Design and implementation of CVVT & CVVL technology in a V8 engine

Ammar Kazi
Level-5 Mechanical Engineering
Student
ASTI Academy
Mohammed Ashhar Quazi
Level-5 Automobile Engineering
Student
ASTI Academy
Mr. Mohammad Sameer Baig
Faculty In-charge
ASTI Academy

Abstract

The CVVT, CVVL, and CVVD are three of the most essential engine head technologies for improving fuel efficiency, generating power, and reducing pollutants (like nitrogen oxides). The study of this technology and its possible combination with other technologies to enhance engine performance and efficiency while lowering fuel consumption and NOx emissions were the main objectives of this project. Thus, by employing the fundamentals of thermodynamics and a Miller cycle that utilized constant pressure heat rejection, more work can be extracted from the engine and more power is generated. As a result, this can be accomplished by changing the compression ratio and actuating the intake valve (early open or late closing).

Keywords- variable valve timing, variable valve lift, Arduino UNO, optimizing engine performance and increase in fuel efficiency.

I. INTRODUCTION

Engine head technologies such as Variable valve timing (CVVT), Variable valve lift (CVVL) and Variable valve duration (CVVD) technology, fundamentals of valve opening and closing as per the crank rotation timing and lift of the valve which can enhance the Engine performance of an automobile vehicle.

Therefore, the term "variable valve timings engine head technology" refers to valves opening or shutting with a delay or early. By reducing the temperature of the engine's body and controlling residual exhaust gases inside the combustion chamber, VVT head technology helps lower NOx emissions. The VVT head technology opens the intake valve during the midpoint and end of the compression stroke while the vehicle is moving at a fast speed, resulting in a bigger power gain at higher RPM. The amount by which the valves physically open is known as valve lift in (VVL engine head technology), and the amount of opening is known as variable valve lift. (Engine head technology using VVD) The duration of time that the valves are open during an intake or exhaust stroke is referred to as valve duration. Therefore, regardless of camshaft speed, variable valve duration remains open.

As we are aware the main purpose of valves is either for suction or exhaust. Intake and exhaust valves are the valves that open and shut the corresponding intake and exhaust passageways. During the admission stroke, the suction valve opens, allowing the fuel-oxygen mixture to be drawn into the burning chamber. The Exhaust valve opens during the final stroke to release the expanded and oxidized gas out of the burning chamber.

Without variable valve timing, these intake and exhaust valves would work in the same way regardless of engine RPM (revolutions per minute) or driving conditions. This isn't ideal since the driver may desire the engine to behave differently throughout the rpm range. For instance, the driver might desire more power at high RPMs, yet fuel economy might be the main concern at low RPMs and lighter engine loads.

By altering the operation of the intake and exhaust valves at different engine speeds, variable valve timing enables these various behaviors. Thus, it helps to improve engine performance while also raising fuel economy and pollutants.

Honda created the VTEC (Variable Valve Timing & Lift Electronic Control) technology to increase a four-stroke internal combustion engine's volumetric efficiency, which leads to better performance at high RPM and less fuel usage at low RPM.

Toyota refers to the variable valve technology that is used in the majority of their vehicles as VVT-i, or Variable Valve Timing-Intelligence.

Though the specifics vary, the systems all use variable valve-timing technology, and depending on how the car is driven, they all make slight modifications to when the engine's intake valves open and close to deliver an air-fuel combination into the engine. To improve performance and cut emissions, this is done. A few variable valve systems also operate on the exhaust valves, which open to release the engine's air-fuel combination.

1.1. Types of valve train types:

- **Overhead valve type (OHV):**

The intake and exhaust valves in an OHV engine are mounted in the cylinder head and are operated by a camshaft located in the cylinder block.

This arrangement requires the use of valve lifters, pushrods, and rocker arms to transfer camshaft rotation to valve movement.

- **Overhead camshaft type (OHC):**

The intake and exhaust valves located in the cylinder head. But the cam is located in the cylinder head.

