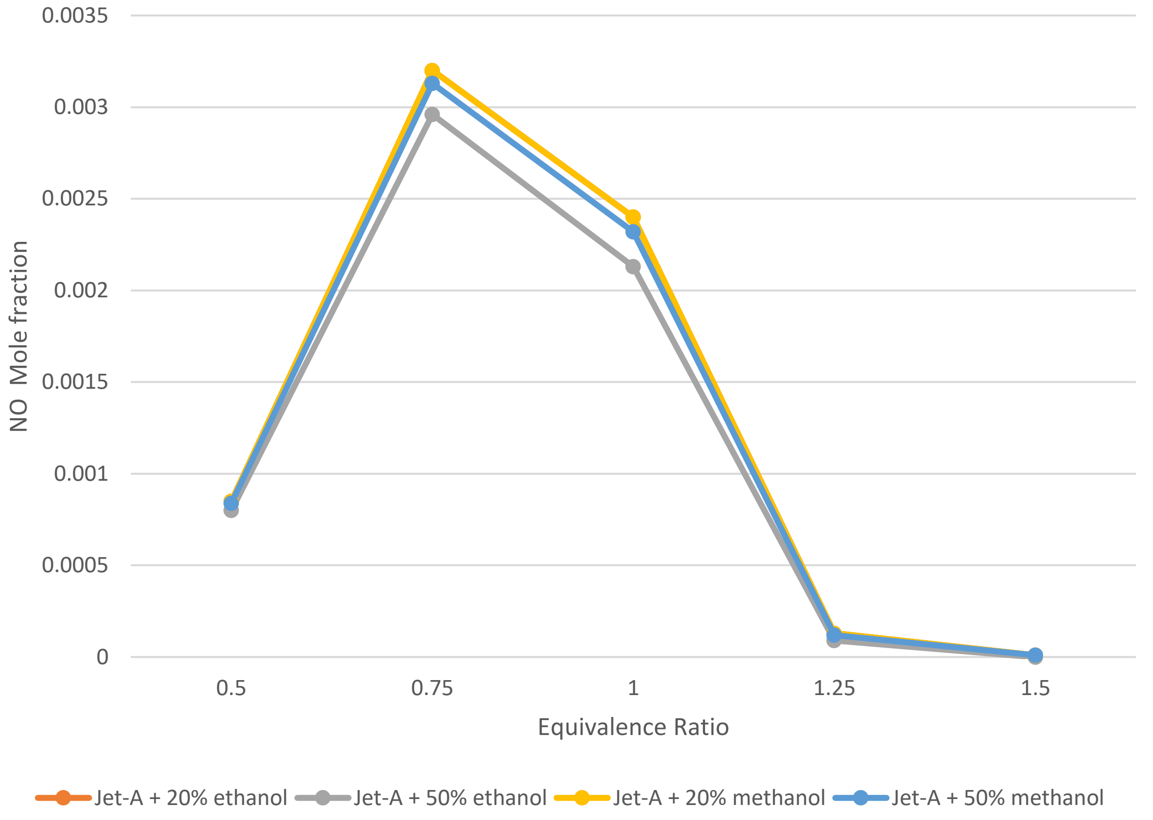


- From eq. ratio 0.75 to 1 CO Mole fraction is increasing in small quantity for all fuel.
- But from 1 to 1.5 (Rich mixture) CO Mole fraction is increasing drastically for all fuel.
- Pure Jet-A fuel is giving maximum CO Mole fraction (CO to have after combustion is not advisable because its harmful hence not desirable)

- From eq. ratio 0.75 to 1 CO Mole fraction is increasing in small quantity for all fuel.
- But from 1 to 1.5 (Rich mixture) CO Mole fraction is increasing drastically for all fuel.
- Pure Jet-A + 50% methanol fuel is giving maximum CO Mole fraction (CO to have after combustion is not advisable because its harmful hence not desirable)

