# Effect Of Swirl Inducton & Masking Of Inlet Valve On Four Stroke Single Cylinder Diesel Engine By Using Ansys Fluent

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***Abstract-*** *In present scenario, whole world is facing the challenge from greenhouse emissions and high fuel consumption. Today there is need to reduce worldwide fuel consumption, greenhouse gas emissions, and air emissions. Air Swirl has great potential to achieve high fuel efficiency and to produce low emissions. Hence there is strong interest in Swirl Induction worldwide. This combustion process stands out as a strong candidate for future automotive engines that consume less fuel while producing substantially lower levels of emissions. Therefore, Swirl Induction combustion technology has prime merit to address these issues for GHG and emissions. In an Internal Combustion Engine the performance, efficiency and emission formation depends on the formation of air-fuel mixture inside the engine cylinder. The fluid flow dynamics plays an important role for air-fuel mixture preparation to obtain the better engine combustion, performance and efficiency. Due to the extreme conditions inside a typical IC-engine (high combustion temperatures and pressures, precipitation of soot and other combustion products, etc.) experimental techniques are sometimes limited in approaching the above mentioned problem. Alternatively, computer simulations (Computational Fluid Dynamics, CFD) offer the opportunity to carry out repetitive parameter studies with clearly defined boundary conditions in order to investigate various configurations. In this paper analysis of influence of the air swirl in the cylinder upon the performance and emission of a single cylinder diesel direct injection engine by using ANSYS FLUENT and experimentation is presented. The intensification of the swirl is done by providing masking on inlet valves. The Modeling of this valves is done by using Creo parametric 2.0 In this work different types of mask are provided i.e. mask with holes & without holes and fins with & without holes to intensify the swirl for better mixing of fuel and air and their effects on the performance and emission are recorded. . The purpose is to create a more atomized mist of the air fuel mixture entering into the combustion chamber giving a more and complete burn of the fuel.This work relates to air intake valves for internal combustion engines. The objective of present workis to mount a mask on a valve head so that it rides with the head during the opening and closing of the valve, but remains stationary with respect to rotational movements of the valve head With respect to the valve seat. Results are compared for maximum swirl and turbulent kinetic energy and finally a physical model is prepared through some suitable materials and through machining. This is particularly true in DI diesel engines. Moreover, the efficiency of an engine can be improved by increasing the burn rate of the fuel/air mixture. This can be achieved in two ways.By designing the combustion chamber in order to reduce contact between the flame and the chamber surface.By designing intake systems that impart a swirling motion to the incoming charge.*

***Keywords***- Air Swirl,GHG(green house gases),masking,CFD,ANSYS FLUENT,creo parametric.

## I. INTRODUCTION

Swirl is one of the principal means to ensure rapid mixing between fuel and air in DI diesel engine. The swirl level at the end of the compression process dependent upon the swirl generated during intake process and how much it is amplified during the compression process. In DI diesel engine, as fuel is injected, the swirl converts it away from the fuel injector making fresh air available for the fuel about to be injected. Swirl is defined as the large scale vortex in the in-cylinder fluid with the axis of rotation parallel to the piston axis.Due to heterogeneous combustion the thermal efficiency of C.I. Engine is less in spite of using a large excess air .Therefore thought of conducting the experiment to overcome the above problem of low thermal efficiency and also to reduce levels of pollution. The thermal efficiency of the conventional C.I. Engine is low around 20%to28% due to low rate of air swirl and improper mixing of air and fuel. If the swirl is weak the products of combustion are not swept away fast from the surface of the burning drop plate. This will further suffocate burning of droplet. Hence to optimize swirl, inlet valve with different shapes (MASKING) on its periphery can be made first and simulated through computational fluid dynamic. The software used for this project is ANSYS FLUENT and CREO PARAMETRIC 2.0. The creo is one of the popular and easy software to use for modeling (solid and meshing). So that we suggested this software to use for modeling of the inlet valve with masking on its head. The conventional inlet valve is as shown above, consisting of combustion face which is exposed to a very high temperatures during the process of combustion. Valve is having a delicate part called seating which should be very accurate enough in dimensions and finishing so that accurate locking and sealing enhances the whole engine performances.Masking is the process of building a small piece of metal on the valve head without disturbing the valve seating; the small pieces are called masks. Here for analysis we have used 2-masked valves, 4-masked valve and 6- masked valve.

## II. LITERATURE REVIEW

Flow of air through the manifold and mixing of the fuel with air inside the cylinder is more important in the case of diesel engine because these factors, directly affect the volumetric efficiency, combustion performance, output and emission levels of the engine. Control of flow through the manifold is critical for meeting the emission regulations and fuel economy requirements. Parameters like engine speed, manifold and combustion chamber configuration directly influence the swirl in DI diesel engines and subsequently it plays a vital role in mixing air and fuel inside the cylinder. Optimization of swirl becomes an important aspect in the design of intake systems of diesel engines[1] . The two parameters swirl and turbulence represents the fluid flow behaviors occurred inside combustion chamber which influences the air streams to the cylinder during intake stroke and enhances greatly the mixing of air and fuel to give better mixing during compression stoke [2]The effect of port diameters on air flow and swirl motion was also investigated. In this case, ports with two different diameters were modeled. In addition, the effect of using one or two intake ports on swirl generation was determined by blocking one of the ports. The results show that higher swirl was generated with a single port and a shrouded valve[3]. The fuel injection introduces additional complexities like two phase flows. Pollutant emissions were controlled by the turbulent fuel–air mixing and combustion processes. A detailed understanding of these processes is required to improve performance and reduce emissions without compromising the fuel economy [4]. The production of turbulence of higher intensity is one of the most important factors for stabilizing the ignition process, fast propagation of flame, especially in case of lean-burn combustion In general, two type of vortices are utilized in order to generated and preserve the turbulence flows efficiently. These vortices are usually known as swirl and tumble flows, which are organized rotations in the horizontal and vertical plane of the engine cylinder, respectively [5].In order to achieve the different swirl intensities in the cylinder, three design parameters have been changed: the cylinder head, piston crown, and inlet duct. In this way, the piston crown is modified i.e. alteration of combustion chamber to enhance the turbulence in the cylinder. This intensification of the swirl is done by cutting grooves on the crown of the piston [6]. Intake generated swirl usually persists through the compression, combustion, and expansion stroke and it can greatly enhances the mixing of air and fuel to give a homogeneous mixture in the very short time. It is also a main mechanism for very rapid spreading of the flame front during the combustion process. Both the bulk fluid motion and the turbulence characteristics of the flow are essential to produce the homogeneity structure of air flow come into cylinder [7-15]

## III. EXPERIMENTATION AND ANALYSIS

### 3.1 Inlet valve models

In this work four varieties of inlet valves are used,
1. Base model (The conventional inlet poppet valves)
2. Type-1 valve (Inlet valve with masks on its back)
3. Type-2 valve (Inlet valve with hole on masks)
4. Type-3 valve (Inlet valve with fins on its back)

In order to produce a swirling motion in the combustion gases, including the air introduced into the cylinder of an internal combustion engine, inlet valves are used upon which are mounted masks so that the stream of the intake gas is throttled across a portion of the valve seat, and the intake gas thus given a desired swirling direction into the cylinder. However, such a valve having a fixed mask must be prevented from rotating in order to keep the mask in its proper aero dynamical position with respect to the valve port. This results in the disadvantage in that the valve head is kept from rotating, and can not self-grind itself upon the valve seat. In general, the objects of this invention are obtained by forming the mask of a separate piece and mounting it upon the valve head so that it will move in a longitudinal direction with the valve head during the opening and closing of the valve. Fig. shows masking on inlet valve.

