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CFD ANALYSIS OF EXHAUST MANIFOLD OF MULTI-CYLINDER SI ENGINE TO DETERMINE OPTIMAL GEOMETRY FOR REDUCING EMISSIONS

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ABSTRACT:
IC Engine is an indispensable piece of present day human culture. It may be a prosaism that IC Engines drives human culture yet for a large portion of the buzzwords it is significantly more exact. Comprehensive research work has occurred in the field of IC Engines and the work has proceeded as of late too. Human culture today is confronting humongous errands of lessening GHG emanations and discharges of suspended particulate issues (SPM), SOX and NOX. Exhausting assets of regular fills has constrained us to search for elective wellsprings of powers. IC Engines are not sufficiently skilled to take a shot at various fills. Hence, specific motors should be produced for such energizes. These option fills must have the capacity to delivered wanted power in the motor keeping discharges underneath gauges. In this manner general there is a tremendous degree in the field of research in IC Engines. Different plans are being used for ventilation system. These are utilized with various sort of motors. Each ventilation system has particular outline attributes related with it accordingly clearly they have effect on different motor execution parameters. Ventilation system is a standout amongst the most basic segments of an IC Engine. The planning of ventilation system is a complex system and is subject to numerous parameters viz. back weight, deplete speed, mechanical effectiveness and so on. Inclination for any of this parameter differs according to creators needs. Generally mileage, outflows and power necessity are three distinct streams or thought with respect to ventilation system plan. This work thoroughly breaks down eight distinct models of ventilation system and finishes up the most ideal outline for slightest emanations and finish burning of fuel to guarantee minimum contamination.

Key words: Multi-Cylinder SI Engine, Exhaust Manifold, Back Pressure, Exhaust Velocity.

1.0 INTRODUCTION:

In an IC Engine toward the start of suction stroke bay valve of chamber opens because of weight contrast. Air fuel blend (if there should arise an occurrence of SI motor) or air (if there should arise an occurrence of CI Engine) is sucked into the barrel through this admission valve from bay complex. Bay complex contains carburettor for blending of air and fuel if there should arise an occurrence of SI Engines. When air or air fuel blend is totally sucked into the barrel whose cylinder has achieved BDC the delta valve closes and pressure stroke starts. As cylinder achieves TDC start is touched off in the blend (SI Engines require outside starting game plan while in CI Engine auto start happens on infusion of fuel) this denotes the start of energy stroke. By and by as the cylinder achieves BDC deplete stroke starts. Amid deplete stroke debilitate valve is opened and the consumed blend is rejected to ventilation system. As fumes stroke is finished suction stroke starts by and by and cycle proceeds. The vitality provided to motor in type of compound vitality of fuel is changed over into warm vitality. In any multi cylinder IC motor, a ventilation system (otherwise called a header) gathers the fumes gasses from various chambers into one pipe. This header is associated with these barrels through twists. It is joined downstream of the motor and is significant part in multi-cylinder motors where there are numerous fumes streams that must be gathered into a solitary pipe.

Frame work:

The acceptance should be free streaming and have the capacity to keep up high motor vitality to enhance proficiency; it likewise needs to blend the fuel to a homogenous gas previously burning happens. With a vast bore to stroke factor there is a lot of space for enormous delta valves that prompts enhanced breathing limit at high motor speed The consumption channel is concurrent/unique to expand the active vitality and decrease the stream misfortune at the valve, tuning of the admission waves is likewise done by the plan of the admission. By making the admission downdraft, streaming is expanded and a tumble movement of the approaching charge can happen inside the chamber. A downdraft admission is additionally the decision in a W-motor, to clear the fumes framework from nearby fumes pipe.

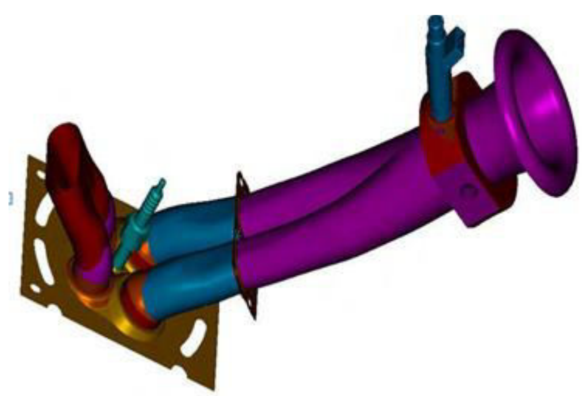

Fig : CAD image of the downdraft intake duct for the W-9 engine.