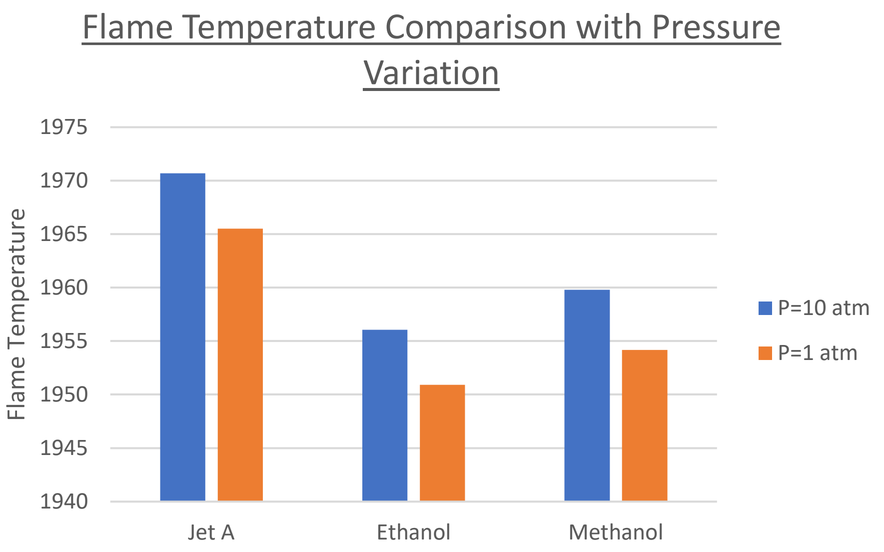
NO Mole fraction vs Equivalence Ratio



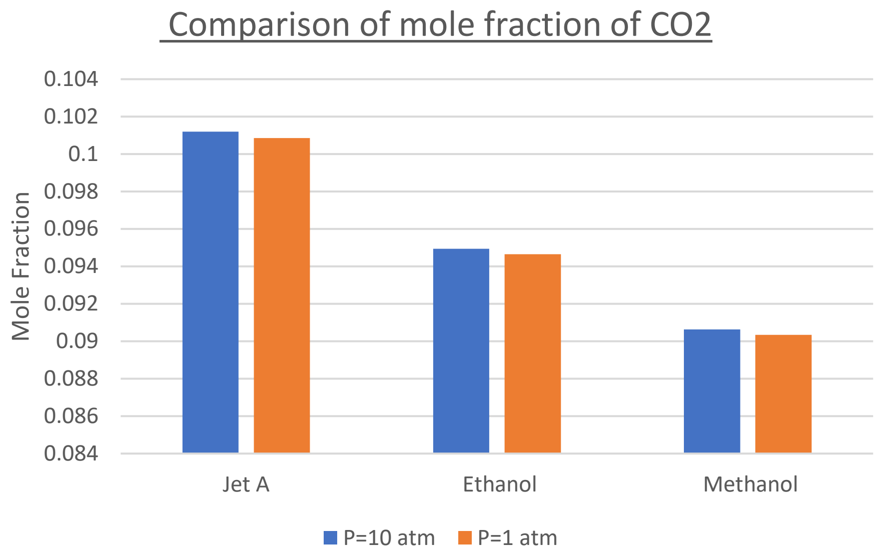


- From eq. ratio 0.5 to 0.75 (very lean mixture) NO Mole fraction is increasing for all fuel.
- But from 0.75 to 1 (lean mixture) NO Mole fraction is decreasing for all fuel.
- From 1 to 1.25 (Rich mixture) NO mole fraction decreasing drastically
- From 1.25 to 1.5 NO mole fraction slope is very small.
- Pure Jet-A fuel is giving maximum NO Mole fraction at 0.75 Eq. ratio (NO to have after combustion is not advisable because its harmful hence not desirable)

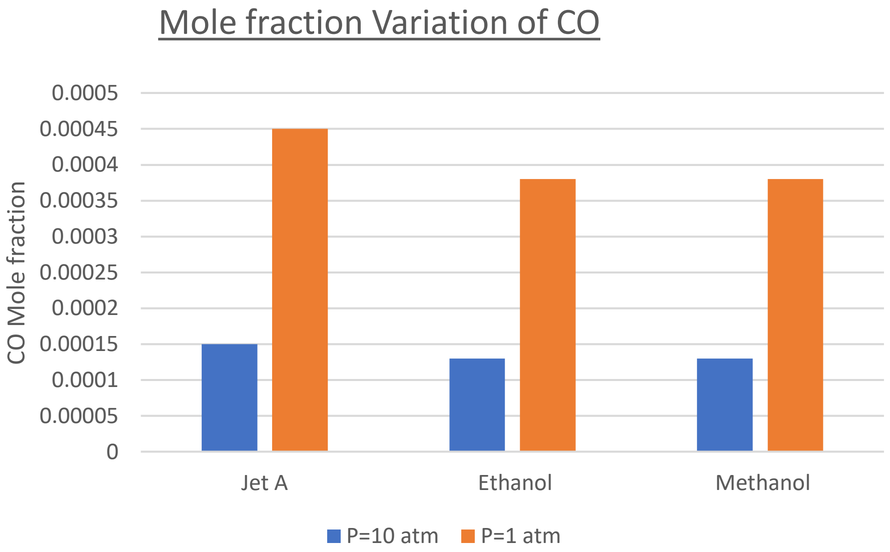
- From eq. ratio 0.5 to 0.75 (very lean mixture) NO Mole fraction is increasing drastically (slope is very high) for all fuel.
- But from 0.75 to 1 (lean mixture) NO Mole fraction is decreasing for all fuel.
- From 1 to 1.25 NO mole fraction decreasing drastically.
- From 1.25 to 1.5 NO mole fraction slope is very small.
- Pure Jet-A + 20% ethanol fuel is giving maximum NO Mole fraction at 0.75 Eq. ratio (NO to have after combustion is not advisable because its harmful hence not desirable)



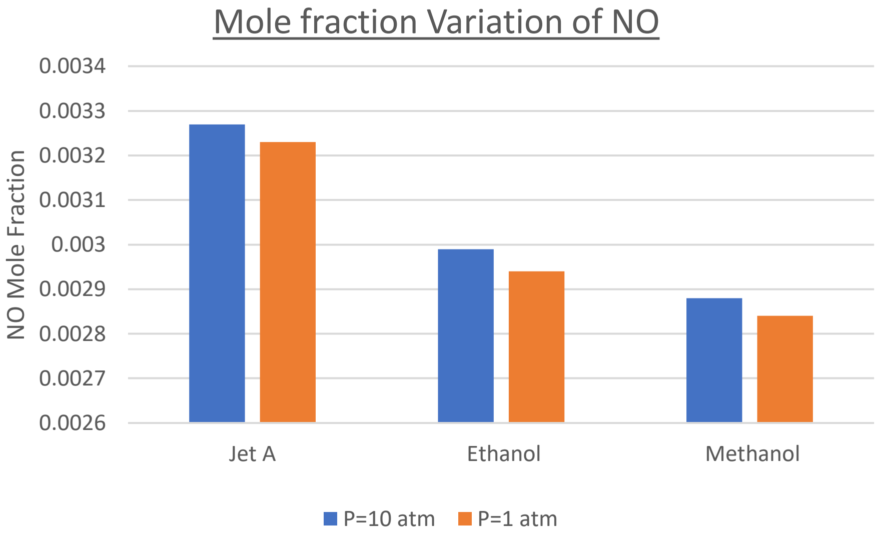
- Increasing in pressure results in increasing the flame temp. but not as significant.
- For Jet-A fuel we are getting highest flame Temp.



