

Combustion Chamber Analysis Using CFD for Operation Condition

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Abstract. The gas turbine ignition chamber is a standout amongst the most basic segments to be unlined, in light of the fact that it must guarantee a steady operation in an extensive variety of air/fuel proportion and load. Among a few estimations engaged with the plan of a burning chamber, the reference region is the most vital physical parameter, particularly by the considerable effect on different measurements. As a rule, this parameter must be ascertained from an investigation of the impediments forced both compound responses and optimal design, i.e., in light of ignition process prerequisites and most extreme weight drop passable in the burning chamber, individually. In this way, the point of this paper is research the impact of the reference territory in the speed profile, in the temperature conveyance, in the blending procedure and in the fire conduct, as per the reference zone utilized as a part of the burning chamber. These numerical investigations were completed utilizing ANSYS CFX, contrasting them and the base esteem figured by Lefebvre [5], for a thermodynamic cycle of 600 kW gas turbine motor, conducted in Gate Cycle program. At last, it can be inferred that a few changes in the reference region figured by Lefebvre [4] creates better outcomes, particularly by enhancing the consuming procedure and the conduct of the fire.

Keywords: fuselage, monocoque structure, bulkhead, Stringers, longerons, skin, Internal Cabin Pressure, Blended-Wing-Body, Multi-Bubble Fuselage (CMBF),

1. Introduction

Pressure Ignition Engines are the significant wellspring of mechanical power, adding to around 8% of world vitality utilization. Its notoriety is a result of the high warm productivity among any inside or outside ignition motor. An expansion in the productivity in this way will have significant effect on petro fuel utilization and also on green house gas discharge. The pressure proportion assumes as vital part in enhancing the warm productivity of Compression Ignition Engine. A higher pressure proportion will require vigorous and durable motor structure and no vibratory reverberation. At the same time the reliance on petroleum derivative can be limited by a superior blend of fuel. The double fuel burning circumstance has demonstrated enhanced warm productivity and lower emanation. In this way the entire issue of enhancing warm productivity of pressure start motor can be tended to by the accompanying three focuses:

1. Achieving better pressure proportion through appropriate outline of ignition chamber and motor structure,
2. Better blend of fuel has demonstrated higher warm productivity and lower debilitate discharge,
3. Reduction in the likelihood of reverberation is accomplished by outlining a steady motor structure

1.1 Improving the Design of Combustion Chamber

Plan of an IC Engine is firmly identified with the impacts, which might be caused by the temperature of the working substances. Architects are dependably looking for ideal outline of I. C. motors. For ideal plan of an IC Motor, the information of rate of exchange of warmth amongst cylinder and gasses from the mass of ignition chambers is of awesome significance. Warmth exchange influences the thermodynamic-execution of the motor and results in warm stacking, which forces an utmost on the motor rating. The comprehension of the warm state in the motor segments is an essential factor.

Correct examination of the warmth exchange rate is troublesome because of unpredictability of the working procedure included. Extensive variety in the cycle temperature, weight and the time subordinate factors associated with counts make the assignment complex. More finished cylinder takes after a close unpredictable geometry and encounters warm variances from various surfaces. It is dependably important to acquire an ideal shape in which warm exchange to the encompassing can be limited and effectiveness of Internal Combustion motor can be made strides.

2. Literature Review

2.1 VALIDATION OF THE PRESENT WORK WITH PUBLISHED LITERATURE

Recorded underneath are portions of the present work which are near the discoveries by the creator:

We have discovered that the twisting causes relative anxiety when the cylinder is limited by the chamber whose limit likewise encounters disfigurement. In this way the anxiety caused is corresponding to the relative restriction as given in fig. 4.1.3(pg.64). In writing audits by Chigrinova et al [2], Musthafa et al[3] and Lowrence et al[4] have broke down the warm worries in the burning council of an I. C. Motor with a view to deciding the ideal thickness of warmth defensive covering on the retaining surface of the cylinder of the barrel.

The present work has discovered that with the LPG infusion, there is noteworthy decrease in smoke level (30%) and NOx and increment in brake warm productivity

In writing audit by Vijaybalan and Nagarjan[27] have discovered that there is lessening in smoke and NOx and change in brake warm proficiency.

We have discovered that for sparing the cost of aluminum material the thickness of Cylinder Head Cover (CHC) can be lessened by the factor of 0.5 times (pg119). Arif Senol Sener [36], pg.110, in his work examined the development and institutionalization of a track for performing weakness and unwavering quality trial of light business vehicle.

