The crankcase breathing of classic motorcycle engines is a subtle and neglected subject. Early motorcycle designers spent more time on what was happening over the piston, than under it. Little has changed on today's marques. These feature the same problems as those with vintage and classic engines. *Rex Bunn*, developer of the Bunn breather technology, shows us how gains can be made to engine power, oil-tightness and service life by making simple improvements to crankcase breathing.

So just what is crankcase breathing? In four-stroke, classic singles, vertical twins, vee twins or boxer engines; air rushes into the crankcase as the piston descends. More air escapes past the piston rings into the sump as 'blow-by vapour' and some passes up the valve guides into the rockerbox. This air compresses and pressures rise as the crankcase is closed. These 'pressure spikes' worry away at gaskets and seals and force through joints, unions and porous castings. The crankcase is vented to let some of this gas escape via breather tubes... at least that's the theory.

OEM Breathers

British makers vented their engines with open tubes, clack and flapper valves or timed breathers. A timed breather is good at cutting return flow, but not so good at passing volumes of air versus eg. the open breathers on Triumph or BSA twins and singles. A typical British timed shaft breather has a bush aperture of approx. 3/16" and a circumference of approx. 3/4. That means the holes overlap for only approx. 8% of shaft rotation, and are superimposed for a fraction of that. Not much blow-by gets out. In older and competition engines with altered cams and timing, OEM breather settings may no longer apply. For competition engines blow-by volume can ramp up at peak revs from ring flutter and a timed breather be found wanting. Classic designers often designed crankcases to operate with a small vacuum, as they tried to control oil leaks. Some classic breathers didn't work when new or now. We can improve on them with new breather technology to keep these engines working more efficiently, while purging blow-by, and cutting oil leaks.

New Developments

My research shows while oil leaks are a sign of breathing problems, blow-by gas inside the engine is a more serious long-term issue. For many riders blow-by gas is a blind spot. It's almost as if exhaust gases, which we rightly see as nasty in the combustion chamber and exhaust pipe... somehow become acceptable once they slip past the rings... and even safe to mix with our oil.

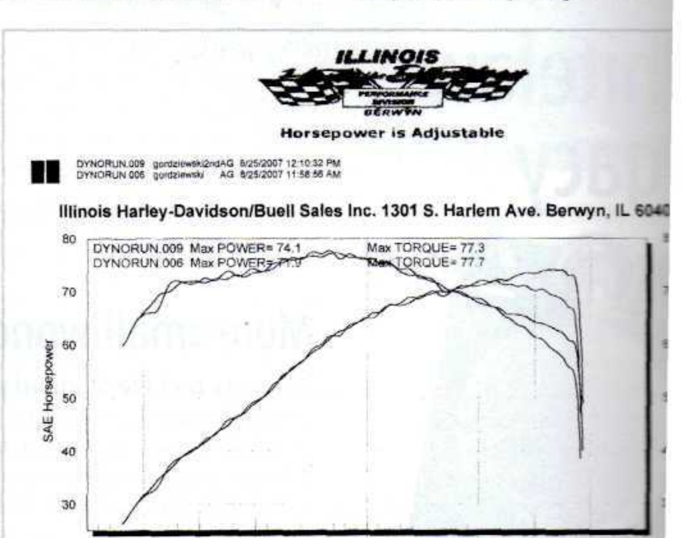
In reality it's like storing your engine oil inside your exhaust pipe.

Blow-by gas isn't benign, inert stuff. It's approx. 70% unburnt flammable fuel, water, sulphur compounds, nitrogen oxides and soot. Oxides of nitrogen fo under the high temperatures and pressures in our air-cooled engines. O cylinder temperatures reach 160C-23 versus car engines at half that. The hydrocarbons, nitrogen and sulphur compounds form a corrosive mixture an "acid rain" inside our engines. This emulsifies with engine oil and sump giving that white fluid in breathers.

Letting this stay in the crankcase is spraying battery acid around inside a watching your engine rust.

Blow-by causes many problems. Th include oil dilution and contamination sludge, loss of oil film, corrosion, cran fire risk and rubber deterioration. As Irving noted approx. 5% unburnt fuel the sump can reduce oil viscosity to than 25%. Classic engines are also p to sumpwater. I find 20-50mls in clas sumps if breathing is neglected. As a

BELOW
Harley-Davidson breather.
BELOW RIGHT
Independent dyno test from USA shows a 6bhp gain and increase in torque.



of thumb Irving set 0.1% for maximum moisture in oil. In a typical classic that's approx. 2mls of water. Today's engine oils average 0.2% or twice that. Worse, I see engines with five to ten times that amount, and as sumpwater. No wonder they need frequent rebuilds!

