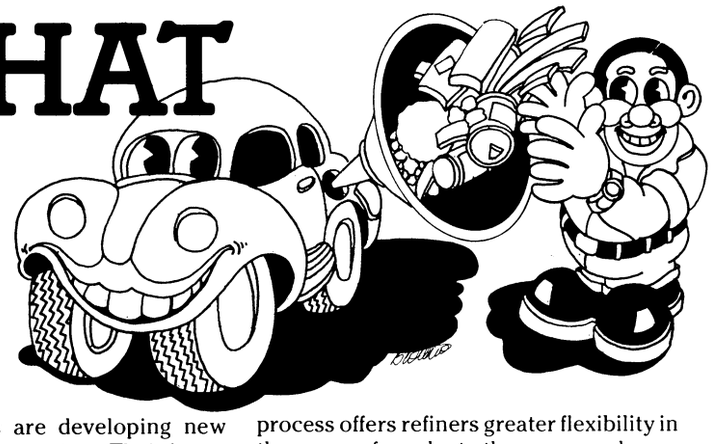
KEEPING THAT



A diversity of research programs seek to ensure that motorists won't end the decade running on empty

BY JANET RALOFF

Perhaps one of the most pressing energy problems in the near future is maintaining a supply of liquid fuels to power the world's automotive fleet, now totaling roughly 300 million cars. When the economy is faring well, some 100,000 new models roll off assembly lines daily. But rapidly spiraling petroleum costs are challenging both the vitality of the automotive industry — the world's largest manufacturing industry — and the national economy.

"The global automobile fleet now consumes about one-fifth of every barrel of oil produced in the world," according to a recent report by the Worldwatch Institute in Washington. Unless ample gasoline extenders or substitutes for gasoline are found, both the price of oil and its availability will be likely to affect if not determine the mobility of drivers—particularly Americans, who own 41 percent of the world's autos. Therefore, in the United States, where cars account for almost one-third of the nation's oil consumption, petroleum issues take on a very personal dimension.

Depending on cars for 90 percent of all personal travel, the average American lavishes 15 percent of his or her personal income on the car. And the average American car, traveling nearly 10,000 miles annually, consumes 706 gallons of fuel; nationally, that's a fleet-wide total of 1.1 trillion miles on 80 billion gallons of fuel. Together with vans and light pickup trucks — which often substitute for cars in everyday use — automobiles in the United States devour more than six million barrels of gasoline daily. In fact, 18 percent of the nation's energy — the most gluttonous diet anywhere — goes for personal travel by car, truck or bus.

As a result, Worldwatch Institute researchers warn that, "Barring a dramatic technological breakthrough on new energy sources, the energy backdrop against which the future of the automobile will be forged is not a particularly bright one." With oil production leveling off, "there will be less and less fuel for cars as the more essential demands for oil expand in the years ahead," writes Worldwatch president Lester Brown together with Christopher Flavin and Colin Norman in their book, *Running on Empty*. "Producing food, powering factories, heating homes, and running trucks and buses," they say, "will all require increased amounts of oil, putting the squeeze on the automobile."

It's in response to this coming squeeze that fuel chemists are developing new strategies to stretch gasoline. Their hope, represented in the potpourri of research described here, is to prevent the current breed of auto from starving before more adaptive species—perhaps lighter weight, more fuel efficient, and alternatively powered—are able to assume a firmer role in the transportation market.

Catalytic squeezers

Ashland Oil Inc. announced two weeks ago the development of a process called atmospheric-reduced crude oil, which permits refiners to squeeze up to 25 percent more gasoline from a barrel of oil. Ashland's chemists have devised a means to transform residual oil — a viscous leftover from refining that traditionally only heavy industry could burn — into 94 octane unleaded gasoline. Regular unleaded gasoline is only around 91 octane, an Ashland spokesman said.

Key to the process is a catalyst made from microspherical silica-alumina crystals. Catalyst and oil need only make contact for a "short" time at "high" temperature, says Lloyd Busch, vice president for operational planning in the refining division at Ashland. After the catalyst is removed, hydrocarbon vapors that have formed are routed to another facility and separated into a combination of refining products that include gasoline, propane, butane, propylene, distillate heating oil and heavy fuel oil. Busch, who declined to give exact details of the "proprietary" process that Ashland hopes to license to a number of major oil refiners, did say that gasoline produced via this route would be cost competitive with gasoline refined in the conventional manner from the lighter (less viscous) fractions of crude oil.

Ashland's development is particularly timely for two reasons. First, it offers an alternate and more profitable product to refiners whose heavy-fuel-oil market is about to erode now that President Carter is pushing heavy industry and utilities to switch from burning oil — often residual oil — to coal (SN: 3/29/80, p. 199). Second, heavy crudes are coming increasingly to dominate the offerings in world oil markets. Since residual oil comprises a greater proportion of the heavy-crude barrel, this process offers refiners greater flexibility in the range of products they can produce.