Amid the previous 20 years, noteworthy advances in controlling fumes emanations from vehicles have been made where the discharges diminishments were accomplished through rearrangement and control of motor working conditions (Beckman et al., 1967). In the writing, very successful fumes treatment gadgets in light of warm and reactant oxidation of hydrocarbons and carbon monoxide has been connected in the motor fumes framework (Cantwell et al., 1966; Bartholomew, 1966; Campion et al., 1972). Then again, fundamental burning procedure adjustment as an option implies for emanations control. The lean ignition process in SI motors is one of this option and it has been shown a

noteworthy contamination diminishments without requirement for fumes treatment gadgets outside to the motor.

3. METHODOLOGY

The problem is solved by using Finite Element Analysis (FEA) method. In this problem, the piston with the rings and wall has been divided into 196 elements having 164 nodes. The division of the elements & nodes for various parts is as tabulated below: Table 1: nodes in chamber

Part	Element		Nodes	
	From	To	From	To
Piston body	1	151	1	107
Piston ring	152	161	108	127
Cylinder wall	162	196	128	164

This is the situation of two dimensional relentless state warm conduction issues in a round and hollow surface. The co-ordinate has been found for every hub. The examination exhibited in this paper is partitioned into two areas, the field circulation and the warm burdens. The Finite Element Technique with tri-precise component is utilized to diminish the variation detailing to an arrangement of logarithmic conditions. The articulations to figure nodal temperature and the relating warm worries at each component are partitioned. The development of limited component approach begins from the variation proclamation of the issue and after that utilizing appropriate shape work various arithmetical conditions are created which level with the quantity of nodal components in the issue area. The fundamental limit conditions forced are convective on all the three sides, i. e. air, water and gas side of the cylinder and the contact limit condition between cylinder ring clearances. At that point the rule of minimization of variation necessary is done and the essential conditions created above are summed up keeping in mind the end goal to get an arrangement of synchronous conditions for entire of the cylinder body. These synchronous conditions are tackled by utilizing PC. Computational calculation and a FORTRAN program code is produced to explain these conditions with a specific end goal to locate the obscure parameters i. e. temperature at various nodal purposes of the cylinder.

Table 2: PROPERTIES OF MATERIALS

Properties of the materials	Aluminum	Cast iron	Cast steel
Density (kg/m ³)	2800	7200	7850
Thermal conductivity (W/mK)	175.0	54.0	45.0
Modulus of elasticity(GPa)	72	95	200
Coefficient of Thermal Expansion(/°C)	23x10-6	12x10-6	12 x 10-6
Poisson's ratio	0.33	0.25	0.30
Specific heat(J/kg K)	920	586	460

3.1 Mesh model

The strong model acquired must be changed over into a work, as appeared in Figure2 . The work is picked unstructured tetrahedral sort, the most appropriate for complex geometries. In the worldwide system, we utilized components of size 0.010 m, with 15 change cycles. Be that as it may, as a result

of the multifaceted nature of the geometry, promote upgrades were done in weakening gaps and the swirled sharp edges, with a most extreme component size of 0.008 m. At last, the work made brought about 2.7 million things put in 4600 hubs.

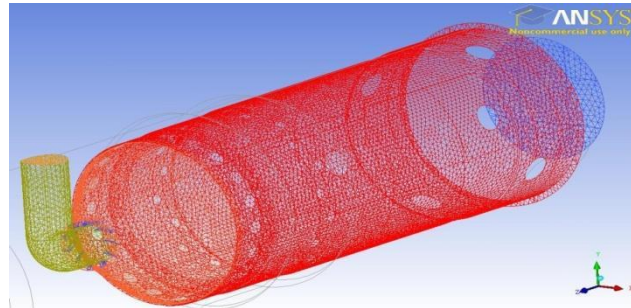


Figure 1: mesh model

3.2 Case 1

As indicated by speed conveyance appeared in Figure 1, it can be checked that the dissemination procedure was intruded, from a given point, bringing about a high speed in the focal area. Notwithstanding, regardless of the blending procedure amongst fuel and air, in the primary district, obviously didn't have been influenced by the attitude of streamlines in Figure 2, the high fringe speed should drag to some portion of the fuel to the finish of the chamber.

