A Parametric Analysis on the Performance of Ideal Scramjets

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Abstract and Background

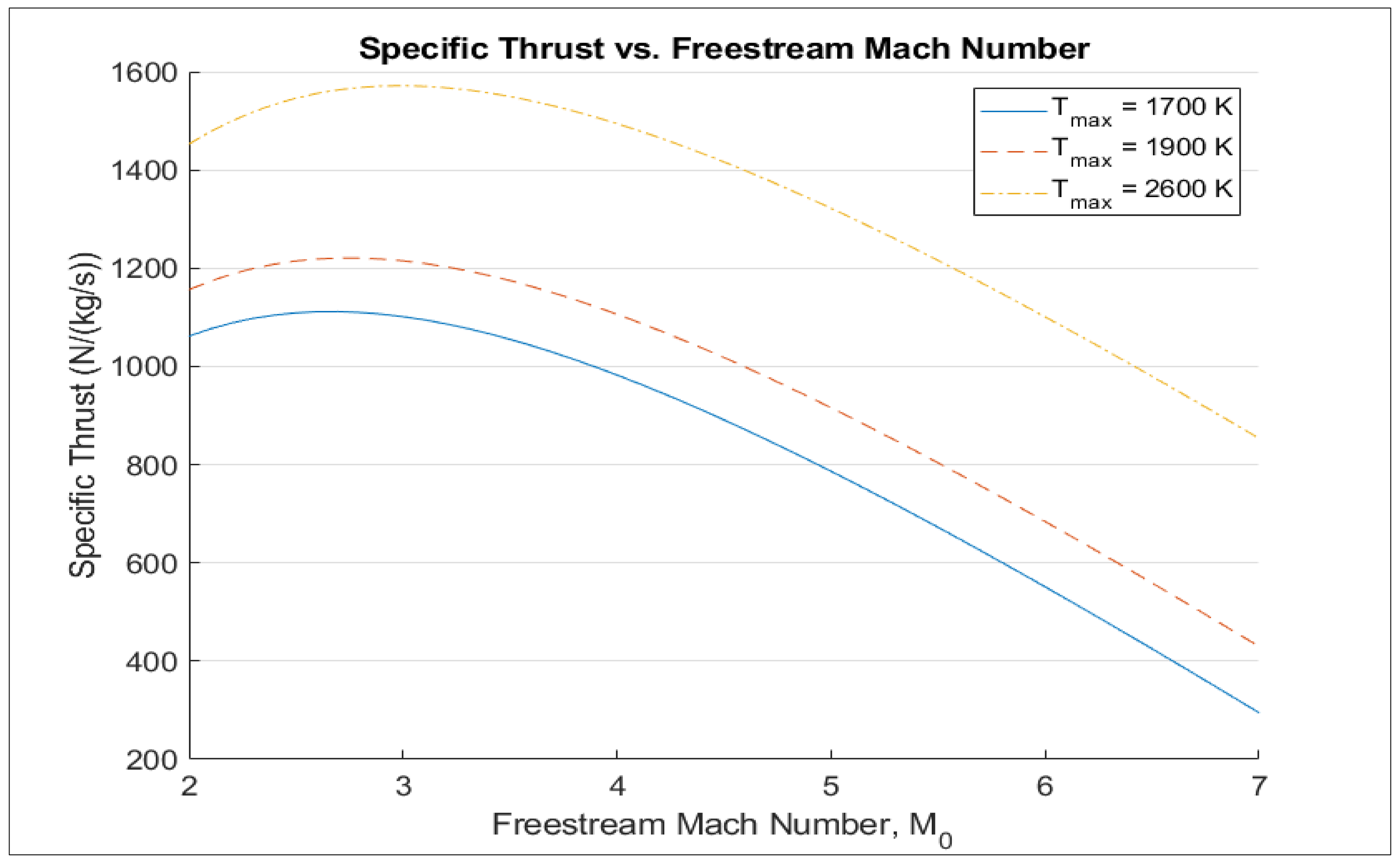
Supersonic combustion ramjets, known as scramjets, are useful for applications where hypersonic flight is desired. Main areas of research include the use of alternative fuels to reduce system weight and increase performance, and suitable combustor materials to allow for the high temperatures occurring in scramjets, and improve performance. While the research is promising, physical testing in scramjet engines can be expensive. Numerical models offer a good alternative to physical testing, and can be used to analyze trends, and to help direct physical models. The purpose of this research is to analyze the performance of a scramjet numerically using an ideal, one-dimensional thermodynamic model.