### 3.2 Engine Specification:

Engine operating parameters:

Water Cooled, Single Cylinder, 4-Stroke Diesel Engine Specifications:

BHP = 5HP = 3.68KW Bore Diameter = 80mm
Stroke length = 110mm Speed = 1500rpm
Brake drum Radius = 147mm C.V of Diesel = 45, 355 KJ / Kg
Orifice dia = 15mm Brake Rope dia = 15.9 mm
Torque arm radius = 0.2 m Compression ratio = 16.5:1
Specific Gravity of diesel = 0.8225gm/cc

### 3.3 Simulation using CFD:

Simulation By Using CFD:
Here valve lift is considered as major criterion for simulation.

Total valve lift = 12mm
This 12mm is divided into 3 parts and called as
Low Lift (valve at 4mm downward movement)
Medium lift (valve at 8mm downward movement)
High lift (valve at12mm downward movement)

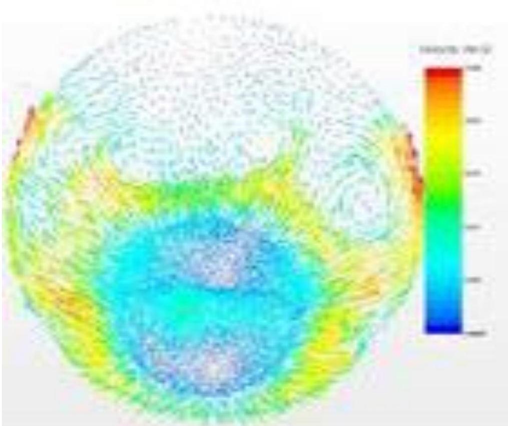
Hence CFD simulations were carried out for analyzing swirl, turbulence, velocity of inlet air and also pressure distribution inside the cylinder during suction stroke and are analyzed at different inlet valve lift positions in comparison with base model.

Here four varieties of inlet valves are used,
1. Type-1 valve (Inlet valve with masks on its back)
2. Type-2 valve (Inlet valve with Hole on mask)
3. Type-3 valve (Inlet valve with fins on its back)

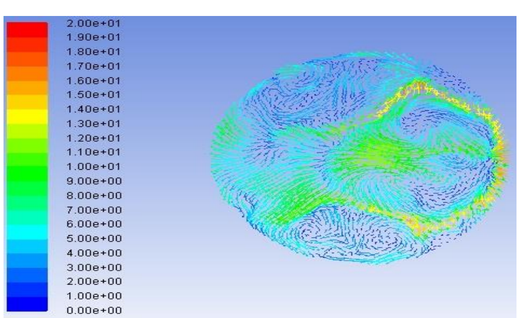
The Simulation requires valve models, engine inlet manifold model, combustion chamber model, engine operating parameters. Below explain with some Analysis of swirl by simulation*:* The swirl intensity is very less at the medium and at high valve lifts. Compare this intensity with the following model; we can notice that which type of valve will give better swirl intensity.

**Base model**

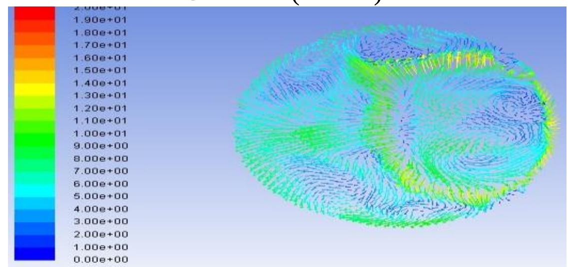
AT LOW LIFT (4 mm)



AT MEDIUM LIFT (8 mm)




AT HIGH LIFT (12 mm)




The swirl intensity is very less at the medium and at high valve lifts. Compare this intensity with the following model; we can notice that which type of valve will give better swirl intensity.

**2) Type-1 inlet valve (valve with masks on its head):**

Fig: 11 Type 1 inlet valve (valve with masks on its head)

Masking is the process of building a small piece of metal on the valve head without disturbing the valve seating; the small pieces are called masks. Here for analysis we have used 2-masked valves, 4-masked valve and 6- masked valve, which are having the following dimensions.

Angle of mask: 120 degree
Width of mask: 2mm
Thickness of mask: 2mm
Outer dia. of mask: 28mm
Inner dia. of mask: 24mm
Hence these masks are split into 2, 4 and 6 pieces angularly i.e., 120 degree/2 = 60d. Masks in 2 pieces 120d/4 =30d. Masks in 4 pieces
120d/6 = 200d.masks in 6 numbers

**Analysis of swirl by simulation**:
**2 masked valve**

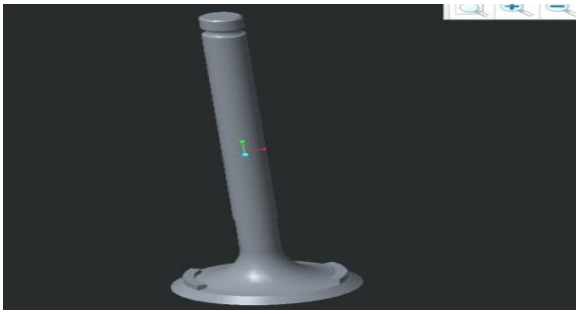
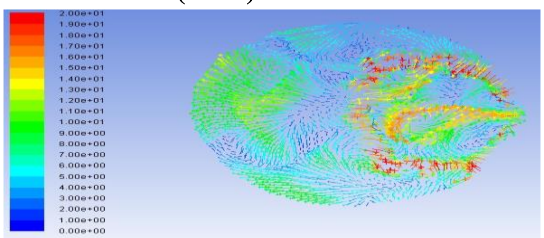
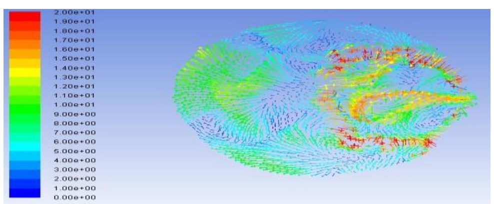


Fig: 12 Type 1 inlet valve (valve with 2 masks on its head)