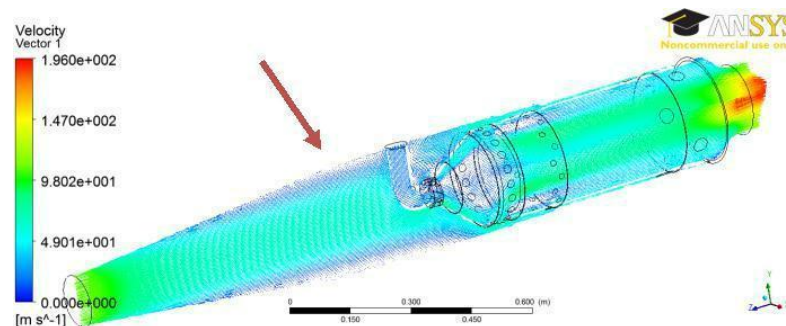


Figure 2: velocity of case 1

The fire temperature introduces high esteems from the furthest points to the focal area of the chamber, demonstrating the trouble of blending the wind stream with fuel in the essential locale, beforehand watched. In this manner, as the wind current dragged only a piece of the fuel, the way that temperatures were hoisted in the furthest points is perfect. Moreover, this reflects in a trouble of blending and in long fire, with high temperatures close to the divider and yield the chamber finally, it can be noted by the temperature appropriation in the outlet plane, Figure 6, that there are some problem areas, even little, yet could influence the respectability of turbine sharp edges. The normal temperature at exit of the ignition chamber was 1028.17 K, near the esteem assessed by Excel sheet estimations and in concurrence with the esteem set in the outline of the burning chamber as 1123K.

3.3 Case 2

It was done a few changes in the first geometry proposed by Lefebvre [6] strategy, with a specific end goal to decrease the speed inside the chamber and enhance the consuming procedure, particularly by the position of the nose, as appeared in Figure 2. This should add to additionally decrease the entry speed in the whirl. Keeping in mind the end goal to gather the stream in the focal district, it was included a spiral swirled, with a specific end goal to keep their grip to the dividers of the arch.

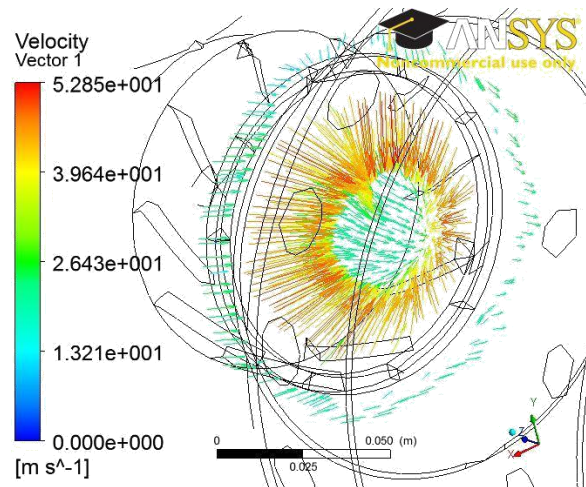


Figure 3: velocity distribution in case 2

3.4 Case 3

Amid the reproductions, it was noticed that a decrease of entry speed at swirler has enhanced the dispersion of the fire along the chamber, and also, the speed profile after the adjustments. Additionally, the swirler outlet stream was enhanced, by gathering it in the focal district.

Be that as it may, the high speed of stream inside the chamber still holds on, even after the progressions proposed. In this sense, the lessening of stream speed inside the chamber may be conceivable from an expansion in the reference zone, at first figured by Lefebvre [6], once the diffuser, the nose and the swirler as of now were researched.

Table 3: Design data of Solar Turbines

Variable	Value	Unit
Air mass flow rate	0,95	kg/s
Inlet total pressure	4,053	bar
Reference area	0.038118224	m ²
Inlet temperature	473	bar
Output power	60	kW

Keeping in mind the end goal to decide the fitting reference range, it was examined the geometric information of a burning chamber annular, Model T-62T-32 to 60kW, produced by Solar Turbines, depicted in Rodrigues [10], from which we approach the information. In view of information appeared in the Table 4, the reference region got was 0.015 m², far from the esteem utilized by Solar Turbines, and with a reference speed of 21.322 m/s. In this sense, the reference distance across at first acquired was changed, until the point when the subsequent territory was near that announced in Table 4. Toward the end, the underlying breadth must be expanded by 60%, bringing about a reference speed of 8.329 m/s.

