Mixing Enhancement Technique in the Jet Engine Burner

Amandeep Kumar, Dharmahinder Singh Chand and Gurjit Singh

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MIXING ENHANCEMENT TECHNIQUE IN THE JET ENGINE BURNER

Amandeep kumar[a], Dharmahinder Singh Chand[b], Gurjit Singh[c]

Research Scholar [a], Mechanical Engg., Chandigarh University Mohali, Punjab 140310, India.

Professor [b], Aerospace Engg, Chandigarh University, Mohali, Punjab 140310, India.

Assistant Professor [c], Aerospace Engg., Chandigarh University, Mohali, Punjab 140310, India.

Abstract

This paper presents the enhancement of the combustion chamber efficiency owing to mixing bychanging the fuel outlet cross-section triangle, square, and circle. Measurements of centreline velocity corresponding to Mach 0.2. to 0.35 and similar measurements were carried out for all cross-section of fuel injection outlet at Mach 0.2,0.25,0.35,0.35 circle, rectangle and triangle 50.1%,57.5%,57.6%,58.35% & 51.81% ,56.46% ,56.52% ,57.31% And 54.66% ,58.83% ,58.83% ,59.62% respectively It was found that maximum efficiency was achieved by employing triangle cross-section of injector since it has two-point contact with the incoming air, which in turns enhances the mixing property.

Keywords: combustion chamber, fuel injector, Mach number, etc.

1. Introduction

A combustor is vital for a gas turbine, ramjet, and scramjet motor any recognize the air-fuel blend stays consumed to pass on the shining energy .it is known as a flame or a starts compartment. popular fuel turbine motor, beginning compartment is dealt with high strain airborne by utilizing the weight gadget. The combustor around formerly warms the airborne in the isobaric condition. After the warming framework, air passes after the combustor by techniques for the spout regulator vanes to the turbine. Asa result of scramjet and ramjet motors, the airborne rapidly is managed toward the spout .in the devouring compartment, combustor mixing is done around there where the oil and airborne jointogether and depleted through the spout

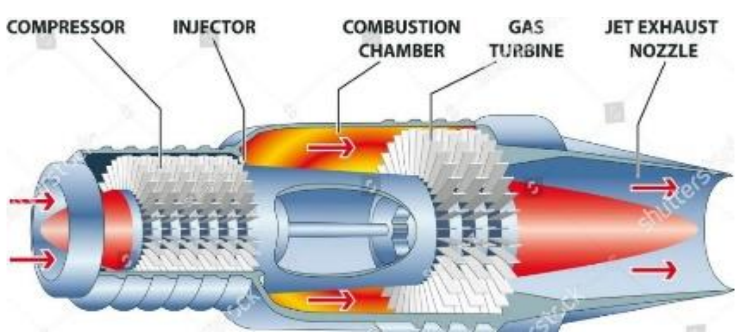


Fig. 1 Schematic diagram of a jet engine

Types of the combustion chamber

- **Can**: they can type ignition office of a gas turbine motor has a hole shaped by the body obliging a fire tube having a swirled, burning zone, blending zone, and a sparkle plug. the cylindrical ignition compartment is

- made for consuming a hydron gen-oxygen blend

- **Cannular**: The following kind of combustor is the cannular combustor; the time is a portmanteau of "can annular". Comparable to the can class combustor, can annular combustors devour separate burning zones controlled in distinct liners through their fuel injectors.

- **Annular:**

  The most commonly used sort of combustor is the completely annular combustor. Recirculation compressors do go with inhibits burn areas and have an unceasing filler and wrapping in a loop

1.2 Mixing

Mixing play important role in achieving satisfactory combustor performance and reduce the emissionof harmful gases like carbon monoxides and nitrogen oxide

A **stoichiometric** reaction is one where the reactants are completely consumed with nothing left over,to produce stable products of the highest possible (negative) heats of formation

Equivalence ratio, fuel-lean/fuel-rich

Equivalence ratio $\phi =$ Actual fuel-air ratio by mass / Stoichiometric fuel-air ratio by mass

- Stoichiometric mixture: $f = 1$
- Fuel-lean mixture: $f < 1$
- Fuel-rich mixture: $f > 1$

In a rich mixture, fuel is excessive which provides enough fuel to use all the oxygen but there are not enough air molecules to use it. A lean mixture means less fuel and excess oxygen but, in this case, fuel economy is more. In combustion mixing the region where the proficiency of the engine depends onnozzle angle, nozzle size, nozzle pores, etc. For incomplete scorching discharge of the NO (nitrogen oxide) and CO (carbon monoxide) released can harm the environment

1.3 Liquid fuel injection

The main purpose of fuel injection is to prepare a fuel-air mixture suitable for the combustion process.

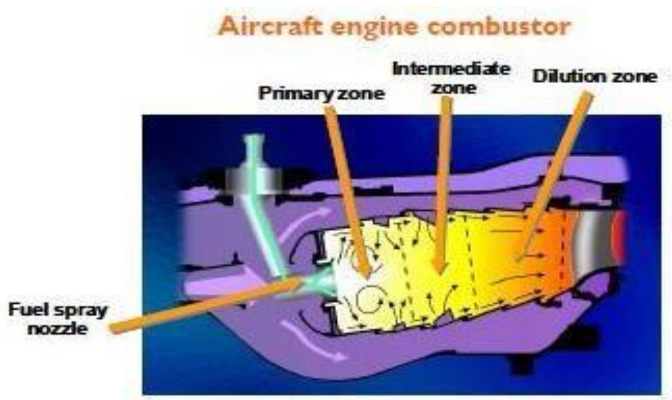
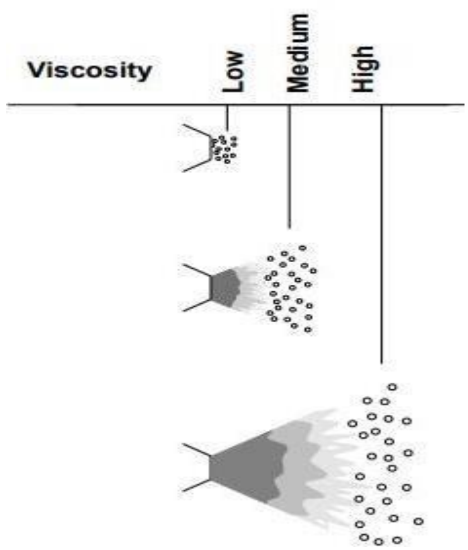


