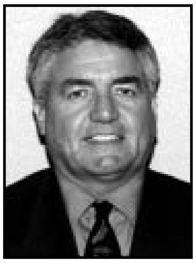

Design Engineering

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Two-bit Engineering

Are automobiles dead? They still don't go anywhere by themselves. AMD gets more press out of trifles than General Motors' tombstone orders. Swords into plowshares ... bumpers into computer discs. Cars can be very sophisticated, with the help of microprocessors. Just think: With networking, you may never need to leave your home ... or your car!

If it weren't for computers 20 years ago, the internal combustion engine would have died by now, and we would have electric and hydrogen vehicles, or else have hideous smog. Microprocessor control port fuel injection, air/fuel ratio by oxygen sensing, infrared degree wheel timing exactness (same HP from 87 or 92 octane!), etc. GM's Generation III small block accomplishes four-valve performance with the generously managed two. A forthcoming advance is electric-hydraulic valve actuation. I'll leave to your imagination the multiplicity of valve timing programs to conduct the performance (*i.e.*, economical power) of your dream engine, integrating fuel delivery programs. Twist a knob and push the pedal! Drag racing still has not allowed *any* microprocessor-controlled acceleration devices—only for monitoring. Yet, ingenuity has pushed the massive machines down to the 1/4-mile limit in 4.5 sec and at 333 mph!

There's no sense in all this progress without addressing the old thermodynamic culprits: Heat loss and friction. Plating can dramatically affect efficiency, with the aid of some engineering design.[1]

Let's start with friction, because it rubs everybody the wrong way. We begin here because nobody does anything without heat loss, and that causes friction. Don't feel picked on. Rules are rules. Here is thermodynamics simplified: (1) You can never get ahead; (2) You cannot break even; (3) You can't even get out of the game.

Friction comes in two flavors: Lubricated and unlubricated. Typically, if surfaces are relatively smooth, they tend to slide, not weld together, if they have dissimilar crystal lattices. They also have less friction when they are oiled. Have you ever heard an engine that is racing without oil? They key treatment ingredient is the film-former. Metal never touches metal, as evidenced by diamond anvil cell testing. This shows that oil "crystallized" at millions of psi's, letting metal pieces rip off without contact. In certain unlubricated conditions, materials can possess *zero* friction.[2]

Although brass on ice is as slick as Teflon®, so may be something else. Unlubricated diamond-like carbon (DLC) was ion-beam-deposited (0.0002 in.) onto CVD diamond coatings (0.000002 in.) on a silicon disc substrate and tested for friction and wear using a CVD diamond-tipped hemispheric stylus. Wear was $2x10^{-7}$ mm^3/nm, and coefficient of friction was 0.005 in nitrogen atmosphere. In humid air and vacuum, $2.5x10^{-7}$ and 0.02, $3x10^{-5}$ and 0.04, respectively. Though DLC use is limited to 480 °F, this coating could be applied to surfaces of bearings, valves, cams, gears and computer discs, etc.[3] Note that the mating surfaces are DLC and CVD diamond.

Now this gives rise to the old correlation between surface hardness and friction. It's actually the shear modulus that predicts hardness rather than bulk modulus. As such, the calculated hardness of beta-carbon nitride is 60 percent of that of diamond (cubic-born nitride is 50 percent). [Crystalline] beta-carbon nitride still has not been synthesized. Films of beta-carbon nitride (amorphous carbon nitride) are better at protecting disc drives than [DLC] amorphous hydrogenated carbon, and were adopted last year. Several hundred 1–2 nm-thick alternating layers of titanium nitride and carbon nitride tested to slightly greater hardness than cubic-boron nitride, the second best to diamond. "In the end, what matters is the performance of a material in a given application."[4]

Lubrication involves EHD filming and rheological fluidity, ZN/P. Surface microstructure is involved with the latter,[5] and crankshaft friction is extremely low anyway, riding the fluid film. The majority of friction in ICE's comes from the rings. The EHD film thickness between piston rings and cylinder wall can be measured in running engines.[6] Chrysler-Benz is contemplating how to eliminate rings. This may be borne of successful pulsed electrophoretic codeposition of cubic-boron nitride/molybdenum disulfide on piston skirts,[7] which reduce wear, friction, etc. Engineering design can look at various developments from the patent literature concerning various ringless piston designs. Engineering designers may be able to adapt the EHD film thickness-measuring technique to assess piston-wall differential expansion. Further, matching CTE of wall with piston (to maintain sufficient gap for a fluid film), as well as differential control of heat adsorption, will become inevitable conclusions. Now we can discuss thermo.

Engineering texts mention that the majority (>89%) of heat is transferred by radiation at furnace temperature (>100 °C). Infrared reflection decimates heat adsorption, if *complete* reflectivity could be achieved. IR wavelengths are from 1–1,000 µm. Water and carbon dioxide (the products of combustion) emit—and absorb—strongly in this region. Experiments with tantalum oxide-coated gold plating (97% reflectivity @ 10 µm) on piston/chamber/wall immediately showed >20 percent power and efficiency at 2,000 rpm, with nearly complete combustion and dramatically reduced block temperature,[8] as well as a demonstrated need for better combustion sealing. Consider near-speed-of-light IR velocity (1 in./nanosec) in the combustion charge and absorbing one of 100 collisions (a 99% IR reflector), and you'll soon see it doesn't take long to absorb radiant heat. Think about existing engines' metal absorption, with reflectivities from 20 percent (oxided) to 70 percent (polished aluminum). However, a two-percent increase in reflectivity (from 97% to 99%) could dictate the need for lower octane, retarded ignition, longer strokes, shorter rods, delayed exhaust valve timing and turbo-supercharging, etc., for inestimable efficiency increases.

References

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