MODENAS CT115s intake port performance enhancement through analyzing volumetric and geometrical design with valve lift adjustment by using CFD Simulation

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Abstract This paper reviews improvement of intake port for Modenas CT115s by using CATIA software for the design and ANSYS software for the simulation result. Intake port is referring to the passage in the cylinder head which connect the intake manifold to the intake valve through which the fuel-air mixture proceeds on its way to the cylinders. The results obtained has been analysed and interpreted in formed of plotted graph. From the analysis, increasing the inlet of the intake port size can increasing the volume flow rate. The main impact is high angle of intake port that can give high torque and power. The decision to choose the proper angle for the each design is important because it will affect the major result for the simulation. Thus, it can be concluded that the increase of the inlet size and using the best angle of the intake port can increase the engine performance which allow higher fuel-air mixture entrance during the combustion process.

Keywords: intake port, geometrical design, air flow pattern, flow characteristic, engine performance

1. Introduction
The basic elements of an internal combustion engine requires three main thing which is air, fuel and a source of ignition [1]. Development of internal combustion engine involves resolving several problem issues. Focusing on MODENAS CT115s intake port which powered using 115cc four-stroke engine is the main project purpose. MODENAS or the specific name is National Motorcycle and Engine Company is a national Malaysian motorcycle company. MODENAS research and development (R&D) team now have put a great effort to improve the engine performance of MODENAS CT115s in order to be competitive among to its categories. Design of the cylinder head for automotive spark ignition (SI) engine is important because it affects the performance, fuel economy and emissions [2]. Accordingly, the manufacturer company has focus on the plan to improve the geometry of intake port to produce high scale fluid motion, which is can generate better tumble in the engine cylinder [3]. Intake port flow is measured by the increasing of horsepower produced and coefficient of discharge (CD).
Several of intake port geometry patterns will affect the amount of air flow that entered the port [4]. In this study focuses on the angle between the entrance plane and the outlet plane (AC), angle between the upper wall and the outlet plane (AV) and the diameter of inlet as shown in figure 2.1[8]. This investigation studied were strictly to know the effect of intake port cylinder head modification to improve the engine performance. The tumble motion that had been naturally produced by the geometry of intake port contributed proper and quick air-fuel mixing that produced higher efficiency does increasing the engine performance [5,6]. The simulation result between the existing and improvement intake port testing will be compared with three different condition of valve lift 0.5mm(low), 3mm(medium) and 6mm(high). These condition can directly the different of flow entrance[7]. Therefore, it is critical to determine intake port to achieve flow coefficient target.

2. Methodology

2.1. A. Design using CATIA software
The intake port design in this project has been divided into two categories which is the existing design and the improvement design. CATIA is multi-platform software. By using CATIA, drafting the dimension intake port design can be made to determine the exactly parameter of the existing and improvement design [6]. Table 1 shows the parameters for existing and improvement design.

![Figure 2.1: Parameter list for existing design](image)

| DESIGN | ANGLE AC (°) | ANGLE AV (°) | INLET DIAMETER (MM) |
|--------|--------------|--------------|---------------------|
| EXISTING | 83           | 58           | 23.1                |
| A      | 37.5         | 60           | 25                  |
| B      | 42.5         | 60           | 25                  |
| C      | 47.5         | 60           | 25                  |
| D      | 52.5         | 60           | 25                  |
| E      | 57.5         | 60           | 25                  |
| F      | 62.5         | 60           | 25                  |

2.2. Simulation using ANSYS software.
In order to study the intake port of MODENAS CT115s the simulation analysis was modules using computational fluid dynamic. ANSYS is an analysis tools that are used to improve the intake passage design by simulation air flow in the design. ANSYS simulation provides the pressure and the velocity of the air flow throughout the solution domain with the boundary condition and complex geometries.
3. Result and Discussion

The first condition is low valve lift which is 0.5mm, second is 3mm which is medium valve lift and the last is high valve lift which is 6mm. However, for the existing intake port design the mass flow rate result show that the peak flow rate is in 3mm valve lift compared to the 6mm valve lift. This is because the flow rate that enters the intake port is already in the maximum flow.

Increasing the inlet size and the angle of intake port make a huge different in simulation result. For the mass flow rate result at high valve lift (6mm), improvement design D show that the mass flow is $6.87 \times 10^{-5}$ kg/s which is the highest compared to the others design. Different result shows at the original intake port result which is $0.16 \times 10^{-5}$ kg/s much lower than improvement design D. However in low valve lift (3mm), mass flow rate $4.65 \times 10^{-5}$kg/s is increasing about 60% from the existing intake port which is $3.17 \times 10^{-5}$ kg/s. Moreover, for the existing intake port volume flow rate the result also show that the maximum flow rate is in 3mm valve lift compared to the 6mm valve lift.
To validate this study of MODENAS CT115s intake port by optimizing engine performance through analyzing volumetric and geometrical design at intake port system, the performance of the original intake port was measured on the flow bench test and simulation test by using ANSYS software. From comparison between the experimental data and the simulated results for the existing intake port, it can be found that the different of the flow coefficient is less than 3.5%. The result obtain from the CFD analysis shows the differences of mass flow rate and tumble ratio between the existing design and the improvement design. The variation of flow for the original design create an improvement value of the mass flow rate as the valve lift increased from lower to medium but decrease from medium to high valve lift. However for the improvement design A, from the result, the optimal value of mass flow rate at the high valve lift was achieved compared to the original intake port.

The valve lift from low to medium and medium to high not only affect the movement of flow in the cylinder but also lead the change of the cross section. The variation of flow cross section, which is cause by the reciprocating motion of valve may result separation of flow field and the backflow of the outlet of the intake port further decrease the flow capacity. The improvement design A is the best design for producing greater percentage of mass flow rate and volume flow rate in the intake port compare to the actual design. Since the result for the improvement design is exceed 10% as required from MODENAS Research and Development Team, means the target and the main objective for this research is achieved.

4. Conclusion

Based on the research and analysis that had been done for intake port of MODENAS CT115s, the experimental and simulation results show that design approach can accurately build the intake port and achieve high performance. Result that been compare for the improvement design and the existing design is mass flow rate, volume flow rate, pressure and velocity. Parameters Av is to determine the direction of the jet flow in the outlet. Parameter Ac controls the direction of the entrance flow and the overall direction of the flow in the intake port. The increase of parameter Ac enhances the intensity of the large-scale vortex in the cylinder. Meanwhile, it causes the formation of the large-scale vortex in advance. In conclusion by increasing the inlet of the intake port will increase the volume flow rate at the beginning of the flow and increasing the velocity result. Other main impact is high angle of intake port that can give high torque and power. The decision to choose the proper angle for the each design is important because it will affect the major result for the simulation and it give some advantages and disadvantages. This is because if the research does exceed the proper angle of the intake port it will give bad result due to the limit that near to the ideal curve condition and hard to install to the motorcycle engine thus it will make the engine performance as low than the ideal performance.

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