

## **Chapter 4. Overview of typical modified engine builds**

There are essentially 3 basic types of modified Twincam builds that people do these days in my observations and I will discuss the elements of each in the following chapters in more detail.

### **1600 cc Competition Engines**

These are typically built for historic racing where there are class engine size limits and other restrictions such as the allowed FIA modifications in European historic racing. This is the type of engine I have mainly built over the years to meet the Australian Historic group SB production sports cars allowed modifications for my Elan.

These engines use a standard stroke crank and 83.5 mm bore to meet the typical 1600cc class limit or maximum overbore allowed limit. The focus in these engines is maximising power and torque across an increased rev range up to 8000+ RPM and aiming for 180+ hp. This requires a strong bottom end with steel crank, stronger, typically H section rods and forged pistons.

Higher compression ratios for use with racing fuels and high lift, longer duration cams are used on extensively ported heads with increased valve sizes to the limits possible or allowed. Cam duration and lift used depends on the type of car and gear box being used with longer duration cams up to around 320 degrees seat to seat and up to 0.500 inch lobe lift possible. These long durations boost top end power but at the expense of mid-range torque, so the extremes in duration and lift are typically built for light open wheelers with Hewland gearboxes where ratios can be matched to the track easily to compensate for the mid-range torque loss

Larger capacity engines are sometimes built with bigger bores and longer stroke cranks to take this type of high revving competition engine's capacity above 1600cc but there are limited competition opportunities in most of the world for this sort of engine, and where it's possible, dropping in a BDx series engine is probably also allowed and a better approach.

These engines can also work well in a road car with a high lift and shorter duration cams as described in the road engine section below but the stronger bottom end that enables higher revs to around the 7500 to 8000 rpm that these cams can be used for producing up to 170 – 180 hp in the best examples.

With modern heads and cams and porting it is possible to achieve on carburettors similar power levels to that achieved in the best fuel injected Cosworth, BRM, Vegantune or Hart 416B race engines from the 60's with much greater reliability

### **1558 to 1600 cc Road Engines.**

Based on the standard block bored to a maximum of 83.5mm and standard crank these engines focus on head modifications and using high lift short duration cams to get the most power with a wide torque band while using a relatively standard bottom end assembly and 6500 to 7000 rpm standard rev limit.

Heads can be ported with bigger valves or left at the standard Big Valve size. Cams are typically in the 0.410 to 0.440inch lobe lift with seat-to-seat durations under 290 degrees.

Power outputs in the 140 to 160 hp range are achievable with this type of engine depending on the valve and porting modifications and specific cam used.

### **1700+cc Long Stroke Road Engines**

In these engines the head work and cams is typically the same as described above for a modified 1600cc road engine or race engines. Porting and valves can be made larger than for 1600cc road engines depending on the actual engine size due to higher port flow rates achievable in the larger capacity engine.

The most common approach is to use a 1600 stroke crank and 83.5 mm bore to get 1700cc and 150hp to 170hp depending on porting and cams used. This can be built on either the 1500 height block or a 1600 height block and a range of rods lengths and piston compression height selected to match the block height used

Bigger bores on the standard Ford blocks are possible but this requires careful ultrasonic survey of the block walls and offset boring to achieve and its only possible in a few blocks. Special alloy blocks and Iron blocks from QED enable larger bores up to 90mm. Special long stroke cranks are also available so building a 2.2 litre twin cam is possible. How much air the head can flow ultimately becomes the limit with these big capacity engines with ultimate HP for a well ported head being around 200 to 210 hp. The real benefit of these big engines is the torque produced at road use engine speeds

## Chapter 5. Twincam Myths

### **The “L” block and bore thickness.**

Much has been written that it is desirable to build modified larger bore engines from the “L” block versions with the large cast L in the exhaust side engine mount boss rather than the standard Ford non-L versions of the blocks. This is based on people claiming the bore wall castings are thicker. This appears to have arisen before ultrasonic testing was common. All the ultrasonic testing I have done shows a similar range of bore casting outside diameters across all block versions, “L” or not, from the earliest 116E to the last 701M and 711M blocks. The bore outside diameter range I have calculate from ultrasonic bores testing I have done is from 88 to 92mm. The individual bore castings all vary within a block within this range, and it is very very rare to have all bore castings at the top end of this range in a single block. The bore outside diameter casting is not actually a circle but has slightly thicker lobes at 45 / 135 / 225 / 315 degrees with zero degrees being at the front of the engine.