Fig.2 schematic diagram for liquid fuel injection combustion chamber

- **Primary Zone** where the mainstream of the oil ignition incomes dwelling
- **Intermediate Region** is the air vaccinated hooked on the combustion region through the additional setof lining cells
- **Dilution Region** is airflow vaccinated done dumps in the facing at the end of the combustion compartment
- **Fuel Spray Nozzle** is rummage-sale to provide improved mixing of the oil and airflow to provide anoptimum spray for combustion

Atomization: Atomization refers to the procedure of breaking up bulk liquids into droplets**.**



(Fig 1.3 schematic diagram of atomization)

2.Literature review

Some authors have completed experimental and simulation studies on combustion mixing to increase the performance of the engine. Some procedures/methods are revealed below

Semiha Oztuna et al [1]

In the current examination, the impacts of hydrogen advancement CH4 are explored mathematically after dissemination fire arrangement and outflows viewpoint. Familiar code is used as the re-enactment device. Four tests were led utilizing petroleum gas as fuel. The outcomes show that the hydrogen expansion to methane fundamentally changes the dissemination fire arrangement in the ignition chamber. The hydrogen-advanced flares develop more extensively and are more limited to regard to the unadulterated methane fire. The most extreme temperature esteem is determined as 2030 K for the case with a 15% hydrogen expansion proportion by mass.

Mohamed Mahdi et al [2]

This paper presents a mathematical examination of a burner of 25 kW power. It assesses the impact of hydrogen on the elements, the dissemination of temperature, the soundness of the fire, the variety of species mass part (CO, CO2. . .), and the radiative warmth transition. Results show that the expansionof hydrogen considerably affects dynamic conduct and fire temperature. The utilization of hydrogen-advanced fuel mixes, for example, syngas, offers extraordinary potential in the decarbonization of gas turbine advances, the authors say. The authors conclude that CH4 results in a more grounded hindering impact on the response science of H2compared to H2. They conclude that scaling connections can furnish sensible concurrence with tests of hydrogen fuel mixes in a back-to-consumed contradicted stream setup.

T. Boushakia,b et al [3]

This paper presents an examination of the dynamic attributes of non-premixed fierce twirling blazes utilizing the sound system PIV method. The outcomes clarify one potential component for the abatement of the NOx emanations when the worldwide proportionality proportion increments employing an expansion of the entrainment rate at the firebase. The results show that the presence of the fire instigates a bigger spiral stream development, higher mean speeds, and higher choppiness forces. It is additionally indicated that the variances of the digressive speed are mostly liable for the most noteworthy choppiness dynamic energy levels at the highest point of the focal distribution zone

Alejandro M. Briones et al [4]

The impacts of H2 improvement on the spread of laminar CH4–air triple blazes in axisymmetric coflowing planes are mathematically explored. A far-reaching, time-subordinate computational modelis utilized to re-enact the transient start and fire engendering marvels. The fire structure and fireelements are specially altered by H2 enhancement, which generously builds the fire arch and combination division angle. The H2 expansion too alters the fire affectability to extend, as it diminishes the Mark stein number (Ma), inferring an expanded inclination toward diffusive–warm flimsiness.

Zhichao Chen a,b et al [5]

A three-segment molecule elements anemometer is utilized to gauge, in the close burner locale, the attributes of gas/molecule two-stage streams with a midway fuel-rich twirl coal ignition burner also, upgraded start double register burner. Speeds, RMS speeds, molecule mean distances across andmolecule volume transition profiles were gotten. For the halfway fuel-rich burner, particles infiltrate thefocal distribution zone incompletely and are then diverted radially.

E. Distasoa et al [6]

The authors conclude that CH4 results in a more grounded hindering impact on the response science of H2compared to H2. The utilization of hydrogen-advanced fuel mixes, for example, syngas, offers extraordinary potential in the decarburization of gas turbine advances, they say. They conclude that scaling connections can furnish sensible concurrence with tests of hydrogen fuel mixes.

Chinonso Ezenwajiaku et al [7]

Polycyclic fragrant hydrocarbons (PAHs) are the cancer-causing segments of ash. This study presents a trial procedure to break down PAH development qualities of a non-premixed methane-air fire with and without hydrogen (H2) expansion. PAH fluorescence power surpasses were seen to increment with expanding tallness above the burner, anyway, this pace of increment decreased with H2 expansion. The proposed exploratory strategy for PAH estimations can be promptly applied to any fuel combinations.

Muzafar Hussain et al [8]

Micromixers are along these lines the innovation suggested for oxy-fuel burning in zero-outflow power plants. Advancing the fuel with hydrogen was found to help fire dependability, which considered lessening the oxygen division further down to a record-low estimation of 13% at a hydrogen part of 65% (by vol.) This offers incredible operational adaptability and spearheading improvement in the turndown and low-load abilities of the cycle, the study found. The outcomes likewise indicated that hydrogen advancement has a negligible impact on fire temperature, what's more, combustor power thickness.

M.S. Irandoost n et al [9]

Micromixers were proposed for oxy-fuel burning in zero-outflow power plants. Micro mixer gas-turbine breakthrough combined with hydrogen advancement to add oxy-fuel burner for use in the Allah power zero-discharge. Advancing the hydrogen fuel was found to assist fire efficiency, which considered dropping the oxygen division further down to a record-low estimate of 13 percent at a 65 percent hydrogen component.

Ahmed E.E. Khalil et al [10]

Colorless Distributed Combustion (CDC) has appeared. CDC rules incorporate the controlled cluster ofhot responsive species to frame a low grouping of oxygen from inside the combustor. Comparing the acquired information Liquid powers with vaporous fills have indicated that the pervasive CDC can be resolved at the oxygen fixation, paying little mind to the fuel utilized. The blend temperature inside the scope of 0.75%.