What's more, the special catalyst Ashland uses "deactivates the function of metals such as nickel and vanadium," Busch told SCIENCE NEWS. Refiners have generally tended to shun heavy crudes, in part because the heavy metals that so often contaminate them would destroy traditional and expensive refining catalysts. Ashland's process is also effective at removing most sulfur pollutants, Busch added.

Gasohol

Another way to stretch crude-oil supplies is to mix or blend alcohol extenders with gasoline. Ethanol, blended in a one-to-ten ratio with gasoline — and known as gasohol — is not only the most popular example, but also one receiving strong federal support through a package of tax incentives (SN: 2/9/80, p. 94).

The ethanol portion of the gasohol mix does not merely replace 10 percent of the gasoline, but rather 16 percent of the value of a petroleum product, says Pincas Jawetz in a paper he presented at an American Chemical Society meeting last September. The reason, he says, is that not only does the addition of ethanol boost the octane value of the unleaded gasoline to which it is added by an average of three points, but it also increases the performance of the fuel as measured in miles per gallon. The energy consultant, who specializes in alcohol fuels, went on to add that "the resulting effect of using one Btu of ethanol is to replace 3.75 Btus of crude or crude products."

There are those who take issue with the type of endorsements offered ethanol by Jawetz and others, however. One of them is Joseph M. Colucci, who heads the Department of Fuels and Lubricants at General Motors Research Laboratories in Warren, Mich. He claims that gasohol's lower heating value — it delivers about three percent fewer Btus per gallon than gasoline — lowers gasohol's fuel economy. He adds that the oxygen content of gasohol "causes vehicles equipped with open-loop carburetion — most of those around today — to operate three percent leaner . . . than with gasoline. This leaner operation can

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increase driveability problems such as surge, hesitation and stalls."

Conceding that gasohol use lowers carbon-monoxide emissions, Colucci says it may also either raise or lower emission levels of nitric oxide and hydrocarbons depending on how one's engine is initially calibrated. Most of these problems, together with the risk of developing vapor lock (due to gasohol's higher level of evaporative emissions), can or are being compensated for in new cars, especially those with closed-loop carburetion.

Brazil's alcohol

While gasohol is already available at more than 2,200 service stations in the United States, Colucci says large-scale commercial gasohol development probably makes better sense right now in regions like Brazil where "ethanol is made from abundant sugar cane, where plenty of land is available for cultivation, and where fossil fuels are limited." In fact, General Motors is producing vehicles in Brazil specially designed to run on ethanol-gasoline blends and is developing cars to run on pure ethanol. Brazil's goal, Colucci says, is to have more than one million vehicles by 1985 fueled by ethanol only.

Brazil began its *Programa Nacional do Álcool*, a commitment to wean its petroleum-intensive vehicular sector onto alcohol fuels, in 1975. Last year, that nation produced nearly 1.1 billion gallons of ethanol, equivalent to 20 percent of its gasoline consumption; by 1986 the nation aims to distill 2.64 billion gallons of alcohol fuels annually.

What made an ethanol program so attractive to Brazil were a couple of severe economic crises. The first was a downturn in the international sugar-cane market that threatened to wipe out the nation's investment in cane production and sugar mills. Then there was a balance-of-payments problem; Brazil, which imports 35 percent of its oil, diverts 40 percent of its export revenues back to pay for it. Since protectionist strategies being adopted by many countries were making it hard for Brazil to increase exports enough to compensate for the spiraling oil-import costs that were gouging its economy deeper every year, the South American power opted for alcohol, which offered a bail-out for the economy in both sectors.

But "it is not desirable for Brazil to remain so dependent on sugar cane," says Antonio J.G. Zagatto of Companhia Enérgetica de São Paulo; "[m]ethanol from wood appears to be the natural complement to the existing ethanol industry." Zagatto says that is why Brazil has revised its alcohol program, phasing down — or out—ethanol to be replaced by methanol.

Methanol

"Production of methanol from wood is more efficient than the production of ethanol from wood or from sugar cane," Zagatto adds. To shore up this contention he provides tables in a paper he delivered at the American Chemical Society's Houston meeting last month, which indicated that on a Btu value per hectare of land farmed, methanol from eucalyptus trees or pine trees has a higher energy value than ethanol derived from the same species, and that ethanol from sugar cane or cassava provides less energy per farmed hectare than does methanol produced from trees.

Zagatto's calculations indicate that a 1,000-ton-per-day methanol plant — using wood, coal or lignite as the alcohol source —should fall within a range of $140 million and $180 million. Assuming it takes 2.6 to 3 tons of wood to create a ton of methanol, Zagatto calculates the wood cost per ton of methanol at between $42.8 and $64.2 — less if the methanol plant is situated within the forest (thereby cutting wood-transport costs).

With oil prices averaging about $30 per barrel (the average contract price for foreign oil is upwards of $32 per barrel), cost projections for methanol of between $114 and $117 per barrel look high. But if availability of fuel is more important than the cost of it—as Brazil suggests is its case — developing a methanol market may prove affordable. Among Brazil's primary worries, however, is that the economics of small-scale wood-to-methanol projects may not hold in the scale up to commercial plants.

