VTEC: Past and Present

- Honda's Revolutionary Technology -

Written by: Richard A. Eash

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SUMMARY

The Honda Motor Corporation has always been a company looking toward the future, not only to serve the consumer, but to advance the automotive world forward. It continued its commitment to this with the release of the variable valve timing solution: VTEC. VTEC was a solution to balance the aspects of power and economy within the internal combustion engine. Power and economy had always been inversely related. More power, less economy and so forth. VTEC changed this, challenging the finality of such automotive realities. VTEC is a method of valve control which extends a motor's flexibility and versatility to levels never before attained. To stay in harmony with the automotive market and demand, other forms and improvements of VTEC would become available. VTEC-E and I-VTEC surfaced, and continue to occupy a crucial sector of automotive transportation and consumer appeal. No other manufacturer can claim such dedication to continuing advancements.

Background

In this modernized and mechanized world we live in, advances and discoveries are made at a furious pace. Things impossible yesterday become a reality the next day. The drive and spirit to improve on things is a crucial part of the human essence. It is this essence that propels civilization into the future every second of every day. One such advancement came from the Honda Corporation in 1989: VTEC was conceived. VTEC, an acronym for Variable valve Timing and lift Electronic Control, is an automotive technology wonder, a mechanical process which improves on older engine designs. Since its first implementation it has gone through further development and evolution. In order to understand the significance of VTEC and its kin, the economic history that lead to that point must be highlighted.

After World War Two, Japan was occupied by U.S. forces for many years. The intent of the occupation was to rebuild a shattered and defeated nation who had been influenced into dreams of Pacific domination. During this period, Japan's social and economic infrastructure went through significant transformations including the adoption of democracy and a strong domestic consumer market. Factories and forges soon began replacing farms and fields. Companies changed from making war machines to manufacturing consumer goods. This transition was Japan's Industrial revolution of sorts. However, due to their classification as an occupied nation, the goods exported were deemed to be inferior and second rate. This international criticism and lack of credibility served to fuel Japanese economy and technology.

In April 1952, the treaty of peace was enacted, effectively returning Japan to its independence. On its own, Japan would continue to climb the ranks of international exportation and manufacturing. One of their strongest sectors would become the design and sale of vehicles world wide. These quality, dependable vehicles contradicted the previous views on Japanese manufacturing potential.

Purpose

Reading this report will assist the audience in understanding the function and significance of VTEC, and the crucial differences of its variations. The consumer market is a do-or-die environment where customer satisfaction and appeal is the deciding factor on many decisions and choices. This business reality ultimately leads to the development of VTEC, but as the needs changed and opportunities arose, other variations of VTEC began to surface. VTEC-E and i-VTEC embody a reflection of the business market for which they were created. Each of these share characteristics of their forbearer, but are specialized in other regards to serve different purposes and goals. The differences, consumer demand, and other aspects of each will be discussed and analyzed to determine which is overall and all around the most practical

Scope

The intention of this report is to discuss and analyze various forms of VTEC technology on a level with automotive consumers and those with general knowledge of modern internal combustion engine components and function. The use of adequate definitions and a supplemental appendix will eliminate doubt or confusion as to the subject manner or descriptions.

ENGINE VALVETRAIN

Understanding the mechanical function of VTEC requires insight into a typical internal combustion engine's (ICE) valve train. Simply speaking, an ICE is a large air pump. As the piston moves downward in the cylinder, intake valves are opened allowing fresh air and fuel to enter. Next, as the piston begins to rise back up, the mixture is compressed with great force. This immense force and the addition of a spark from the spark plug ignites the air/fuel mixture in a process known as combustion. The combustion force drives the piston back down. On its next trip up, exhaust valves open, releasing the toxic gas and fumes out from the cylinder. This continued process drives the engine. Controlling when and how much air is drawn in and expelled during the combustion cycle is the function of the valvetrain. Comprised of valves, valves springs, lifters, and a camshaft(s), the valvetrain's role in engine performance, efficiency and reliability is critical.

Before VTEC was implemented into engine design, valve operation was controlled by a camshaft(s) with one profile. Meaning, each valve was operated by its own cam lobe indirectly through a lifter arm. The cam lobe shape determines the distance the valve opens (lift) and how long it remains open (duration). The larger the lift and the longer the duration of the valve the more air the engine can ingest and expel. More air flow develops more power and torque. Unfortunately, larger amounts of lift and duration can make more power but at the cost of fuel economy and low rpm drivability. This left the more powerful cam profiles to serious race engines only. The Honda engineers went to the drawing board with the intention of designing a system that would permit incredible higher rpm power, but still be civil enough for daily driving. They concluded that variable valve timing could fulfill their requirements.