Kurji el at [11]

Syngas or biodiesel can be used to meet gas turbine operating costs. The use of mixtures of biodiesel and CO_2 / CH_4 blends resulted in lower CO production, that is, 87 percent lower at 10 percent CO_2 forthe situation. Results showed that a significant decrease in NOx of ~ 50 percent was achieved in all Conditions for blends of biodiesel /CO_2 /CH_4. The fuel is initially either liquid or solid. Determines trends in NOx and CO emissions. At different equivalences, a comparison between the blends was carried out Proportions.

Zakaria Mansouria et al [12]

This paper centres around the CH_4/air non-premixed fire settled trial and mathematical examination. Fire dwells under a worldwide equality proportion of = 0.8, a worldwide identicalness proportion Elevated twirl of Sn=1.4 and at encompassing weight. The investigation of normal results for both demonstrates the presence of a focal distribution zone (CRZ), a whirling plane field (SJ), and shear layers (SL) hydrogen is added and hydrogen ranges from 0 to 15 percent, says the study. It further increases the characteristics of auto-ignition and the global heat release rate.

Zakaria Mansouria et al [13]

The Kelvin-Helmholtz flimsiness prompted ring structures and the twirling shakiness-initiated finger structures. The whirling plane at that point turns out to be full-grown, with a 222 Hz swayingrecurrence. The stream in the region of offal complex conduct, including a distribution locale, includes an injector. At the burner leave, the 3D stream structure, Vortex dangers are the primary ones.

M.A. Mergheni et al [14]

Paper examines the impact of the proportionality proportion on no prefixed qualities'- methane fire with secluded planes from a burner. The 25-kW power burner is made out of Three synchronized planes, a solitary focal stream of methane encompassed by two planes of oxygen. To consider the cooperation of choppiness response, the swirl scattering model is applied. The investigation wasdirected with different proportions of worldwide comparability (0.7, 0.8, and 1)

K.K.J. Ranga Dinesh et al [15]

Fire highlights of whirling non-premixed H2/CO syngas fuel combinations were mimicked. The combustor formation chose remains the TECFLAM Bunsen burner. Diffusivity of hydrogen in H2-rich fuel is principally answerable aimed at the making of a lot heavier fire in a whirling fire. The estimates for H2 and CO-rich blazes show significant varieties among speed and CO-rich flares.

Zouhaier Riahi et al [16]

Now air combustion, nitrogen produces low-slung combustion yields and high energy consumption. The calculation of hydrogen to natural gas, Combustion means the rise in temperature of the adiabatic flare. Improves the stability of the flame, increases CO2 emissions, reduces the formation of CO, but favours NOx, according to research in the journal Chemiluminescence.

M. Saediamiri et al [17]

Nonprefixed biogas fire relentlessness was probably focused on fluctuating the fuel Composition and CO2 and changing the math of fuel spouts. The fuel was delivered through an encased central spout. A co-centre breeze current that experiences a generator of low-spin (25-point vanes). The closures showed that the imperatives of the bio as fire sufficiency are especially sensitive to the structure of the fuel. It broadened the authenticity of these associations with have all turning bursts that are non-premixed and premixed

R. W. SCHAEFER et al [18]

Whirl, utilizing 45-degree twirl vanes, was applied to the stream. The burning happened at barometricalweight inside an air-cooled quartz chamber. Estimations of the gas test were gotten to show decreases in CO fixation with hydrogen. Close to the slight soundness limit, the fire structure Direct brilliant pictures and planar laser actuated fluorescence estimations have been recognized. The reformist OH. Results recommend that the expansion to the methane/air combination of a moderate measure of hydrogen.

Michael Seibert et al [19]

Hydrogen delivers equal advantages to pure benefits when provided as part of a "reformer petrol" combination. Tests used JP-8 and either hydrogen or bottled flames to test the temperature profiles of dual shot flames. Combustion is pushed earlier from all supplementary fuels, making more stable and reduced-size potential. To sustain fuel energy intake at a constant stage, the the-8 flow rate was decreased to 5.5 kW.

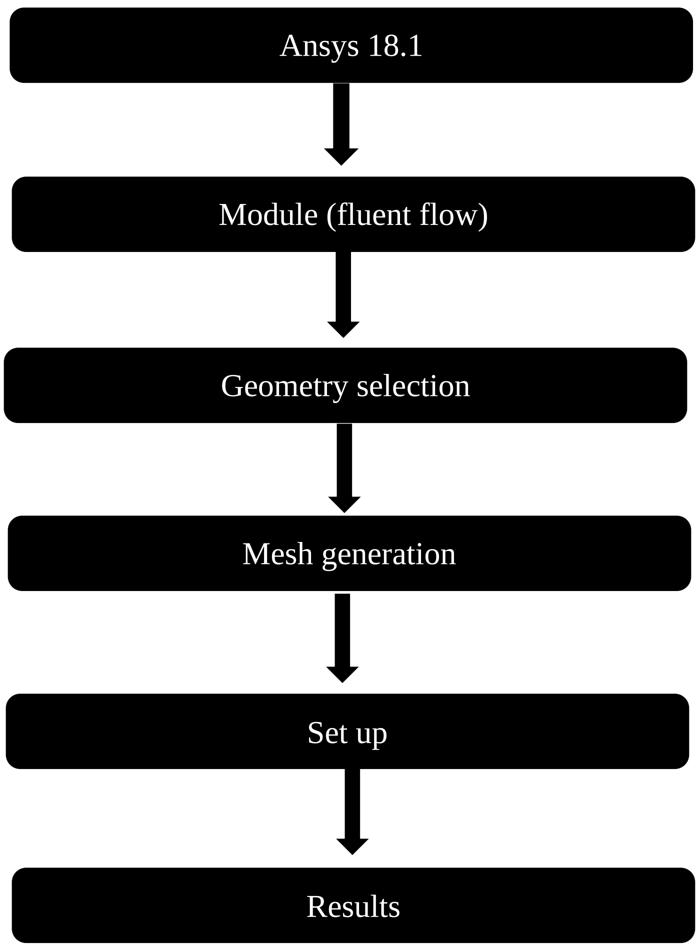
flamesF. Hamppa,b et al [20]

Hydrogen-enhanced fuel mixes, for example, syngas, proposition extraordinary impending in the decarburization of gas turbine advances through replacement formerly development of the thin working cut-off. It is demonstrated that CH4 has a more grounded hindering impact on the response science of H2. The authors conclude that scaling connections can give sensible arrangement tests to determine the properties of the hydrogen-advanced fuel.