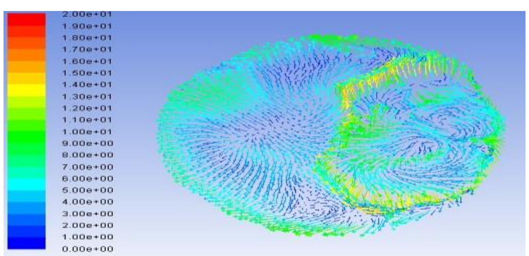
AT LOW LIFT (4 mm)




AT MEDIUM LIFT (8 mm)



AT HIGH LIFT (12 mm)




**4 masked valve:**

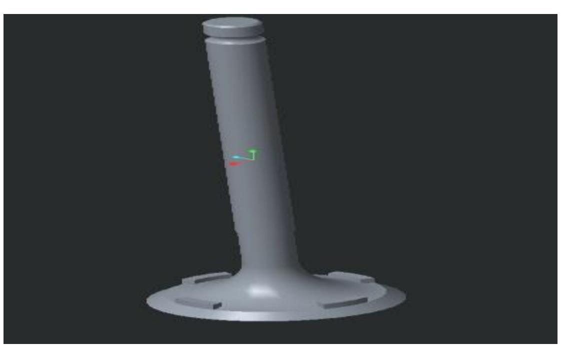
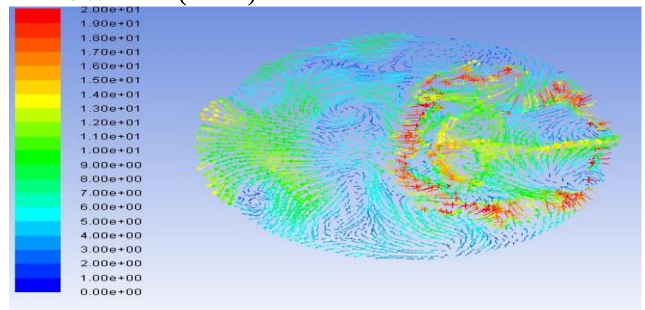
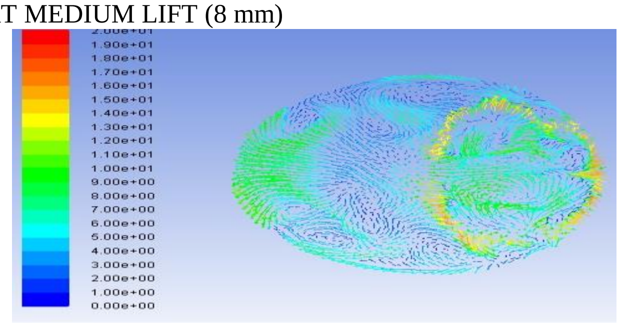


**Fig: 13 Type 1 inlet valve (valve with 4 masks on its head)**

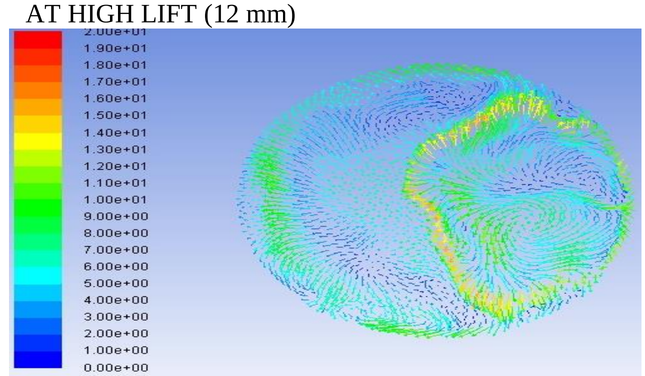
AT LOW LIFT (4 mm)




AT MEDIUM LIFT (8 mm)




AT HIGH LIFT (12 mm)




**6 masked valve:**

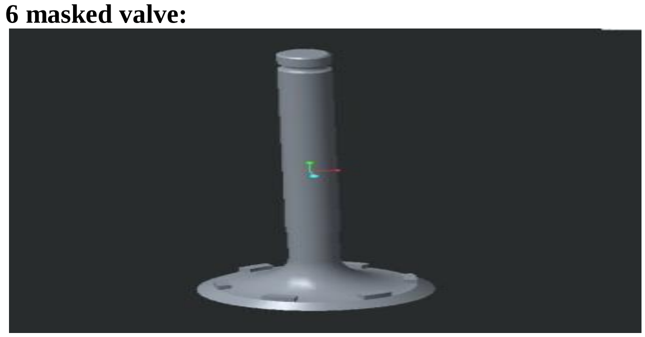
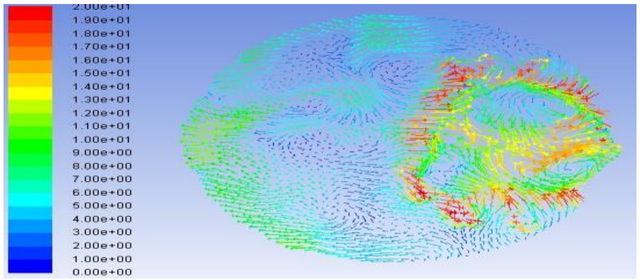
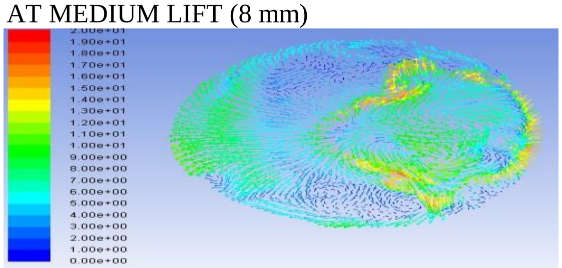


**Fig:14 Type 1 inlet valve (valve with 6 masks on its head)**

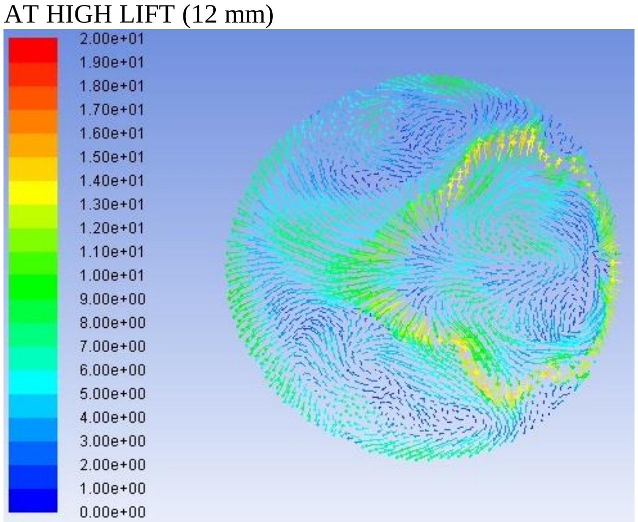
AT LOW LIFT (4 mm)