- Increasing in pressure results in increasing the CO_2 mole fraction but not as significant.
- For Jet-A fuel we are getting highest CO_2 mole fraction

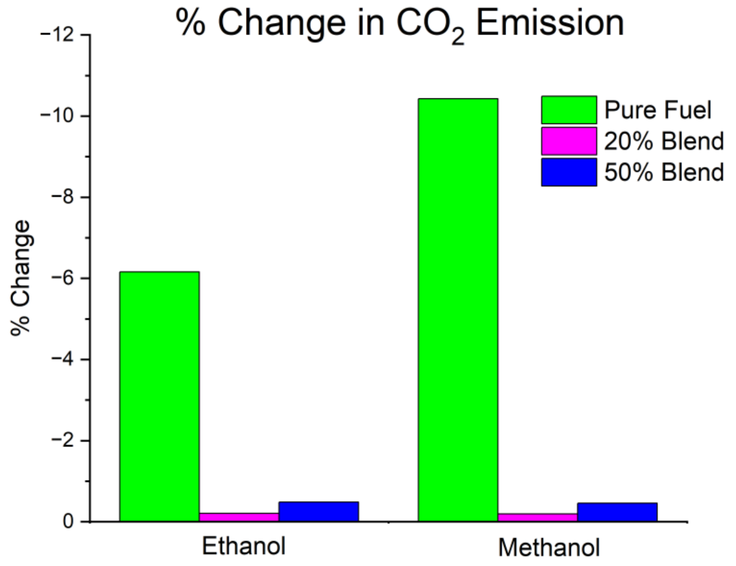


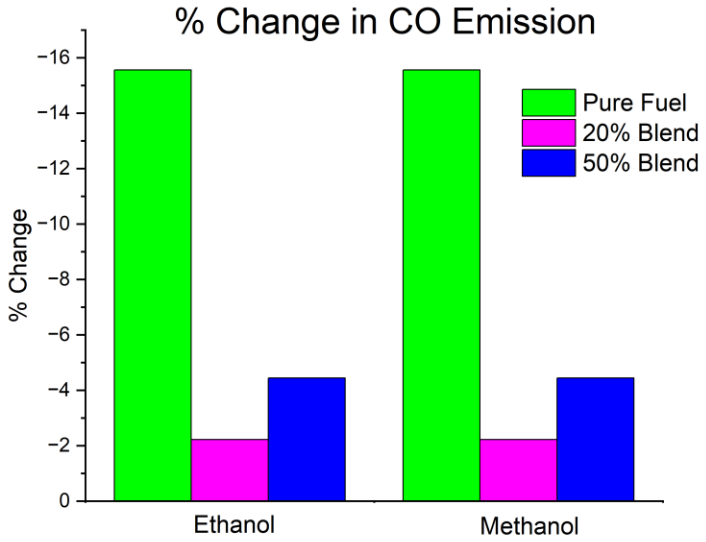
- Increasing in pressure results in decreasing the CO Mole fraction but not as significant.
- For Jet-A fuel we are getting highest CO Mole fraction.

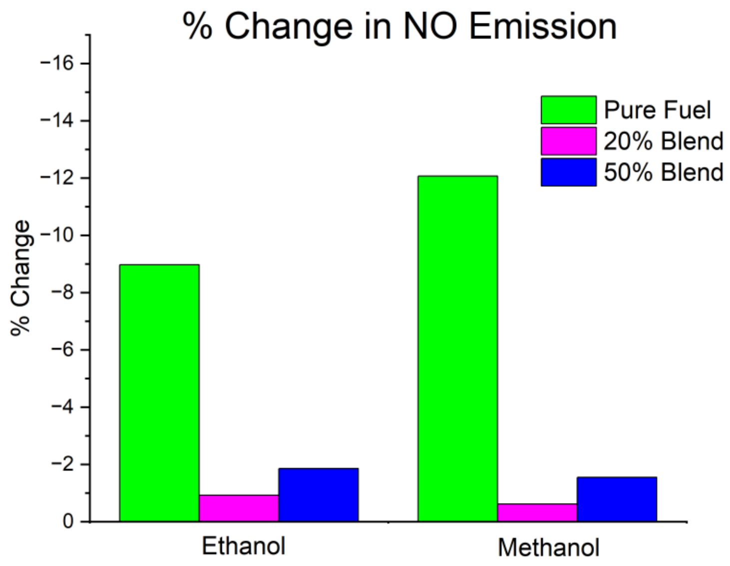


- Increasing in pressure results in increasing the NO Mole Fraction but not as significant.
- For Jet-A fuel we are getting highest NO Mole Fraction.