3.Objective

1. Mixing enhancement by varying injection outlet cross-section
2. Incrementing combustion efficiency
3. Reduction in specific fuel combustion

4.Methodlogy



Parameters	values
Mass flow rate of air	0.6 kg/s
Mass flow rate of main flow	0.0015kg/s
Fuel temperature	293k
Atomization pressure	0.6, MPa
Diameter of liquid fuel droplets	0.04mm

Table.1 parameter for present study

Geometry

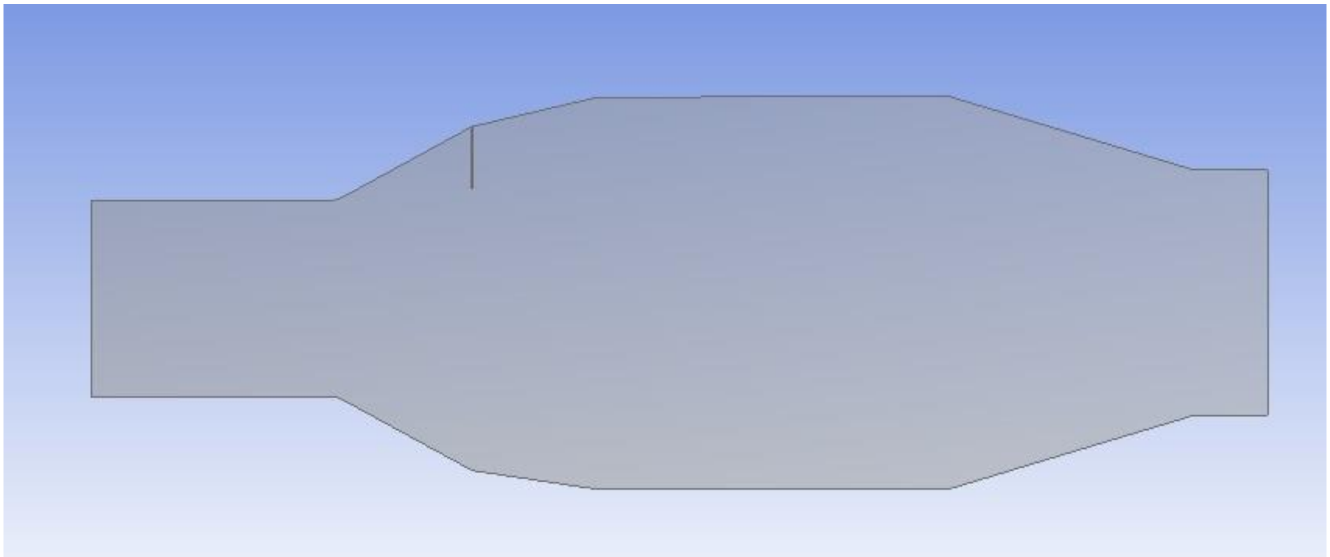


Fig. 3 schematic diagram of combustion chamber

Meshing

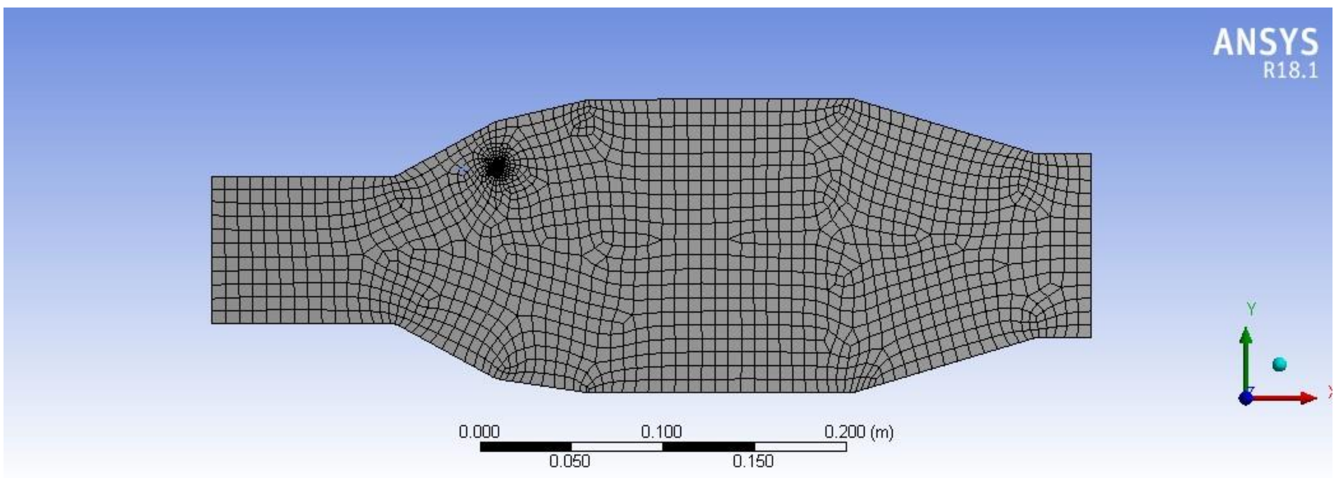
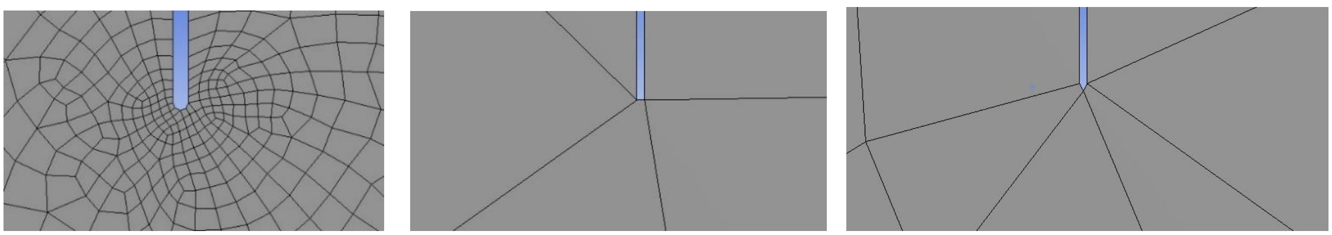