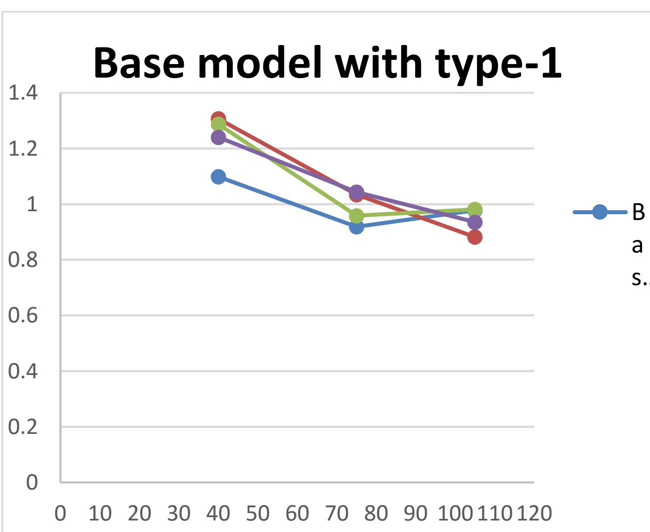


AT MEDIUM LIFT (8 mm)

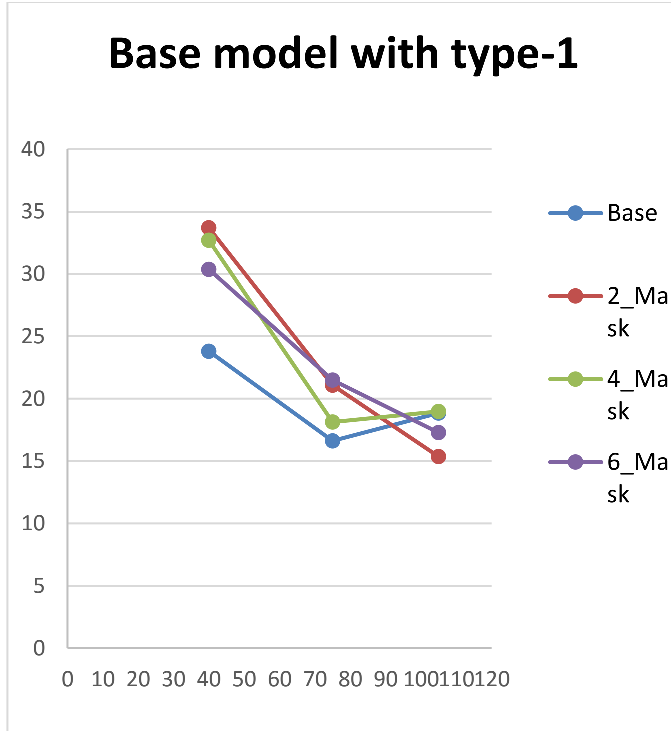


AT HIGH LIFT (12 mm)




**Graph:1 Swirl Ratio Vs Crank Angle (Masking On Valve)**




**Graph:2 Turbulence Vs Crank Angle (Masking On Valve)**

**2) Type 2 Valve (masking with hole)**

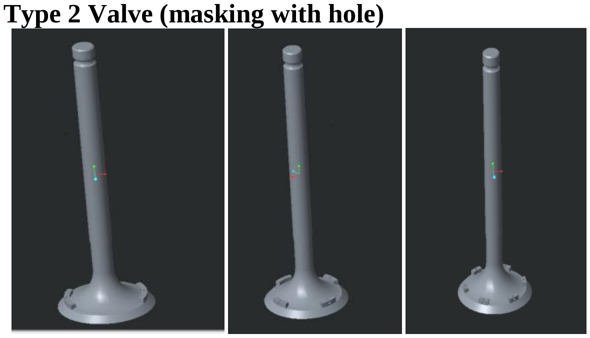


**Fig.15 Type 2 Inlet valve ( masking with hole)**

Masking is the process of building a small piece of metal on the valve head without disturbing the valve seating; the small pieces are called masks. Here for analysis we have used 2-masked valves, 4-masked valve and 6- masked valve,(with hole on mask) which are having the following dimensions.

Hole diameter: 0.5 mm
Angle of mask: 120 degree
Width of mask: 2mm
Thickness of mask: 2mm
Outer dia. of mask: 28mm
Inner dia. of mask: 24mm
Hence these masks are split into 2, 4 and 6 pieces angularly i.e., 120 degree/2 = 60d. Masks in 2 pieces 120d/4 =30d. Masks in 4 pieces
120d/6 = 200d.masks in 6 numbers

**Analysis of swirl by simulation:**

**2-mask with hole**

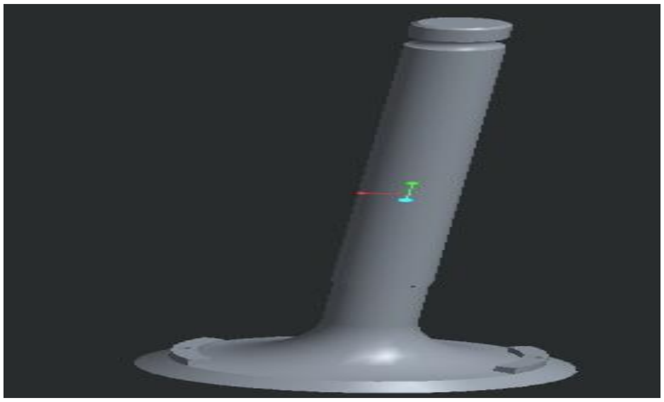
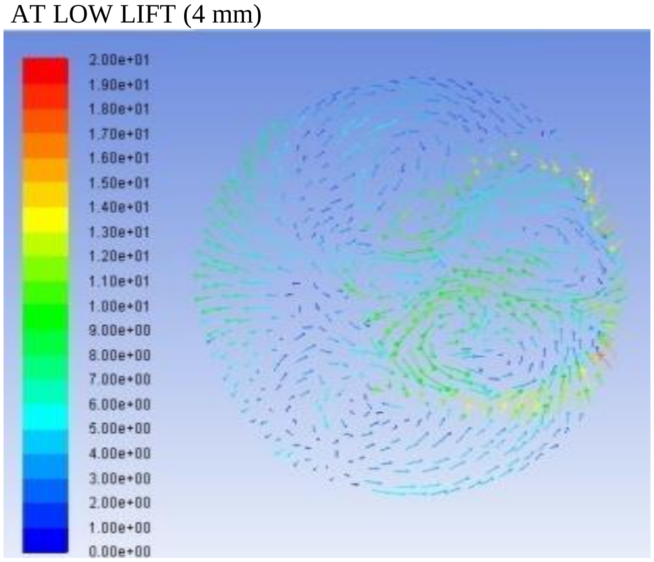


