ASSIGNMENT 1

TOPIC : IDEAL AND REAL RAMJETS

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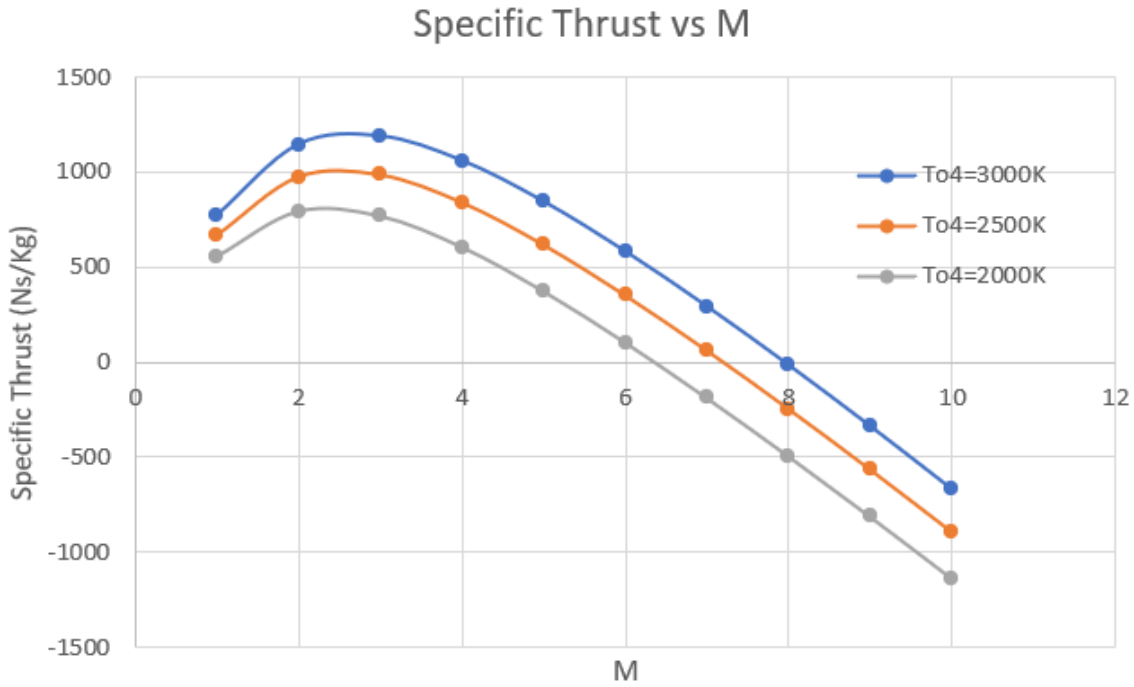
IDEAL RAMJETS

Specific thrust v/s Mach number plot

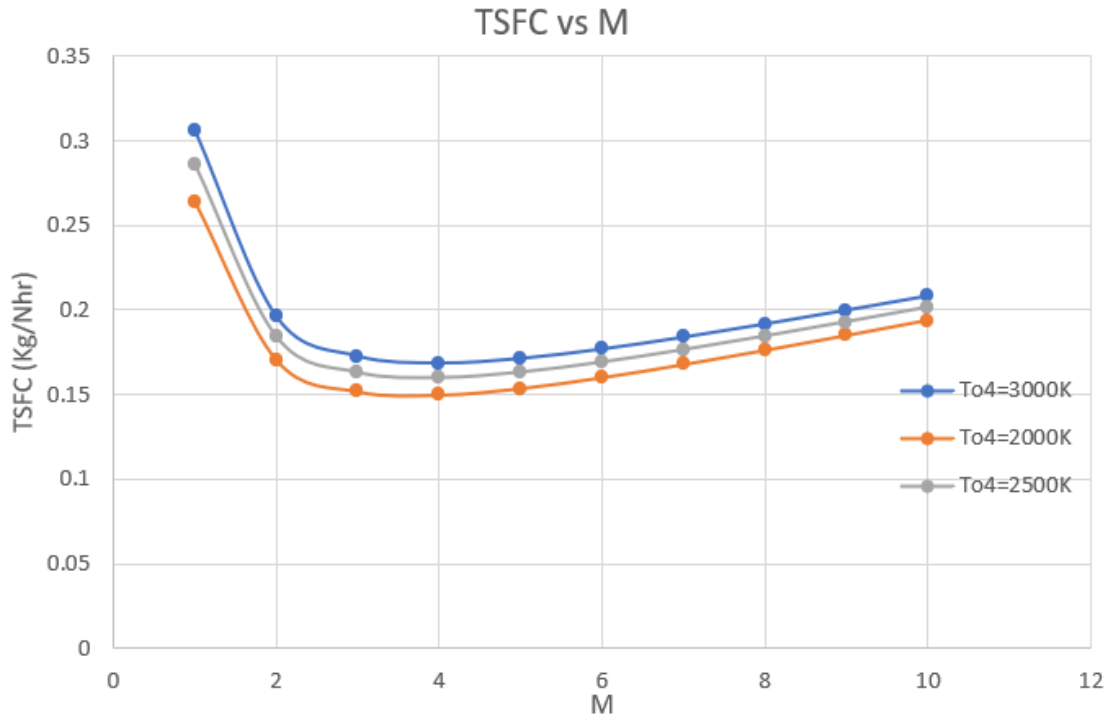
- BEST PERFORMANCE IS ACHIEVED BETWEEN M~ 2-3.
- HIGHER THE T_{MAX}, HIGHER THE MAXIMUM VALUE OF SPECIFIC THRUST.