Fig. 4 Meshing

Types of cross section



a) Circle b) Square c) Triangle

For circle Cross section

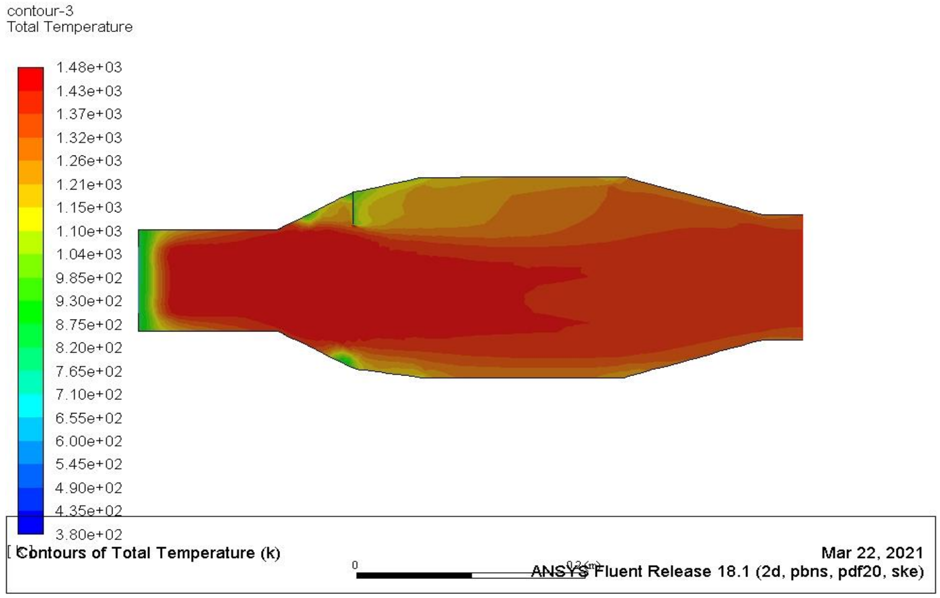


Fig.5 total temperature at Mach 0.35

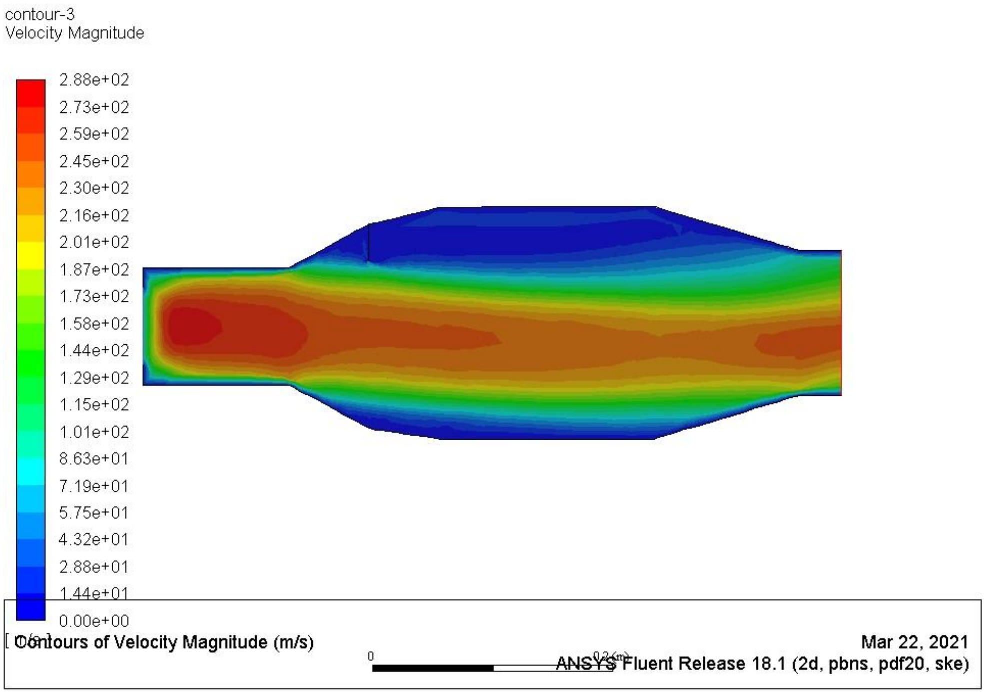


Fig. 6 total velocity at Mach 0.35

Sr.no	Mach number	Inlet Pressure (bar)	Shape of fuel outlet	Efficiency (%)
1	0.20	3	Circle	59.3
2	0.20	4	Circle	52.5
3	0.20	5	Circle	57.6
4	0.20	6	Circle	57.6
5	0.20	7	Circle	50.1
6	0.25	3	Circle	7.30
7	0.25	4	Circle	59.30
8	0.25	5	Circle	58.20
9	0.25	6	Circle	57.7
10	0.25	7	Circle	57.5
11	.30	3	Circle	7.80
12	0.30	4	Circle	7.90
13	0.30	5	Circle	59.3
14	0.30	6	Circle	58.3
15	0.30	7	Circle	57.6
16	0.35	3	Circle	8.40
17	0.35	4	Circle	8.70
18	0.35	5	Circle	9.10
19	0.35	6	Circle	59.29
20	0.35	7	Circle	58.35