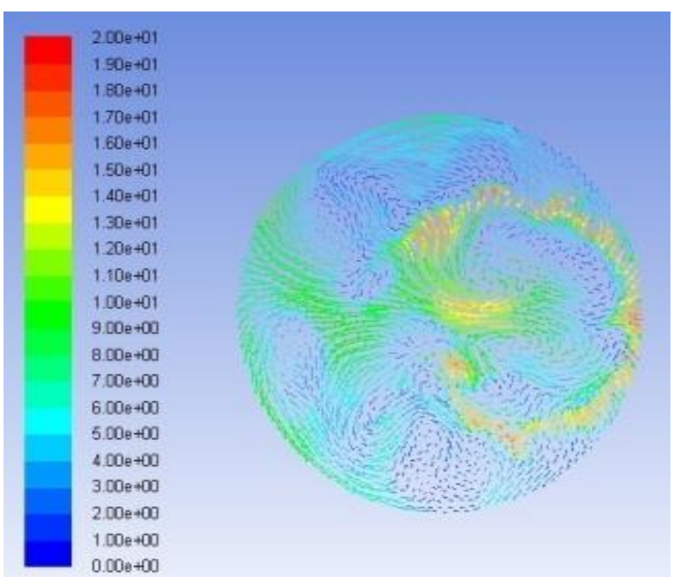
**Fig.16 Type 2 Inlet valve( 2 masking with hole)**

**Analysis of swirl by simulation:**

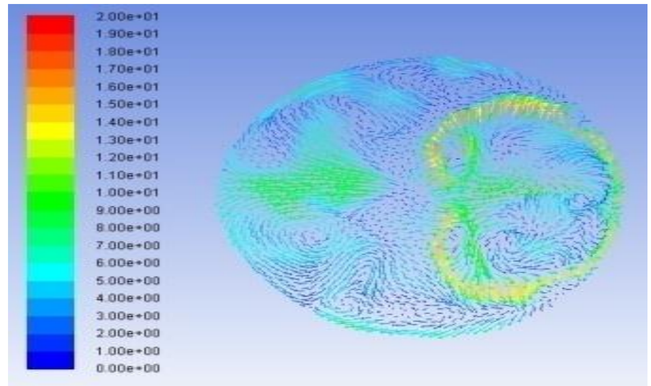
AT LOW LIFT (4 mm)




AT MEDIUM LIFT (8 mm)




AT HIGH LIFT (12 mm)




**4-mask with hole**

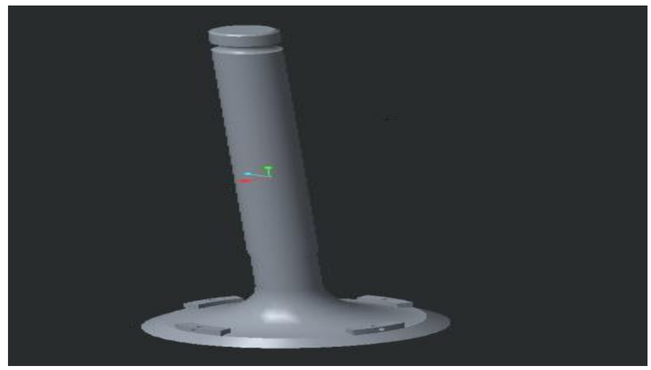
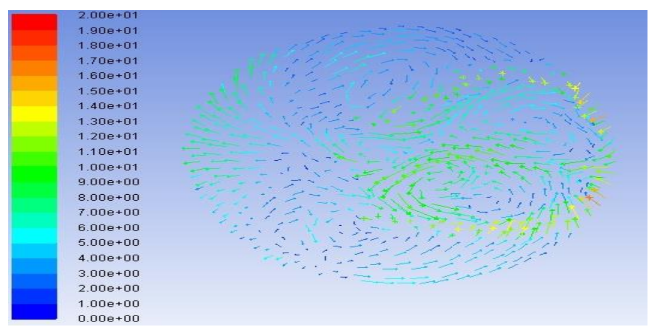


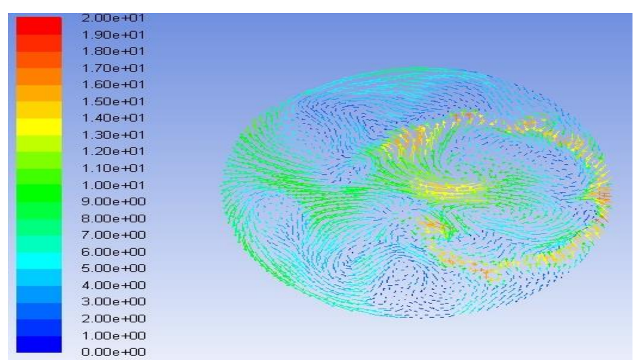
**Fig.17 Type 2 Inlet valve (4 masking with hole)**

**Analysis of swirl by simulation:**

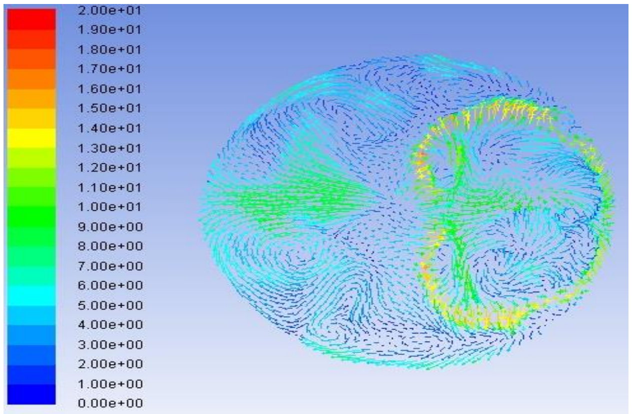
AT LOW LIFT (4 mm)




AT MEDIUM LIFT (8 mm)




AT HIGH LIFT (12 mm)



**6-mask with hole**

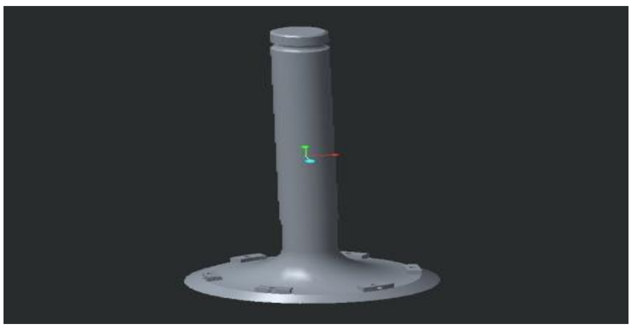
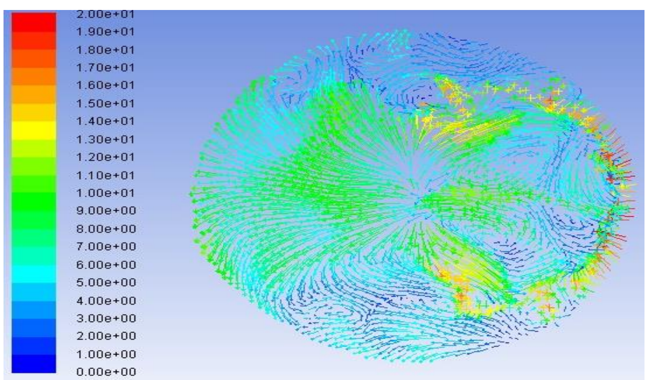
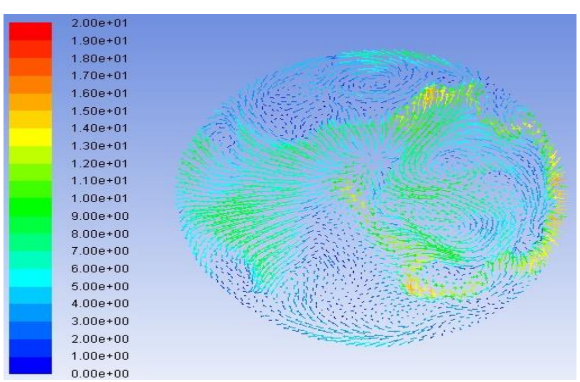