EFFECTS OF INCREASED BACK PRESSURE:

At expanded back weight levels, the motor needs to pack the fumes gasses to a higher weight which includes extra mechanical work as well as less vitality extricated by the fumes turbine which can influence intake manifold help weight. This can prompt an expansion in fuel utilization, PM and CO emanations and fumes temperature. The expanded fumes temperature can bring about overheating of fumes valves and the turbine. An expansion in NOx discharges is additionally conceivable because of the increment in motor load. Expanded backpressure may influence the execution of the turbocharger, making changes noticeable all around fuel proportion typically enhancement which might be a wellspring of discharges and motor execution issues.

2.0 LITERATURE REVIEW:

Mr.Kulal et al. In (2013) work extensively examinations eight distinct models of ventilation system and closed the most ideal outline for slightest fuel utilization. CFD is the present pattern on car field in decreasing the cost impact for investigation of different models on the premise of liquid stream. A multi-chamber Maruti - Suzuki Wagon-R motor with most extreme speed of 1500 rpm is taken for the examination. The heap and execution test is led. From the investigation back weight and fumes temperatures are measured. The mass stream rate and speeds are figured. Course through the ventilation system is investigated utilizing industrially accessible programming with mass stream rate and weight as limit conditions.

Mr.HessamedinNaemihad(2014) utilized numerical recreations (CFD techniques) for evaluating the stream misfortune coefficient in manifolds. The stream bay and exit was displayed utilizing 'mass-stream delta' and 'weight outlet' limit conditions, with the thought that the stream was compressible. The outcomes from various turbulence models – standard k-ε, standard k-ω, SpalartAllmaras model and RNG k-ε show – were thought about as far as stream misfortune coefficient against the trial information. In view of their outcomes, the creators had watched that the RNG k-ε turbulence show forecasts were in close concurrence with the exploratory information. The plan of ventilation system for a 4-stroke high power medium – speed diesel motor was done the mill operational scope of the medium-speed diesel motor was in the scope of 700 – 1500 rpm and has control yields up to 6000 kW. The ventilation system will experience warm extension because of high temperature of fumes gas and furthermore presented to the vibration caused by the interior burning motor.

Mr.MohdSajidAhmed(2015)had connected CFD techniques to recognize the ideal ventilation system for a 4-stroke 4-barrel SI motor. They had considered five variations of ventilation system, in light of the complex pipe geometry, - joined bay pipe, different straight-concurrent, diminished united length and expanded disparate length, decreased dissimilar length and expanded merged length, indistinguishable focalized and unique and lessened straight length. The CFD recreations were performed utilizing ANSYS FLUENT with un-organized lattices. 'Mass stream gulf' limit condition was connected to display the stream channel. In light of their outcomes, the creators proposed that the base back-weight at the ventilation system outlet could be accomplished by having reducers.

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3.0 METHODOLOGY:

CATIA began as an in-house improvement in 1977 by French air ship producer Mr.Avions Marcel Dassault, around then client of the CADAM programming to build up Dassault's Mirage contender stream. It was later received in the aviation, car, shipbuilding, and different ventures. PC Aided Three dimensional Interactive Application (CATIA) is outstanding programming for 3-d outlining and demonstrating for complex shapes.Commonly alluded to as 3D Product Lifecycle Management programming suite, CATIA underpins different phases of item improvement (CAX), including conceptualization, plan (CAD), designing (CAE) and assembling (CAM). CATIA encourages synergistic building crosswise over orders around its 3DEXPERIENCE stage, including surfacing and shape plan, electrical, liquid and electronic frameworks outline, mechanical designing and frameworks building.

Engine Specifications

Following engine parameters were considered for calculation of mass flow rate at different loading conditions. The flow through exhaust manifold was considered density based.

Table: Engine Specification

Engine	**4 Stroke 4 Cylinder SI Engine**
Make	Maruti-Suzuki Wagon-R
Calorific Value of Fuel (Gasoline)	45208 KJ/Kg-K
Specific Gravity of Fuel	0.7 gm/cc
Bore and Stroke	69.05 mm X 73.40 mm
Swept Volume	1100 cc
Compression Ratio	7.2 :1