IDEAL RAMJETS

TSFC v/s Mach number plot

- FOR SMALL MACH NUMBERS, AS M INCREASE TSFC DECREASE RAPIDLY.
- FOR LARGER MACH NUMBERS, AS M INCREASE CHANGE IN TSFC IS NOT SIGNIFICANT.

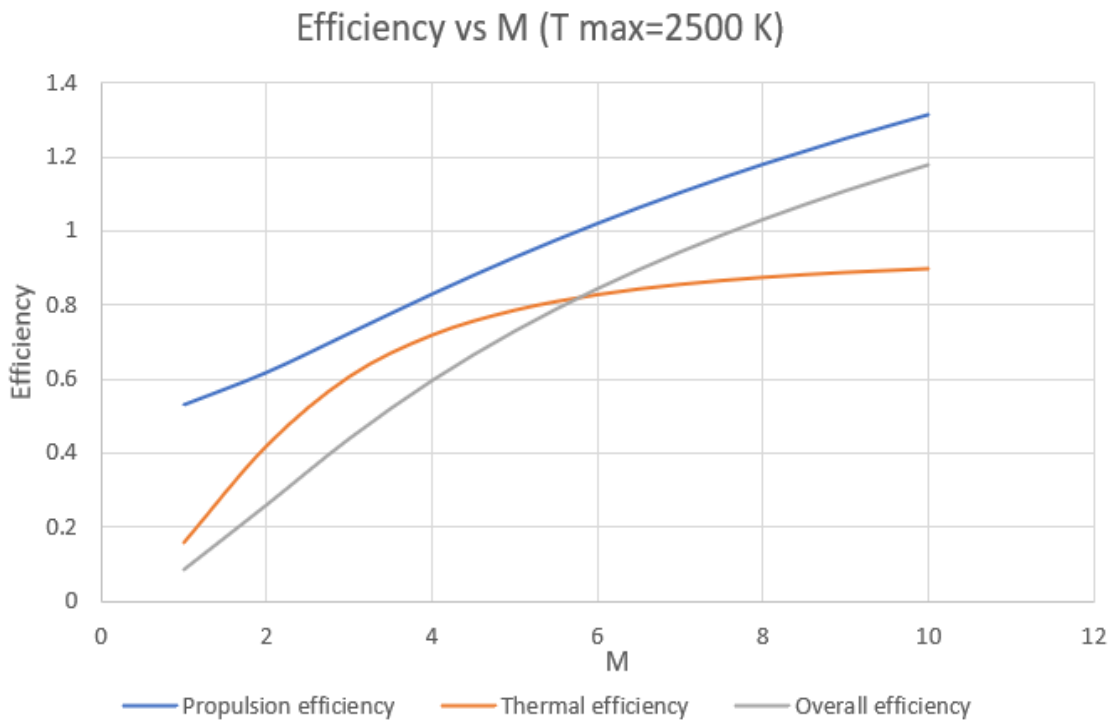


IDEAL RAMJETS

Efficiencies vs Mach number plot

- EFFICIENCIES INCREASE WITH INCREASE IN M.
- VALUE OF PROPULSION EFFICIENCY IS HIGHER

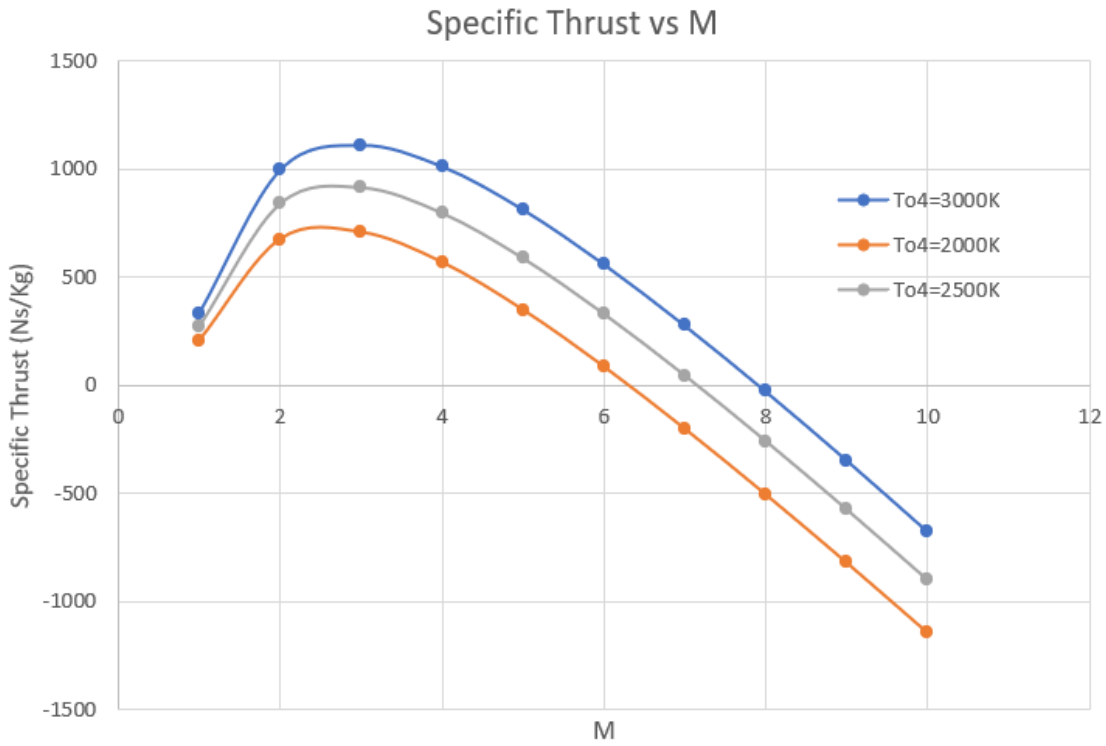
THAN THAT OF THERMAL AND OVERALL EFFICIENCY.