**Fig.18 Type 2 Inlet valve (6 masking with hole)**

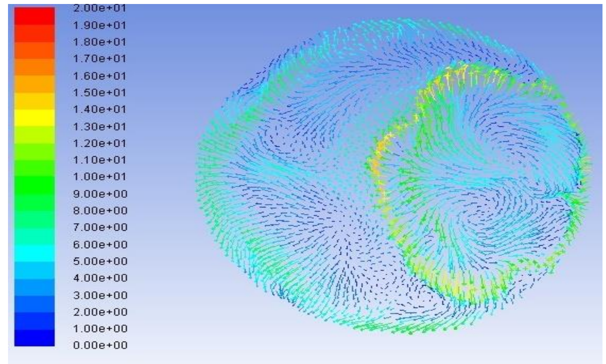
AT LOW LIFT (4 mm)

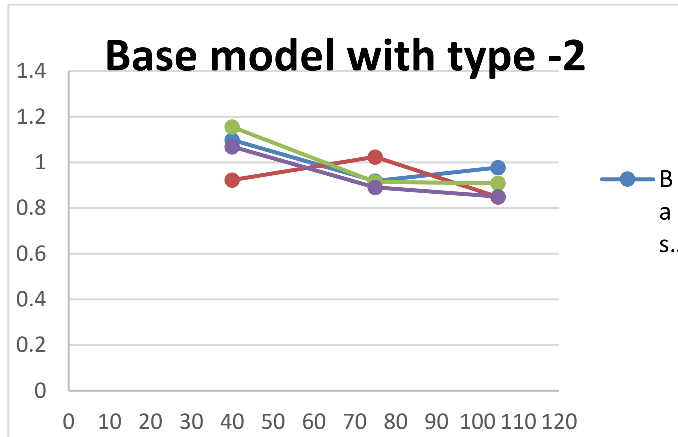


AT MEDIUM LIFT (8 mm)

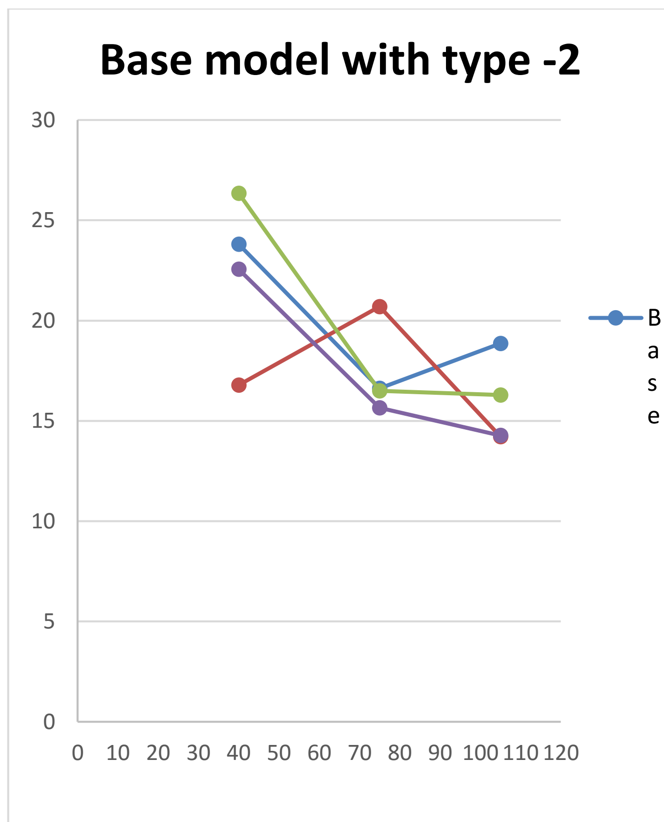


AT HIGH LIFT (12 mm)






**Graph: 3 Swirl Ratio Vs Crank Angle (Masking with Hole)**




**Graph:4 Turbulence Vs Crank Angle (Masking with Hole)**

**4) Type-3 valve (Inlet valve with fins on its back)**

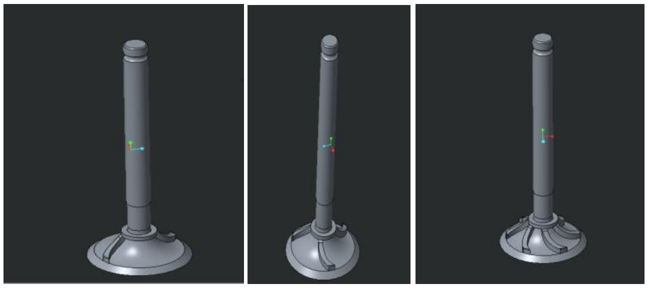


**FIG-19 Type-3 inlet valves(valve with extended fins)**

In this type a small ring consisting fixed vanes are used as fins and are easily detachable from the valve body. The fins are equi-spaced on a circular orbit with varying numbers say two, three and six as shown in figure. . The dimensions are:

Inner ring dia-7.8mm
Thickness of ring: 2mm
Width of ring: 2mm
Length of vane: 12mm
Width and thickness of vane: 2mm
Angle of vane: 45 degree bent approximately down to adjust on valve head.
Simulation using CFD