It was thought important to mimic this new burning chamber, utilizing now the figuring's with the reference width expanded half. Subsequently, the ignition chamber geometry has changed, including more space for burning procedure and decreasing stream speed, particularly in the focal area as appeared in Figure

By the progressions did, may likewise be noticed that the decrease of stream speed in the fire tube supported the burning procedure and the passageway of air through the openings, as appeared by the temperature circulation in Figure 3 and the mass portion of CH₄ in Figure 4.

Another favorable position of the reference measurement expanded can be found in Figure 16, by the change in the blending procedure. It was completed an appropriately normal conveyance and more uniform temperature in the outlet plane. In flow Simulation 2, there were some problem areas with 2000.0K of temperature, with a normal of 905.2K. In the flow Simulation 3, the dissemination was more uniform, however even with some problem areas, yet with a normal temperature of 1110.9 K, near the plan and incentive at 1123 K.

4. Results and Discussion

4.1 Temperature distribution

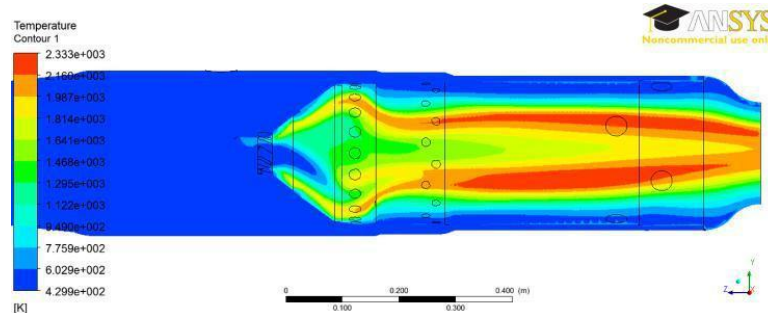


Figure 4: Temperature distribution in longitudinal plan YZ

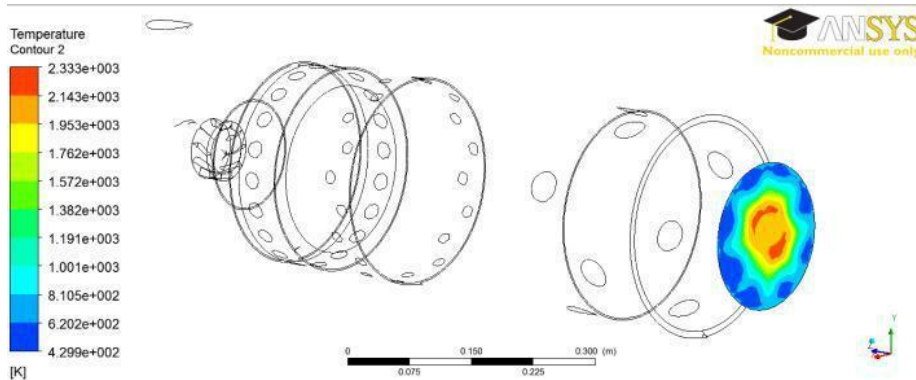


Figure 5: Temperature distribution at outlet plane

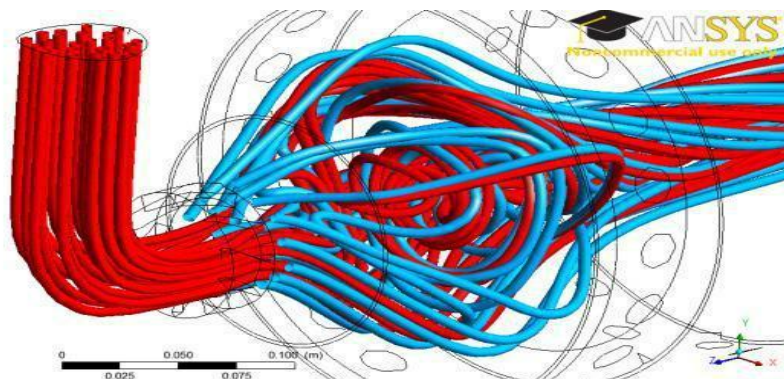


Figure 6: Simulation for flow distribution in the combustion chamber,

4.2 Velocity analysis

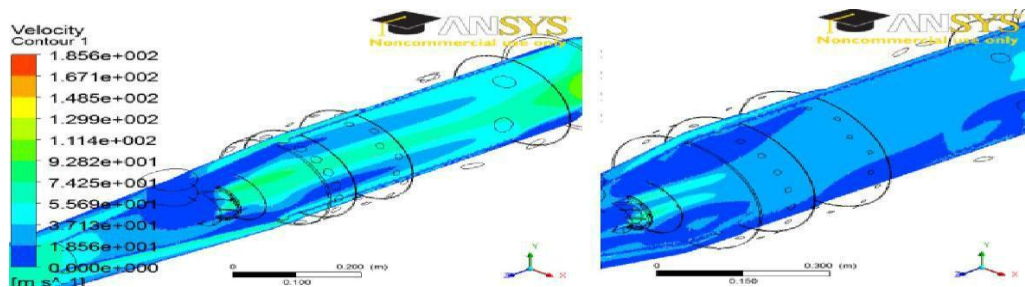


Figure 7: Velocity distribution

4.3 Temperature case3 results

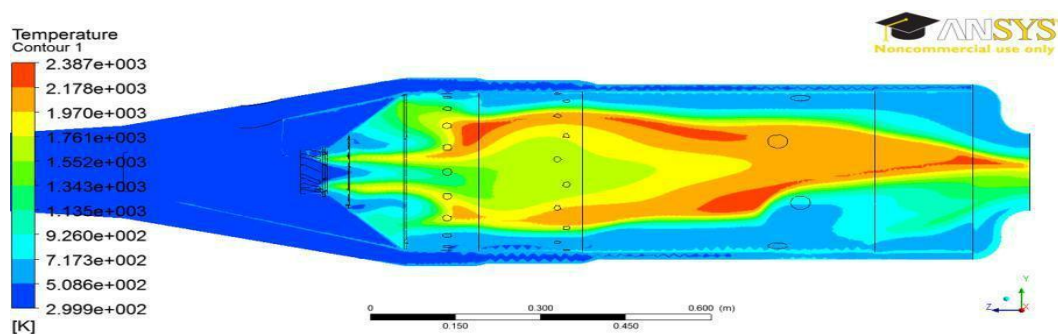


Figure 8: Temperature distribution in case 3

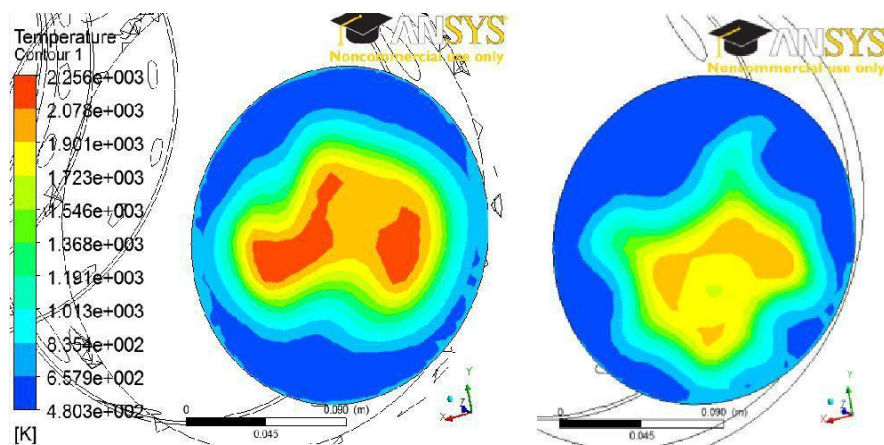


Figure 9: Comparison of outlet temperature distribution: case 1 & case 2

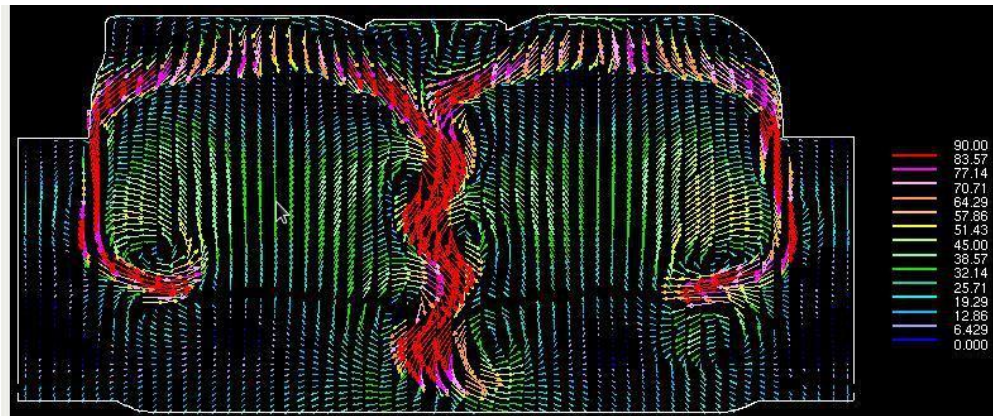


Figure 10: Velocity profile of engine without pre-chamber for 6 mm of intake valve lift

