Failures of Toyota twin cam engines by Terry O'Beirne

Major failures of modern twin cam engines fall into one of several broad categories.

- Wear for age
- Unexpected breakage of a cam timing belt
- Damage to an internal component by using the engine outside its design limits
- Lack of oil
- Lack of coolant
- Ingesting debris

I'll talk about all of these with particular reference to all the 1980's-90's era Toyota twincam performance engines, but especially the 4AG & 3SG where we have the most experience. Because the oldest of these engines is now over 20 (4AG), & the common "young" ones (3SG or 1JZ) at least 10 years old, a pattern of failures is starting to appear & this short article just reflects what we are seeing. There will always be engines that are better & worse than what I describe, so don't be concerned if what I'm saying does not exactly match your personal experience.

Wear for age.

Experience suggests all these engines will operate quite successfully between 200,000 & 250,000km if serviced & driven as intended, & largely un-modified. None of these engines should exhibit any internal problem up to 100,000km. At about 100,000, the cam timing belt has stretched, has considerable wear to its teeth, & its roller bearings are getting noisy. For that reason, when you change a cam belt, change both the tensioner & idler rollers. It is also wise to change the cam, crank & oil pump seals at the same time, as removing the belt is not an easy job in any of these Toyotas. We always recommend to our 3SG customers, that we change the water pump at the same time, as the belt has to be disturbed to do this. Note that in most cases, a failed timing belt will cause some other damage.

Beyond about 150,000km piston rings are starting to lose their tension & not working as well as originally. This causes a slight loss of compression (maybe down to 110-130psi on a cranking test) & allows combustion gasses to blow into the sump, degrading the oil. Turbo engines seem worst and may show values under 100psi. For this reason, older engines, especially turbo ones, need more frequent servicing, & if used around town only, oil change periods of about 5000km are sensible. We have not found any particular oil that dramatically improves this situation, but in our shop we use Penrite HPR10 or HPR15 (semi synthetic), depending on the application.

Carbon build up in the head may be considerable in engines used in city cars, especially beyond about 175,000km, to the point that performance is affected. In one recent case, an engine with 200,000km.was so clogged up, that the compression on 2 cylinders was very low, but this was not immediately obvious. It was only when we could not find an obvious cause for a general lack of performance, did we eventually find this. This is exacerbated in modern engines because oil fumes from the engine internals are recycled thru the intake system rather than vented. In most cases, this requires head removal & valve seats re-cut, carbon removed etc.

Japanese import engines are showing a distinct pattern of lower overall life & we attribute this to poor servicing in their early life. The poor servicing allows ultra-fine carbon (and metal) particles to circulate for unusually long times, plus the oil is chemically breaking down from acids etc. All together this results in abnormal wear to all the moving parts, especially the crank bearings. The 4AG 20valve engines seem to be the worst by a large margin, with most of the imports being simply terrible once dismantled. The picture shows the oil scum inside the cam cover of a "low km" 3SG import—clearly negligible servicing.

All the 3S engines have abnormal wear in #3 cylinder because of a stale spot in the cooling system. When engines beyond about 100,000 are dismantled, #3 cylinder always has the most wear & often needs re-boring to make it optimum. The 1GG has the same problem with #5. Other bores appear to last to 2000,000 km before re-boring would be needed. The pistons however are typically worn out well before this. The 4AG pistons of all versions, wear much more quickly than 3S & even at distances as low as 100,000km., they would be replaced if the engine was dismantled for some reason. Thankfully, oversize cast pistons for most engines are quite cheap, but if you want better quality forged ones, then the price escalates rapidly. The stock cast 4AGZE & 20V pistons are also a silly price as there is no competition for these as yet.

The abnormal bore wear is 3S engines is becoming so acute with older engines, that the #3 cylinder rarely cleans up at the first "conventional" overbore (0.5mm), however, a 1mm overbore sorts it out. That however, is the maximum bore for which pistons can be easily bought, so any further bore wear will necessitate sleeving the block, or a new block. Forged pistons however , usually can't be obtained off-the-shelf in 1mm oversize

When 3S & 7M engines are dismantled, the deck surface (where the gasket sits) is commonly buckled. The cause is probably the water flow patterns (like the bore wear). This is part of the cause of blown head gaskets on overly boosted engines. When the engine is stripped for a rebuild, this is easy to rectify, but impossible otherwise. This is one reason why many head gasket jobs don't work.