**2-Fins**

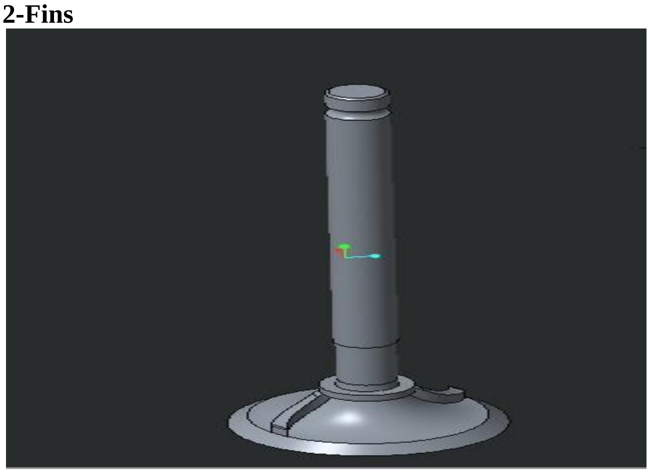
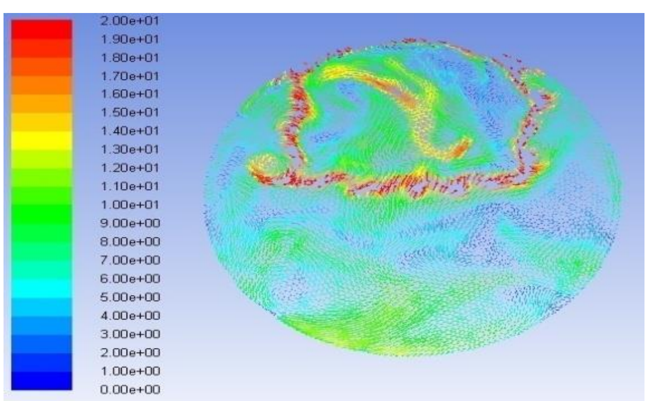
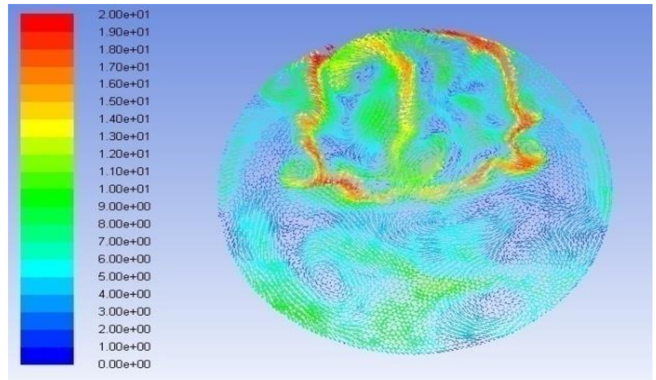


**FIG-20 Type-3 inlet valves (valve with 2 extended fins on its head)**

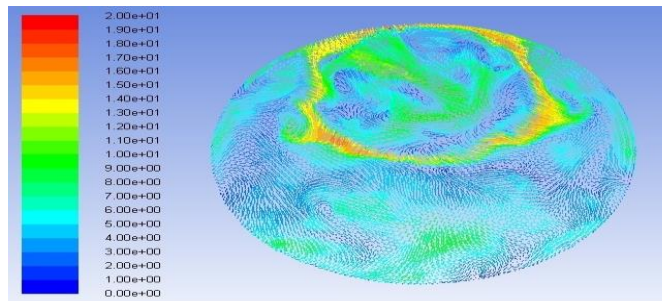
Analysis by simulation
AT LOW LIFT (4 mm)




AT MEDIUM LIFT (8 mm)




AT HIGH LIFT (12 mm).




**6 –Fin**

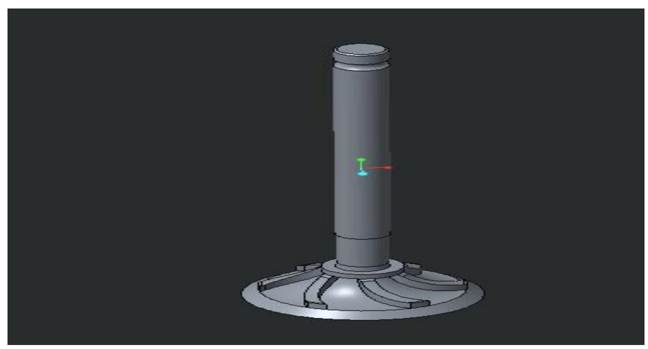
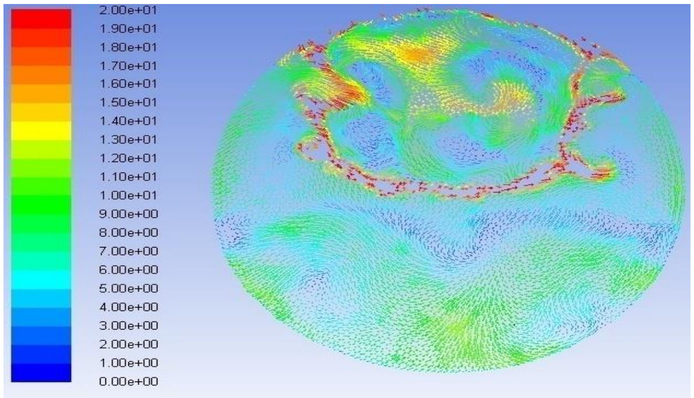


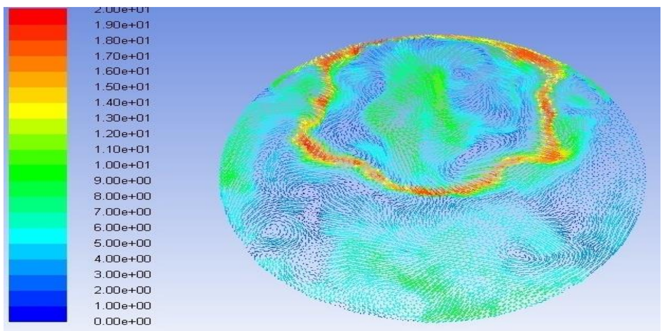
**FIG-22 Type-3 inlet valves (valve with 6 extended fins on its head)**

**Analysis simulation**

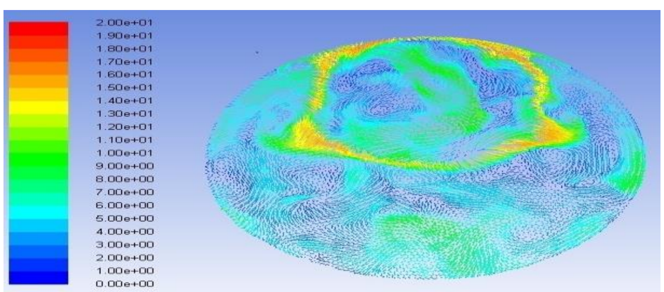
AT LOW MEDIUM (4 mm)




AT MEDIUM LIFT (8 mm)




AT HIGH MEDIUM (12 mm)




