The Influence of a Capacitor Based Ignition System Enhancement On Engine Thermodynamics and The Resulting Improvements in Performance and Efficiency

The physics behind the Capacitor Based Ignition (CBI) enhancements is somewhat controversial, but at closer scrutiny very logical. We claim that if you do the same work in a much shorter time you increase the power. After all, the age-old formula for power is: $P=W/t$. In the case of the CBI, the spark is discharged in one very short plasma pulse rather then in a much longer time like in conventional ignition systems. This shorter spark duration increases the usable power of the spark tremendously. To illustrate this point further, picture a 55 Gallon drum filled with gasoline. The drum is the ignition coil and the 55 Gallons of gasoline is 100% of the available spark energy stored in the ignition coil. Now punch a hole into the drum so the gasoline can drip out and set the whole thing on fire. Let us assume it will take many days for all the gasoline to burn, drip by drip. That's the spark duration. Now take the same drum (ignition coil) and the same 55 Gallons of gasoline (100% of available spark energy) and throw a match into the drum so everything blows up in 1 second. That's the CBI spark duration. The same energy is released in a much shorter time, increasing the power of the event substantially.

The way CBI achieve this effect is solely attributed to the built-in capacitors. Once a capacitor is fully charged, it will release the stored energy in an ultra short pulse, or burst. Just think about the flash of a camera, which is powered only by a 1.5 Volt battery, yet it creates a burst of light many times brighter then even the 110 volt lights in your home. That’s the power of capacitor-based technology.

Furthermore, a short spark duration increases ignition timing accuracy. The spark of a conventional ignition system is so weak that a long spark duration is necessary to assure combustion initiation. However, this situation doesn't guarantee that the set timing point is actually when combustion initiation starts. This can happen at some point during the spark's duration. Whereas with CBI, the ultra powerful spark guaranties that combustion is initiated at exactly the set timing. At an engine speed of 7500 rpm and a spark duration of 4 milliseconds, it will takes 135 degrees of crankshaft rotation to release all the energy of the spark. In comparison, the CBI spark will have released 100% of the available energy in less then 1 degree of crankshaft rotation. Now that's timing accuracy.

This brings us back to our claims that CBI increase the engine performance while decreasing fuel consumption. It is industry-wide accepted that a more powerful spark does assure faster and more reliable ignition, furthermore, a larger and hotter flame kernel provides faster flame-front growth and more complete combustion, and since the whole combustion process is shorter the thermodynamic efficiency of the engine is increased. All this translates into better fuel efficiency, more horsepower and torque. To find out exactly how much more and to verify the claims regarding faster combustion and increased thermodynamic efficiency, we put a high performance 350 Chevy through its paces. We used a very sophisticated engine dyno that was equipped with an engine cycle analyzer (ECA). This device measures the combustion temperature and pressure inside the engine in reference to the exact crankshaft position (crank-angle-degrees). The results speak for themselves. Full throttle horsepower was up an incredible 7.3 hp and torque a full 7.8 lbs-ft, whereas, brake specific fuel consumption (BSFC) was down 5.67% and exhaust gas temperature (EGT) an average of 37EF. This does indicate a more efficient engine, extracting more horsepower and torque while using less fuel. The drop in EGT is an indication that combustion is occurring at a faster rate, where more of the thermodynamic energy (heat) has been turned into kinetic energy (torque) by the time the exhaust valve opens. Further analyzing the data of the ECA showed peak pressure was up by 3.6% and was reached 1.2 degrees sooner. Peak combustion temperature was up by 1.7% and was reached 1.0 degree sooner. Furthermore, the ECA revealed a much lower cycle to cycle variation. This lower cycle to cycle variation manifests in a much smoother running engine and increased horsepower and torque. All this evidence supports the claim that a CBI ignites the air-fuel mixture quicker and more complete.

Test Perimeter:

Engine	high performance small block Chevrolet
Size.	350 CID
RPM	4000
Throttle	wide open

	Horsepower	Torque	BSFC	EGTEF
Conventional	319.5	370.6	.53	1372
CBI	326.8	378.4	.50	1347

Overall Results:

RPM	Horsepower	Torque	BSFC	EGT
2000	+ 0.8 (0.64%)	+2.2 (0.67%)	-2.78%	-52 (4.76%)
2500	+ 3.4 (2.05%)	+7.2 (2.06%)	-4.17%	-47 (4.27%)
3000	+2.4 (1.17%)	+4.2 (1.17%)	-2.09%	-43 (3.82%)
3500	+3.2 (1.31%)	+4.8 (1.31%)	error	-39 (3.37%)
4000	+5.9 (2.08%)	+7.8 (2.10%)	-4.17%	-35 (2.90%)
4500	+2.5 (0.80%)	+2.9 (0.79%)	-2.09%	-33 (2.60%)
5000	+4.5 (1.53%)	+5.1 (1.52%)	-1.97%	-23 (1.74%)
5500	+7.3 (2.28%)	+7.0 (2.28%)	-5.67%	-25 (1.83%)
Average	+3.8 (1.48%)	+5.1 (1.48%)	-3.0%	-37 (3.17%)

The CBI equipped engine shows an average horsepower and torque improvement of close to 1.5%. Peak improvements are almost 2.3%. Due to improved combustion efficiency, average full consumption is down almost 3% and EGT is reduced by 37EF.

Data of Engine Cycle Analyzer
Evidence of improved Thermodynamic Efficiency

	Pmax	Crank Angle @ Pmax
Conventional	863 PSI	10.6 Degrees ATDC
CBI	894 PSI (+3,6%)	9.4 Degrees ATDC (-1.2)

	Tmax	Crank Angle @ Tmax
Conventional	2743EF	21.0 Degrees ATDC
CBI	2792EF (+1,7%)	20.0 Degrees ATDC (-1.0)

With CBI installed combustion was not only enhanced, indicated by an increase in maximum cylinder pressure, it also occurred faster, indicated by the pressure peak occurring over one full degree sooner.