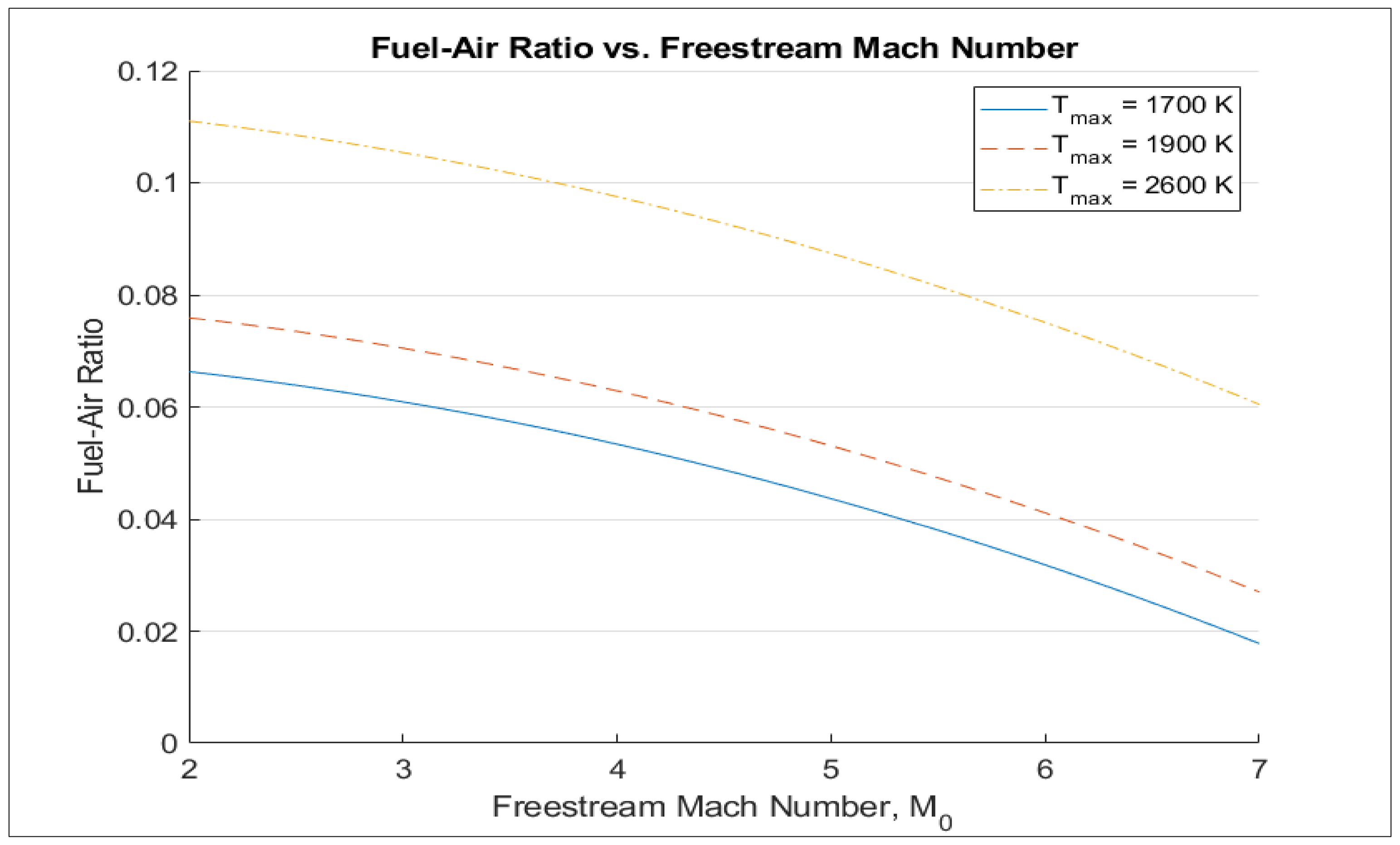
Methods

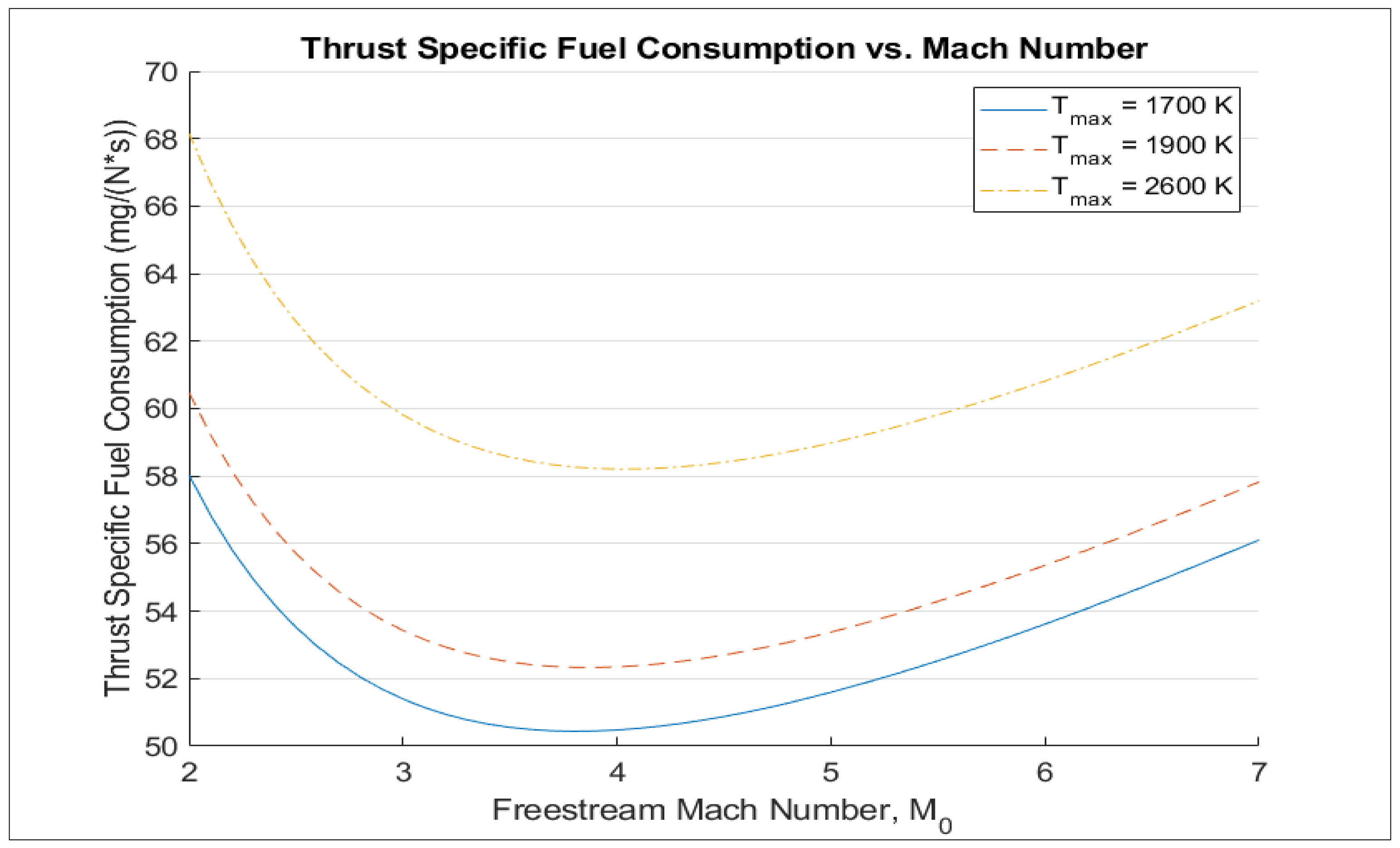
- An ideal system was setup for the analysis using these assumptions:
  - Isentropic diffuser and exhaust
  - Combustion treated as constant heat addition process
  - Combustion occurs under constant Mach number
  - Inlet and outlet pressures are equal
  - Calorically perfect air as operating fluid
- Combustor materials were varied, and were modelled using their maximum allowable temperature (T):
  - Inconel, T = 1700K
  - C-SiC, T = 1900K
  - NB-Cb752, T = 2600K
- Fuels were varied, and were modelled using their lower heating values (LHV):
  - JP-7, LHV = 43,500 kJ/kg
  - Alt. 1 (64% ethylene + 36% methane), LHV = 48,208 kJ/kg
  - Alt. 2 (60% ethylene + 30% methane + 10% n-heptane), LHV = 47,780 kJ/kg
  - Alt. 3 (44% ethylene + 56% ethane), LHV = 47,368 kJ/kg