Table.2 Circle efficiency

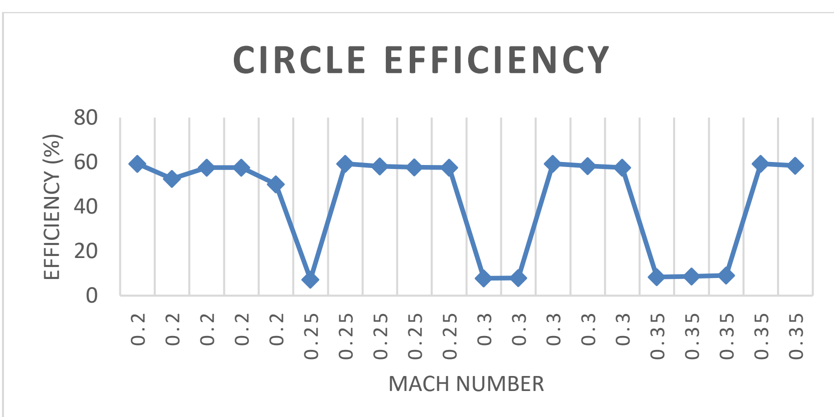


Fig.7 Graph on circle efficiency

For rectangle cross section

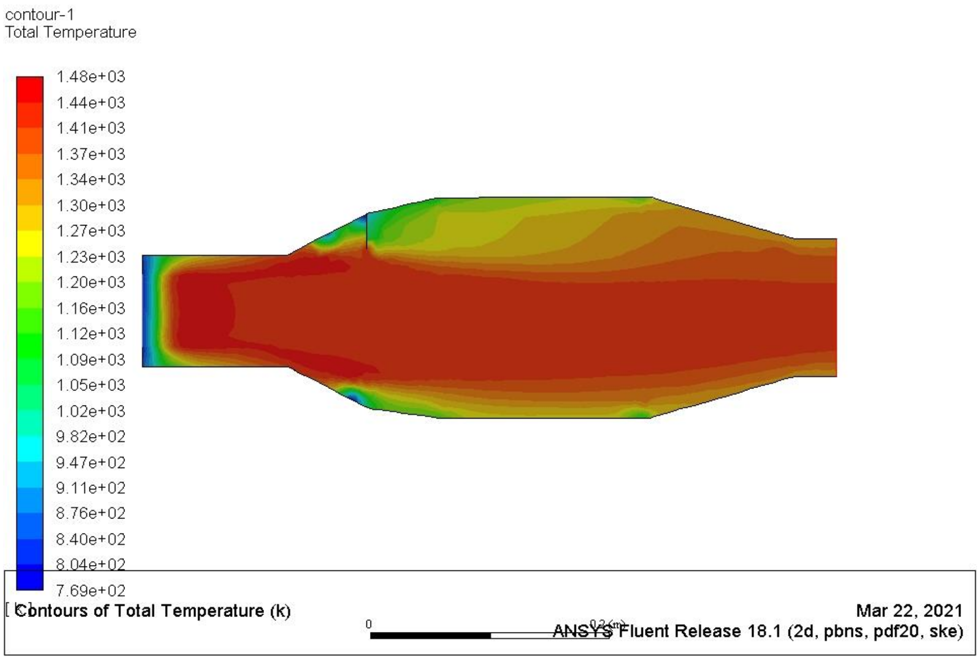


Fig. 8 total temperature at Mach 0.35

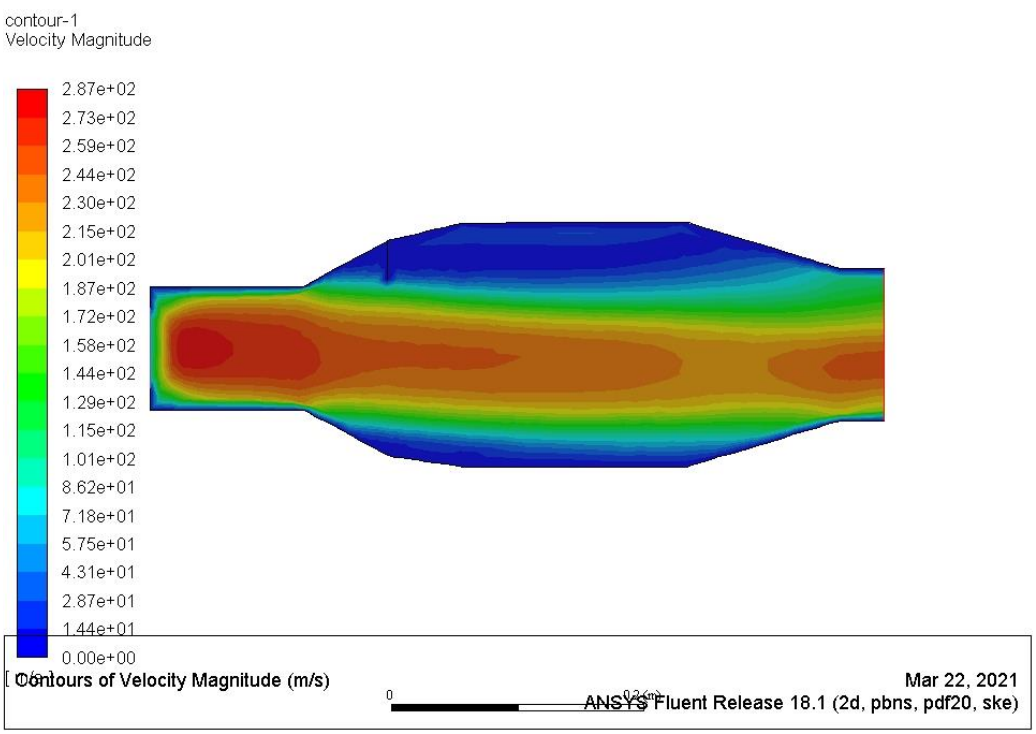


Fig. 9 total velocity at Mach 0.35

Sr.no	Mach number	Inlet Pressure (bar)	Shape of fuel outlet	Efficiency (%)
1	0.20	3	Rectangle	58.24
2	0.20	4	Rectangle	57.20
3	0.20	5	Rectangle	56.64
4	0.20	6	Rectangle	56.6437
5	0.20	7	Rectangle	51.81
6	0.25	3	Rectangle	6.30
7	0.25	4	Rectangle	58.25
8	0.25	5	Rectangle	57.18
9	0.25	6	Rectangle	56.71
10	0.25	7	Rectangle	56.46
11	0.30	3	Rectangle	6.76
12	0.30	4	Rectangle	7.0
13	0.30	5	Rectangle	58.30
14	0.30	6	Rectangle	57.27
15	0.30	7	Rectangle	56.52
16	0.35	3	Rectangle	7.35
17	0.35	4	Rectangle	7.96
18	0.35	5	Rectangle	8.1
19	0.35	6	Rectangle	58.24
20	0.35	7	Rectangle	57.316