6 –Fin

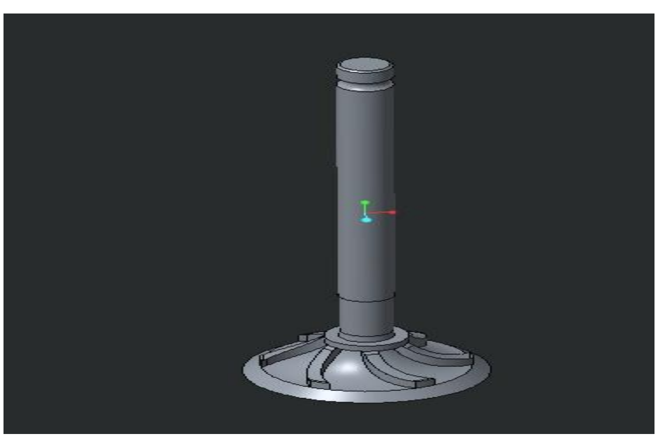
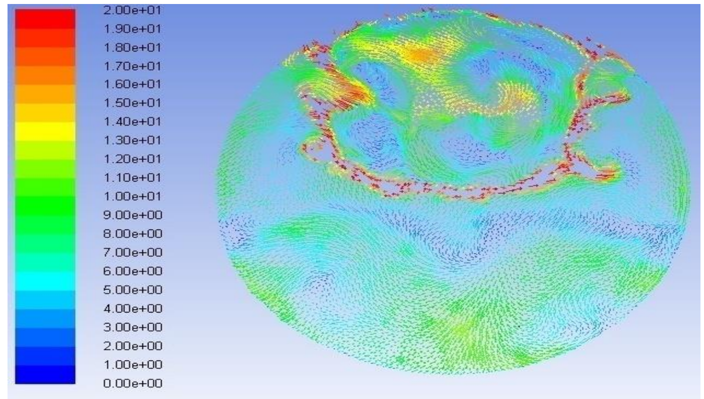


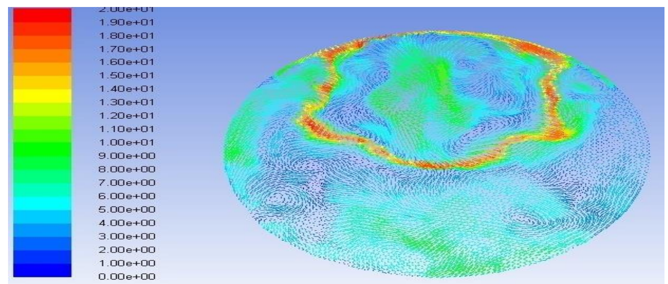
**FIG-22 Type-3 inlet valves (valve with 6 extended fins on its head)**

**Analysis simulation**

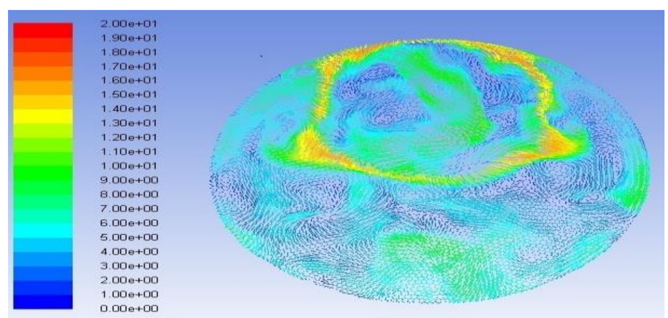
AT LOW MEDIUM (4 mm)

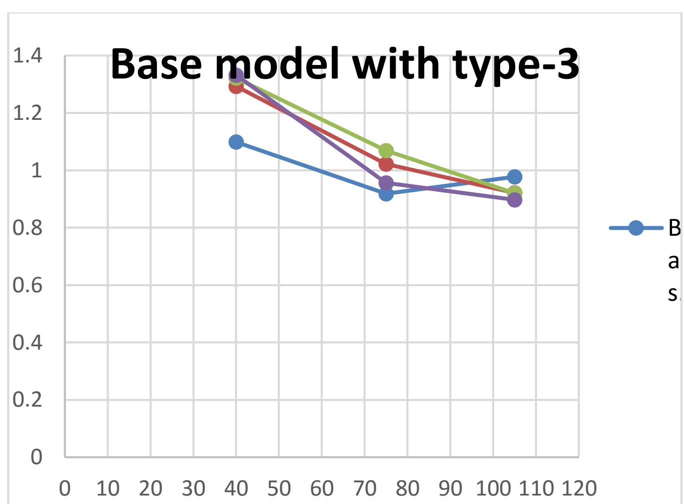



AT MEDIUM LIFT (8 mm)

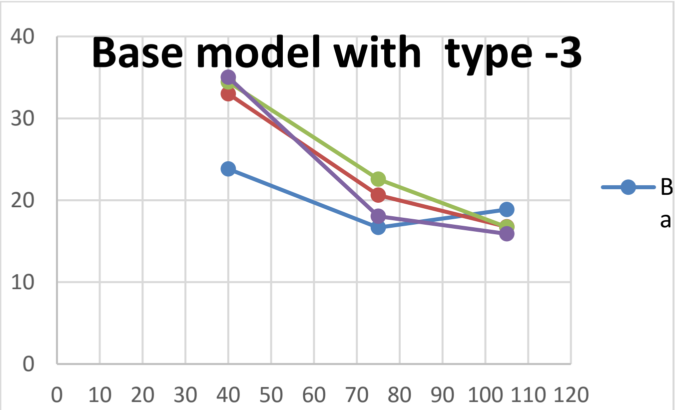



AT HIGH MEDIUM (12 mm)



**Graph:5 Swirl Ratio Vs Crank Angle (fins on valve)**




**Graph :6 Turbulence Vs Crank Angle (fins on valve)**

## IV.RESULT AND DISCUSSION

Graphs of Swirl Ratio & Turbulence give idea to optimize the swirl through inlet valves

All the result are in comparison with base model of valve. Tested at three lift 1] low (4mm) [2] medium (8mm) & [3] high (12mm)

Results are given in three types

1) Result from masking of valve without hole at three type of lift (Graph no.1& 2) : In this 2 mask valve at low lift gives high SR. and turbulence 1.306662 & 33.70 respectively.

2) Result from masking of valve with hole at three type of lift (Graph no.3 & 4): in this 4 mask valve at low lift gives high SR. and turbulence 1.155587 & 26.36 respectively.

3) Result from fin valve at three type of lift (Graph no.5&6): in this 6 fin valve at low lift gives high SR. and turbulence 1.331928 & 35.018 respectively.

From above discussion we have the best result of 6 fin valve at low lift which gives Higher SR and turbulence among all type valve at different lifts.

And also we can say that when valve tested at different lift, at low lift all type valve gives maximum SR and turbulence compared to other lifts.

## V.CONCLUSION

After performing and simulating by CFD we got different result of valve of type 1, 2 & 3 at different lift .

Among all the result we can concluded that,

In type -3: 6 fin valve gives better result than all other types at all lift, in the comparison with base model. Hence 6 fin valve is the best valve which gives the better result in terms of swirl ratio and turbulence.

Effect of this valve as follows:

1. It increases the proper air-fuel mixture.
2. It increases proper combustion.
3. It minimizes the exhaust emission.
4. It gives the better utilization of intake air and fuel.
5. Optimization of inlet air to the engine can be done by means of inlet poppet valves.
6. CFD simulation can advise better results.
7. Masking of inlet valves improves swirl rate and intern brake thermal efficiency of engine.
8. Fins also increase the swirl rate and hence we can get better thermal efficiency.
9. Pollution levels are also decreased with both valves when compared to conventional valve.

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