oxygen in the exhaust gas to enable those hydrocarbons to be removed simply by fitting an oxidation catalyst into the exhaust system.

The challenge for the engineer is to maintain combustion and driveability at these lean air: fuel ratios. This is achieved by encouraging turbulence in the engine's cylinders and by the propagation of a large flame area at early stages of the combustion process. Heat losses from the engine are minimised by designing the combustion chamber with a minimum surface area: volume ratio. Also, to ensure good combustion it is necessary to produce a high energy spark.

Conclusions

The motor industry now has two alternative technologies to meet the new standards. Already in the Federal Republic of Germany, where there are fiscal incentives to encourage the sale of "clean" cars by collecting lower road tax, three-way catalyst cars are being sold and unleaded petrol is widely available. Undoubtedly some car manufacturers will opt for this proven route, and particularly for cars greater than 2 litres the three-way catalyst using platinum promoted by rhodium will be the preferred choice. For smaller cars, the choice is between the lean-burn engine, fitted with a palladium-promoted platinum oxidation catalyst and the three-way catalyst with an engine fuel management system controlled to ensure that the exhaust maintains the stoichiometry necessary for efficient operation of the three-way catalyst.

References

1 B. Harrison, B. J. Cooper and A. J. J. Wilkins, *Platinum Metals Rev.*, 1981, **25**, (1), 14
2 A. F. Diwell and B. Harrison, *Platinum Metals Rev.*, 1981, **25**, (4), 142
3 "Royal Commission on Environmental Pollution", 9th Report, April 1983, H.M.S.O.
4 Press Release 7803/85, European Commission, 27/28 June 1985

Space Station Auxiliary Propulsion Jets

Resistojets have characteristics that make them attractive for space station auxiliary propulsion systems. For this arduous application the resistojet must have the capability of functioning with a variety of onboard propellants such as carbon dioxide, methane, hydrogen, ammonia and hydrazine.

Because of its excellent resistance to corrosion and high temperature oxidation, platinum has previously been considered for a similar application, but pure platinum was found to have inadequate strength. Many rhodium-platinum alloys are stronger, but in carbon dioxide at temperatures above 1200°C a volatile rhodium carbonyl compound forms and this loss of rhodium weakens the alloy. After extended operation at high temperatures platinum and its alloys also experience grain growth, which results in reduced stress-rupture performance, the formation of voids and physical distortion. It was for these reasons that grain stabilised platinum metals were developed in the late 1960s and early 1970s, primarily for use in the glass industry.

The preliminary results of compatibility experiments made to determine the effects of different propellants on platinum stabilised with 0.6 per cent yttria have recently been reported by M. V. Whalen, S. P. Grisnik and J. S. Sovey of the National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio, U.S.A. ("Compatibility Experiments of Facilities, Materials, and Propellants for Electrochemical Thrusters", NASA Tech. Memo. 86956, 1985, 16 pp).

For the tests, which generally lasted for 100 hours, annealed tubes of grain stabilised platinum were formed into coils. When surrounded by a flow of carbon dioxide, hydrogen or ammonia, an electric current was passed through the coils heating them to 1300°C, a typical operating temperature for resistojet heaters. Coils were also tested in a flow of methane and in mixtures of carbon dioxide and methane while heated at 500 to 600°C, a range chosen to avoid carbon deposition.

Measurement of mass losses after testing indicated a minimum life of 100,000 hours, which exceeded by a factor of ten the life required for the potential space application. Some corrosion of the surface occurred during heating in hydrogen and more especially in the ammonia environment. While grain stability was apparently not affected during these short-term tests, the results of long-term exposure to reducing atmospheres has yet to be determined.