

Analysis of Effect of Inlet Swirl In Four Stroke Single Cylinder Diesel Engine With Different Inlet Valve Geometries Using CFD

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Abstract. Flow patterns are essential to ensure that the engine can produce high performance with the presence of swirl and tumble effect inside the engine cylinder. This paper provides the simulation of air is simulated in the software to predict the flow pattern. The flow pattern is simulated by using the steady state pressure based solver. The domain used for the simulations predicated on the particular engine parameters. Mistreatment the CFD problem solver ANSYS FLUENT, the CFD simulation is earned for four totally different geometries of the valve. The geometries consist of Horizontal, Vertical, curve and arc springs. In this simulation, only the intake strokes are simulated. From this results show that the velocity of the air flow is high during the sweeps the intake stroke takes place. This situation is produced more swirls and tumble effect during the compression, hence enhancing the combustion rate in a whole region of the clearance volume of the engine cylinder. This will initiate to the production of tumble and swirl in the engine cylinder.

1. Introduction:

Due to heterogeneous combustion the thermal efficiency of diesel Engine is less using a large excess air. Therefore to increase the thermal efficiency of C.I engine mixing of fuel and air is important factor. To improve the mixing of air and fuel, the air swirl is created inside the combustion chamber. If the swirl is weak the products of combustion don't seem to be hyped up quick from the surface of the burning drop plate. This will further suffocate burning of droplet. Hence to optimize swirl, inlet valve with different shapes on its periphery can be made first and simulated through computational fluid dynamic. Results are



compared with the help of velocity and pressure.

Here five varieties of inlet valves are used,

1. Conventional inlet valve
2. Valve with horizontal blades
3. Valve with vertical blades
4. Valve with curve springs
5. Valve with arc springs

2. Valve Designs:

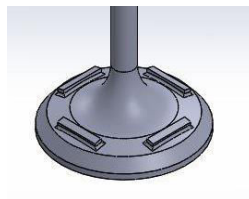


Figure 1. Valve with horizontal blades

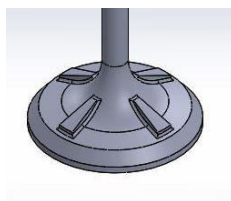


Figure 2. Valve with vertical blades

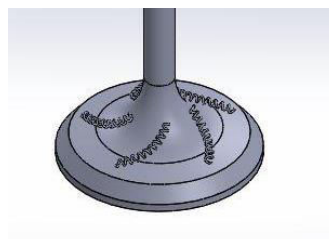


Figure 3. Valve with curve springs

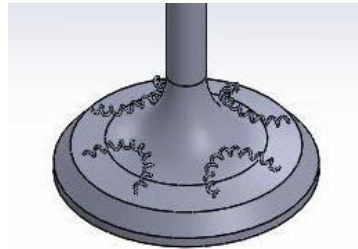


Figure 4. Valve with arc springs

3. Analysis of Normal Piston Ring:

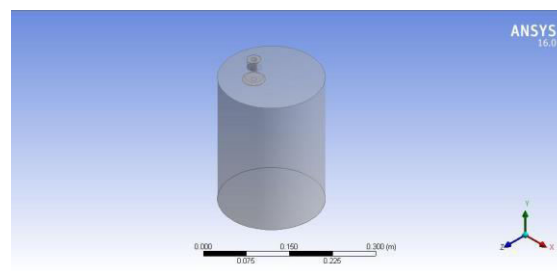


Figure 5. Created component is imported and edited for flow analysis in ansys workbench 2016

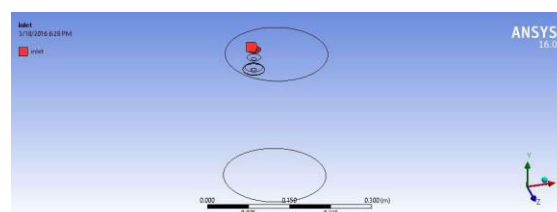


Figure 6. Assigning inlet conditions for flow to enter

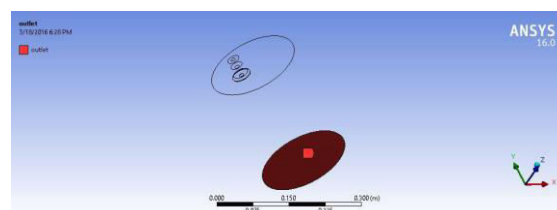


Figure 7. Assigning outlet condition for exit of the flow

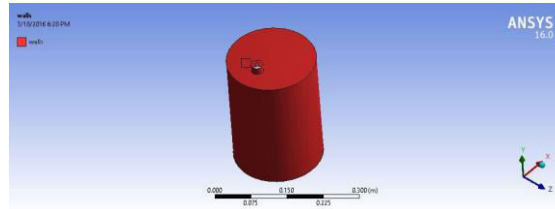


Figure 8. Assigning walls for controlling flow region

4. Velocity and Pressure Analysis:

In physics, mass–energy equivalence may be an idea developed by Einstein that explains the link between mass and energy. It states each mass has an energy equivalent and vice versa—expressed mistreatment the formula