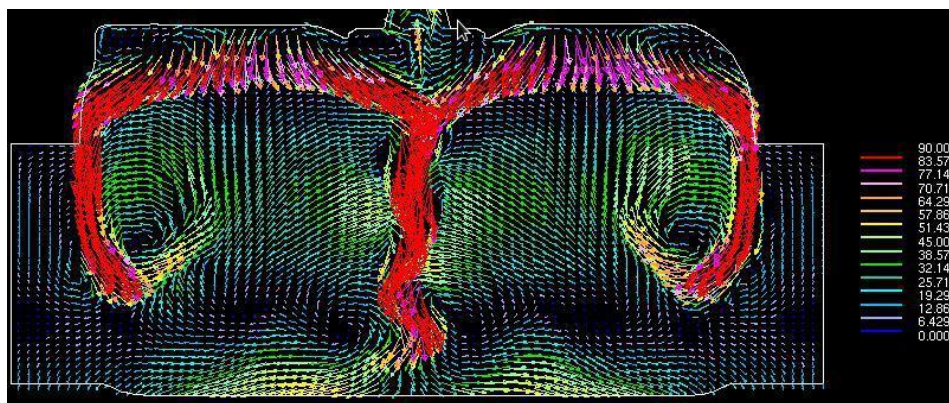


Figure 11: Velocity profile of engine with pre-chamber for 6 mm of intake valve lift

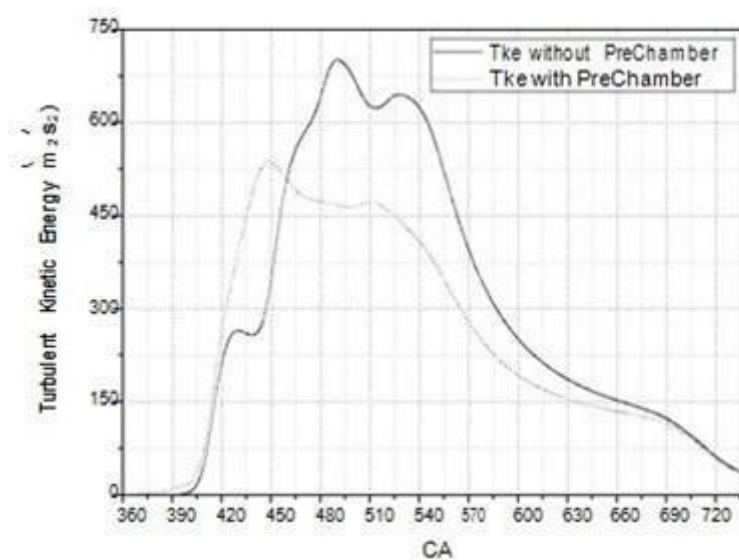


Figure 12: Turbulent kinetic energy

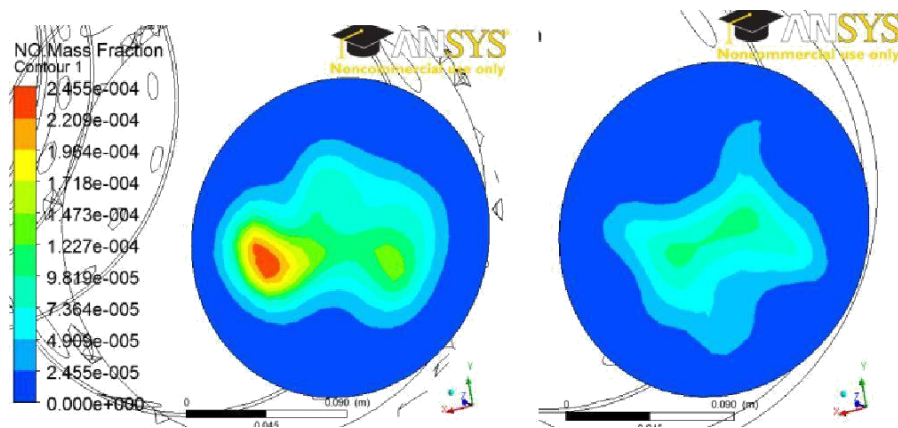


Figure 13: Comparison of outlet NO distribution: (a) case 1 1, (b) case 2

The turbulence kinetic energy are showed in the Figure , and for the maximum valve lift, the turbulence production associated with the jet interaction penetrates to the middle of the engine cylinder has higher magnitude for the engine configuration without prechamber than the engine configuration with prechamber. Comparing both the engine configurations is possible to verify that the engine configuration with prechamber gives a homogeneous turbulent kinetic energy profile.