Valves are operated directly by the camshaft or through cam followers or tappets.

- **Double overhead camshaft type (DOHC):**

The majority of today's vehicles use dual overhead cam engines. They are often significantly more efficient engines than OHV or SOHC, allowing better airflow with less obstruction. Four valves per cylinder are operated by two camshafts, each with its own camshaft for the intake and exhaust valves.

1.2. Modern variable valve technology for engine head:

- **Variable Valve Timing (CVVT):**

Toyota invented the variable valve timing technology for automobiles known as VVT-i, or variable valve timing with intelligence. With the 2JZ-GE engine featured in the JZS155 Toyota Crown and Crown Majesta, it was initially released in 1995.

The five-valve per cylinder 4A-GE engine used in the AE101 Corolla Levin and Sprinter Trueno is powered by the VVT-i system, which takes the place of the Toyota VVT system that was first launched in 1991. The VVT system is a two-stage cam phasing mechanism that is hydraulically regulated.

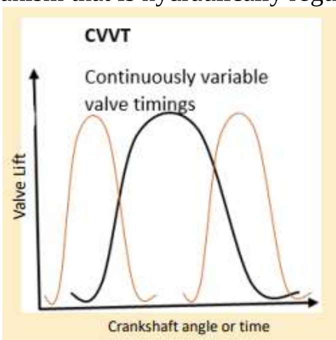

Figure 1. Graphical representation of CVVT

- **Variable Valve Lift (CVVL):**

Variable valve lift (VVL) is a piston engine technology used in automobiles that alters the height at which a valve opens in order to enhance emissions, fuel efficiency, or performance. Discrete VVL, which uses fixed valve lift levels, and continuous VVL, which allows for variable lift, are the two major types of VVL.

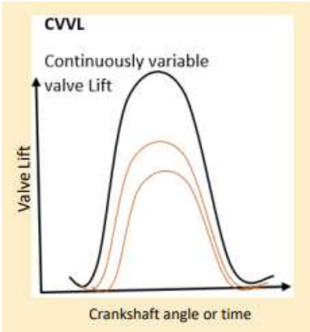

Figure 2. Graphical repesentation of CVVL

- **Variable Valve Duration (CVVD)**

The period of time an intake or exhaust valve in a reciprocating engine is open, expressed in degrees of crankshaft rotation. The duration of time that the valves are open during an intake or exhaust stroke is referred to as valve duration. Therefore, regardless of camshaft speed, variable valve duration remains open.
By changing the speed of cam and camshaft we can increase or decrease the valve duration (using proper link mechanism to change the centre of axis of rotationof cam).
In 2019, Hyundai motors developed 1st CVVD after researching for 10 years.

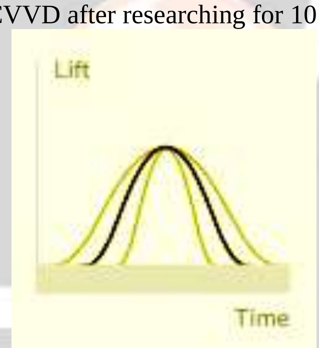

Figure 3. Graphical representation of CVVD

II. WORKING PRINCIPLE

In current automobile IC engines, the air-fuel ratio plays a major role in giving power to the engine and it also an important measure for antipollution. The ratio is referred to as the stoichiometric mixture, frequently shortened to stoich, if precisely the right amount of air is supplied to totally burn all of the fuel.
High pumping loss, high peak cylinder pressure, and high compressor outlet temperature can all result from an extremely high air-fuel ratio. High temperatures in the exhaust gasses and decreased combustion efficiency may result from an overly low air-fuel ratio.
The Miller cycle is a modified over-expanded cycle that offers a larger expansion ratio than compression ratio with the benefit of improving thermal efficiency when compared to typical internal combustion engine operating circumstances. In practice, this variation in expansion ratio can be attained by a compression stroke that includes either a late or an early intake valve closure. By increasing the expansion ratio to increase thermal efficiency at the cost of a decrease in brake mean effective pressure, this effectively shortens the compression stroke while maintaining the combustion and expansion processes as usual to enable the extraction of additional energy before the exhaust process.

