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Numerical Analysis of Diesel Engine with Modified Inlet Valve

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Abstract*: The Internal combustion engine is one of the widely used mechanical system. The primary aspect of all types of engines is the amount of power produced which, is affected by the complete combustion of a mixture of air and fuel. The objective of this present work is to outline the improved performance of single-cylinder Compression Ignition engine with the aid of geometrical modifications of Inlet manifold. The Study is performed on Kirlosakr CI engine. For modeling of engine assembly, CATIA V5 Software has been used. The Numerical simulations are performed with Ansys 14.5 and solver used as CFX. In this work, two different engine models such as Conventional valve and Modified valve with plate is being considered for CFD analysis. The simulation study of air flow motion with a valve lift of 4 mm, 6 mm and 8 mm is performed for both valve configurations. This numerical analysis aims to maximize the air velocity in the inlet valve with minimum turbulence which in turn improves the engine performance. The study is performed on the single cylinder four-stroke variable compression ratio diesel engines. In the present study, the air flow motion inside the intake manifold of an engine is simulated and investigations are performed by considering the six conditions of the intake valve. The results obtained acts as a basis for further investigation of a variety of valve geometry.

***Index Terms*: Analysis, Air, Engine, Velocity**

I. INTRODUCTION

Performance and power output are primary concern for Compression Engines irrespective of Applications where they are being used. So many people are coming with geometrical modifications of engine components such as use of different types of pistons with modified piston head. Providing additional features on valve such that air flow velocity will be improved and which will lead to complete combustion fuel. This maximizes the output power of engine. Modified intake valve design for obtaining high swirl. The result shows that with increase in valve lift swirl intensity reduces as Poppet valve geometry is considered better than other geometries because it gives highest swirl in intake manifold. [1]. had evaluated effect air swirl at intake manifold of diesel engine. In this study modified valves are provided with masks and flow rate has been studied [2]. Effect of swirl on engine performance. Through Numerical simulation of inlet and exhaust manifold. The various geometrical configurations such as helical, winding, helical-winding etc. are studied. Helical winding geometry has better swirl rather than other two models. P [3].Investigations are carried out for diesel engine intake manifold of TATA INDICA. Numerical modeling result shows that Model 2 gives better air flow distribution than other models hence model 02 has high swirl [4]. Studied changes in intake manifold design for the purpose of improving engine performance. During the study three different configurations were studied. For original model same velocity was reported at each outlet with increment in air velocity about 15% [5].Proposed numerical study of single cylinder diesel engine with vanes for improving swirl. The intake manifold has provided with vane type geometry while parameters like number of vanes and vane angle is varied during the investigation. Results shows that model with six vanes is having less pressure drop and swirl produced by this model is higher than other models [6]. Numerical analysis with three different innovative inlet manifolds for understanding air flow. The results are showing that geometry number three has better air flow behavior [7]. Numerical Analysis of single cylinder four stroke petrol engines for knowing mass flow rate during suction and power stroke. The valve lift has taken as 2mm, 4mm and 6mm. The swirl intensity reduces with stroke length while mass flow rate increases with increment of valve lift [8]. Investigations are done for achieving better swirl flow inside single cylinder diesel engine. In order to obtain this six different intake manifold configurations were evaluated. The models are designed with helical groves. The model MM8 shown high value of turbulence indicating better air-fuel mixing, The air swirl also results into reduction in cylinder temperature [9]. Swirl flow motion investigation inside engine cylinder manifold with variable height vanes. The results shows that vane with smaller height are better than vanes with higher height with respect to air swirl motion [10]. M. N Channappagoudra et al. (2013) [10] had performed effect of air swirl on engine emissions. With biodiesel as working fuel. During the analysis the modified piston head geometries are taken. Piston geometries are modified by providing grooves on piston. The piston with 6 grooves in combination with Honge biodiesel results into better air swirl and low amount of emissions. Since various researchers had undertaken study of performance improvement of diesel engine. During this study parametric analysis of intake manifold is performed. Some people had come with introducing vanes, modifying poppet valve by providing masks, adding number of slots, helical grooves etc.

