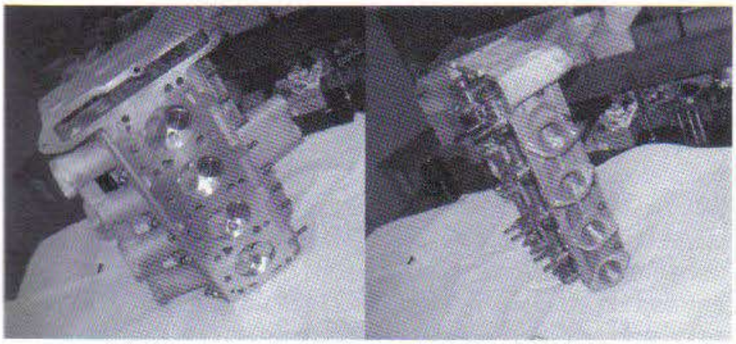

Porting and Cam Tuning for Volumetric Efficiency of the Lotus TwinCam and the History of the Stromberg/Weber conversion

The Lotus Twin-Cam has been and probably will always be one of my favorite motors to tune. It offers up many power advantages, and some challenging disadvantages inherent in the Hemispherical design with valves at 27°.

When I review what I've done with the cylinder head over the past 20 years of fiddling, I really didn't start to make 'consistent power' until I adopted consistent machining parameters. Though the technological discount of modern CAD and CAM support of CNC machining I have been able to get much more consistent and precise results.

About 12 years ago as my Tool and Die shop was challenged by off-shore companies, I decided to get into a product that would certainly never be challenged from off shore completion. From my Cosworth dabbling, I knew Ken Duclos, a true motor man and Atlantic driver. Together we decided it was time for 'A modern Twin-Cam development' and what better test bed than my own Lotus Cortina race car, born was the Stromberg-Weber conversion.

Stromberg-Weber conversion technical

The first aspect of the TC design that we decided needed to be updated was the cylinder head. In 1990, I designed the manifold in CAD, and using my CNC tooling machined the first manifold from a large chuck of billet. From that billet, and careful progressive flow bench testing and CNC porting, over 16 years, we have the base line of the manifold as we know it today.

The long intake runner of the Twin-Cam has some inherent design problems particularly in the last 1.5 to 2 inches, it is this area of the port which must be very precise or the incoming charge can stall, and tumble. The head in the original format is very difficult to precisely port, fundamentally because the port is so long. This was the rational behind the Stromberg-Weber conversion, being able to remove the manifold allowed very accurate CNC machining of this area of the port.

Today with the advent of easily accessible computer simulation, I've further dialed in the important effects volumetric efficiency has on the Twin-Cam. For the Twin-Cam, as for any motor, understanding how to tweak the volumetric efficiency of the cylinder head is the key to making power.

Volumetric efficiency is the percentage of the flow obtained from the exhaust with respect to the flow of the intake, it is a mathematical relationship, giving a very important window as to how the motor will perform. Ideally we want this efficiency to be around 70 to 80%.

If the volumetric efficiency is high, at lower exhaust valve timing events, the incoming intake charge is going down the exhaust. The resulting motor will run poorly at slow engine speeds, low in torque. If the volumetric efficiency is low, at high exhaust valve timing events, the engine will not scavenge properly, and kill the power of the incoming charge. Another way of understanding this is valve overlap, generally higher overlaps of 60 degrees are associated with longer duration cams promoting higher exhaust volumetric efficiencies. The result, overlap and the associated added exhaust volumetric efficiency giving better higher rpm savaging, these are the higher horsepower motors, good for light formula race cars, but are often termed to peaky for heavier sedans, and not comfortable on the street. In today's world of springs capable of carrying higher cam accelerations, it is possible to have the best of both world with higher lift and less duration, and the use of asymmetrical cams.

The Lotus TwinCam hemispherical, 27° valve inclination is likely to be more volumetric efficient at lower engine speeds because the valves are facing each other, they are basically tangent, thus income charge is likely to go down the exhaust. This situation has become a problem for the average fellow who wants a torquey street motor. Through the 40 years of Lotus TC history, there is a lot of tradition, unfortunately, time has moved on, today's fuel is different, lighter, more oxygenated, more likely to combine with exhaust gases. The traditional cam grinds of the past tend to add duration and less valve lift thus opening up higher exhaust valve efficiencies, the result added overlap as mentioned is often known as a peaky engine.

Through the past 12 years I've been racing both the Lotus Cortina, a TC Escort, as with all sedans, they are heavy, it's easy to loose speed, thus as a driver you really appreciate torque when you need it. I drive my race cars in hard, brake as late and hard as I dare, and plant the accelerator coming out of the turn fast, difficult to do when the engine is down 3-4000 rpm from late the braking, particularly with traditional long duration high overlap cams. As a race driver I'll take drivability over a peaky high horsepower motor any day!

To correct, and obtain a more torque and progression from the TC, from our actual engine dyno results, I've been able to confirm and tweak a computer engine simulation program to test and confirm my porting and valve timing events or lobe centers. We designed cams to control the volumetric efficiency's for today's fuels, using high lift and lower duration.

Interestingly, although I've incorporated precision into my porting and chamber design, and final flow bench computer simulation, I still have minor 2-5% volumetric efficiency surprises, I call these days the beginning of no end.

The terrible fact is, if there is a slight bump, or hollow in the port, particularly where the induction or exhaust gases are highly compressed, will result in delaminate flow, and knock the volumetric efficiency out. The critical area in the induction side is the short turn, the last 1.5 to 2 inches as the port turns into the cylinder. This area must be just right. This area sets up the velocities and flow for the rest of the port to the carburetor.