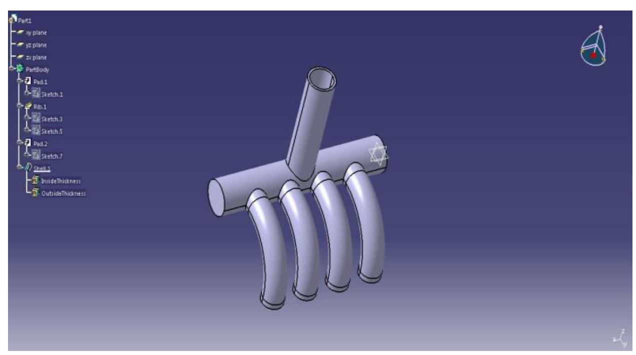

fig :long bend side exit (lbse)

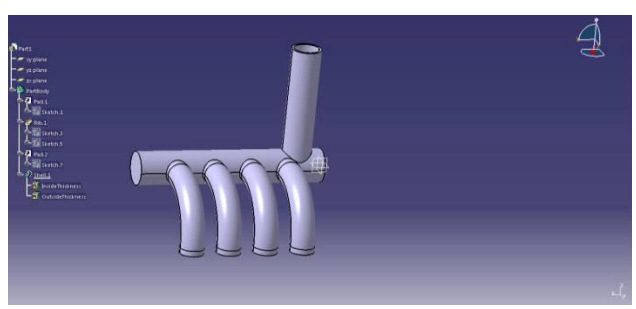

Fig : long bend side exit(lbse)

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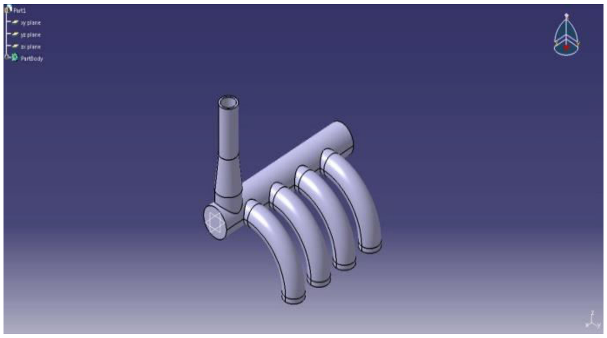

Fig : long bend centre exit with reducer (lbsewr)

MESHING:

The Figure demonstrated is the coincided model of inflexible rib coupling in the ANSYS investigation for the static basic process. To examine, the FEM triangular sort of work is utilized for the unbending spine coupling in the ANSYS condition. The quantity of components utilized as a part of this lattice is 71441and the quantity of hubs is 122228.In this procedure customary kind of cross section is done to investigate the procedure.

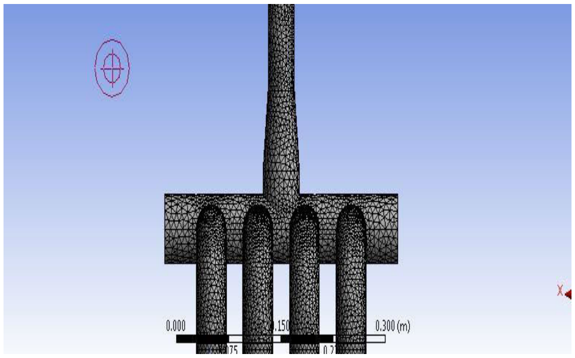

Fig: Meshing model

4.0MATERIAL FLUID PROPERTIES:

Exhaust gas will be considered as an incompressible fluid operating at 230-280 ^{0}C. The material properties under these conditions are

Material	Air + Gasoline
Density (kg/m^3)	1.0685
Viscosity (Pa-s)	3.0927 x 10^5
Specific heat (J/kg-K)	1056.6434
Thermal conductivity(W/m^{2}k)	0.025

Boundary Conditions

The inlet mass flow rates for different models at six different loading conditions are given below using these mass flow rates the pressure and velocity contours were obtained.CFD Analysis of Exhaust Manifold of Multi-Cylinder SI Engine to Determine Optimal Geometry for Reducing Emissions.

Boundary	Mean Hydraulic Diameter
INLET 1	1 0.00877m
INLET 2	2 0.00877m
INLET 3	3 0.00877m
INLET 4	4 0.00877m