$$E = mc^2$$

Where E is that the energy of a physical system, m is that the mass of the system, and c is that the speed of sunshine during a vacuum (about 3×10^8 m/s). In words, energy equals mass increased by the speed of sunshine square. as a result of the speed of sunshine may be a terribly sizable amount in everyday units, the formula implies that any touch of matter contains a awfully great deal of energy. a number of this energy could also be discharged as heat and lightweight by chemical or nuclear transformations. This additionally serves to convert units of mass to units of energy, irrespective of what system of activity units used.

Fluid medium used: Cynamidyl-radical

Boundary conditions:

Inlet

Type: velocity inlet (5m/s)

Outlet

Type: pressure outlet

No of iterations used: 10

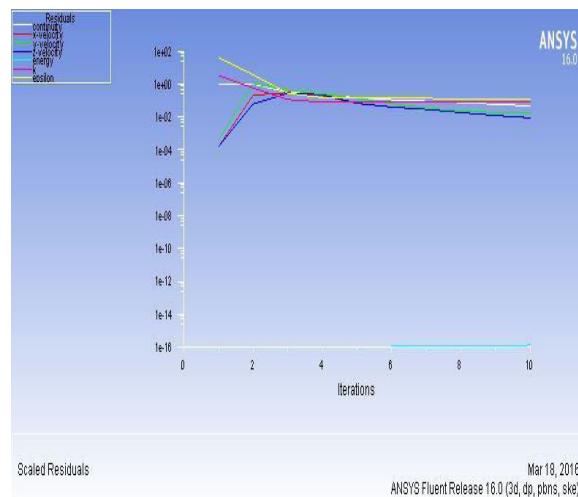


Figure 9. Graphical data for the solved results

5. Velocity flow over a normal valve design:

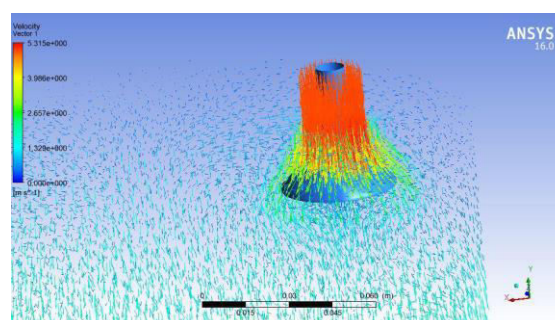


Figure 10. Velocity flow over a normal valve design

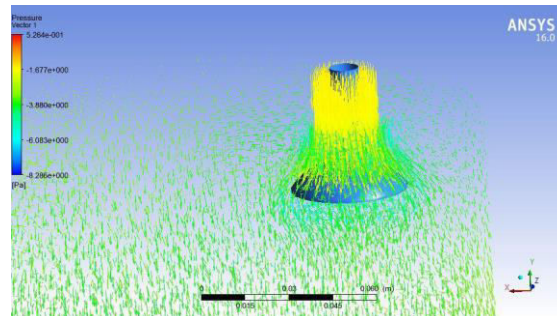


Figure 11. Pressure distributions due to the flow of fluids

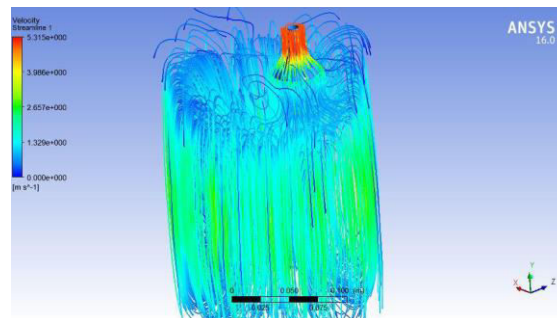


Figure 12. Stream line flow over a normal valve design

6. Analysed Results of Various Geometries of Engine Valve:

6.1 Results for engine valve with horizontal blade structures:

The first design which has modified with the horizontal blade structure where else this design helps to know and improve the results and take further steps in the valve modifications.