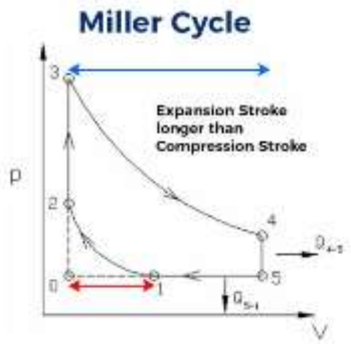

Figure 4. P-V diagram of Miller cycle

In order for the engine to compress against the pressure of the supercharger rather than the pressure of the cylinder walls, a Miller-cycle engine leaves the intake valve open for a portion of the compression stroke. A gain in efficiency of around 15% marks as a result.

VTEC is the common name for this combination (CVVT and CVVL) which improve the volumetric efficiency of IC engine and it not only varies the
timing but also lift the valves.

Table-01 difference between VTEC and VVT-i

	VTEC	**VVT-i**
Working principle	It is a valve train system to improve the volumetric efficiency of a four-stroke internal combustion engine. It not only varies the timing but also lift the valves.	It varies the timing of the intake valves by adjusting the relationship between the camshaft drive (belt, scissor-gear or chain) and intake camshaft. Does not lift the valves.
Stands for	intelligent-VTEC (Variable Valve Timing and Lift Electronic Control)	Variable Valve Timing with intelligence
Intake camshaft	The intake camshaft is capable of advancing between 25 and 50 degrees when the engine is running.	The timing of the intake valves varies by adjusting the relationship between the camshaft drive (belt, scissor-gear or chain) and intake camshaft
Phase changings	Phase changes are implemented by a computer controlled, oil driven adjustable cam gear	Engine oil pressure is applied to an actuator to adjust the camshaft position

III. MATERIAL USED

There are various kinds of components and equipment used in the making of this project such as, we will be using square aluminum tubes to create a frame that will hold all the components and there are a lot of mechanical parts which will be controlled using an Arduino programming board. Following are the material used:

1. Engine specifications:

Manufacturer: Toyota ZZ engine
Engine type: Inline 4
Engine code: 1ZZ
Valves: 16
Fuel type: Petrol
MAX. Power: Max. output is 109 hp (81 kW; 111 PS) at 6,000 rpm
MAX. torque: max. torque is 150 N·m (111 lb·ft) at 4,400 rpm
Compression ratio: 10.0:1

1.1. Head specifications:

Valve arrangements: Double over-head cam (DOHC)
Valves: 16
Material: Aluminum

Figure 5. VVT engine head

2. Engine specifications:

Manufacturer: Honda VTEC
Engine type: Inline 4
Engine code: D16A
Valves: 16
Fuel type: Petrol
MAX. Power: 127 hp at 6,600 rpm
MAX. torque: 107 lb/ft torque at 5,500 rpm
Compression ratio: 9.6:1

2.1. Head specifications:

Valve arrangements: Single over-head cam (SOHC)
Valves: 16
Material: Aluminum

Figure 6. VVL engine head

IV. RESULTS

Upon applying the condition of Engine brake torque, mean effective pressure, BSFC and ISFC to the engine with VVT at inlet and VVL Technology at exhaust, following are the results which we achieve:
Figure 11. summarizes the increases in power and torque [Figure 7.] working produced by enhancement in volumetric efficiency. [Figure 8.] With a speed of 3500 rpm, the improvement is 28.5%. [Figure 10.] shows the BSFC reductions arising from thermal improvements. According to [Figure 9.] precise valve opening and lifting adjustments can increase the effectiveness of the engine and the economy of fuel. 5500 rpm to 6000 rpm is almost minimal in terms of the working of the engine. Higher performance is expected at this engine speed by adjusting the first shot valve. In addition, the lowering of a specific brake to use the engine fuel at roughly 4000 rpm is not taken into account either. So, the first engine, which is also the most advanced engine speed, may have elevators engineered to give superior fuel efficiency at this engine speed. With the newly revised valve assembly and flexible lift assembly, however, the engine's performance and economy are not compromised at certain speeds. Therefore, after combining the VVT and VVL technology in an engine the overall performance got enhanced by 28% at 3500rpm of vehicle.