It is rare that the bores are actually centred in the bore castings and with careful offset boring larger bores can be achieved reliably and a high percentage of all standard Ford blocks or L blocks can go to 83.5 mm bores with an acceptable 2.5mm / 0.1inch minimum wall thickness. Very few blocks, either L or non-L, will go to 85mm with acceptable wall thickness

### **Deepening valve spring pockets is needed.**

In the 60's high lift racing cams required the spring pocket to be deepened to accommodate the valve and springs and some race engine builders and cam suppliers still say this is required. However, with improvements in spring materials, and spring and retainer design and thin steel followers even the highest lift cams can be fitted without needing to deepen the spring pockets

### **The standard crank is good for 7500 rpm.**

David Vizard in his book says a standard cast iron crankshaft is good for 7500 rpm continuously with limited bursts to 7800rpm which is probably where this comes from. This is based on the crank being Tufftrided and using steel main caps.

Tufftriding is a proprietary low temperature surface hardening process. The components are placed in a heated salt bath where a reaction takes place between the salt melt and the surface of the components. During the reaction nitrogen and carbon are absorbed and diffused.

Unfortunately, my observations are that standard cranks fail rapidly if used above 7000 rpm for even short periods on the track regardless of how they may have been heat treated.

### **The standard water pump bearing is inadequate.**

The water pump bearing only fails prematurely due to excessive belt tension load. This is due to the belt tightening significantly as the alloy front cover heats up. The belt needs to be loose enough to turn the generator / alternator pulley by hand on a cold engine. When the engine is hot the belt tension will be correct and the standard water pump bearing will last as long as other major engine components.

Water pump conversions are sold with larger diameter stronger bearings, but they are not really needed if the belt is kept properly loose when the engine is cold.

### **You need to fit an oil restrictor in the head to stop it flooding with oil**

Lots is written on this with various size restriction holes in a bush recommended to be fitted in the oil passage to the head. In my experience this is not a problem even with high pressure / high volume pumps. If the cam journals and bearings are within specification tolerances and valve stems and guides also within specification, there is no excess oil problem with the head flooding and oil burning in the engine via the valve guides. I believe fitting the restrictor has come about because people were trying to compensate for other problems with worn valves and guides or cam bearings

## Chapter 6. Camshaft and valve gear selection

Personally I would use the cast iron cams but would modify them for the fitting of long sprocket bolts to reduce the risk of the cams breaking at the oiling groove on the first journal with the higher lift profile. This is probably not absolutely necessary for a QED 420 cam running the very low load Q55 springs. QED themselves do not do it, but then again QED are just a parts seller these days and appear to have lost all their detailed engine modification knowledge over the years. I believe Kent cams who make a similar 0.420 lift profile cam will do the long sprocket bolt modification if requested.

Steel cams are stronger and don't require the long sprocket bolt modification. However steel is more prone to galling failures than cast iron, which is a surface failure due to micro welding between the cam lobe and follower. Thus it's more problematic getting the cam and follower to bed properly on running in and not fail due to galling especially when running steel cams on steel followers and many followers you buy these days are steel though you still maybe able to get cast iron ones. However you may then run into other problems as you may need to use thinner steel followers depending on the set up of the valve train to accommodate the QED 420 lift. You can get steel followers with DLC coating or you can phosphate coat the cam and followers and either of these treatments can help prevent the galling problem.

Always use a good assembly lube on the cams and followers and a good high ZDDP oil for running in the new engine which also helps prevent the galling failures which mainly occur during run in.

I would always use new followers with a new cam.

## Chapter 7. Building a larger capacity or high RPM bottom end

A 1600 tall block with a 83.5mm bore, with a 1600, 77.62 mm long stroke crank, for 1700cc displacement and combine that with a light 5.230 inch / 132.8mm rod (that length is the Cosworth design for a BD motor) and with a light forged piston with modern thin rings and it all works to produce great torque and power for a road engine with the right high lift short duration cam, the right valves and porting and the right carb set up and right exhaust and right ignition and the right balancing details. This comes with no significant increased vibration versus a 1500 twin cam in my experience at least up to 7000 rpm.....

I have never experienced a build like this at 8000+ rpm but at those revs a 1500 block short stroke Twincam will scream beautifully but it is certainly not vibration free as I know from failed oil pumps, distributors and alternators in race engines as all of which struggle with the vibration in the nose of the engine at 8000+ rpm. The water pump is actually the most reliable ancillary in a race engine as long as you keep the V belt as loose as possible

There are many details you need to get right but I dont believe its a truck engine and I dont think Cosworth designed trucks either 😊

Bore to stroke of 1.08 and rod ratio of 1.71 also say its not a truck engine.

You should get around 170hp or 100 hp/litre at 6500 to 7000 rpm which is certainly not a truck engine and not bad for a modified 70 year old design road engine running on carbs with no 4 valves or Variable valve timing and lift, or knock sensors and electronic ignition or any of the other modern naturally aspirated engine stuff done by people like Honda or VW or Mazda or others and they have not got much better output per litre in the last 20 years despite all of this ( but maybe they are crippled a little by emissions regs unfortunately) .