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The study was performed as numerical simulations for all these cases and it has been reported that with aforesaid modifications with intake manifold significant improvement has been observed with respect to air swirl motion inside the cylinder, increase in turbulence caused complete mixing of air and fuel. In some cases with these geometrical modifications such as changing valve lift resulted into considerable amount of rise in mass flow rate. This summarizes that there is still much scope for improving engine performance with the help of different gemotrerical structures. With this objective present study has focused on numerical simulation of single cylinder diesel engine with plate like structure placed on intake valve CI. Engine.

Table 1. Engine Specifications.

Sl	Parameter	Specifications
1	Engine Make	Kirloskar TV1 VCR Engine
2	Number of Cylinders	01
3	Cycle	4 Stroke
4	Rated Power	3.5 KW @ 1500 rpm
5	Cylinder Diameter	87.5 mm
6	Stroke Length	110 mm
7	Compression Ratio	12 to 18
8	Cooling Medium	Water Cooling
9	Intake Valve Opening	4 Degree ATDC
10	Intake Valve Closing	25 Degree ABDC

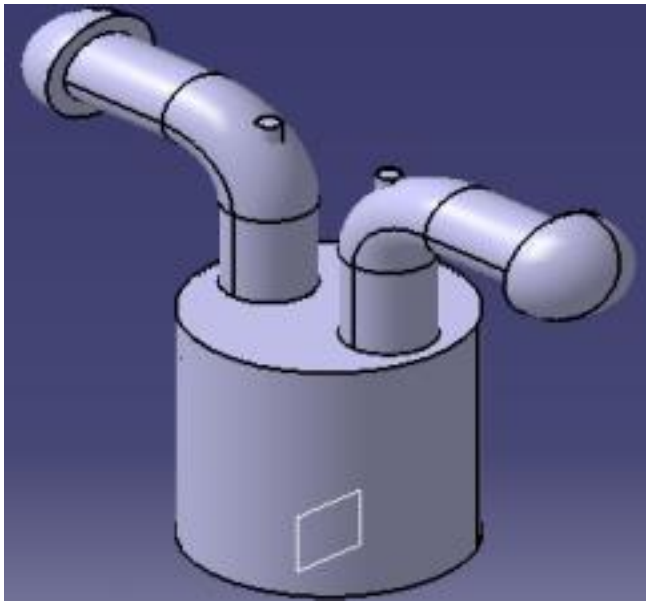

Fig. 1. Assembly of Engine Cylinder

II. NUMERICAL SIMULATION

The 3d geometry of engine cylinder with valves is modeled in CATIA V5, while further analysis is performed with Ansys 14.5. The Solver used in this simulation is CFX which is considered as better for existing type of analysis. CFX is solver used by commercial CFD software and product of ANSYS more than twenty years history. The CFD software gives solution in various domains such as multiphase flow, reactions, turbulence, simulation of heat and mass transfer and fluid flow. CFX solver has potential of investigating complex nature of models involved with fluid flow and thermal analysis.CFX is also able to solve models meshed as unstructured type of meshing which is mainly used in complex assemblies. CFX gives quite good results for the analysis performed for both compressible and incompressible fluid. The part of simulation boundary conditions are defined for this model. In this analysis two inlets are considered with Velocity inlet. The cylinder bottom is considered as outlet which is nothing but pressure outlet. For wall no slip condition is defined. The geometry has been meshed with Tetrahedral element with minimum edge length of 0.5mm, manual sizing. The resulting nodes will be 902663 where as number of elements were 459430.

