IGNITION SYSTEMS – PART 2

IGNITION TIMING

Ignition Timing Principles

The combustion of air-fuel mix in the combustion chamber is a controlled burn. It is not an instant explosion. The controlled burn takes time. As engine speed (rpm) increases, there is less time for the controlled burn of combustion to take place. The faster the engine is run, the less time there is for fuel to burn.

Complete combustion of the entire air-fuel mix should occur just slightly after the piston reaches top dead center on the compression stroke. This location is about 10 to 20 degrees after top dead center.

Complete and total combustion therefore occurs during the beginning of the power stroke as the piston is beginning to go down on the power stroke. At this point the explosion will produce maximum power, maximum cylinder pressure, and ram the piston down the cylinder on the power stroke.

To allow for the time it takes for the air-fuel mix to completely burn, the ignition spark must be timed to ignite the air-fuel mix before the piston reaches top dead center on the compression stroke. However, complete and total combustion should occur slightly after top dead center.

If the air-fuel mix reaches "complete combustion" before the piston reaches top dead center, the result will be severe vibration, knocking and possible engine damage as the explosion tries to reverse the direction of the piston and crankshaft. There will also be a loss of power as the completed explosion works against the rising piston that is coming up on the compression stroke. **The ignition spark is too advanced in this example – the spark is ignited too early.**

If the air-fuel mix reaches full combustion too far after reaching top dead center, when the piston is going down on the power stroke, this also causes loss of power, engine knock, overheating, and can cause backfiring through the exhaust valve. **The ignition spark is too retarded in this example – the spark is ignited too late.**

In addition to timing the spark at the proper time before top dead center to allow for combustion time, the spark timing must also be advanced progressively further as engine speed increases. The time available for combustion decreases as the engine turns faster. Therefore, the spark timing must occur even earlier to compensate for the fact there is less time for controlled combustion.

Engines with a lower compression ratio will need more time for combustion because lower compression results in a slower burn. Therefore, ignition timing will need to be advanced further to give the air-fuel mix more time to burn.

Higher engine compression causes more rapid combustion of the air-fuel mix. Less spark advance is needed for engines having a high compression ratio.

For example, a Suzuki GSXR-1000 sport bike with a 12.5 to 1 compression ratio requires an ignition advance of only 4 degrees BTDC at idle speed. In contrast, a large Harley V-Twin cruiser with an 8.5 to 1 compression ratio requires an ignition advance of 20 degrees BTDC at idle speed. The bike with the higher compression ratio requires 16 degrees less advance ignition timing at idle.

Other factors that also affect ignition timing can relate to an intake valve not opening at the correct time, or a fuel injector not injecting the fuel into the combustion chamber at the correct time.

Greater engine load also affects ignition timing. More load causes the air-fuel mixture to burn faster. More load requires less ignition advance. Less engine load causes a slower burn. Less load requires more ignition advance.

The air-fuel ratio and the octane rating of the fuel will also affect burn time. Fouled spark plugs or water in the fuel can also affect combustion time along with many other factors.

The job the ignition system performs is nothing short of incredible considering the amount of time it has to perform its job.

A high performance sport bike turning 12,000 rpm will fire one spark plug 100 times per second! Because the sport bike has 4 cylinders, the ignition will have to manage the ignition of 4 spark plugs – thus firing a total of 400 times per second at 12,000 rpm.

If this is not enough, each combustion occurs after a computerized ignition has analyzed engine speed, crank angle, throttle angle, gear position, and other considerations before choosing when to trigger the ignition. **The time crunch to analyze all of this data and fire one plug is only 1/100'th of a second per cylinder at 12,000 rpm.**

Mechanical Advance of Ignition Timing

Older engines use the principle of inertia and centrifugal force to advance ignition timing. Weighted "arms" that are spring loaded are attached to a cam plate. The ignition points are mounted on the cam plate. As engine speed increases, the weighted arms spin faster and centrifugal force throws the weights outward. The arms pivot outward.

As the weights pivot outward, they also cause the cam plate that holds the points to "rotate forward". The breaker points, located on the cam plate, are now "relocated" to an advanced position relative to the cam that bumps open the points. *(See the "mechanical points" in the "Battery and Points Ignition System" illustration on page 17)*

In other words, the points will be bumped open sooner than they would be if the engine speed was slower. This earlier bumping (opening) of the points advances the ignition timing.