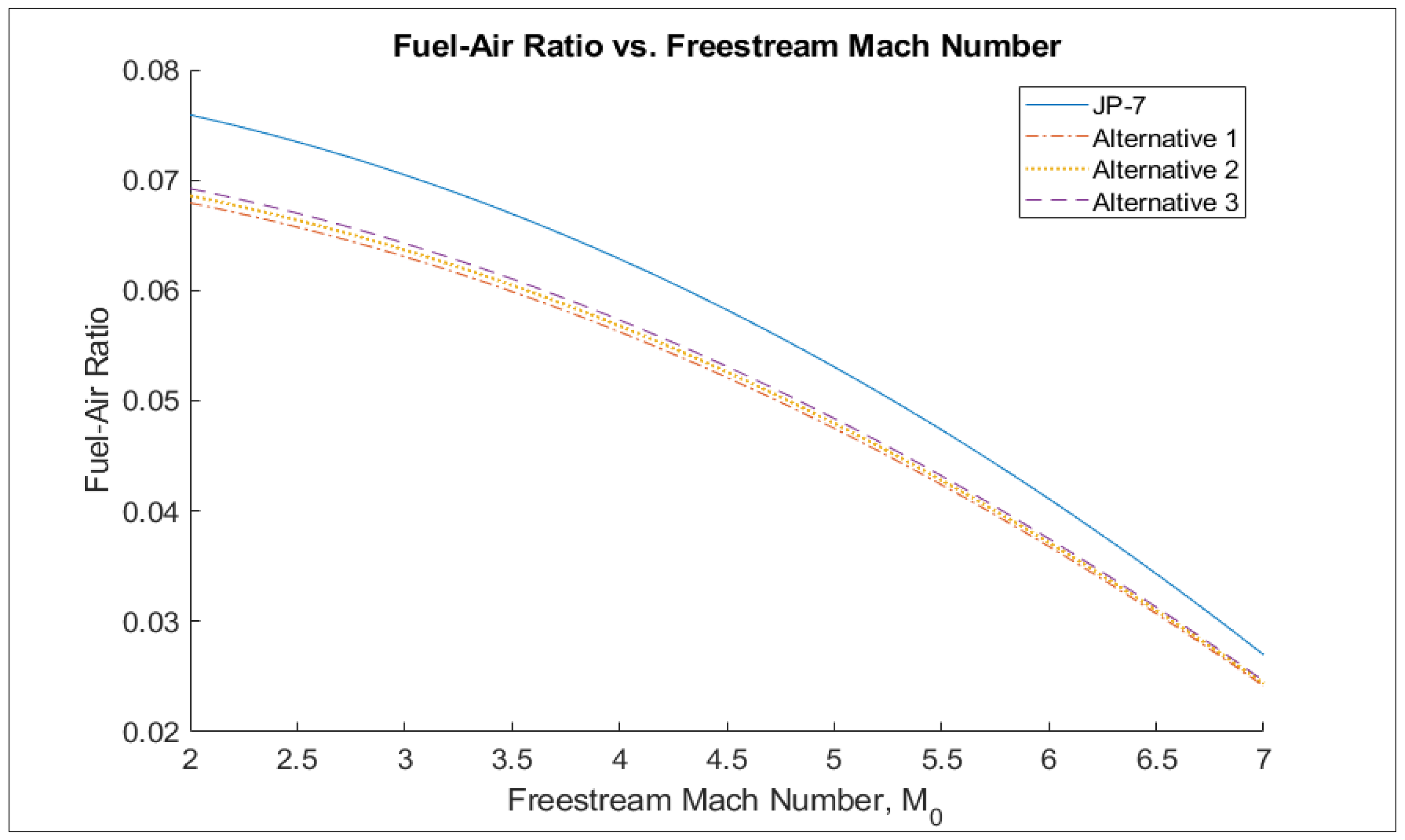
Results

The plots show specific thrust, fuel-air ratio, and thrust specific fuel consumption for the three combustor materials, and fuel-air ratio for the four fuels.









Conclusion

- The data from this analysis shows:
  - the three alternative fuels used can produce a lower fuel air ratio than JP-7.
  - increasing the maximum allowable temperature of the combustor increases thrust output, but also increases fuel consumption.

Future Work

- Future work on this includes:
  - Performing the analysis using combustion conditions other than constant Mach number, such as constant velocity, area, or pressure.
  - Comparing these results with those from more complex modelling, such as through CFD.

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