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All highly boosted engines seem to have a problem with big-end bearing wear, that plays a role in catastrophic crank failures. When we dismantle these engines, we commonly find the big-end bearing shells have been hammered so hard they have lost their tension & are no longer "springy" in the conrods. The conrod journal is also often out of round. To help solve this we replace the bearings with types that have hardened steel backings. These were designed for race use, but the cost increase is so little, we use them in most boosted engines we build, even if for street use only. The 3SG suffers the most, but problems are being reported with low km 2JZ engines.

Nearly all of external attachments on these engines start failing at around 150,000-200,000. The most common ones we see are idle speed control valves, TVIS actuators, alternators, ignition coils, throttle position switches. We observe very few failures with injectors so it looks like they will last to 300,000km or maybe beyond. That is not to say they are still perfect, but cleaning with new O-rings, solves 95% of their problems.

Aging or failures of temp sensors & the exhaust oxygen sensors can cause the engine to run rich (too much fuel). Some of the unburned fuel washes oil off the cylinder bores & can increase cylinder wear if it stays that way for a long time. Most of these sensors need replacing at around 200,000km or 15 years.

The distributor oil seals is a common failure in Toyotas but it seems quite variable, between about 100,000km and 200,000km. The 3S engines seem the worst. All are relatively easily fixed.

Unexpected failure of a cam timing belt

Toyota originally specified a change period of 60,000km on their engines built in the 80's to early 90's, & 100,000km thereafter, because belt technology changed. It is possible to fit the last specification belt to most of these engines. When buying a belt , ask your supplier for one made with highly saturated nitrile rubber (HSN) or better, so it is then likely to last around 100,000km's.

Aftermarket gears can drastically reduce the life of belts. Some of them are so badly machined they have sharp edges & imperfect tooth shape. Others are not hardened so they wear quickly, & this increases the chance of the belt jumping a tooth. We found 1 well-known brand that caused the belt to run off and wear its way through the top plastic cover. Operating an engine without its timing belt covers is just asking for trouble. One bit of debris tossed up from the road can cause the belt to be thrown off, wrecking the engine.

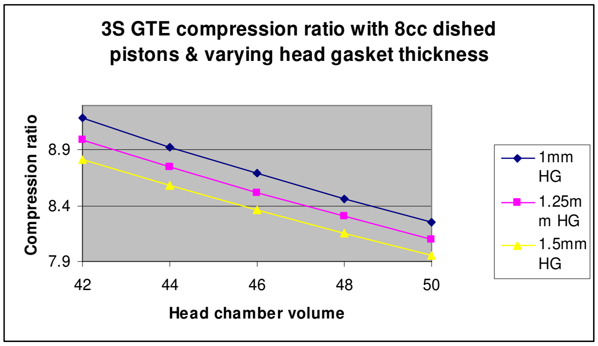
Many of these engines don't have hydraulic belt tensioners to control belt tension as the belt wears. This makes them more susceptible to belt jumping with age or because of poor cam pulleys.

Damage to internal components by using the engine outside its design limits

This covers many of the failures we are now seeing, & it is totally driver controlled. Whilst all these engines can tolerate some performance improvements, every one of them reduces engine life &/or reliability to some small extent, so it always a trade off. There is no such thing as "zero risk" when it comes to performance increases, but with care and attention to detail, the risks can be quite low. Boost increases, no matter how small, contribute to premature failures of the factory pistons. The 4AGZE & 2JZGTE pistons appear to be the most durable, but the 3SGTE & 7MGTE ones are very intolerant due to their design. Most boost related problems occur when there is no compensation by changing the fuel and/or ignition maps. The regular use of high boost without such compensation, results in detonation & soon after, cracks start appearing between the rings lands. This leads to stuck rings, bore scratching & eventually catastrophic failure when a big chunk breaks out of the piston. The later flat-top 3SGTE pistons seem to suffer the most. Even the best forged pistons will not stand this situation for very long. The adjacent picture shows the small cracks that develop in the ring lands of 3SGTE pistons, & what happens after a short time.

Significant boost increases also contribute to the bearing failures I mentioned before. These bearings can fail with little to no warning. The bearing progressively gets squashed from overloading & at some time, usually during a big rev or with reduced oil flow, the bearing spins in its housing & "melts". The conrod & crank are usually destroyed. Provided there is only "normal" wear for age, the remedy for wear is replacement of the bearing shells at about 150,000km. We now can supply much better quality bearings for performance use, than what Toyota provided.