Table 1. Velocity and pressure for engine valve with horizontal blades

| CONTENT | MINIMUM | MAXIMUM |
|----------------|---------|---------|
| Velocity (m/s) | 1.286 | 5.143 |

| | | |
|---------------|--------|-------|
| Pressure (pa) | -5.392 | 8.199 |
|---------------|--------|-------|

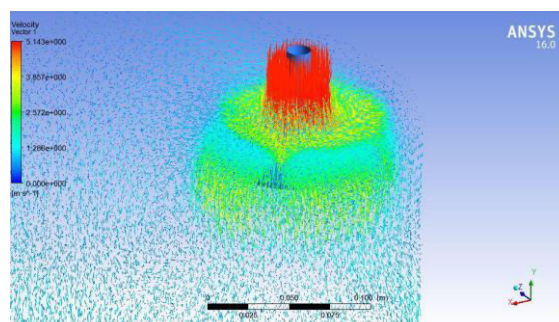


Figure 13. Velocity flow over a valve with horizontal blades

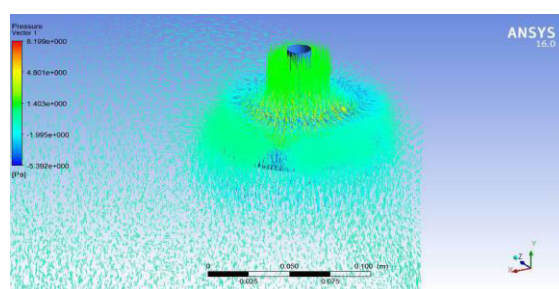


Figure 14. Pressure distributions due to the flow of fluids

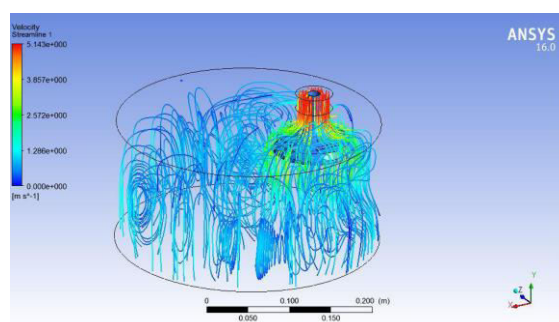


Figure 15. Stream line flow over a Horizontal valve blade design

6.2 Results for engine valve with vertical blade structure:

The second model of valve which has vertical blades on the surface of the valve. This model does not support much better increase of velocity according to design which is done but a 0.621 m/s of velocity is

increased where the inlet air velocity is 5m/s.

Table 2. Velocity and pressure for engine valve with vertical blades

| CONTENT | MINIMUM | MAXIMUM |
|----------------|---------|---------------------|
| Velocity (m/s) | 1.405 | 5.621 |
| Pressure (pa) | -1.106 | 8.562e ¹ |