REAL RAMJETS

Specific thrust v/s Mach number plot

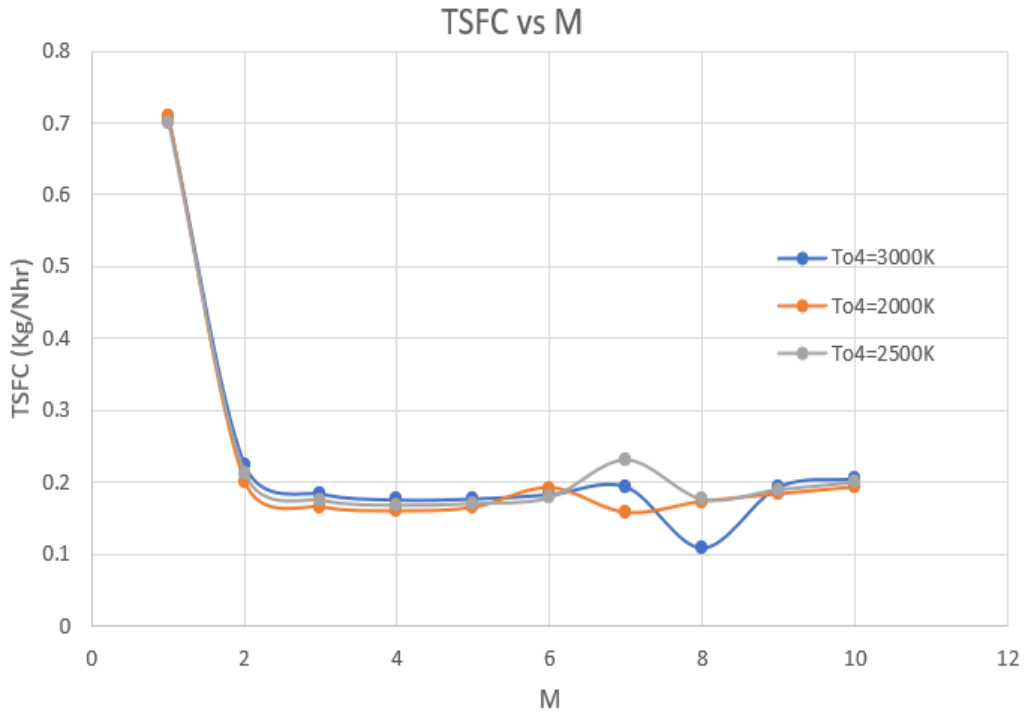
- THE SPECIFIC THRUST INCREASE TO A MAXIMA, AND THEN DECREASES.
- AFTER A CRITICAL MACH NUMBER, THE SPECIFIC THRUST TURNS NEGATIVE.



REAL RAMJETS

TSFC v/s Mach number plot

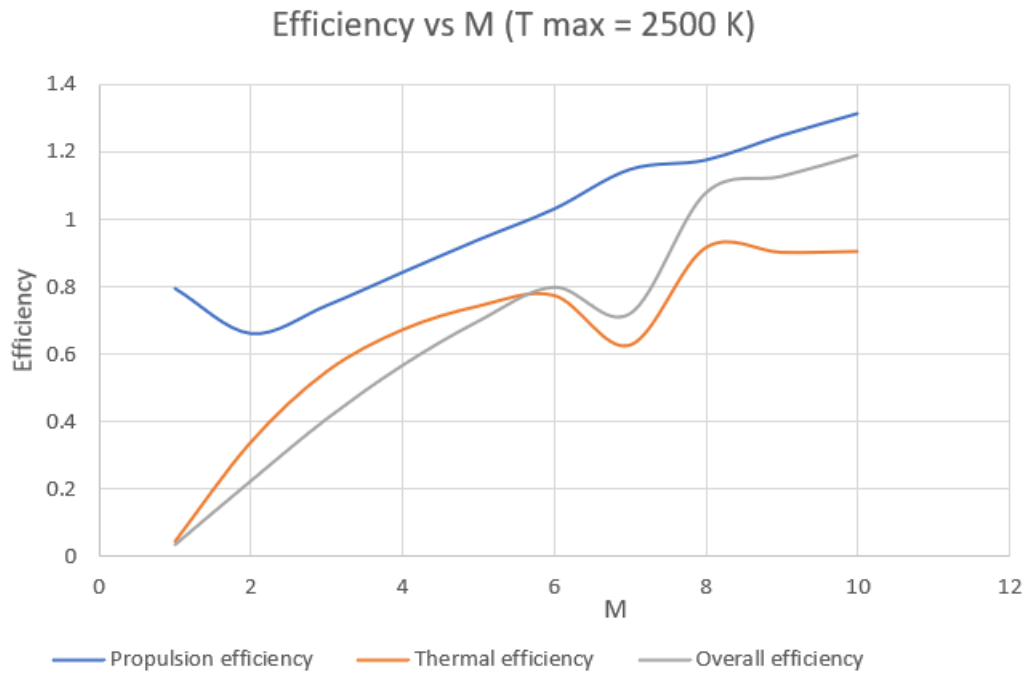
- THE TSFC VALUES CORRESPONDING TO DIFFERENT T_{MAX} ARE CLOSER.
- THERE IS A STEEP DECREASE IN TSFC VALUE BETWEEN M~ 0-1