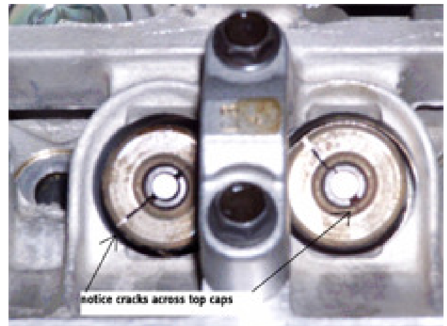
We have noticed a few cases where owners have fitted the wrong pistons to turbo 3SG's. Some of the US-sourced forged flat-top pistons are made for the Gen 1 heads which have a chamber volume of around 52cc. When these pistons are used in Gen 2 or 3 engines with 44-48cc head chambers, the compression gets unacceptably high, so detonation occurs more easily. If you want to buy your own pistons for a rebuild, make sure you get the supplier to confirm the crown volume is suited for your head and gasket combination. This means you have to accurately measure the chamber volume after the head is faced. Do not use the 1mm thick metal head gaskets on boosted engines, unless you are perfectly sure of the piston & chamber volumes. The chart below gives you an idea of how compression changes with gasket thickness and chamber volume. This is calculated for a 0.5mm over-bore 3SGTE, with an 8cc dish in the top of the piston. All Toyota twin cams engines suffer from too much compression from using thin head gaskets on old engines.



Boost increases beyond about 1bar, especially if accompanied with detonation, can result in head gasket failures. In extreme cases, the steel "fire ring" around the bore gets pushed sideways & the head is damaged in the process. The engine will have a major water leak & almost no compression on one or more cylinders.

Using poor quality fuel also allows detonation & this is more common if boost is increased (by any amount) & or the cylinder head has been shaved. The factory knock sensors are not quick enough & metal is dragged off the crown of the piston & it gets pounded into the head face. This is noticeable by pock marks in the head face (see pic). At least 50% of the boosted engines, & even a few NA ones, we have apart, have this problem. The only way to solve it is better fuel combined with a programmable ECU. In many cases, the miniscule bits of piston that get embedded in the head start to glow red hot , causing further detonation problems. We find some of them are so hard, we have to dig or hand grind them out, before re-facing the head.

Valve bounce occurs when the factory rev limiter is disabled & the engine is repeatedly pushed beyond about 8000rpm. The top spring retaining plate &/or the valve collets then crack, sometimes allowing the valve to drop onto the piston destroying the engine (see cracks in cap in adjacent pic). Springs in engines more than a few years old or that have been subjected to overheating, will have lost some of their tension, so valve bounce will occur at slightly lower revs than originally. In general, cracks are a rare fault, but soft springs are not.



The fitment of larger than needed injectors &/or boosted fuel pump pressure, will make the engine run rich & can accelerate bore wear. We routinely see engines where injectors are grossly over-rated for the actual performance. Oversize injectors in a stock engine are basically a waste of time that will cause it to run badly.

Ingesting debris

Using poorly maintained non-standard or inferior design air filters, allows fine dust to enter the engine. Scratches on the pistons & bore are a dead give-away that this has happened, or the intake pipe has been cracked. This problem does not occur overnight, but usually takes months unless the car is used in a very dusty environment. Incidentally, Jap import engines coming from some city areas are really terrible in this regard. Fine carbonaceous grit from air pollution is found right thru the air intakes & also in the air-conditioning filter. If you are using an oiled cotton filter, make sure you only use the recommended oil, as a lot of this oil gets ingested & some of it burns onto valve stems etc.

Opening an engine is serious business, so if you decide to do this, make sure you have the facilities to keep crap out. We have repaired many engines that have not lasted as long as they should have, because of debris. Grass, dirt, sand, bits of rag, nuts, bolts, washers, & even the occasional tool, have been found in sumps. Some "big" stuff is generally harmless, but it's a sign of bad workmanship.