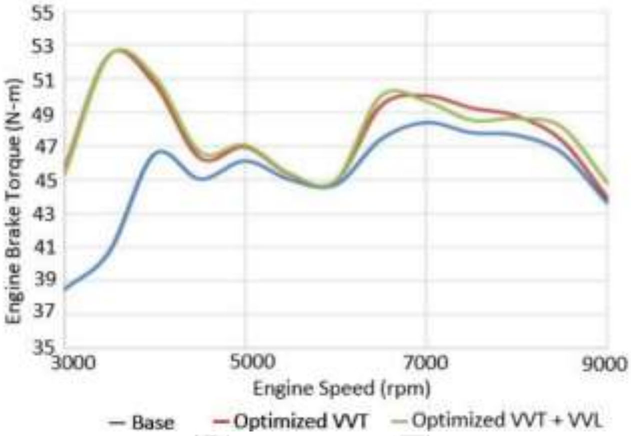

Figure 7. Enhancement in Brake torque of engine

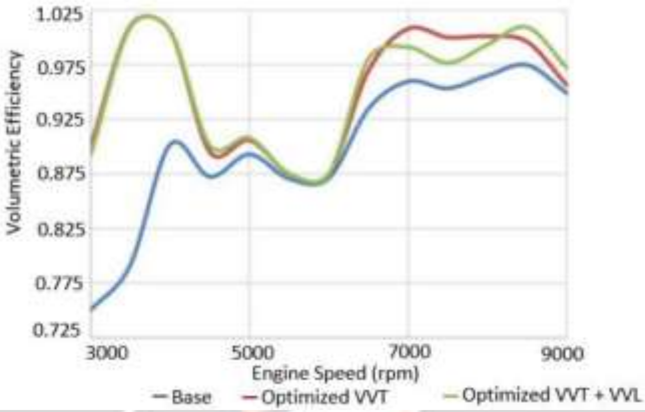

Figure 8. Comparison of volumetric efficiency

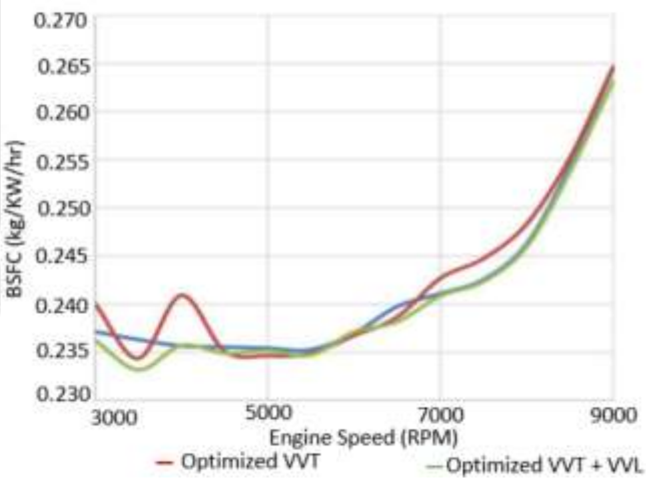

Figure 9. Improvement in brake specific fuel consumption

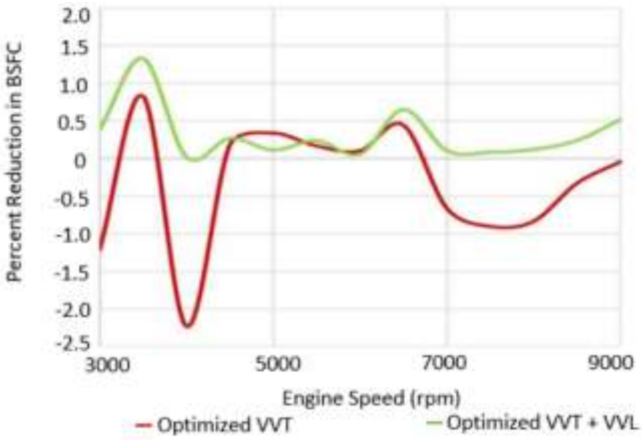

Figure 10. Percentage reduction in BSFC

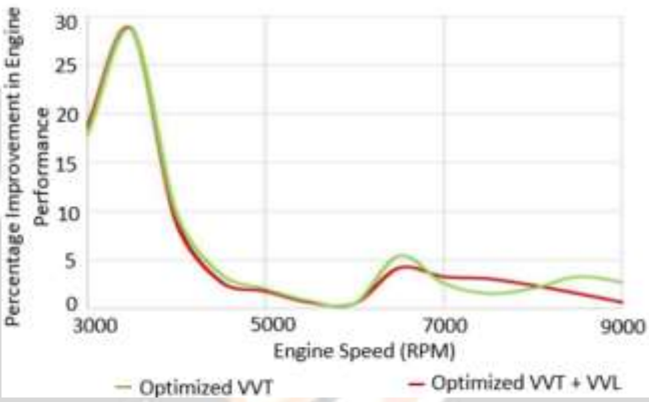

Figure 11. Enhancement in the performance of engine

V. CONCLUSION

In conclusion, the study objectives established for this study were successful. These goals were to study various engine head technologies, evaluate engine head technologies' mechanisms and functioning, and also to increase energy production to improve the efficiency of engines using the Miller cycle concept and VVT and VVL engines, and evaluate engines using both VVT and VVL technology for brake power, speed, and other functions. Reading, controlling, and evaluating the valve tuning intake event