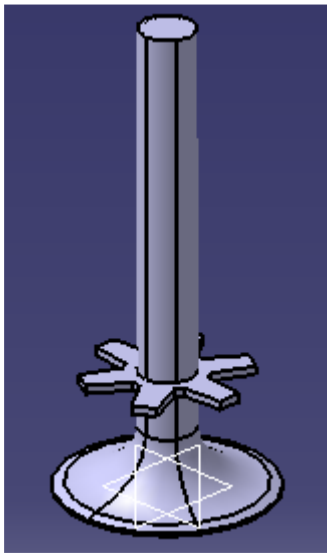

Fig. 2. Modified Valve

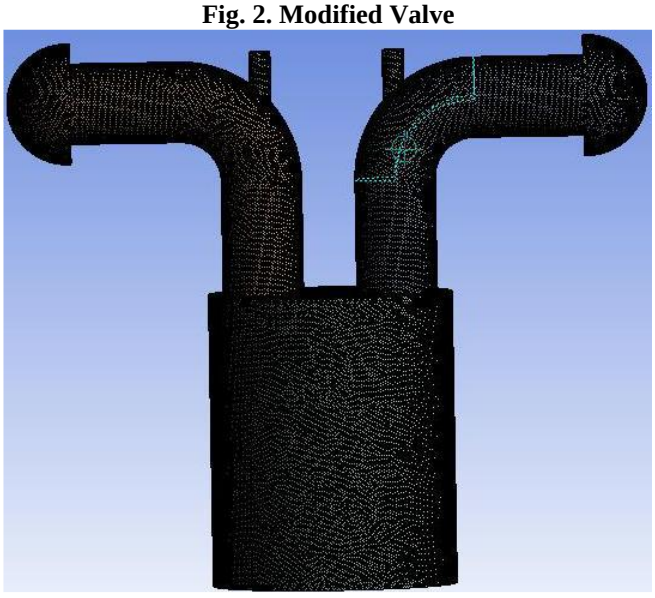

Fig. 3. Meshed Model

III. RESULTS AND DISCUSSION

Steady state air flow computations are performed for six different valve lifts viz. 4 mm, 6mm and 8mm for both regular valve and new modified valve configurations. The calculations are carried out by solving compressible Naiver-Stokes equation for mass, momentum and energy.

The air flow velocity in regular intake valve is high in pipe side than liner part. Hence, turbulence produced in regular inlet valve was more than that in case of modified intake valve with plate. The In-cylinder air flow velocity is noted as lower than that around valve, for all valve configurations of lift. Due to sudden rise in sectional area near engine outlet, the air flow velocity is seen as rapidly increasing.

Maximum air flow streamlines tend to move towards bottom of the cylinder. In case of conventional valve, the nature of air movement inside the cylinder is more than that with modified valve. For conventional valve having lift value of 4, 6 and 8mm the value of total pressure 2.86e+015 Pa, while total velocity is 7.14e+08 m/s, turbulent kinetic energy as 4.36 J/Kg. For modified valve having lift value of 4mm, 6mm and 8mm value of total pressure 1.59e+09 Pa, while total velocity is 6.73e+02 m/s and turbulent kinetic energy as 3.72 J/Kg.

IV. FUTURE SCOPE

This research work may be further extended with respect to following points.

1. Change the valve lift positions to higher side and compare the results.
2. The existing plate is of 2mm thickness the parametric study may be also extended by changing thickness of plate.
3. In this work VCR engine is only taken for study, other engines such as Engine with EGR need to be studied.
4. The present work may be extended by means of applying optimization techniques.

V. CONCLUSION

The air flow motion affects the combustion of fuel at a greater extent. The engine performance will be better with the effect of the axial and radial velocity of air. Since the area nearer to the valve velocity of air should be more which gives complete mixing of air and fuel. Hence with such high velocity higher turbulence will be created and which gives good air swirl. In the present study irrespective of valve lift for a modified valve the vortex forming was lower inside the cylinder than non- modified valve. The modified valve also has higher turbulence than the rest of the conventional valve. The use of higher valve lift, modification of existing plate, including the newer type of plate structure is some of the areas for further study.

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Dr. Amit M. Patil was born in Sangli, Maharashtra, India in 1984. He obtained his Bachelor Degree in Mechanical Engineering in 2006 from Shivaji University Kolhapur, Maharashtra. He completed his Post Graduation in Design Engineering at D Y Patil College of Engineering, Akurdi, Pune in 2013. He had completed his Doctoral studies from JJTU Rajasthan. Currently, he is working as Assistant Professor in the Department of Mechanical Engineering at Zeal College of Engineering and Research at Narhe, Pune, and Maharashtra, India. His research interests Machine Design IC engine, FEA. He is Also a life member of Indian Welding Society (IWS).