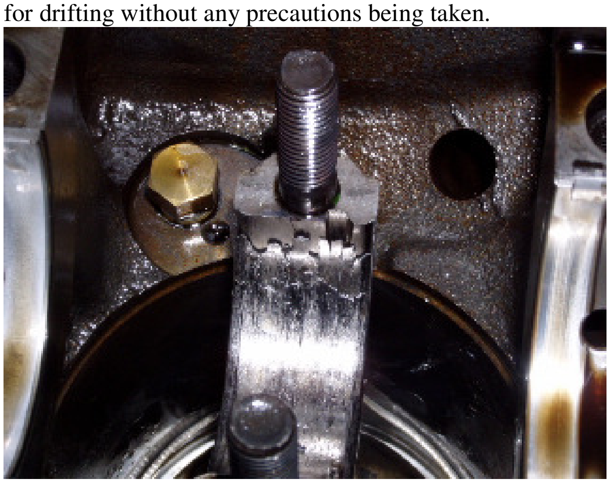
The oil coolers found on many of these engines are traps for rubbish that is very hard to clean out. Engines that have had a major blow-up, often fill the oil cooler with debris that won't just run out when the oil drains. In extreme cases, the cooler is a write-off also, as the inner passages are so fine, they can't be cleaned. Ultrasonic cleaning is often needed for the water to oil types like on 3SG's.

Lack of oil

All sideways mounted Toyota engines have barely sufficient oil in the sump, so the loss of much more than 0.5

litre, presents a major hassle, especially if the car is used in competition. This seems to be the biggest killer of older turbo engines where oil is lost via the turbo oil seal.

When the oil level is low, & a car is cornered particularly hard, the oil sloshes away from the pickup in the sump. One gulp of air under full load is all it takes for the bearings to be deprived of oil & metal to metal contact occurs. The rattle that often eventuates cannot be subsequently cured by just adding oil & signals a big bill. In most cases, #3 big-end bearing is squashed thin & partly melted to the conrod, & the crank is usually written-off. The picture shows the con-rod bearing failures typically seen in 4AG engines used for drifting without any precautions being taken.



For most of these engines we modify the sump to hold an extra 0.5-1 litre to help this problem, & this is mandatory in competition cars. Road cars only need the sump to stay full, but they can always use extra capacity (ie it does no harm & may just save your engine). Overfilling a standard sump is however, not a solution as the crank can strike the oil & this robs power, causes frothing or even physical damage in the case of extreme over-filling. For outright competition cars, an extra pressurized oil accumulator is fitted, or we swap to a dry sump system.

Most modern engines do not use (lose) much oil so owners have forgotten to check it regularly. What more can we say!!

Lack of water

Overheating causes a sequence of events that varies a little, depending on how fast water is lost. The cylinder head starts to soften & bend with the holding down bolts losing their tension. In extreme cases, the head gasket will burn out from combustion gasses being pushed past it. In most cases, only a short time of operation without water will write off an alloy head. The temp sensors in the water outlet won't work if there is no water passing them, so a sudden loss of water (burst hose etc) may give ZERO warning. The best solution is total hose replacement on engines over 15 years old, plus a temp sensor that monitors the outside head temperature & drives a buzzer or other light.

A leaking head gasket will not always result in noticeable oil in the sump (the oil goes milky). Any large workshop will have a chemical test unit that can detect the presence of combustion gasses in the cooling water. This is a sure sign of a damaged head gasket or cracked head. Cracked heads are not common with any of these engines. In many cases with both A & S engines, be aware that swapping head gaskets can cause overheating as the water transfer holes don't align. The picture shows the Gen 3, 3SG head with its unique holes up between the exhaust valves.

Most of these engines use non-reuseable head bolts, so if you need to change the gasket, toss the bolts. Be aware that all the M engines had marginal head bolts to start with, so they are just a time bomb waiting to go off.

Most Toyotas have plastic radiator tanks that are prone to cracks in the curved part of the top or end tanks. In a few cases, the pipe part of the tank cracks off inside the hose.

When we get heads on engines that are so soft they can't be re-used, it is common to also find the piston rings have also lost their tension. The actual bores don't seem to suffer much, so the engine can usually be easily repaired if a replacement head can be found.

The thermostats & radiator caps used in all these engines are generally very reliable; however expect to change them at 100,000km or thereabouts, to avoid problems. Whilst rare, a stuck thermostat can cause chronic overheating. GT4's commonly have the wrong design of radiator cap fitted and it's not the same as other common Toyotas of the period.

Road & Track is a small engineering shop specialising in performance enhancement work. We supply a large range of stock & performance oriented parts for all Toyotas. Our race experiences with various Toyotas over many years mean we get a large number of these in to be modified, or simply serviced. We design & make many parts, testing them on our own vehicles before releasing them to the public. More info can be found at www.roadandtrack.net.au.