Modelling and Fabrication of Engine Valve To Improve Performance of An I.C Engine

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Abstract: Modelling and fabrication of engine valves are made to increase the turbulence process by swirl. By proving swirl process to increase fast combustion phenomenon and enhance the efficiency of an engine. Engine should work at minimum speeds in order to have decrease the mechanical losses and good combustion enabling improves the combustion efficiency and mechanical efficiency (1). For this process be used to improves brake thermal efficiency and increase the usage of air-fuel mixture in combustion process which less impact pollution release to environment. The main importance of this work is to evaluate the performance of an Engine and to improve it by changing the valve design. Manufacturing of intake valves made to do an experimental work. this being done after modelling of valve and fabrication and then experimental work on test engine to compare two valves. Even if we adapt the this concept and also additional concentration required on inlet manifold.

Key Words: Turbulence, Air swirl, Mechanical efficiency, Thermal efficiency, Air-fuel ratio.

1. Introduction

The inside-cylinder flows of Internal Combustion Engine have drawn much importance to the automotive area. It is due to the fact that the flow structure developed by intake flows is related very nearly to the design changes and enhancement engine performance parameters of the engines. The generation of turbulence of higher impact is one of the most crucial concepts for altering and stabilizing the ignition process, high movement of flame (2), mainly in case of less air-fuel mixture burn combustion. In general, two types of process are utilized in order to develop and preserve the rotational flows efficiently. These concepts are usually known as swirl process and tumble flow process, which are produced the rotations in the horizontal and vertical plane direction of the engine cylinder, respectively. By this process of engine performance was improved.

By adaption of these two types of fluid motion in development of turbulence i.e. swirl and tumble, we are only main focus on swirl and how to improve swirl which are mainly depends on factors like changing inlet valve design etc. after checking the previous works we implemented an idea in valve design to improve swirl and for analyzing the amount of swirl produced, we mainly focus on a parameter called swirl ratio. As swirl ratio is more impact on to increase the turbulence (3, 4). Main theme here is to introduce a valve with 3 mask and 3 grooves in fluid flow. This valve all ways comes, over valve head attached to valve stem this is directly introduced to develop the turbulence at the entering stage of fluid into the chamber and hence produce high swirl.

Swirl is mainly used to supply the required amount of fuel-air mixing quantity. Swirl is generated with the support of a suitable inlet port and it is amplified at the end of the compression stroke by forcing the air towards the cylinder axis into the combustion chamber. The experimental work is carried out on a single cylinder four stroke diesel engine. A diesel generator is the combination of a diesel engine with an electric generator (often an alternator) to generate electrical energy.
There are models used in the experimental analysis and compared with each other they are

1.1. Conventional Valve:
The conventional inlet valve consisting of the face which is impact to very high temperature and pressures during the process of combustion. Valve is having a sensitive area called seating which should be very clear enough in dimensions and finishing so that accurate locking and sealing improve enhance the whole Engine Performances.

1.2. Modified Valve (3Mask & 3Groove):
Grooving is the process of removing a small amount of piece of metal on the valve head without disturbing the valve seating area; the small cavities are called grooves (5, 6). The small built-up pieces called MASKS. In this type of Valve consisting three Grooves in numbers with small pieces build on head and a three number of small built-up pieces.

2. Modelling of the Engine valve:
The modelling of engine valve is done in Catia-V5 software without changing dimension (as per engine valve specifications). But here we are adding a small built-up pieces called MASK. Making Grooves by removing small amount of material in order to compensate the weight and valve timing.

The Specification addition features of engine valve are
Width of the mask: - 4mm  
Thickness of the mask: - 45 degrees  
Width of the groove: - 3mm  
Depth of the groove: - 3mm  
Outer diameter of the groove: - 22mm  
Inner diameter of the groove: -8mm.

3. Fabrication of Engine Valve:

In order to check and compare the performance of the engine, both conventional and modified valves must be used. And the modified valve needs to be separately manufactured in order to maintain the exact same dimensions and weight of the valve, so that the valve timing would not change by the effect of increase in weight. Care must be taken while producing the valve, so that the weight of the Conventional Valve and Modified Valve remain the same.

3.1. Production of Valve in CNC machine:

In this process a stainless-steel billet of 120* 40mm is taken and the dimensions of the conventional valve are fed to the CNC machine so that there is no sign of error can be made. As we feed the dimensions of the valve, the system takes over the machine and starts the operation. The tool used in this operation is called as high-speed steel (HSS). And the billet is rotated at approx. 1500rpm. As a result, the excess material is chipped off and the required shape of the valve is obtained.