But all that is just my personal opinion. Everyone needs to make their own decisions about what they do, but all power to people prepared to put their money into a project like this and breath new life into Twincams and Elans for the current era.

## Chapter 8. Building a good breathing cylinder head

*Start with a good head - Head thickness / Valve size in Big Valve heads*

*Blunted splitter in Stromberg head.*

*Include some of the head flow testing done*

[quote="HCA"]

As for breathing, I have not a clue what to suggest is best. I have stretched my budget and maybe mistakenly gone for a John Wilcox head - 1.6 and 1.4 valves, ported 45mm with throats widened and polished to 33mm and fast-road cams. Rohan has tactfully remained quiet on this, but a local engineer - one of the few 'Mr Cosworths' in France - sucked his breath in saying that at low revs, the engine might demand my foot be heavier on the right pedal...! His thoughts are that the throats should only have been enlarged to 30mm... We will see! If you see a near new Wilcox head for sale next year, you will know!

[/quote]

Hi Hal

I don't know the details of the Wilcox head modifications or the source of the head itself so its hard to comment on how it will perform in a 1700cc road engine but it will be interesting to findout :).

A standard original twin cam head had 29mm ports so going to 30mm only seems pretty conservative to me. I measured one of my original heads that been race ported with a 33mm throat and the McCoy head I use now for racing has a more slightly oval shaped throat at around 34mm vertical and 35mm horizontal. There is a lot more than just the throat size when porting a head, but I guess it gives some indication of the extent of the work done

What I do know is that 1600cc engines i have built with the McCoy converted heads and similar short duration high lift cams have very good lowdown torque when used with 34mm or 36mm chokes in the carbs. 38mm chokes generate more top end power on the track but struggle to work well at more normal road engine speeds, though perhaps more time on the dyno could improve their low rpm performance.

A 1700 cc engine like your building should be even better with higher port velocities and bigger capacity improving lower speed performance. A similar engine I helped a friend build recently using an old racing head of mine with 33mm ports is certainly a great performing road engine in his Elan with no lack of low rpm torque

## **Chapter 9.** Carbs, exhaust, oil pump and cooler system and other accessory details



## Chapter 10. Reference data

### **Reference Books**

- (1) *Miles Wilkins – Lotus Twin-Cam Engine*
- (2) *David Vizard - Tuning Ford Twincams*
- (3) *Dave bean Engineering – Lotus Elan, Plus2 and Cortina catalogue*

### **Burttons Tuning Guide**

<https://www.burtonpower.com/tuning-guides/tuning-guide-pages/ford-lotus-twin-cam-8v-tuning-guide.html>

### **Cosworth Twincams**

[http://www.colinchapmanmuseum.co.uk/?page\\_id=2802](http://www.colinchapmanmuseum.co.uk/?page_id=2802)

[https://en.wikipedia.org/wiki/Lotus-Ford\\_Twin\\_Cam#Cosworth\\_developments](https://en.wikipedia.org/wiki/Lotus-Ford_Twin_Cam#Cosworth_developments)

### **BRM twin cams**

<https://forums.autosport.com/topic/90782-brm-lotus-twin-cam-engine/>

<https://www.classicandsportscar.com/features/bourne-supremacy-brms-lotus-elan>

### **Other Useful Web links**

#### **Removal and rebuilding of a competition twin cam**

<https://lotuselan.net/forums/viewtopic.php?f=39&t=46421>

#### **Head flow testing**

<http://users.erols.com/srweiss/tablehdc.htm#Lotus>

<https://lotuselan.net/forums/viewtopic.php?f=39&t=50143>

**QED**

<https://qedmotorsport.co.uk/product/cylinder-head-small-large-port/>

**SAS**

**Dave Bean Engineering** – an authorised reproduction of pages in the catalogue

<http://www.team.net/www/morgan/history/kenteng.html>

**Tony Ingram**

<http://lotus7.com/Home.html>

**Wikipedia write up.** It repeats some of the myths but overall not too bad

[https://en.wikipedia.org/wiki/Lotus-Ford\\_Twin\\_Cam](https://en.wikipedia.org/wiki/Lotus-Ford_Twin_Cam)

**Cranks**

<https://lotuselan.net/forums/viewtopic.php?f=39&t=34325&start=15>

**Ford Lotus blocks from Cortina club**

Again repeats a few myths but overall OK

<https://www.lotus-cortina.com/library/block/blocks.htm>

**Vegantune**

The link below gives some more details but it's all vague and more details are also in the Wilkins book

[http://www.colinchapmanmuseum.co.uk/?page\\_id=2852](http://www.colinchapmanmuseum.co.uk/?page_id=2852)