Table.3 Rectangle efficiency

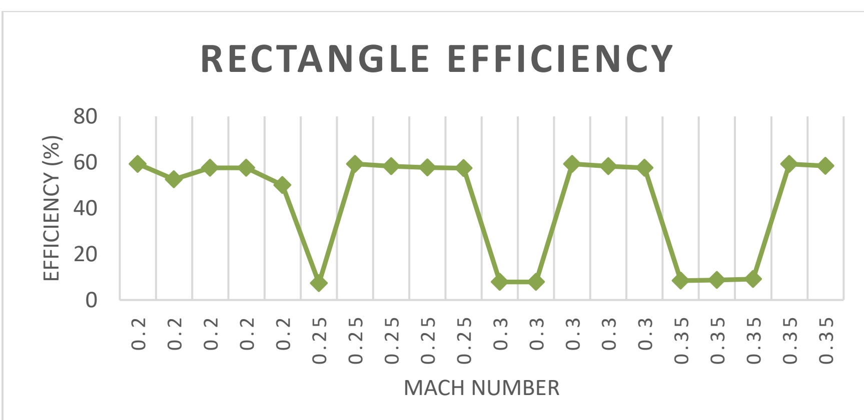


Fig .10 Graph on rectangle efficiency

For triangle cross section

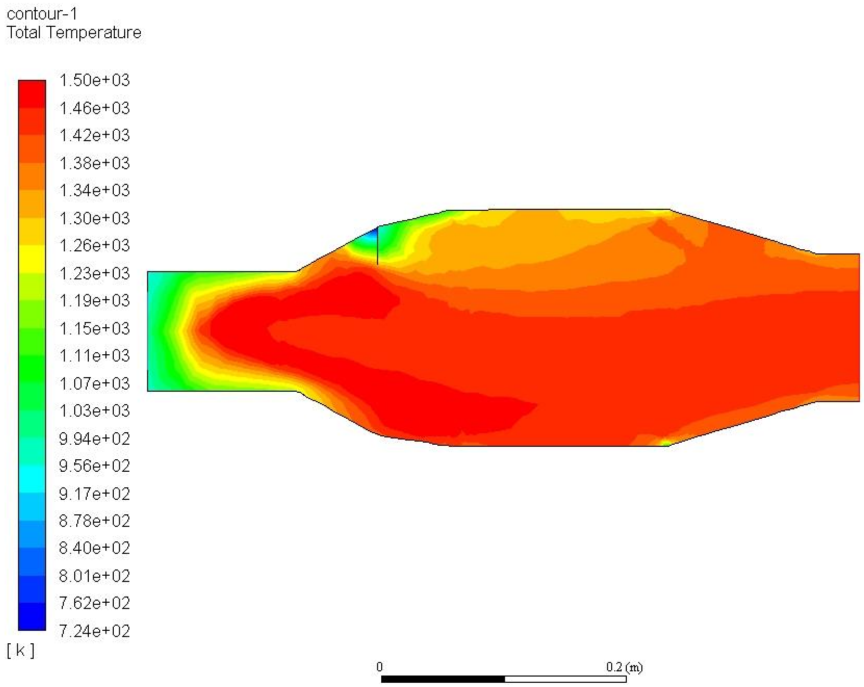


Fig. 11 total temperature at Mach 0.35

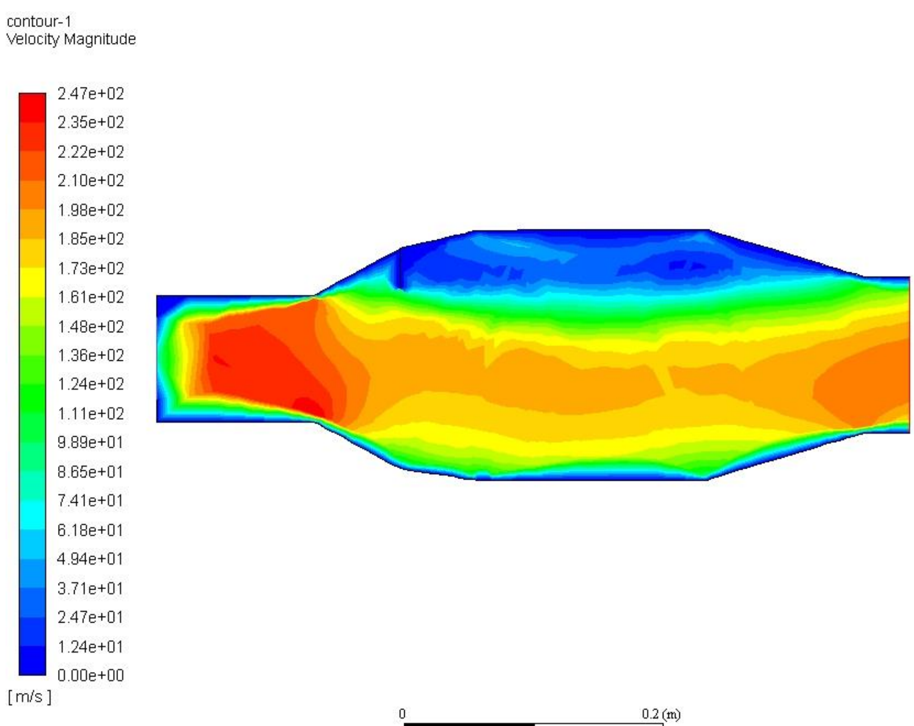


Fig.12 total temperature at Mach 0.35

Sr.no	Mach number	Inlet Pressure (bar)	Shape of fuel inlet	Efficiency (%)
1	0.20	3	Triangle	60
2	0.20	4	Triangle	59.54
3	0.20	5	Triangle	58.938
4	0.20	6	Triangle	58.932
5	0.20	7	Triangle	54.66
6	0.25	3	Triangle	8.6012
7	0.25	4	Triangle	60.5929
8	0.25	5	Triangle	59.52
9	0.25	6	Triangle	59.10
10	0.25	7	Triangle	58.839
11	0.30	3	Triangle	9.011
12	0.30	4	Triangle	12.11
13	0.30	5	Triangle	60.619
14	0.30	6	Triangle	59.59
15	030	7	Triangle	58.833
16	0.35	3	Triangle	9.67
17	0.35	4	Triangle	9.99
18	0.35	5	Triangle	11.3
19	0.35	6	Triangle	60.56
20	0.35	7	Triangle	59.629