3.2. Making Grooves to the Valve:

After the production of valve in CNC machine, grooves are made to the valves as per specified in the modelling. Adding grooves to the valve is done by electric discharge machining (EDM) in which copper electrode is used to cut the valve and make grooves to it. In this process spark is generated at the tip of the electrode which helps in cutting the valve accordingly. This concept is also called as Spark erosion process. The coolant which is used in this process is called spark EDM oil.

Fig 3. Preview of Sketch  
Fig 4. Engine Valve  
Fig 5. Manufacturing of Grooves in EDM machine
3.3. Manufacturing of Masks:
Masks are stainless steel structures which are initially made in circular shape on lathe machine and are made to cut on grinding machine(8). They are cut in such a way that each of the mask is of 120 degrees and placed in between the grooves of the valve. They are grinded through grinding process and welded to the valve. Each of the Mask is about 3mm thickness and placed at 120 degree angle to the valve.

3.4. Welding of the Masks:
After manufacturing of the masks, they are welded on to the valve by a method of welding called brazing. In brazing brass is used as filler material to weld the two materials of different thickness. As the thickness of the masks is too low, and the thickness of the valve is too high, the masks cannot be welded by arc welding process, as it melts the masks(7). Therefore, the brazing process is used to weld the masks on to the valve. Brazing is done at 450degree Celsius temperature at which the filler material melts but the welding temperature still remains below the melting point of base metal. As a result, the welding is done perfectly on the valve.

![Fig 6. Modified Valve](image)

3.5. Buffing of the Valve:
Buffing is the finishing processes for smoothing a work piece's surface using an abrasive and a work wheel or a leather strop. Initially polishing refers to that use an abrasive that is glued to the work wheel, while buffing uses a loose abrasive applied to the work wheel. In order to improve the surface finish, Polishing is a more impact process while buffing is less impact on metal surface finish, which leads to a finer and good finish. For this valve buffing process is used in order to have a smooth and brighter finish of the valve.

4. Installation of Valve in the Engine:
After the buffing of the valves, the clearance of the valve is noted and checked in order to install it in the engine. Installation of the valve begins with the removal of rocker arm assembly followed by removal of engine head. After removing the engine head, old valves are replaced by the modified valves with masks on its head. After replacing the conventional valve with the modified valve, all the other components of the engine are reassembled in their original positions. The engine that is used for this experimentation is single cylinder 4-Stroke Diesel Engine, with 1500RPM and 5 BHP of horse power. The fuel used in this engine is H.S diesel.
4.1. Experimentation:
In order to conduct the experiment, the valves should fit in the engine head perfectly. Then only the experimentation can be started. After the reassembly of the engine, the engine is started and the values of engine speed, time required for fuel consumption, voltage, current and manometer readings are taken. The values of the above are required to calculate the efficiency related engine, and Air-Fuel Ratio. For every 10ml drop of fuel, the time required for fuel consumption, voltage current, and manometer readings are taken(9,10). Initially to start the experiment, the engine should be started by rotating the Engine shaft. After starting the engine, by maintaining constant voltage of 220 volts, and by adding 5 consecutive loads, the values of manometer reading and the time required for drop of 10ml fuel is noted down for all of the 6 loads i.e. one no load conditions and 5 other consecutive loads. Calculations are done based on the values that are obtained during the experiment and the below formulae are used to calculate the values of related efficiencies of an engine and Air-Fuel Ratio.

Observation Table:

| Load [N] | Engine speed [RPM] | Time for 10ml fuel consumption in [sec] | Generator Voltage [v] | Generator current [amps] | Manometer reading (h1) [mm] | Manometer reading (h2) [mm] | Manometer reading h=(h1-h2) [mm] |
|----------|---------------------|----------------------------------------|-----------------------|-------------------------|-----------------------------|-----------------------------|---------------------------------|
| No load  | 1630                | 71                                     | 220                   | 0                       | 66                          | 73                          | 139                             |
| 1        | 1599                | 58                                     | 220                   | 4.1                     | 63                          | 69                          | 132                             |
| 2        | 1586                | 47                                     | 220                   | 8.2                     | 62                          | 67                          | 129                             |
| 3        | 1576                | 40                                     | 220                   | 12.4                    | 61                          | 66                          | 127                             |
| 4        | 1556                | 34                                     | 220                   | 16.5                    | 58                          | 64                          | 122                             |
| 5        | 1545                | 28                                     | 220                   | 20.8                    | 57                          | 62                          | 119                             |
Table 2: Modified Valve:

| Load (N) | Engine speed (RPM) | Time for 10ml fuel consumption in (sec) | Generator Voltage (v) | Generator current (amps) | Manometer reading (h1) (mm) | Manometer reading (h2) (mm) | Manometer reading h=(h1-h2) (mm) |
|----------|-------------------|----------------------------------------|-----------------------|--------------------------|-----------------------------|-----------------------------|----------------------------------|
| No load  | 1600              | 75                                     | 220                   | 0                        | 69                          | 74                          | 143                              |
| 1        | 1590              | 62                                     | 220                   | 4.1                      | 66                          | 73                          | 139                              |
| 2        | 1580              | 50                                     | 220                   | 8.2                      | 63                          | 69                          | 132                              |
| 3        | 1569              | 42                                     | 220                   | 12.4                     | 62                          | 67                          | 129                              |
| 4        | 1552              | 36                                     | 220                   | 16.5                     | 61                          | 65                          | 126                              |
| 5        | 1542              | 29                                     | 220                   | 20.8                     | 60                          | 64                          | 124                              |