At these levels, clouds form in the crankcase, and rise into the rockerbox where it literally rains.

As well as oil leaks and blow-by damage, my research shows poor breathing causes power losses in our engines. This is due to drag and the piston(s) wasting work by pumping air in the crankcase. Charles Falco* noted a decade ago that "...the piston, which has a surface area of approx. 9 sq. in. in the case of a 500cc, would have to travel the entire length of its stroke against a force of approx. 130 pounds (9x14.7=132lbs)." He predicted an extra 10% or roughly three free bhp might be gained from a 500cc engine, if breathing could somehow be optimised. A decade later, Australian researchers achieved this. On the first independent dyno tests with a Vincent and Bunn breather, such gains in bhp and torque were recorded. The Harley-Davidson engine records similar gains.

Classic Breather Faults

All breathers are compromises. Open breathers waste power, contaminate compartments and admit dirt. Valves stick and malfunction in the filthy conditions. Tubes clog with emulsion, leading to pressurising, oil loss and seizing. Later British designs worsened blow-by problems, so bikes could pass emission tests. They re-cycled blow-by into the oil tank, timing chest or chaincase... anywhere but outside the engine where it could be detected! This remedy contained emissions, but spread corrosive blow-by over points, Boyer, alternator, clutch and chain. It denatured oil, and pressurised oil tanks. These problems afflict Triumphs, Nortons and BSA's.

On today's bikes the same problems are seen in eg. Moto-Guzzis, Royal Enfields and Harley-Davidsons. Their re-cycling breathers also sacrifice engine function and service life, to satisfy emission requirements. From the viewpoint of crankcase breathing, this is poor design. Fortunately classic engines face no emission requirements. We can optimise breathing to preserve these engines for the next generations.

Car PCV Breathers

These are a classic waste of money. Since WWII cars have used a recycling system with PCV (Positive Crankcase Ventilation) valves. Car engines are different. They are multi-cylinder engines where the big wet sumps and barrels act as surge chambers. While there's air turbulence, there's less air displacement in and out of the crankcase v's classic bikes. Car PCV valves are both non-return valves and metering devices. PCV valves have a flow rate for a make and model. Its luck if one matches a classic bike. As well, they're designed to work in a cooler, cleaner place with an intake vacuum, not the hot, dirty, pressured bike crankcase. At high rpm they hold open and are of no use as valves at all. Car breathers, along with modern bike systems, are more about emission compliance than engine operation. They have no place on classic bikes.

Fire Risk with Breathers

Where breathers recycle blow-by into the inlet tract, a flame path opens to the crankcase. Classic crankcases fill with flammable gas at times like a two-stroke. Recycling without a flame barrier invites a crankcase fire, if an engine backfires. Re-feeding blow-by also dilutes the charge, interferes with pressure, fouls the carburetter and impacts on engine temperature and pressure at high revs. It can affect combustion and even fuel choice, acting as an octane booster. After relieving poor breathing, engines may need tuning and/or higher octane fuel.

The Ideal Breather Valve

The new Bunn Breather technology satisfies the following requirements for a classic breather valve.

(A) Opens and closes at low pressures – Our engines generate very low air pressures when breathing properly. Valves must open and close with very little pressure gradient. This excludes many valves sourced from industry eg. plumbing valves designed for a hundred times our pressures and for water, not gas-aerosol mixtures.

(B) Handles low air flows – It's a misconception 'more breathing is better'. In fact our engines don't pass much air when breathing properly. Only 2-10 litres per minute are required to breathe a 500-1000cc engine. Big breather tubes are unnecessary.

(C) Handles low air speeds – With the new breather designs, our engines generate a blow-by velocity of approx. 1 meter/sec. This is a 'very light breeze' on the Beaufort scale.

(D) Cycles from 1-6000+rpm – The typical range on road and track for classic engines. As peak blow-by generates every fourth stroke (or second revolution); valves need to operate at half engine rpm or sometimes less, depending on the aerodynamics.