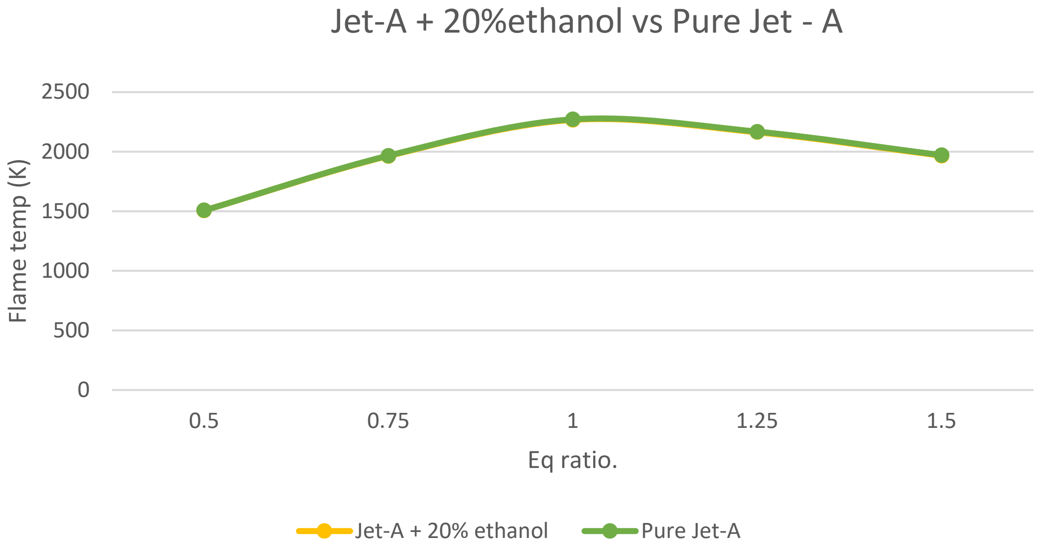
% Change in various emissions with respect to Jet A for Pure Ethanol, Pure Methanol and their 20% & 50% blend with Jet A

