This initiative developed neat and near-neat alcohol-fueled vehicles and stimulated private industry to develop and market oxygenated fuels and additives such as ethanol, methanol, tertiary butyl alcohol, and methyl-tertiary-butyl ether. These and other oxygenates are now blended with gasoline in quantities up to 10% by volume, replacing more than 24 million barrels of oil (139.2 trillion Btus) on an annual basis. Oil import requirements were reduced as a result of the implementation of these research results, and a broad technology base was established that directly contributes to national security.

The combustion characteristics of oxygenated fuels, particularly ethanol and methanol, also benefit the environment, especially in regions that have not attained air quality standards, such as southern California. DOE is working with the Environmental Protection Agency, the California Energy Commission, and the California Air Resources Board to develop alcohol fuels implementation strategies that will simultaneously reduce petroleum dependence levels and enhance environmental conditions.

Understanding "Engine Knock"

A significant increase in the thermodynamic efficiency and a corresponding decrease in the fuel consumption of automotive spark-ignition engines can be achieved by increasing the compression ratio. However, the extent to which the engine compression ratio may be increased is limited by the onset of engine knock and the possible risk of engine damage. Knock is the engine response to a rapid, nonuniform pressure rise in the combustion chamber. Such high rates of pressure rise appear to be caused by the nearly uniform autoignition of the end gases before the flame passes through them.

The results of recently completed experiments and kinetic modeling simulations of the compression ignition process provided new insight into the problems of autoignition and engine knock. It is now known that the role of low-temperature chemistry in the end gases is to provide enough heat to cause the end-gas to ignite by itself. The exact kinetic mechanism is under continued investigation.

DOE research provides clarification on which factors are most important, so future work can be better directed toward possible mitigation of problems. It may even be found that these thermal, fluid mechanical, and chemical mechanisms can be harnessed and controlled to provide rapid energy release, high compression ratio, and minimum risk of mechanical damage. These should lead to higher efficiency, cheaper operation, and a better competitive position for U.S. products.

Combustion Characteristics of Alternative Diesel Fuels

Since the 1930s, cetane numbers have been used successfully to rate the ignition quality of diesel fuels on the market. However, attempts to rate the ignition quality of a wider variety of alternative fuels for diesel engines have met with limited success. The lack of an accurate rating procedure poses a serious problem for engine manufacturers and fuel producers as they try to assess engine designs and alternative fuels for use when the current supply of high-quality diesel fuel is depleted or disrupted. In particular, recent tests of several alternative fuels found that ignition quality did not always correlate with cetane number.

With DOE support, the ignition characteristics of several alternative fuels for diesel engines were measured in a constant-volume combustion "bomb" to investigate the shortcomings of the current American Society for Testing and Materials cetane rating method when applied to these fuels. In a parallel effort, the same fuels were tested in direct- and indirect-injection diesel engines. Scientists found that combustion-bomb testing provides additional essential and complementary information to conventional engine testing. For example, important differences in the low-temperature ignition kinetics of alternative fuels were detected with the bomb technique that were not evident in the existing cetane rating procedure.

The bomb tests indicated that the current procedure must be modified to enable accurate evaluation of the broad range of future alternative fuels. This fundamental method of characterizing the combustion of fuel sprays in diesel engines should lead to better approaches to improving ignition and combustion properties of alternative fuels.

Sources of Unburned Hydrocarbon Emissions from Automotive Engines

Lack of knowledge of basic thermochemical processes involved in the combustion of fuels has resulted in escalating equipment costs for pollution control and