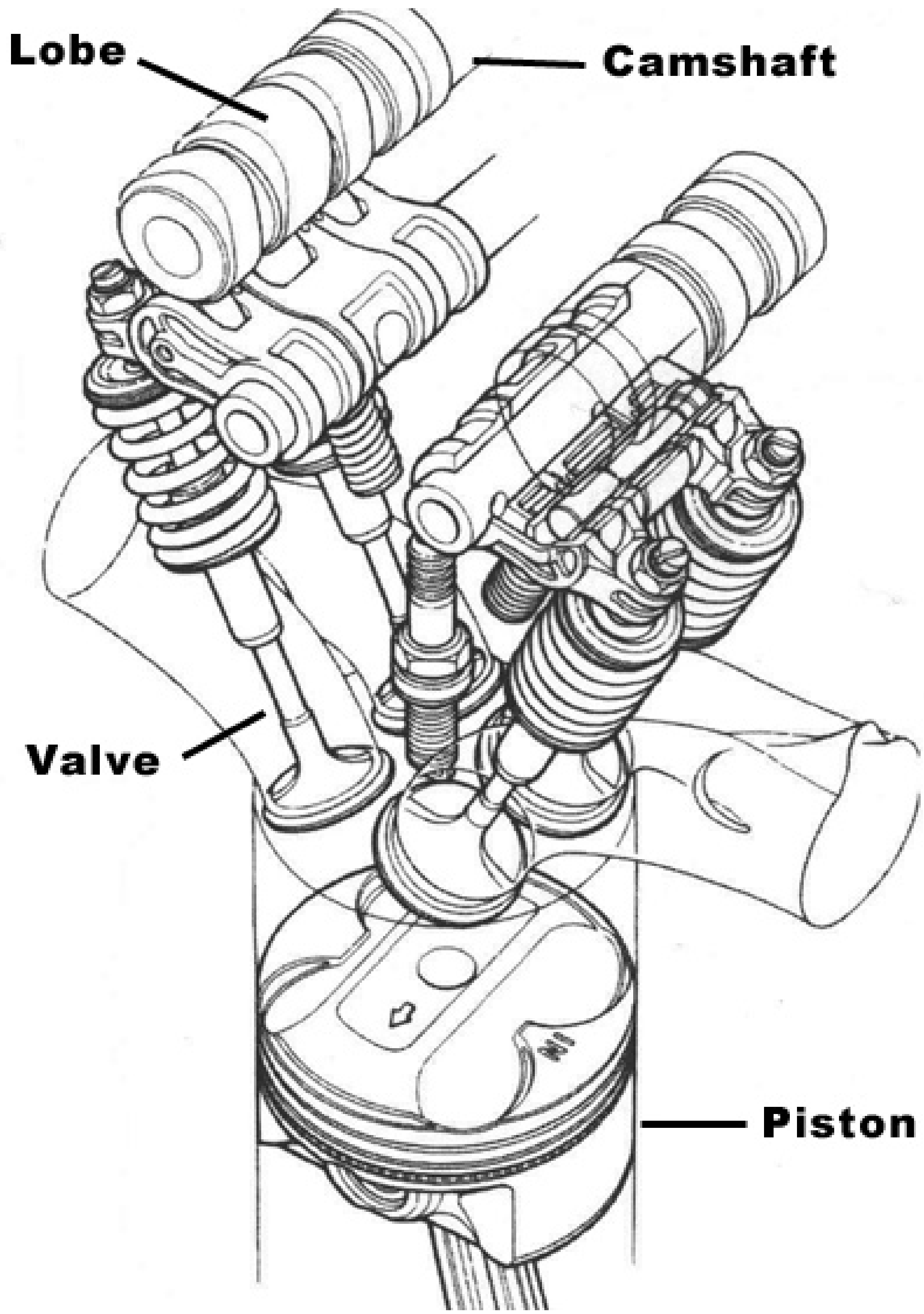

Figure 1 – Engine Components (Sherwood)

