TechStop.qxp 4/5/06 11:57 AM Page 1

ULTIMATE TUNING OF MECHANICAL FUEL INJECTION

by Robert Szabo

Drag racing mechanical fuel injection is a simple hydraulic system. It follows all of the scientific rules of any other hydraulic system such as the ones that are throughout manufacturing; dump trucks, tractors with hydraulic shovels, hydraulic elevators and many other applications around us. With some setup provisions, mechanical fuel injection provides a very high capacity for horsepower making. It is the standard in many injected as well as supercharged classes. It works well with gasoline, methanol, ethanol and especially nitro. Since mechanical fuel injection is not adaptive like a carburetor, it requires proper adjustment. That can be a tough obstacle to a new tuner without fuel injection experience.

FUEL INJECTION WITH EXPERIENCE

An experienced methanol fuel injection tuner will know that a 0.034 inch diameter nozzle and a 0.130 bypass will get the stacker injected Big Block in the ball park with a seven gallon a minute fuel pump. He knows the bypass is a return path for tuning the engine. It provides a route to return excess fuel to the fuel pump. He knows if he increases the bypass jet to a 0.135 inch diameter, the car will run well in warm weather. He also knows that on a cold day, he may have to run a 0.125 inch (smaller diameter) jet, necessary for the more dense air from the cold temperature.

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Some fuel injection racers have found the center of the operating window for their fuel injection. They seldom change a jet or poppet pressure for any of the IHRA tracks they compete at all year. They travel to a known number of racetracks and stay within their setup range. The key for this trouble-free performance is that they found the center of an operating window.

INDUSTRIAL PROCESS

My last industrial (non-racing) contract was to develop spot welding for the GM Suburban aluminum lift gate in the rear of the vehicle. This was the first ever low-cost, aluminum assembly to go into high production. This manufacturing task had hundreds of variables to monitor with many settings per weld. The engine makes the same power for the same air density, wherever that may be. From then on, racing has been a blast. In a typical local racetrack condition, qualifying is in the same. The engine makes the same power for the same air density, wherever that may be. It also makes a predictable change in power for the same change in air density.

The day before an event, I predetermine my jetting for the event temperatures. With Internet information about the hourly weather predictions for the next day, I set up my jetting decisions for the different temperatures according to the time of day. When that time occurs during the next day of competition, I change jets according to my predetermined plan. I do not have to think about jetting decisions during race day. That was a major relief since there always seemed to be something else that needed full attention such as the qualifying position or the competitors’ performance levels.

LEAN LIMIT

After an outing with an air to fuel ratio several steps leaner than where I started, I checked spark plugs to see if any heat was building on the threads. One of the techniques used by many racers is to run plated spark plugs. Then after a run, the spark plugs are removed. The threads are examined to see if any telltale discolorations are present. A certain number of threads with plating discolorations are a tuning indicator. That indicates a certain level of heat build up in the engine. Subsequent tuning to that same number of thread discolourations maintains a tuning baseline. After this outing, one thread was discolorized in spark plugs from most of the cylinders. That would indicate still a rich mixture with little heat build up.

After I returned home, I disassembled the engine and found two melted piston domes. The piston domes were sunk in the middle from overheating from excess lean running. I was surprised that the spark plugs did not reveal the heat that caused this damage (that peculiarity is under analysis for my next book on methanol). However, I had just found my lean limit. This lean limit was about 30% away from the rich limit where I started from several weeks earlier. I replaced the pistons to restore the engine, and that was the last engine damage that I encountered with this high-powered bracket racing combination.

I chose an air to fuel ratio in the middle. Having fun with no tuning burden

Over that time period, the racecar has been a blast. In a typical local racetrack condition, qualifying is in early afternoon at 95+ deg. F temperature. Competition continues into the evening with temperatures down to 65 deg. F. That temperature change would require a jetting change in my engine.

I found that mechanical fuel injection is an exact science and not an art. I confirmed the math and kept corrobormating the jetting changes. Near the end, I could choose a setup to run a specific quarter mile elapsed time anywhere between 8 seconds down to 6.6 seconds. In one test outing, I set up a 6.70 and ran it. Then in the next test outing, I set up a 7.50 and ran it.

From hundreds of runs, I kept records of the math and procedures for how to tune mechanical fuel injection. From that, I found that mechanical fuel injection is an exact science and not an art. Once the system pressure and air to fuel ratio is controlled, the engine starts the same, warms up the same, has the same response, and opens the high speed the same. The engine makes the same power for the same air density, wherever that may be. It also makes a predictable change in power for the same change in air density.

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LEADING IT DOWN

In the next outing, I leaned down the air to fuel mixture about 5%. This was done with some simple math calculations for a known change. Little if any raw fuel shot out the exhaust on the run. I made several test runs and returned home. The engine oil was less soupy from methanol contamination. In a series of several more outings, I leaned the engine in fairly equal ratio points of about 5% increments for each outing. Again, some simple math was used to determine reliable and uniform lean out steps.

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THE RACERCAR PROCESS

A racecar is nothing more than a process, just like any other production process. There are benefits from good adjustments and perils for bad ones. My racecar experience was always more difficult than my industrial experience until I realized that the process window concept with its benefits would apply equally to racing.

FUEL INJECTION PRESSURE DETERMINATION

After that realization, the first tasks I did with my blown alcohol bracket Funny Car was to determine a fuel injection operating pressure window. I started out with a larger total jet area for the injectors and bypass jets. That results in a lower pressure. I had access to some math that determined the approximate value of that pressure. I tested the racecar and noted the engine characteristics.

After a series of test runs, I selected a total jet area for the best system pressure for response and reasonable fuel pump loading. Then I reduced the total injector and bypass jet area. That produced a higher pressure.

During this test, I maintained the same ratio of injector area (to the engine) as bypass jet area. That kept the same air to fuel ratio in the engine. After a series of test runs, I selected a total jet area that provided the best system pressure for response and reasonable fuel pump loading.

Higher pressure provides good response. Lower pressure provides better fuel pump life. A tradeoff is necessary. With a preliminary value selected, I kept that total jet area to maintain a system pressure of about150 psi. That was done for all subsequent test and competition outings.

AIR TO FUEL RATIO DETERMINATION: RICH START

The next task was to determine my air to fuel ratio window. In a series of test outings, I started with a rich mixture and, in subsequent outings, leaned the engine in fairly equal steps. In the first outing, the engine was set up so rich that some amount of raw methanol was shooting out the exhaust pipes on the run. The engine did not heat up. After a few test passes, I took the racecar home, changed the soupy oil and prepared it for the next outing in a week or so. The oil was soupy from methanol contamination washing by the piston rings. This became my rich air to fuel ratio limit.

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