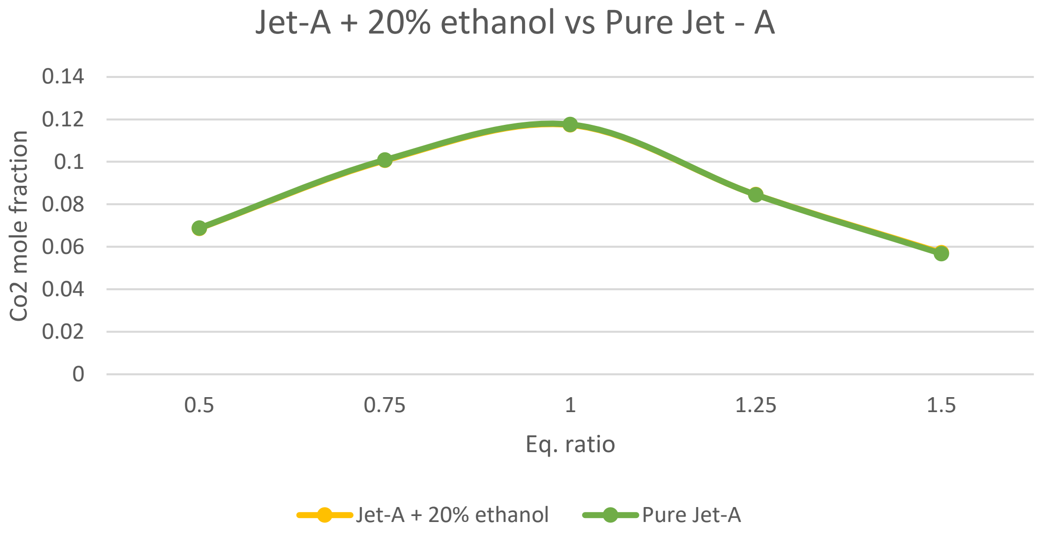


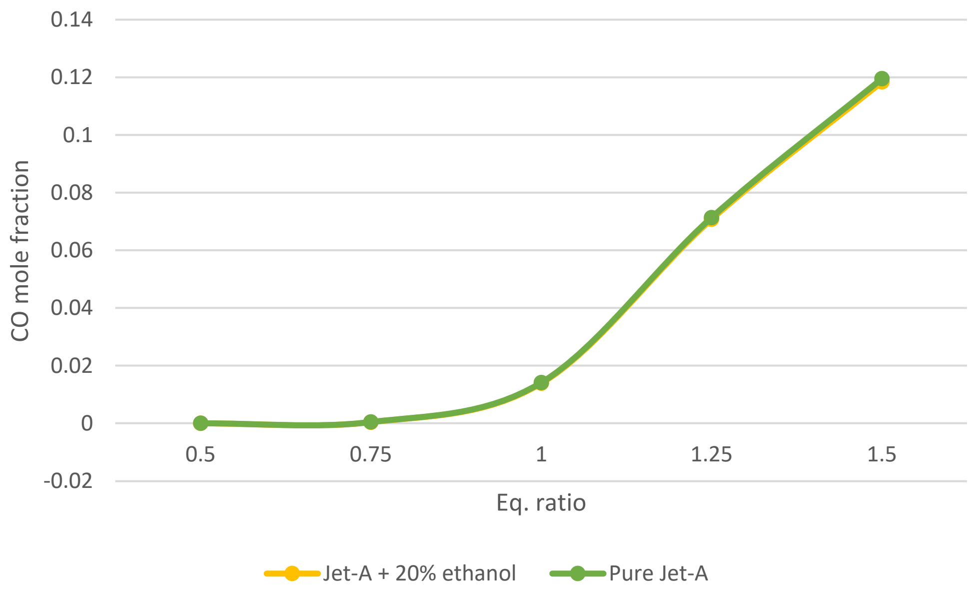


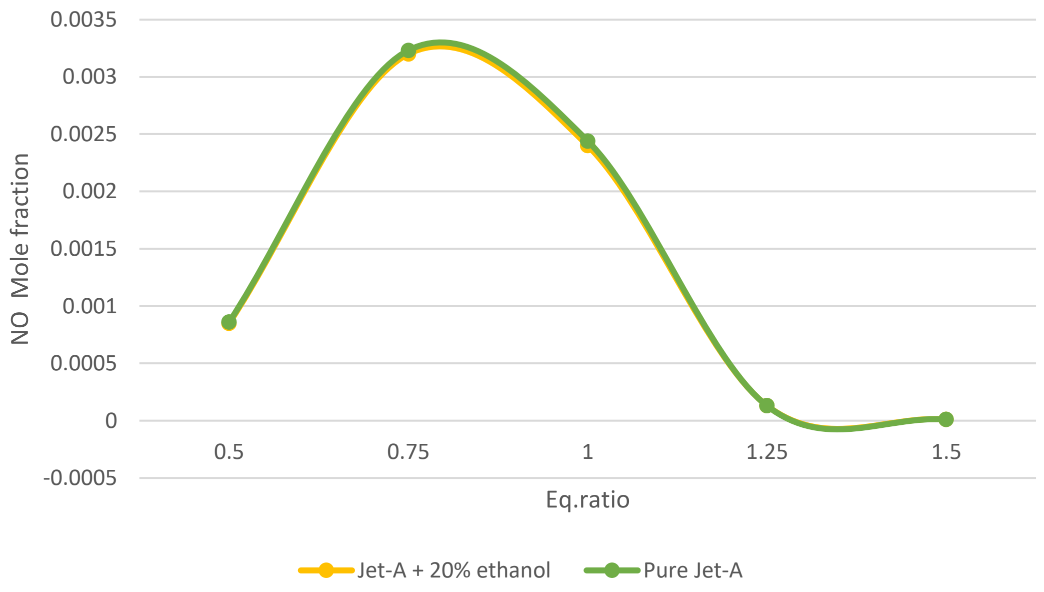


