Valve Lift Overlapping Effect by Analyzing Engine Charge Flow in Various Cam Profiles for on Modenas CT115s using CFD Simulation

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Abstract Cam profile plays a critical role which adjusts the valve lift to allow the air fuel mixture flow in into cylinder in order to obtain the optimum performance of engine. This paper reviews the effect of valve lift overlap by analyzing charge flow in various cam profiles for and determine the optimum overlapping valve lift to enhancement of cam performance. By using Ansys software, the parameters like volumetric efficiency, mass flow rate and velocity will be measured which ultimately make impact up on the engine power and torque. Therefore, for this study 0.5mm to 3mm are tested to figure out the effects in combustion process. Overall, by considering the discussion, the results shows that valve lift adjustment of 2mm for both intake and exhaust valve has the best performance among others.

Keywords: cam profile, overlap valve lift, air flow pattern, cfd simulation.

1. Introduction

In general, cam is a device, formulated with three basic components of kinematics cam, which acts as the driving part a follower, serves as a pioneer component and fastened frame [2]. Cam is a mechanical component that handles other segments called followers, throughout a certain movement by higher connections. A cam can be customized, mostly in the form of an engine component that is always associated with followers. The main function of the camshaft in the engine is used to move a motion to the intake and exhaust valves to control the closing and opening of the valves in an internal combustion engine [1, 5]. Valve train operation carried out by the action of the cam and cam geometry. If transporting the movement is not perfect, the engine's performance will be also affected [4]. As the cam pivots, the point contact moves, and hence the operative force is transferred to the follower [7]. Besides, cam is a component that works to transmit a power by motion of mechanical from a speed constant to variable speed and widely used in automotive industry due to the superior
properties for high speed in operation, accuracy in motion, rigidity of structure and low cost production. The location and shape of the lobe will determined the timing of the valve opening-closing motion, its lifting height and valve movement rate for one complete cycle in which could affect the engine performances. The simultaneous open time of the inlet and exhaust valves is referred to as valve overlap [3, 4]. The inlet valve is usually opened well before the TDC so that the overlap period is located on either side of the TDC. In addition to reducing the residual gas fraction, overlap aids inducting the fresh charge from the inlet port provided that the inlet pressure is higher than the exhaust pressure [6]. Other than that, valve overlap is problematic in engines where the fuel is premixed with the inlet air prior to entering the cylinder. A small part of the fresh charge may slip from the inlet to the exhaust port during the overlap period, particularly if the overlap period is long. Long overlap promotes high-speed operation as the scavenging improves but at low speed the combustion quality deteriorates and cyclic variation increases [5]. In this project, optimizing the engine performance by increasing the performance of cam by improve the cam profile curve using mathematical method is main objective of MODENAS R&D team and this research. Cam curve performances analysis will be conducted based on its several radius of base circle, rb from Polynomial method and all possible engineering parameters in order to determine the best cam design that will produce high performances throughout. The analysis of the cam will be done by using computerized engineering software such as CATIA V5 for designing and, ANSYS for simulation. This analysis is designed so that optimization of the cam profile can be done and thus, the factor affecting the optimization of the cam can be determined. Then, the results from the analysis could contribute in enhancing the engine performance for the MODENAS motorcycles.

2. Methodology

A. Design using CATIA software

For this study, several parts of Modenas Ct115s engine such as intake port, exhaust port, intake valve, exhaust valve and combustion cylinder are designed by using CATIA software. 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 design as shown in figure 1.[6] Figure 2 illustrates the adjustment of valve lift for intake assembly.

![Figure 1: Isometric view of assembly drawing](image1)

![Figure 2: The adjustment point of valve lift between port and valve](image2)
### B. ANSYS Simulation

Since the parameter of the research is considering the air flow to determine the mass flow rate and volumetric flow rate, the suitable analysis to be used is FLUENT Analysis. Therefore, for this study, 0.5mm to 3mm are tested to figure out the effects in combustion process. In this research, they have been transferred to the ANSYS software to be analyzed and simulated. The current simulation of ANSYS has partially done somehow need to be analyzed in detail. It is because there are some parameters that need to be considered, such as mass flow rate, volume flow rate, inlet velocity, pressure and others. Thus, more researches need to be discovered in order to obtain the best solution from it.