REAL RAMJETS

Efficiencies vs Mach number plot

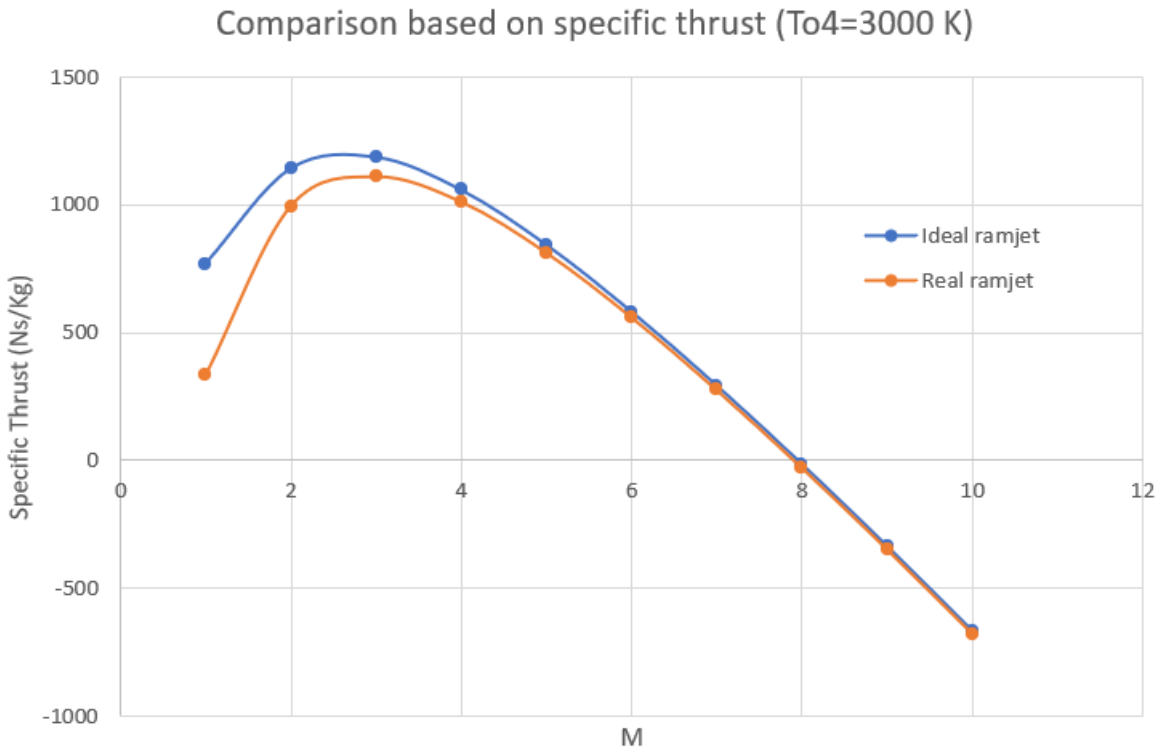
- PROPULSION EFFICIENCY DECREASE UPTO M~2, THEN INCREASES.



IDEAL VS REAL RAMJETS

Comparison between Specific thrust (T_{MAX}=3000 K)