VTEC: The Original

In a VTEC equipped motor, a specialized camshaft(s) is present. What sets it apart is that is has two distinct lobe profiles. One set of lobes is termed the "mild" profile. The mild profile operates the valves during less demanding engine situations, such as cruising on the highway or at idle. The low lift and short duration of these lobes makes the engine behave quietly, smoothly, and fuel friendly. At a predetermined engine speed and throttle the ECU, through the use of oil pressure, hydraulically pushes a special pin horizontally to link adjacent lifter arms (Wong). This linking switches the valves to operate on the "wild" lobe profile. The wild lobes feature higher lift and more duration than the mild, making a surprising amount of power all the way to engine redline. This point of lobe change and pin actuation is known as the VTEC crossover. VTEC is available in two valvetrain configurations: single camshaft and dual camshaft. Dual cam engines have one to control intake valves and one to control exhaust valves. In a VTEC dual cam, both camshafts have mild and wild profiles. In single camshaft VTEC engines, the single cam controls all valves, with only the intake valves getting a wild profile (Cao).

Having above standard fuel economy and a spirited kick of power from the same engine gave VTEC instant appeal. It's really like having two engines in one - A 'sedate' one for grocery-getting, and the other a red-blooded high revving screamer (Sherwood). Also, being a Honda built engine meant it could reliably run for over one-hundred thousand miles. Unfortunately for consumers, VTEC engines were only available in higher end versions of Honda models such as the Civic, Prelude and Accord, and had less gas mileage then their cheaper, non-VTEC counterparts.

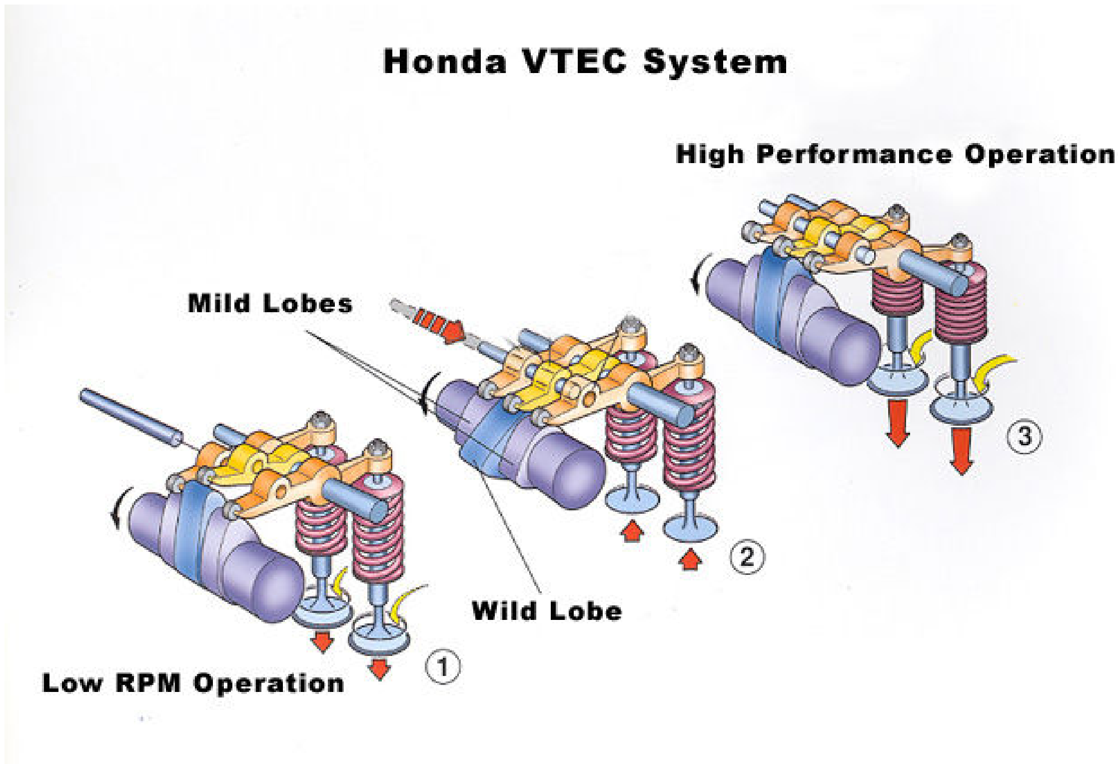

Figure 2 – The VTEC Activation Process

VTEC-E: The Fuel Saver

With the success of VTEC, the engineers at Honda devised a plan to retain the functionality of VTEC, but implement changes to increase fuel economy and improve emissions even further. The constant fluctuation in gas prices though out the world insured that a market for fuel efficient vehicles was here to stay. This reality gave rise to VTEC-E, the E meaning economy. The secret to VTEC-E's supremacy both in efficiency and emissions stems from the changes made to valve operation and behavior.