### 3. Result and Discussion

In this research, valve lift overlap is considered as the variables in order to obtain the value of mass flow rate and volumetric efficiency. Figure 3 below show the assembly design that undergoes the analysis and simulation by ANSYS which explained the results gained by differentiation of the valve lift which are 0.5 to 3.0 mm.

**Figure 3:** Simulation for 0.5mm to 3.0mm valve lift overlapping

By simulation analysis, the data results obtained are collected whereby mass flow rate and volume flow rate are considered in table 1.
Table 1: Mass flow rate and volume flow rate for each valve lift overlap

| Valve lift overlap (net) | Mass flow rate, (kg/s) | Volume flow rate, (m³/s) |
|-------------------------|------------------------|--------------------------|
| 0.5 mm                  | 4.2805517E-05          | 3.4942645E-05            |
| 1.0 mm                  | 3.5963294E-05          | 2.9357330E-05            |
| 1.5 mm                  | 5.0495768E-05          | 4.1221065E-05            |
| 2.0 mm  **2.0 mm** 5.7555582E-05 | 4.7008385E-05 |
| 2.5 mm                  | 1.1988420E-05          | 9.7870779E-06            |
| 3.0 mm                  | 3.3470984E-05          | 2.7323056E-05            |

Figure 4: Comparison for mass flow rate and volume flow rate for each valve lift overlapping

The purpose of this chapter is to show how the valve lift parameters affect the mass flow rate, and volumetric efficiency. Results from the ANSYS Workbench calculations are illustrated as shown in figure 4.

Theoretically, smaller valve overlap will improve the engine performance because when the air fuel in cylinder that enter is compressed more tight, the combustion of fuel is actually almost to completely burnt which perform a better fuel efficiency. However, if the valve lift overlap is too low, it would causes an insufficient air fuel to enter through the cylinder at the intake stroke while at the exhaust stroke, burnt compressed gases are not be able to expelled from the cylinder as a whole, and caused the remains of the gases left inside. Consequence, there will be a performance loss and fuel efficiency reduction. Mass flow rate through intake valve with different valve lift speed for peak volumetric efficiency increases while the peak volumetric efficiency itself is slightly decreased. The peak volumetric efficiency occurs at high engine speed as the valve lift increases while the volumetric efficiency itself increases. A lower valve lift will result in a better volumetric efficiency at low engine speed, and higher valve lift has a greater volumetric efficiency at high engine speed. At the high engine speed, a low valve lift result in a smaller mass flow per crank angle during most of the open duration of the intake stroke. Since volumetric efficiency is calculated based on the integral of mass flow into the cylinder through the intake valve, a smaller mass flow per crank angle will result in a lower volumetric efficiency.

4. Conclusion

The research and analysis for the valve lift overlap is carried out by using the simulation of ANSYS Workbench software in order to determine the mass flow rate and volumetric efficiency. As shown in graph result, valve lift of 2mm has the highest mass flow rate and volume flow rate; velocity
magnitude; and static pressure. Based on the results of the simulation, the following conclusions can be drawn:

1. By increasing intake valve lift, the engine speed for peak volumetric efficiency will increase.
2. IVC timing has much more dominant influence on volumetric efficiency than intake valve opening (IVO) timing.
3. Volumetric efficiency will decrease with a retarded intake valve closing (IVC) time at low to normal engine speed, due to reverse flow. It will increase at higher engine speeds.

Overall, by considering the discussion, the results from ANSYS simulation analysis shows that valve lift adjustment of 2mm for both intake and exhaust valve has the best performance among others. Hence, 2mm is selected as the optimum valve lift overlap.

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6. References

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