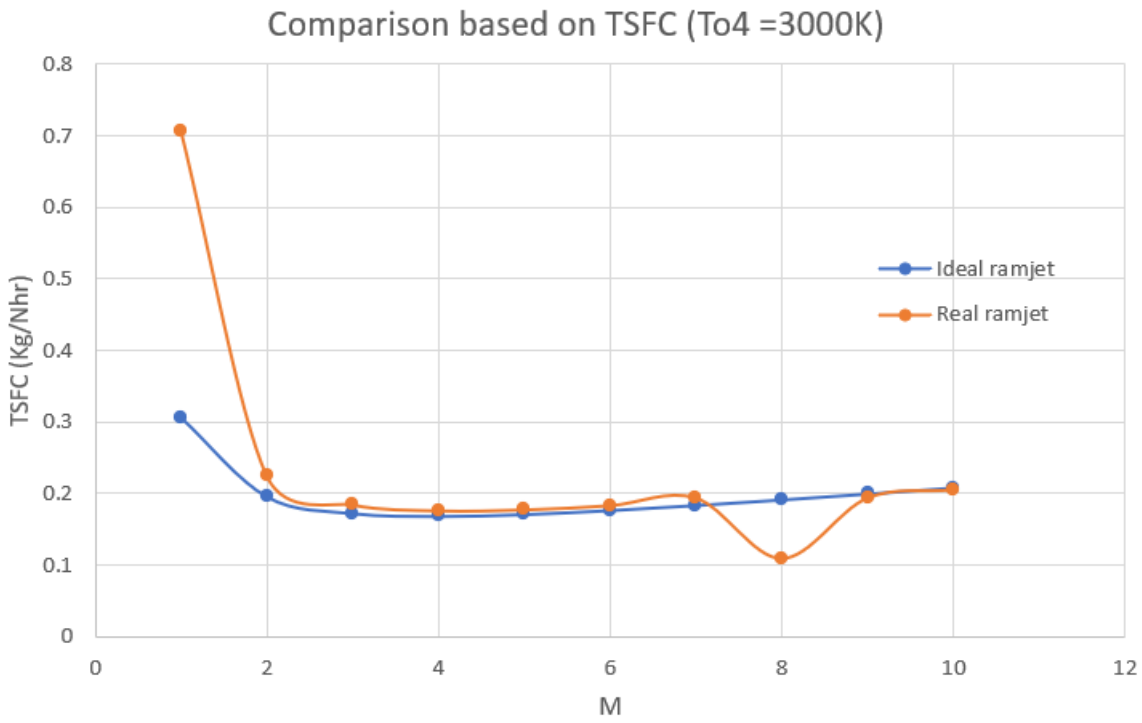
- THERE IS A REDUCTION IN SPECIFIC THRUST COMPARED TO IDEAL RAMJET.
- THE DIFFERENCE IN SPECIFIC THRUST VALUE IS SIGNIFICANT AT LOWER M VALUES.



IDEAL VS REAL RAMJETS