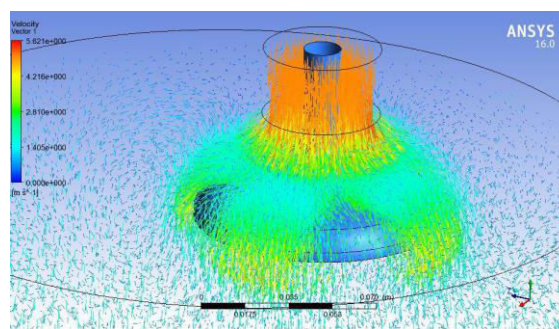


Figure 16. Velocity flow over a valve with vertical blades

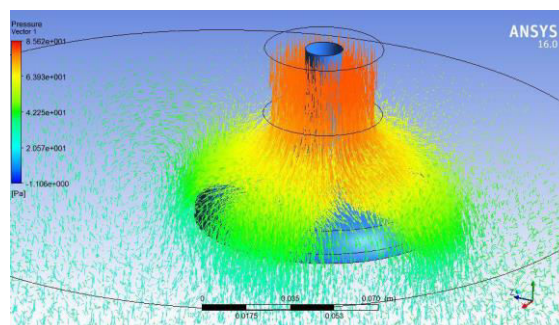


Figure 17. Pressure distributions due to the flow of fluids

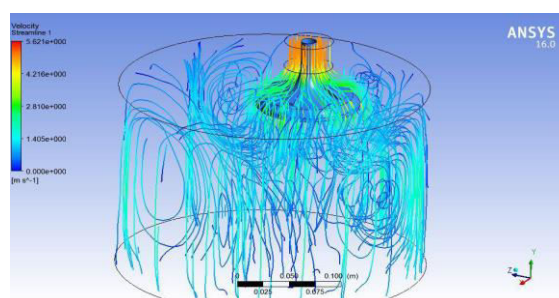
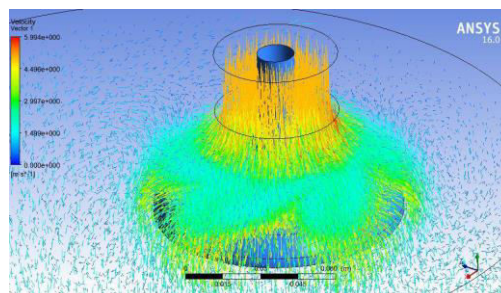
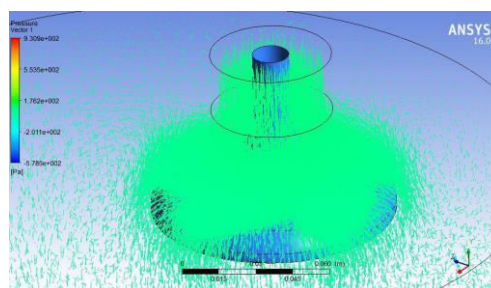


Figure 18. Stream line flow over a vertical valve design**6.3 Results for engine valve with curve springs:**

The third result with the model curved springs which a springs fixed in a slight curved structure at the top of the valve where else a another approaches of the swirl motion in the valve where comparing to result of previous model of valve it is slightly about 0.373m/s this not much but a good improved for applied inlet velocity of 5m/s.

Table 3. Velocity and pressure for engine valve with curve springs

| CONTENT | MINIMUM | MAXIMUM |
|----------------|----------------------|---------------------|
| Velocity (m/s) | 1.499 | 5.994 |
| Pressure (pa) | -5.785e ² | 9.309e ² |

**Figure 19 Velocity flow over a valve with curve springs****Figure 20. Pressure distributions due to the flow of fluids**

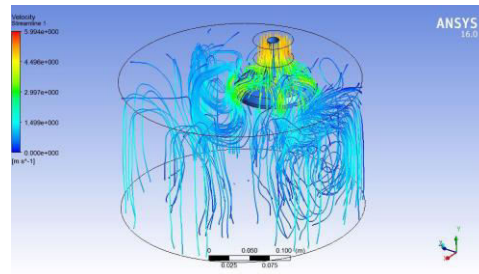


Figure 21. Stream line flow over a curve spring valve design

6.4 Results for engine valve with arc springs:

The result with the curved springs is the fourth model of the approached model. It features fine springs arranged in an arc shape. Comparing all results, the fourth model with arc springs gives a good result where the velocity at the inlet is 5 m/s, and it results in an increased velocity to 1.212, where the good velocity changes happen to be good swirl motion in the chamber.

Table 4. Velocity and pressure for engine valve with arc springs

| CONTENT | MINIMUM | MAXIMUM |
|----------------|----------------------|---------------------|
| Velocity (m/s) | 1.553 | 6.212 |
| Pressure (pa) | -3.365e ² | 1.462e ² |