Table.3 Triangle efficiency

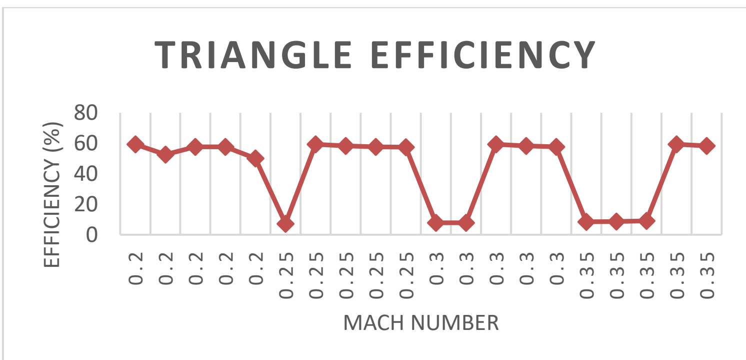


Fig.13 Graph on triangle efficiency)

5.Result

In fig 14 it is seen that at Mach 0.20 rectangle efficiency is invariant while changing the pressure 3 to 7 bar at Mach number 0.20 its sudden decreases at Mach 0.25 pressure 3 bar after that it increases its efficiency at pressure (bar) 4 to 7 at Mach 0.3 at bar 3 and 4 sudden decreases as we increase pressure with same Mach number efficiency increases 5 to 7 (bar) at Mach 0.35 at pressure 3to 5 efficiencies invariant it increases at pressure 6,7.

In the case of the circle at Mach 0.20 to 0.35, the efficiency increases 7.80% to 59.3% here no efficiency reduction is found while increasing Mach number. In the case of the triangle at Mach 0.25 minimum efficiency 8.016% to 60.59% it increases to Mach 0.25 then suddenly reduced at Mach 0.30,0.35 after it will again increase, in circle maximum fuel mixing at mid-zone beyond that swirling form due to incomplete combustion takes place. it has only one contact mixing on the other hand triangle has two contacts of mixing to get complete fuel combustion less unburnt fuel is remaining to get efficiency 60.59% at Mach 0.35

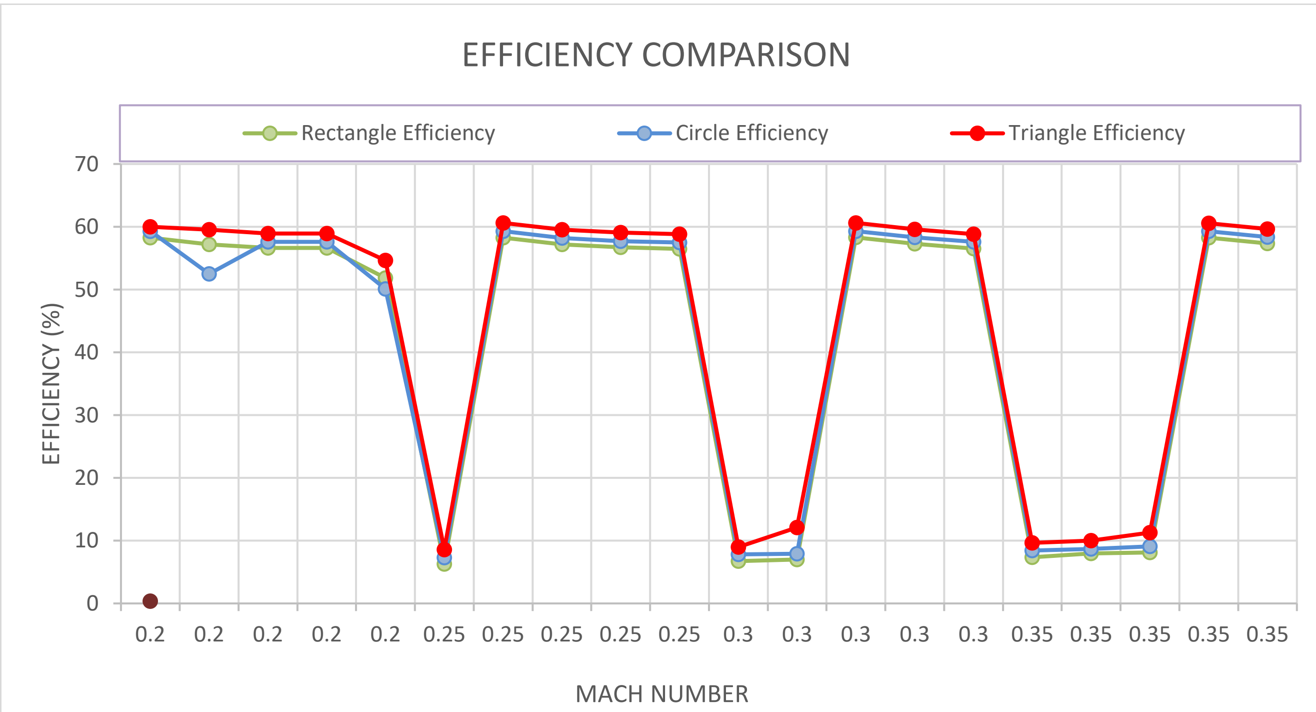


Fig.14 efficiency comparison

6. Conclusion

The results of the present investigation demonstrate that the mixing caused by the triangle is superior to the identical cross-section of the circle and rectangle. The mixing promoting efficiency is increased with increase Mach number It is found that among the triangle is a better mixing promoter. that provides better efficiency less emission of unburnt fuel to reduce the impact of environmental pollution

7. Future Scope

- It is recommended Mach number less than 0.35 use triangle type fuel injection for better efficiency for jet engine
- It is recommended Mach number more than 0.35 use Circle type fuel injection for better efficiency for jet engine
- Further studies and experimental investigations should be conducted to improve the efficiency of a jet engine, especially in the fields of combustion mixing, fuel injection, and afterburner

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