Comparison between TSFC values (T_{MAX}=3000 K)

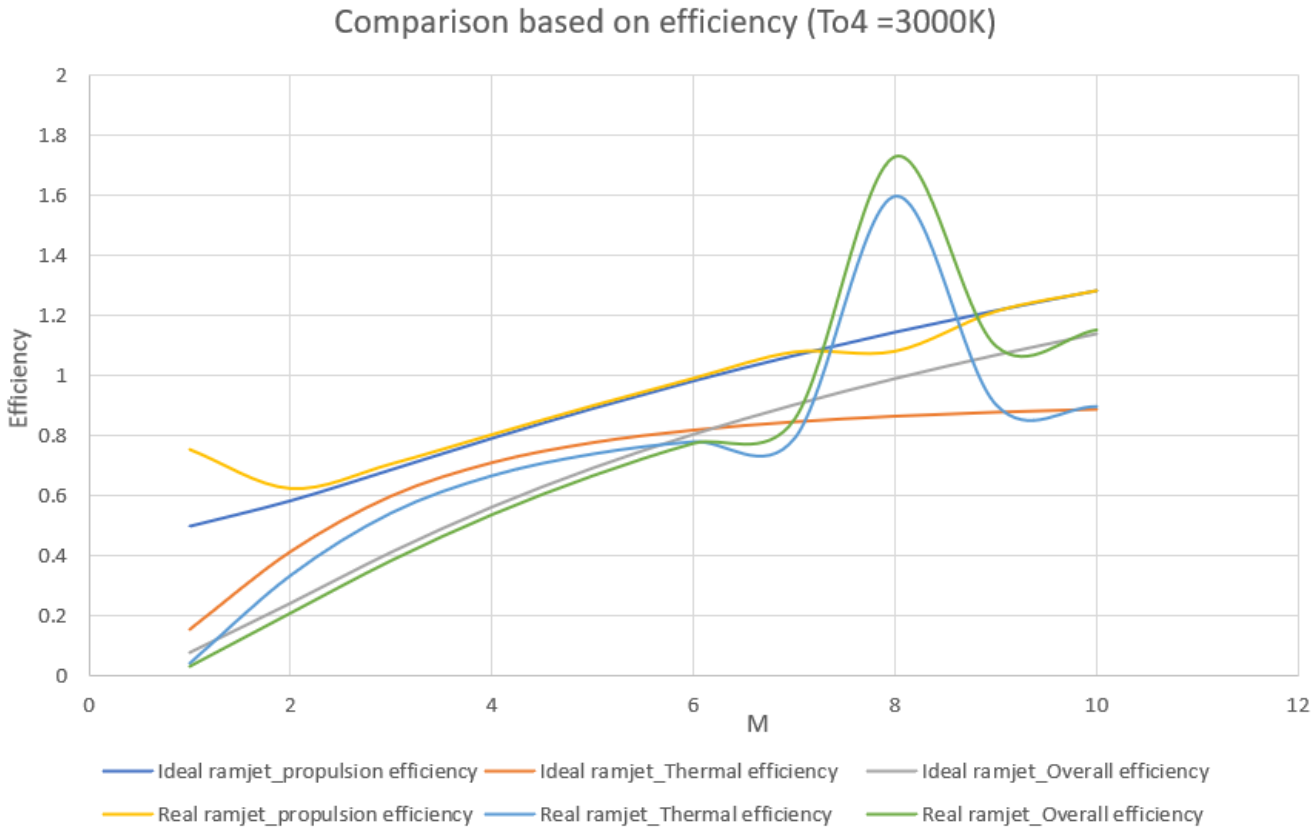
- INCREASE IN TSFC COMPARED TO IDEAL CALCULATIONS.
- THE DROP IN TSFC VALUE FOR LOW M IS MORE IN REAL CASE.