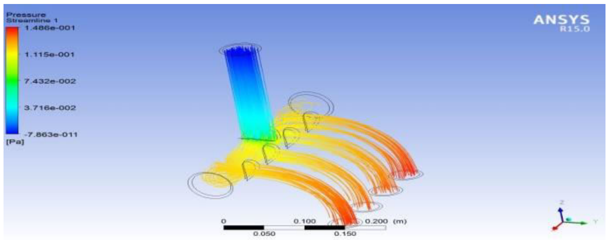

Fig :Pressure stream line

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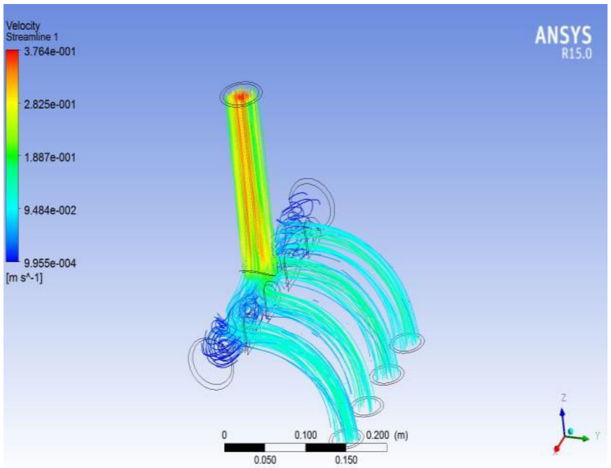

Fig :velocity stream line

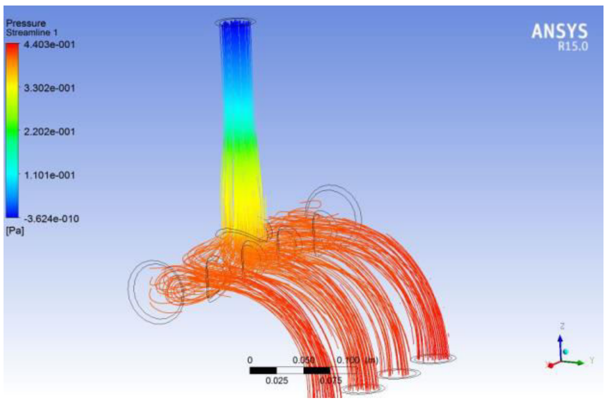

Fig :Pressure

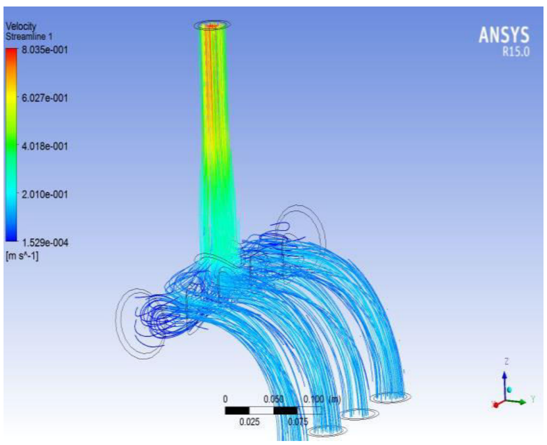

Fig :Velocity

SHORT BEND LEFT EXIT:

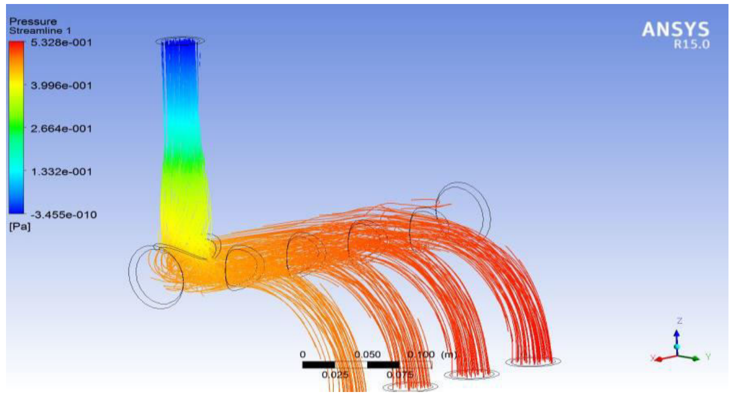

Fig :Pressure

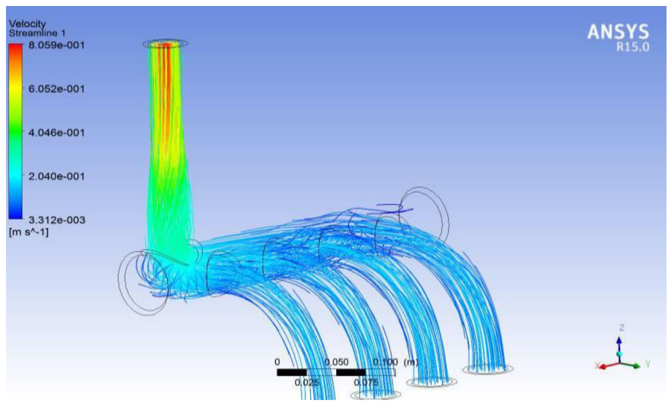

Fig :Velocity

SHORT BEND CENTRE EXIT:

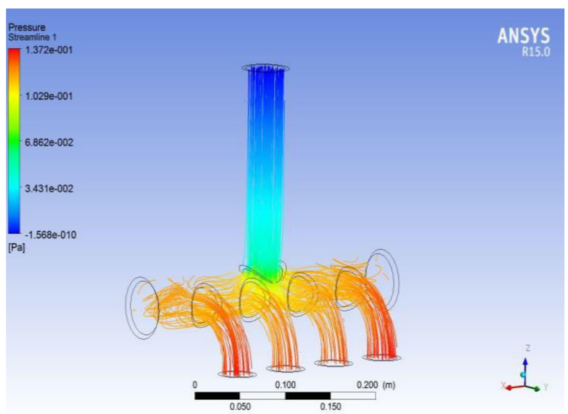

Fig : Pressure

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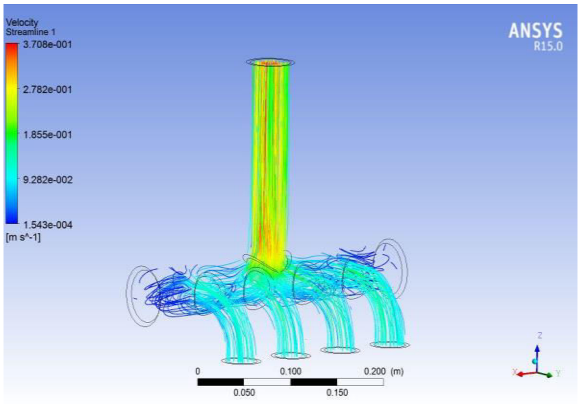

Fig : Velocity

SHORT BEND SIDE EXIT:

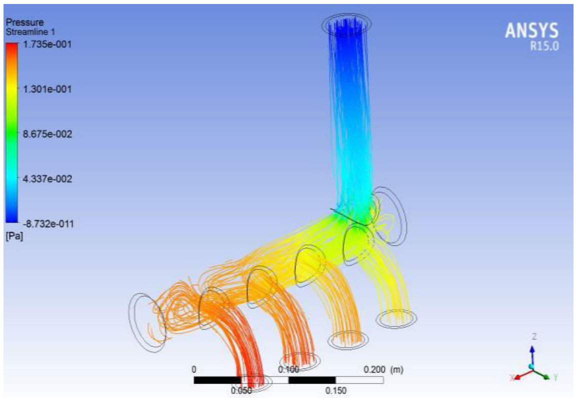

Fig:Pressure

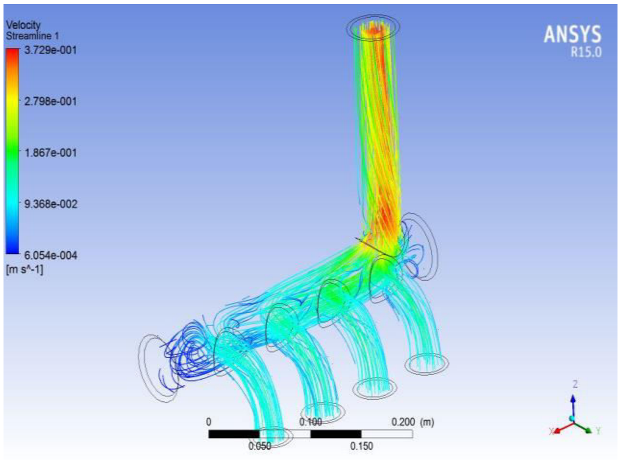

Fig : Velocity

The exhaust manifold with reducer is considered for this analysis at different mass flow rates in turbulent region. In this analysis five mass flow rates are considered and analysed. The mass flow rates were considered randomly and entire analysis depends on the mass flow rate considered.

CONCLUSIONS:

In this thesis the investigation is to find out pressures and velocities at various mass flow rates in the exhaust manifolds with Long Bend Side Exit (LBSE), Long Bend Middle Exit (LBME) and Reducer and find out the performance of the exhaust manifold with various modifications in its design or adding a component for the exhaust manifold to increase its effectiveness. In the current analysis mass flow rates considered in the exhaust manifold are 2 kg/s, 4 kg/s, 6 kg/s, 8 kg/s ,10 kg/s, 12 kg/s in all the various modifications in the exhaust manifolds. From the above investigations it is found that Long Bend Middle Exit (LBME) with Reducer is giving the better performance.

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