Comparison between Jet-A + 20%ethanol vs Pure Jet - A

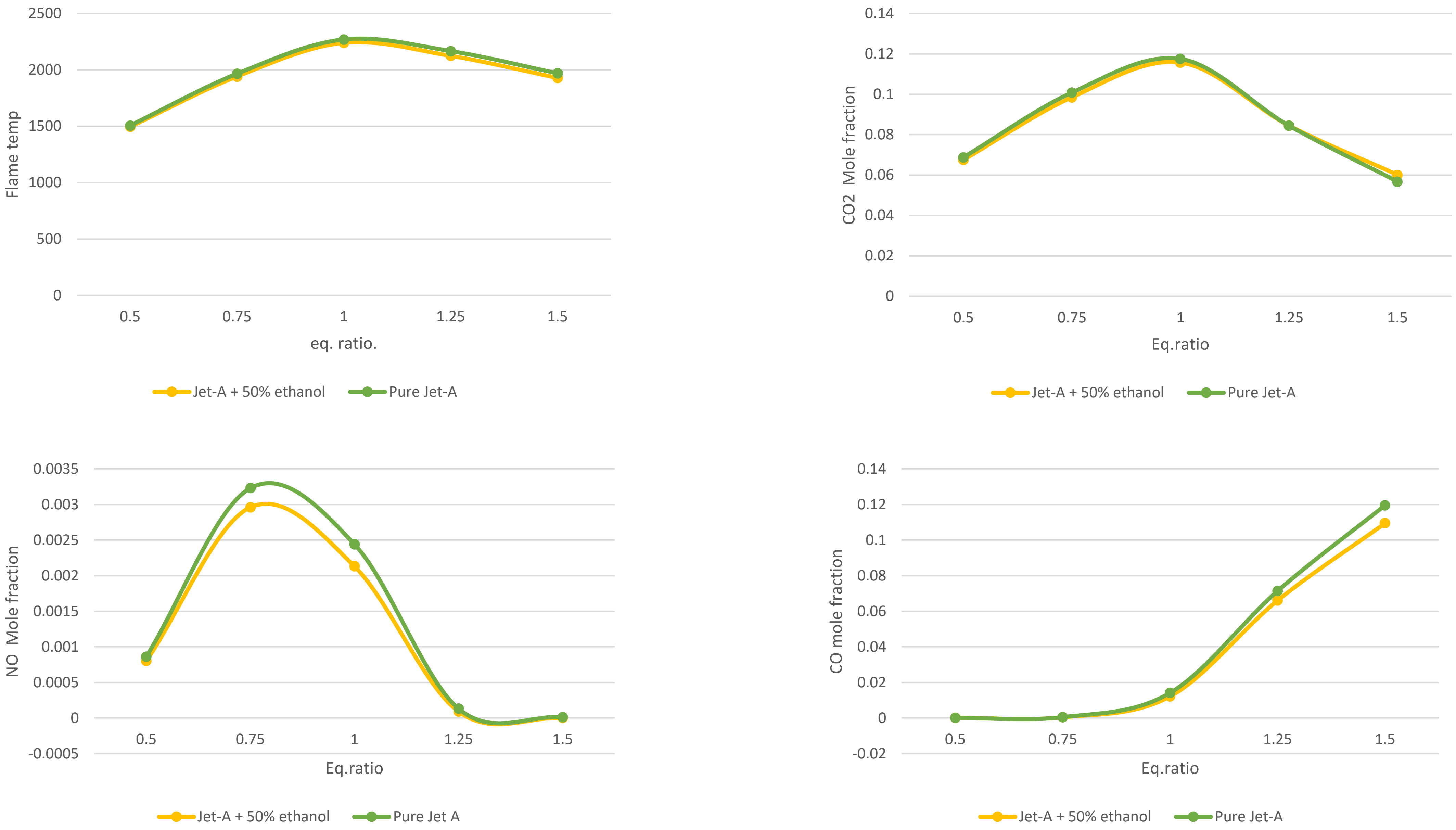




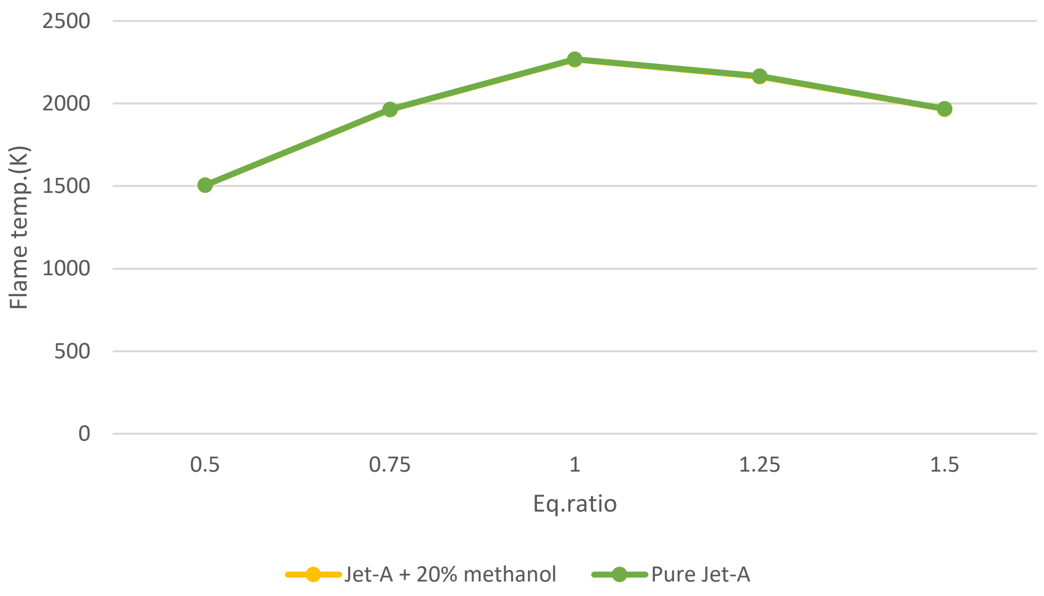