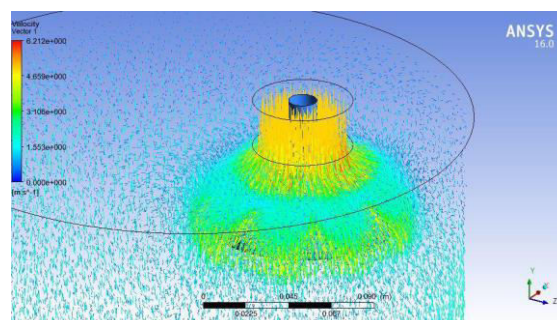


Figure 22. Velocity flow over a valve with arc springs

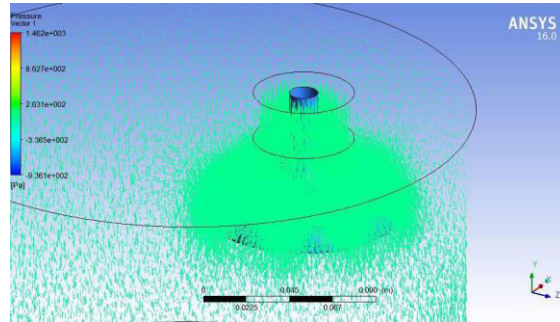


Figure 23. Pressure distributions due to the flow of fluids

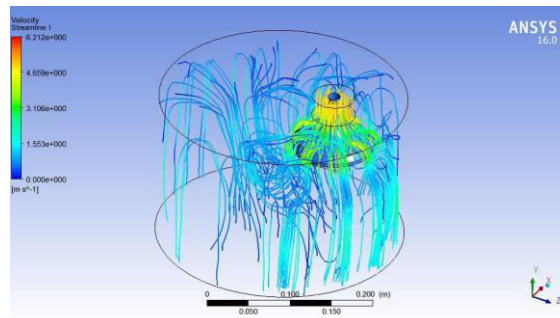


Figure 24. Stream line flow over a arc springs valve design

7. Conclusion:

Design optimisation of the intake/exhaust valves and piston bowl is crucial to understand the on top of mentioned needs. The utilization of CFD analysis in conjunction with optimisation tools will facilitate shorten the look optimisation cycle time. If we have a tendency to approach in experimental testing, it's terribly pricey similarly as time intense. The CFD analysis tool permits insight into the minute flow details that otherwise don't seem to be capture mistreatment flow bench tests. during this project work, the inner flow characteristic within the combustion chamber is investigated computationally for the various geometries of valve. The governing equations for unsteady, three-dimensional, compressible, flow are resolved with the 2 equation RNG $k-\epsilon$ model to think about the quality of the pure mathematics and fluid motion. The general flow field within the combustion chamber and varied quantities, comparable to pressure, rate distribution were examined for all geometries of valves. While examination all the results of

various geometries of engine valve it's found that distribution of engine valve with arc spring attachments provides most velocity that tends to activates the most swirl motion that the correct quality of charge is discharged at correct content.

References:

- [1] Abdullah .N.R, Shahrudin. N.S, Mamat .R, Mohd .A, Mamat .I and Zulkifli .A 2013. Effects of Air Intake Pressure on the Engine Performance, Fuel Economy and Exhaust Emissions of a Small Gasoline Engine. *Journal of Mechanical Engineering and Science*. Vol. 6, pp. 949-9
- [2] Alfaiz .M, Musthafah .M.T, Rosli .A.B, Ali .M.S and Muhaimin .A. 2013. New Design of a Low Cost Small Engine Dynamometer for Engine Testing. In: 3rd International Conference and Exhibition on Sustainable Energy and Advanced Material. Trans Tech Publ. Melaka. pp. 642-647.
- [3] Bari .S and Saad .I. 2013. CFD modelling of the effect of guide vane swirl and tumble device to generate better in-cylinder air flow in a CI engine fuelled by biodiesel. *Computers & Fluids*. Vol. 84, pp. 262-269.
- [4] Hiregoudar Yerrennagoudaru .Dr, Shiva Prasad desai 2014 . Inlet Air Swirl On Four Stroke Single Cylinder Diesel Engine Performance. *International Journal of Recent Development in Engineering and Technology* Volume 2, Issue 6, ISSN 2347-6435.
- [5] Huang .R, Yang .H and Yeh .C.N. 2008. In-cylinder flows of a motored four-stroke engine with flat-crown and slightly concave-crown pistons. *Experimental Thermal and Fluid Science*. Vol. 32, pp. 1156-1167.
- [6] Fontanesi .S, Cicalese .G and Severi .E. 2013. Analysis of Turbulence Model Effect on the Characterization of the In-Cylinder Flow Field in a HSDI Diesel Engine. *SAE Technical Paper*.
- [7] Kumar .V, Sivagaminathan .N, Gopalakrishnan .N, Morton .S, Marine .M and Radavich .P. 2000. Air flow and charge motion study of engine intake port. In: *Proc. 37th National and 4th International Conference on Fluid Mechanics and Fluid Power*. Number FMFP10-CR-10. pp. 26-30.
- [8] Pandey .K and Roy .B. 2012. CFD Analysis of Intake Valve for Port Petrol Injection SI Engine. *Global Journal of Researches in Engineering*. Vol. 12.
- [9] Puneekar .H and Das .S. 2013. Numerical Simulation of Subcooled Nucleate Boiling in Cooling Jacket

of IC Engine. SAE Technical Paper.

[10] Ramasamy .D, Aik Soon .K, Walker-Gitano Briggs .H and Zainal .Z.A. 2013. Variation of Airflow Pattern through Dissimilar Valve Lift in a Spark Ignition Engine. Journal of the Chinese Institute of Engineers. Vol. 36, pp. 1083-1096.

[11] Ramasamy .D, Zainal .Z, Bakar .R and Kadirgama .K. 2014. Mass fraction burn comparison of compressed natural gas and gasoline.In: Applied Mechanics and Materials, Trans Tech Publ. pp. 442-446.