5. Results and Discussion

Table 3: Conventional Valve:

| LOAD [N] | B.P [kW] | B.S.F.C [kg/kWh] | B.M.E.P [bar] | I.P [kW] | Mech. Efficiency (%) | Brake Thermal Efficiency (%) | Volumetric Efficiency (%) | Air-Fuel Ratio |
|----------|----------|------------------|---------------|----------|----------------------|-----------------------------|--------------------------|-----------------|
| No load  | 0        | -                | 0             | 3.75     | 0                    | 0                           | 83.69                    | 53.77           |
| 1        | 1.002    | 0.514            | 1.36          | 4.752    | 21.08                | 15.91                       | 83.14                    | 42.80           |
| 2        | 2.004    | 0.317            | 2.742         | 5.754    | 34.826               | 25.80                       | 82.87                    | 34.29           |
| 3        | 3.031    | 0.2464           | 4.173         | 6.781    | 44.69                | 33.19                       | 82.74                    | 28.95           |
| 4        | 4.033    | 0.2178           | 5.625         | 7.783    | 51.81                | 37.55                       | 82.14                    | 24.12           |
| 5        | 5.084    | 0.2098           | 7.141         | 8.834    | 57.55                | 38.98                       | 81.704                   | 19.62           |

Table 4: Modified Valve:

| LOAD (N) | B.P (kW) | B.S.F.C (kg/kWh) | B.M.E.P (Bar) | I.P (kW) | Mech. Efficiency (%) | Brake Thermal Efficiency (%) | Volumetric Efficiency (%) | Air-Fuel Ratio |
|----------|----------|------------------|---------------|----------|----------------------|-----------------------------|--------------------------|-----------------|
| No load  | 0        | -                | 0             | 3.35     | 0                    | 0                           | 86.51                    | 57.63           |
| 1        | 1.002    | 0.4808           | 1.3679        | 4.352    | 23.02                | 17.01                       | 85.83                    | 46.97           |
| 2        | 2.004    | 0.2981           | 2.7533        | 5.354    | 37.43                | 27.44                       | 84.17                    | 36.91           |
| 3        | 3.031    | 0.2346           | 4.1927        | 6.381    | 47.50                | 34.85                       | 83.79                    | 30.65           |
| 4        | 4.033    | 0.2057           | 5.6401        | 7.383    | 54.62                | 39.75                       | 83.72                    | 25.96           |
| 5        | 5.084    | 0.2026           | 7.1561        | 8.434    | 60.27                | 40.37                       | 82.59                    | 20.75           |
Fig 9. Mechanical Efficiency vs Load

Fig shows the variation of mechanical efficiency with load, as the load increases the mechanical efficacy increases and it decreases the nature at 5kw load.

Fig 10. Brake Thermal Efficiency vs Load

Fig 11. Volumetric Efficiency vs Load
As mentioned before, the main theme of this work is to improve the performance of an I.C engine by doing some changes in the valve design and dimensions, after drawing above graphs the expected result is achieved. The overall average values of conventional valve parameters like Mechanical Efficiency, Brake Thermal Efficiency, Volumetric Efficiency and Air-Fuel Ratio are 34.99%, 25.23%, 82.69%, and 33.92% respectively. Whereas the overall average values of the modified valve parameters like Mechanical Efficiency, Brake Thermal Efficiency, Volumetric Efficiency and Air-Fuel Ratio are 37.14%, 26.57%, 84.60%, and 36.47% respectively.

Conclusions:
Investigation of the influence of engine performance by changing the inlet valve profile configuration is the following main conclusions

1. Introducing of inlet valve profile configuration it influence the utilization of power was improved due to this Mechanical Efficiency of an engine increased by 2.15%,
2. The swirl concept improves by changing the area of profile due to this better mixing will takes place by this Brake Thermal Efficiency was improved by 1.34%,
3. Volumetric Efficiency is the main factor in engines due to this intake air was induction taken much improved compared to convention valve improved by 1.91%,
4. By changing the valve profile it effects on air fuel ratio much improved due to this the performance of an engine improves, compared to convention valve Air-Fuel Ratio is increased by 2.55 for the Modified Valve.

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