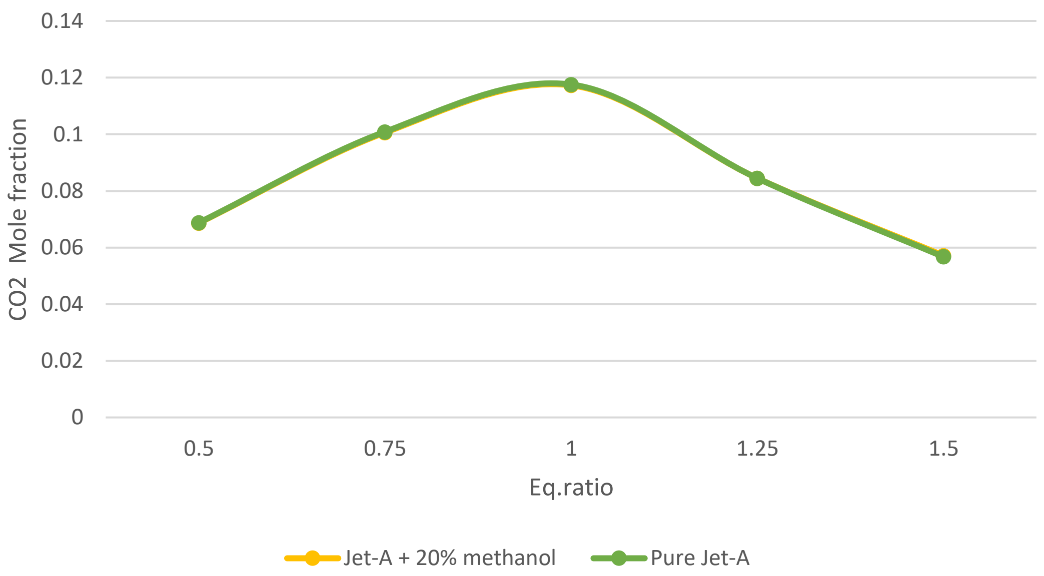


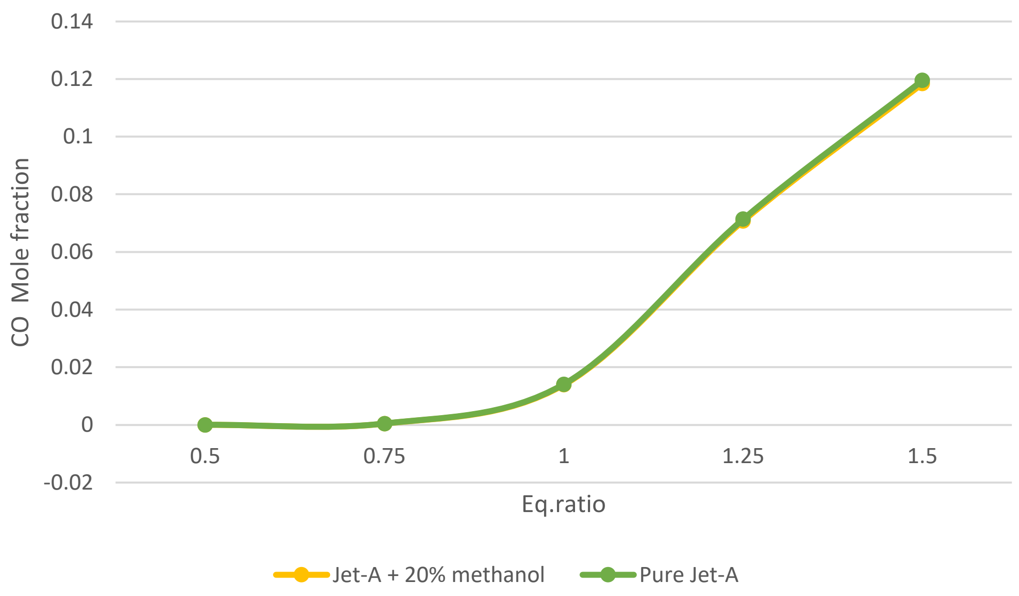
Comparison between Jet-A + 50%ethanol vs Pure Jet - A