All VTEC engines feature four valves per cylinder; two intake and two exhaust. In standard VTEC all valves operate continuously. In VTEC-E engines however, the mild profile allows one intake valve to remain closed during light load, low demand situations. The closing of this valve increases the air/fuel mixture's tendency to swirl as it moves through the cylinder. This swirling, increases the time the mixture is present within the cylinder, ensuring more complete, more efficient combustion. Rapidly accelerate the engine to the VTEC crossover speed and the wild profile takes control bringing all valves into operation.

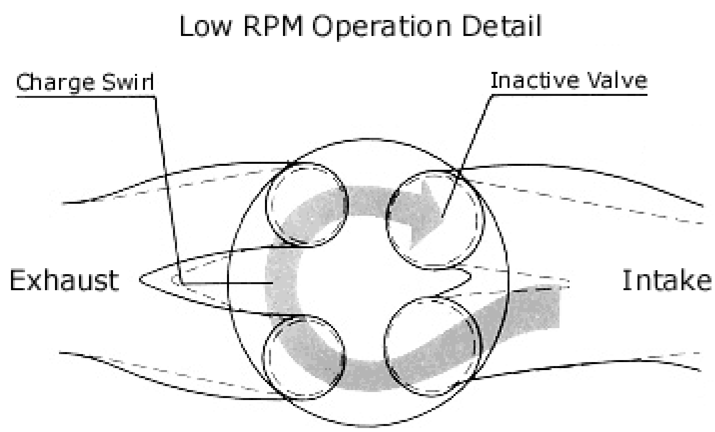

Figure 3 – VTEC-E Combustion Characteristics (Cao)

VTEC-E engines achieve their goals. They maximize fuel usage and run remarkably clean while still leaving a degree of quickness. This satisfies environmentalist and those concerned with prices at the pump. Of course these strengths do not come without weakness. Engines with VTEC-E incorporated sacrifice the maximum power and torque available from standard VTEC for the sake of economy.

i-VTEC: The Modern

i-VTEC made its debut in 2001 Honda vehicles. This stage in VTEC evolution is by far the most advanced and versatile incarnation to date. i-VTEC engines contain two camshafts that share valve operation. Operating with two camshafts allows for an expanded tuning ability opposed to a single camshaft. One camshaft controls intake valves, the other exhaust valves. During engine operation, there are brief moments when both intake and exhaust valves will be open simultaneously. This phenomenon is known as overlap. The problem with overlap is that exhaust gases leaving the cylinder can restrict or disturb the fresh air entering. This is especially true at low engines speeds and idle. This opposition is unwanted, but an unavoidable part of the combustion process. The key is to minimize duration at idle, and permit more at redline; which variable valve timing allows.

The I in i-VTEC signifies intelligent; for good reason. Honda introduced many new innovations in i-VTEC, but the most significant one is the addition of a variable valve opening overlap mechanism to the VTEC system (Wong). As the engine is running, the ECU monitors the degree of overlap present and can actually adjust this amount on the fly. This is accomplished by actively varying the intake cam timing through the use of the Variable Timing Control (VTC) mechanism. This allows for a further refinement to the power delivery characteristics of VTEC, permitting fine-tuning of the mid-band power delivery of the engine (Wong). This adjustment was never before possible with the engine running. i-VTEC engines not only get this technology, but also contain the features of standard VTEC.

The marketing for these motors is directed to the performance enthusiast. They are mated to higher end versions of Honda and Acura vehicles, bumping standard VTEC from its top spot. The prices for these vehicles easily extend beyond twenty thousand dollars, putting them out of reach for many younger consumers. Since release, aftermarket manufactures have been steady in releasing performance components for these engines. Having no where near the degree of aftermarket VTEC support, but still adequate to satisfy speed needs of buyers, i-VTEC is a wise choice for consumers interested in a modern, cutting-edge vehicle.