IDEAL VS REAL RAMJETS

Comparison between Efficiencies (T_{MAX}=3000 K)

- OVERALL EFFICIENCY IS HIGHER FOR IDEAL RAMJET.
- AT LOW M, THERE IS A DIFFERENCE IN THE TREND OF PROPULSION EFFICIENCY.



FURTHER DISCUSSION

1. Why does specific thrust become negative beyond a critical Mach number?

The specific thrust is given by the equation $\frac{\mathcal{T}}{\dot{m}_a} = [(1 + f)u_e - u]$ .As M increase, u, stagnation temperature at atmospheric condition(T_{0a}) also increase. u_e is given by $u_e = \sqrt{T_{04}/T_{0a}}\,u$. The increase in T_{0a} is greater than increase in u, hence at higher M, the specific thrust value decreases. After a particular M(critical Mach no), specific thrust turns negative.

FURTHER DISCUSSION

2. Why does TSFC decrease with increasing Mach number?

As M increase, T_{0a} increase, hence stagnation temperature at the entry combustion chamber(T_{02}) also increase. The SFEE across CC is given by, $(1 + f)h_{04} = h_{02} + fQ_R$ .Total enthalpy is almost a constant(T_{04} achievable depends on your engine design). Due to high M, h_{02} contributed is also high. Hence there is not much need of fuel to get burnt. m_f decreases, hence TSFC decreases.

FURTHER DISCUSSION

3. Why does the propulsion efficiency increase with Mach number and Thermal efficiency curved out at high Mach numbers? (Do these values make sense at high Mach numbers? If not, why?)

Assuming f~0, propulsion efficiency is given by $\eta_p = \frac{2}{1+\sqrt{\frac{T_{04}}{T_{0a}}}}$, as M increases, T_{0a} Also increases, thus propulsion efficiency increases.

At higher Mach values, as M increase, stagnation temperature at atmospheric condition(T_{0a}) also increase and thus fuel air ratio decreases. Under the same conditions, rate of change in kinetic energy also decreases, since exhaust velocity flattens out. Thus the ratio of these quantities converges at high M.

FURTHER DISCUSSION

The efficiency values at high Mach values, doesn't make sense. As M increases, T_{0a} increases and then it exceeds T_{04}, which is the maximum temperature of the cycle. Under this situation, the cycle works without even fuel addition, this violates law of thermodynamics.

FURTHER DISCUSSION

4. Specific thrust from Real Ramjets is much lesser than that of ideal ramjet at low Mach numbers. This difference decreases at higher Mach numbers - Why?

At lower Mach numbers, the difference between the exhaust velocities of ideal and real ramjets are more. But at higher M values, both exhaust velocities get closer.

REFERENCES

- Mechanics and Thermodynamics of Propulsion, Second Edition- Philip G Hill, Carl Peterson.