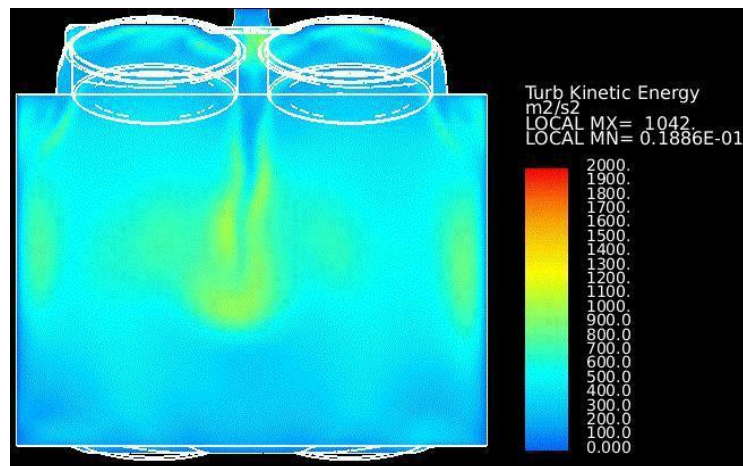


Figure 14: Turbulence kinetic energy profile of engine with pre-chamber for 8.5 mm of intake valve lift

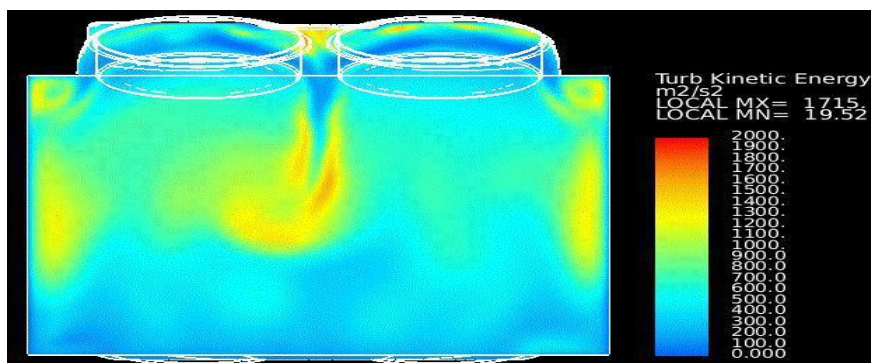


Figure 15: Turbulence kinetic energy profile of engine without pre-chamber for 8.5 mm of intake valve lift

5. Conclusion

The computation solved for the transient analysis of intake and compression strokes for motored engines with and without the torch ignition system were carrying out for engine speed at 4500 rpm, having a good agreement with the experimental tests. In this work, a involving moving valves and piston, possibility that the flow field could be analyzed completely, showing the in-cylinder airflow influence of the prechamber under the main combustion chamber.

The fluid flow and turbulence characteristics acquired from the simulation were taken into account to verify the better homogeneity of air structures of prechamber engine compared with the engine without prechamber. This homogeneity, in the beginning, could generates a smaller air-fuel mixture process inside the main cylinder but it is possible to observe that the turbulent kinetic energy increases more quickly during the intake valve open for the engine with prechamber giving a better air-mixture process. By the other hand, the mixture process also are due by the tumbling phenomenon and for this reason the air-fuel mixture for the engine with prechamber can keep an adequate mixture process for two different stages, one during the admission stroke until the maximum intake valve open and the other during the compression stroke period.

The prechamber air filling is strongly influenced by your position in the main combustion chamber and the geometry design. The results has been proven that for a homogeneous engine charging the prechamber air filling starts since the intake valve open and increase during the compression stroke. The prechamber filling stage is very important during the intake valve open because in this period the turbulent kinetic energy magnitude is higher, providing a better air-fuel filling that will leading a better combustion process.

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