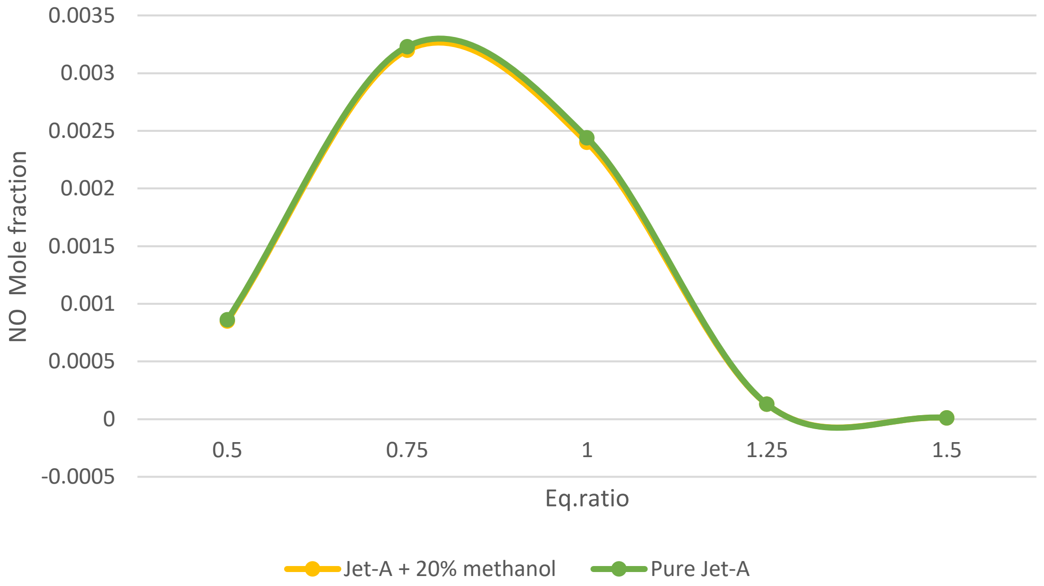


Comparison between Jet-A + 20% methanol vs Pure Jet - A

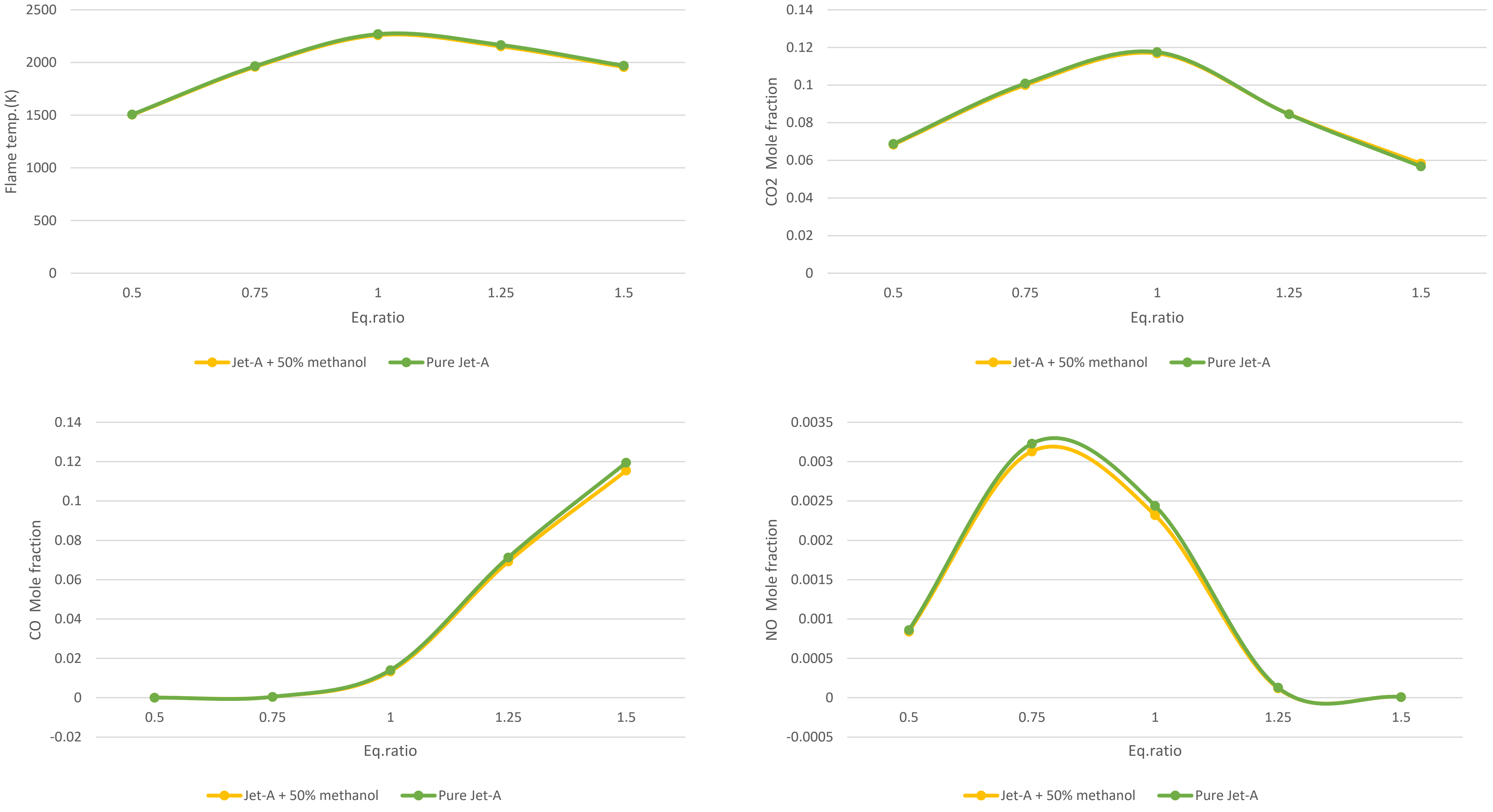








Comparison between Jet-A + 50% methanol vs Pure Jet - A



Finally conclude and express your views on the potential aviation fuel.

If we see the eq. ratio vs flame temp. graph (Page 1) at stoichiometry for pure Jet-A fuel the flame temp it is giving is 2269.6K and from Jet-A + 20% methanol combination it is giving 2266.84 K which is almost near about values, so if we consider the Gas turbine engine, turbine blade material is going to face this much high temp. so the disadvantage is that it can have material melting issue because the temp. is more than 1500K hence to prevent from such issue we need to use additional blade cooling technology or we need to put extra effort to give turbine blade coating or we need to use different costly material. So the designer have the priority of cost he/she should go for – we should go for pure methanol fuel because its giving lowest temp. of 2148.45K.

But, if we see from the advantage prospective one can have higher turbine inlet temperature(after combustion) and take advantage of more work output from turbine and can get more exit velocity from gas turbine engine result in higher thrust – hence once should go with stoichiometry with pure Jet-A fuel.

Now if you see from the prospective of aviation industry, 1st point - they always concerned about fuel consumption (they always want SFC of the engine to be low as much as possible), moderate thrust(not very high speed) so hence we can go with less temp. fuel - Methanol will be the best option from these. (1474.75K).

2nd point – if you see the methanol CO and NO mole fraction at eq. ratio of 0.5(even burning less fuel) we are getting the lowest mole fraction among other fuels which is good and advantageous because we know the CO and NO is harmful for human beings and atmosphere, any regulatory body will not allow to have CO and NO at the exit of combustion. - hence methanol will be the best option among these fuels.

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Continued…

From the rocket engine prospective, we always want high temp. at the exit of nozzle hence pure jet-A fuel will be the best potential fuel.

Now if you see for pure Jet-A, Flame Temperature Comparison with Pressure Variation at 10 bar pressure we are getting more flame temp. (1965.51K) means storing the propellent at high temperature can be beneficial to get a high temp. at the exit of nozzle.

Summary –

For Gas Turbine Engines:

•Flame temperature is a key consideration.
•Pure Jet-A fuel has a flame temperature of 2269.6K at 1 eq. ratio.
•Combining Jet-A with 20% methanol results in a slightly lower temperature, 2266.84K.
•High temperatures can pose material melting issues for turbine blades, necessitating cooling technology, coatings, or more expensive materials.
•For cost-conscious designers, pure methanol fuel with a lower temperature (2148.45K) is a viable option.

Advantages of Pure Jet-A for Gas Turbine Engines:

•High flame temperature can allow for higher turbine inlet temperature.
•This leads to increased work output, more thrust, and higher exit velocity from the engine.

Aviation Industry Priorities:

- Fuel consumption (specific fuel consumption or SFC) and moderate thrust are paramount.
- Lower temperature fuels like methanol (1474.75K) align well with these goals.
- Additionally, methanol produces lower CO and NO emissions at an equivalence ratio of 0.5, which is vital for regulatory compliance and environmental concerns.

For Rocket Engines:

- High exit temperature from the nozzle is desirable.
- Pure Jet-A fuel is advantageous in this context.

Consideration of Pressure Variation at 10 Bar:

- At 10 bar pressure, pure Jet-A fuel produces a higher flame temperature (1965.51K).
- Storing the propellant at higher temperatures can be beneficial for achieving a high exit temperature from the nozzle.

In summary, the choice of fuel depends on the specific application and its requirements. Gas turbine engines in the aviation industry prioritize fuel efficiency and moderate thrust, making methanol an attractive option. Rocket engines benefit from the high temperature of pure Jet-A fuel. Additionally, pressure considerations at 10 bar highlight the advantage of storing propellants at higher temperatures for achieving desired flame temperatures in rocket engines.