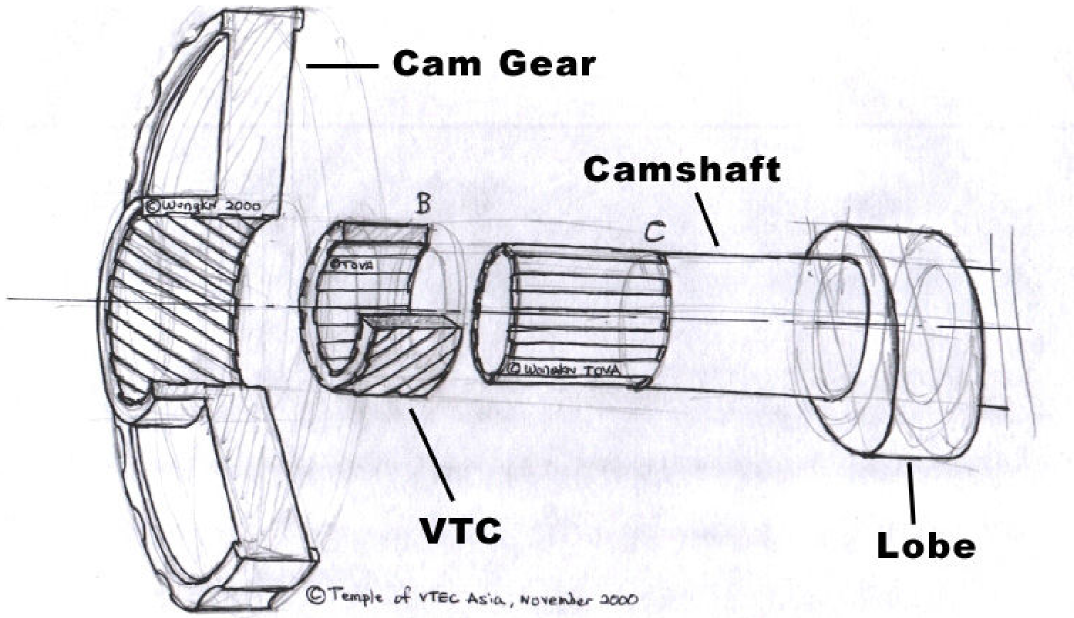

Figure 4 – The Variable Timing Control Mechanism (Wong)

CONCLUSIONS

With such a variety of engines and variable valve timing choices, consumers can become confused and form misconceptions as to what will adequately suit their needs. For the sake of all out performance, standard VTEC is the wise choice. Its veteran presence in the market has given aftermarket manufactures time to develop a multitude of parts focused solely on increasing performance and power. For the long distance driver, VTEC-E is the best candidate to get them to their destination with ease, affordability and enough passing power to frequent the express way. i-VTEC, being the newest to the family is just now developing a following and has not yet reached its plateau of potential.

Undoubtedly, Honda will continue to evolve their variable valve timing technology to new heights, meeting the needs of consumers and retaining its position as the premier developer of variable valve timing technology. As for now, if pure fun and affordability sound enticing, stick to the tried and trued classic VTEC. Cars with VTEC are everywhere and can be built for serious speed and power. Otherwise, your options are open.

APPENDIX

Terminology

camshaft:

A shaft with cam lobes (bumps) which is driven by gears, a belt, or a chain from the crankshaft. The lobes push on the valve lifters to cause the valves to open and close. The camshaft turns at half the speed of the crankshaft.

valve duration:

The length of time, measured in degrees of engine crankshaft rotation, that a valve remains open.

valve lift:

Distance a valve moves from the full closed to the full open position. It is usually about a quarter of the diameter of the port.

valve lifter:

[1] The cylindrically shaped component that presses against the lobe of a camshaft and moves up and down as the cam lobe rotates. Most valve lifters have an oil-lubricated hardened face that slides on the cam lobe. So-called "roller lifters," however, have a small roller in contact with the cam lobe -- thereby reducing the friction between the cam lobe and the lifter.

valve overlap:

A certain period in which both the intake and exhaust valve are partially open. The intake is starting to open while the exhaust is not yet closed. It is usually expressed in degrees of crankshaft rotation and determined by the valve timing, valve overlap is necessary for the efficient flow of gases in and out of the combustion chamber

valve timing:

Adjusting the position of the camshaft to the crankshaft so that the valves will open and close at the proper time. Also see variable valve timing

[2] The system of valves that lets the fuel charges in and let the exhaust gases out.

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