Zagatto described three different prototype wood gasifiers — each expected to produce 100 tons of methanol daily — that Brazil expects to have operating within two years. Private Brazilian, U.S. and West German firms are engineering the development of the systems. Zagatto also mentioned operation of a four-cylinder GM auto and six-cylinder GM pickup truck, both fueled with methanol, that have logged 21,700 miles of operation "without any problems at all." In addition, diesel-electric locomotives are being retooled to use both diesel and methanol fuels. And 15-megawatt electric generators fueled by methanol-fired boilers are also under development.

But interest in methanol fuel is not confined to Brazil. European development of methanol-fueled vehicles during the 1930s led to war-time introduction of methanol-fired sedans. Since then, U.S. trials of methanol fleets have surfaced periodically in university and commercial institutions. In fact, just this month the Wall Street Journal reported on a three-month experiment by the Bank of America using 12 methanol-powered cars. The bank has 50 more on order, and "if all goes well, we'll convert the entire fleet of 1,600" says bank vice president, Merle Fisher.

Methanol to gasoline

But methanol — alone or blended with gasoline as an extender — need not be the end product. Witness Mobil Oil Corp.'s one-step methanol-to-gasoline process, also aired at the ACS Houston meeting last month. "Methanol is in effect about half water and half useful energy," explains Charles R. Morgan of Mobil's Paulsboro, N.J., research center. "What the Mobil process does, essentially, is to wring out the water and rearrange the remaining hydrogen and carbon atoms into the concentrated, high energy fuel we know as gasoline." Again it is the catalysts, a new breed of "shape-selective" ZSM-5 (synthetic zeolite) ones, that make the difference. And they will transmute ethanol, too. The 93 octane unleaded gasoline so formed represents 60 percent by weight of the hydrocarbons. But it is possible to squeeze an even greater amount of gasoline from the methanol by alkylating propene and butene byproducts with isobutane.

Mobil's efforts involved four-barrel-per-day test runs. But the West Germans already have under design a 100-barrel (of gasoline) per-day scale up of the Mobil process. And on April 1, the New Zealand government announced plans to sign with Mobil for a 12,500-barrel-per-day gasoline-from-methanol plant. But the big test involves a $3 billion joint effort between W.R. Grace Co. of New York and the U.S. Energy Department. Grace plans a commercial, indirect-liquefaction coal-to-gasoline facility in Baskett, Ky. After first gasifying high-sulfur caking coal into methanol, the Grace facility would use the Mobil process to convert 16,000 tons of methanol into 50,000 barrels of gasoline daily. Vehicle testing by Mobil demonstrated road antiknock and driveability performances equal to or better than most commercial unleaded gasolines in direct-comparison tests.

Butanol

All the attention given to ethanol and methanol, particularly as gasoline extenders and octane boosters, tends to eclipse consideration of another alcohol — butanol. A higher alcohol — with a longer hydrocarbon chain — its properties fall closer to those of diesel fuel and gasoline than do either of the previously mentioned alcohols. And its miscibility (mixability)

with water makes it completely miscible with diesel fuel even at low temperatures (diesohol — a diesel/ethanol blend — can prove troublesome during winter cold spells since the alcohol promotes phase separation, particularly when water is present).

Butanol, like other alcohols, is a fermentation product of grains or starchy products; the difference, say Antonio Moreira and Terry Lenz of Colorado State University, lies in the microorganisms carrying out fermentation. Its production steps, well known since the 1930s, have been largely ignored owing to the former economy of refining oil for fuel and petrochemical feedstocks.

Today "all butanol fermentation plants in the United States are setting idle or are being converted into ethanol facilities," the Colorado State pair say in a paper presented in Houston last month. But having explored the economics of producing a high-grade blending agent from liquid whey — a troublesome byproduct of the dairy industry — they now find acetone-butanol fermentation "economically attractive when based on waste materials" such as whey. Before advocating a butanol renaissance, however, they say ways must be found to level off the seasonal variation of feedstock availability and to increase the yield per fermentation batch — now a disappointing 1.2 percent.

Octane Boosters

Octane boosters offer another promising way to extend gasoline supplies. "An increase in octane number achieved by a refining process is usually accompanied by a corresponding loss in the yield of gasoline per barrel of crude," explains Robert J. Hartle, senior research chemist in the petroleum products division of Gulf (Oil) Research and Development Co. Hartle and G. M. Singerman recently reported on a new class of nonmetallic antiknocking agents made from derivatives of aniline dyes. Although not yet commercially available, orthoazidoaniline — or OAA — appears able to substitute for the traditional and environmentally troublesome antiknock compounds such as tetraethyllead. The main problem with the compound and its attractive cousins, also under test, is the complicated chemistry and high cost associated with their production.

The quiet renaissance occurring throughout the automotive engineering community will be likely to foster the evolution of radically different engines and a medley of alternate fuels to power them. But the fruits of this revolution will not gain a commercial stronghold in time to prevent the premature retirement of those autos now tooling down the nation's highways unless programs like those highlighted here can synthesize, emulate, or stretch the gasoline that feeds their voracious appetite. □