and valve lifting valve results satisfactorily. The engine's performance (torque and power) improved by 6.02 percent on average across the entire range of working speed with a maximum improvement of 28.5 percent at 3500 rpm and a least improvement of 0.05 percent at 6000 rpm due to the proper selection of valve opening and lifting valves.

Further enhancement can be achievable with the implementation of **continuously variable valve duration [CVVD]** for all enhancements we achieved in the above experiment such as enhancement in brake torque of engine, improvement in brake specific fuel consumption, reduction of nitric oxide and improvement in fuel economy.

VI. REFERENCES

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VII. APPENDIX

These are the pictures of the project that were designed on the solidworks software:

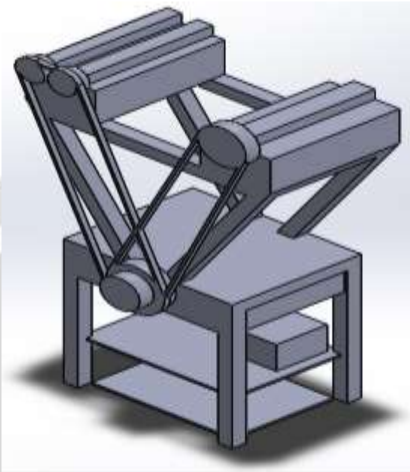

Figure 12. Isometric view

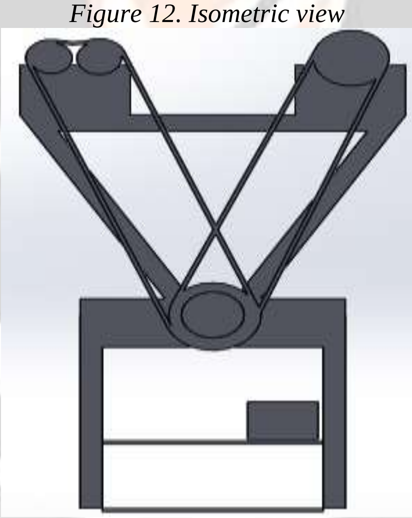

***Figure 13.** Front view*