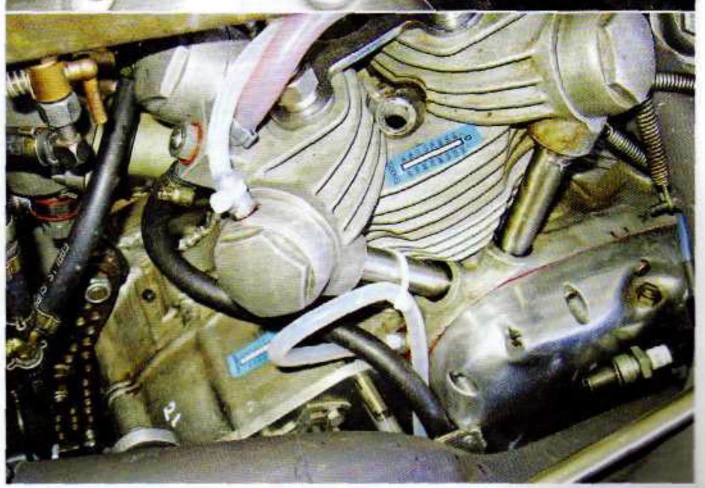
(E) Minimal weight – The ball, disc or flap must be light. The lighter the better at high speeds. Spring valves often fail this hurdle.

(F) Works at lean angles – Car valves stay upright and when tilted, bind or alter performance. This is no good on a heeling bike!

(G) Optimal performance over the range of bike crankcase pressures – the normal pressure range is 700-820mmHg.

(H) Good sealing – Unless the valve is designed to seal at very low pressures, it may leak. This involves the materials technology of mating surfaces where eg. Harley-Davidson and Royal Enfield fall down.

(K) Copes with sun and weather exposure, heat, fuels, methanol, oils, water, blow-by acids, soot etc. ➢



The Bunn Breather fitted to a current model (TOP) **Royal Enfield and** (ABOVE) **Vincent v-twin.**

***Charles M. Falco**
University of Arizona (1997-present), UA Chair of Condensed Matter Physics and Professor of Optical Sciences. He was notably co-curator of the Guggenheim Museum's 'The Art of the Motorcycle' exhibition.

(L) A long service life – ideally years.

(M) Serviceable – the valve must be easy to open, inspect and clean. Valves operate in filthy conditions. It's unrealistic to expect them to operate without an occasional check. Some US manufacturers make no provision for this.

(N) Transparent Housing – Seeing inside the valve lets you check it. It helps diagnose engine problems along the road. This is a particular feature of the new Bunn breathing technology.

(O) Low maintenance – Inspect and clean once a year.

(P) Reasonable Price – Classic riders will not pay $200 for US chromed breathers that are often just catch-cans.

(Q) Invisible – For classic and concours bikes, modern parts are hidden.

(R) Bolt-on – Classic riders want an easy, fast install.

(S) Cuts power losses – Power and torque gains are welcome.

Preferred breather valve types

One group of valves performs best in classic bike breathing, and has been used since pioneer days. These are based on human heart and leg vein valves. They include...

(A) Flap valves – these operate on a hinged-flap principle and include 'reed valves' in outboard motors and two strokes. Sometimes the hinge is replaced by a spring as in Matchless and AJS. The Harley-Davidson umbrella valve is a flap valve, as are valves in respirators and duckbill valves in Royal Enfields.

BELOW

Owners of later Triumph and BSA twins and singles find a MIG diffuser makes a fine union for the timing plug.

(B) Ball or Disc valves – where a ball or disc seals against a seat eg. Moto-Guzzi.

How and where to connect breathers?

Our fathers made little provision for breathing, but it's possible to fit improved breathing to nearly every classic and vintage bike. Unions can be formed from a range of existing covers and drillings, avoiding permanent alterations. Access is gained via timing plugs, rev-counters, valve-lifters, OEM breather unions, rockerbox hatch-covers, inspection covers or filler plugs. The latter can be replaced for concours. Owners of later Triumph and BSA twins and singles find a MIG diffuser makes a fine union for the timing plug, as shown in the illustration at left.

New breather technology

Australia leads the world in new classic motorcycle breathing advances. In the new Bunn breathing technology, valves are grouped and balanced to achieve target figures for crankcase pressures, blow-by flow and velocity.

For Vincents, Enfields, Harleys, Triumphs, Nortons or BSAs the Bunn breather form a blow-by extraction system. Properly designed and balanced, it forms a doubl acting air-pump in the crankcase. Exhaus breathers are connected, often via the crankcase. A filtered Inlet breather is connected via eg. the rockerboxes. Over successive strokes blow-by is evacuated, as the breather takes over the crankcase the exhaust and Inlet breather airflows are balanced to ensure the crankcase never again pressurises.

This has a number of benefits for class riders. It reduces crankcase pressures an swings to cut oil leaks. It purges blow-by and sumpwater, preserving engine oil viscosity while cutting wear and corrosio to extend engine service life. It creates a unidirectional airflow that reduces entrained oil, foaming and oil venting an cuts oil drag and power losses. The new technology is versatile, with a series of around 700 bikes to date, covering class British and American marques. ■

Readers wishing to correspond on crankca breathing or the new Bunn breather technology can email Rex Bunn on rexbunn@bigpond.com