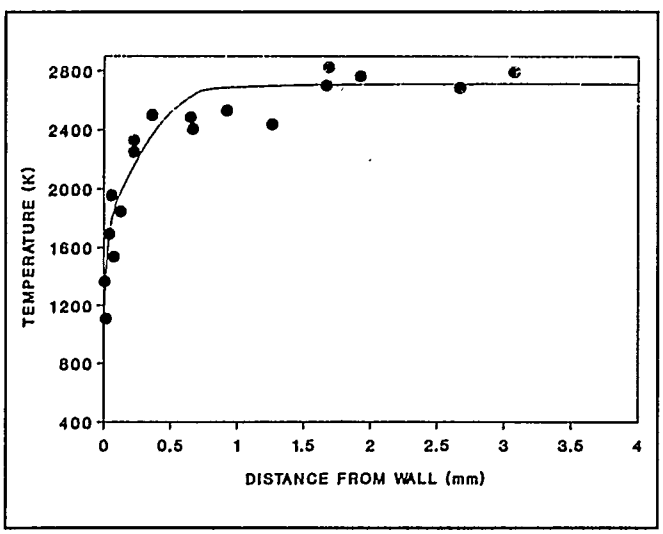
techniques may permit the substitution of ceramics for metals in many end-use applications at elevated temperatures, high-stress levels, and in oxidizing environments.

Thermal Boundary Layer Measurements in Engines

Despite the importance of the thermal boundary layer in understanding engine combustion processes, there have been no previous quantitative measurements of the temperature profile near a wall in an operating internal combustion engine. In most engine combustion heat release computations, the thermal boundary layer is calculated theoretically because direct measurements are not possible. Nitric oxide emissions from an engine chamber are most sensitive to peak temperatures in the chamber, and these temperatures will be calculated incorrectly unless the thermal boundary layer is accurately modeled. Under DOE funding, researchers have been able to acquire the first detailed in-cylinder measurements of the thermal boundary layer evolution in an operating internal combustion (IC) engine. These techniques demonstrated excellent spatial resolution of better than 0.08 mm and were able to traverse to within 0.05 mm of the wall. Profiles were generated several times during the expansion stroke, showing the growth of the layer from fractions of a millimeter to nearly two. These measurements are a necessary first step in developing a complete picture of the combustion-wall interactions. Combined with wall heat transfer measurements being performed collaboratively with researchers from the General Motors Research Laboratory, the fundamental knowledge developed should lead to new engine designs that simultaneously optimize emissions control and fuel efficiency.



First detailed in-cylinder measurements of the temperature profile for the thermal boundary layer in an internal combustion engine.

Ceramic Joining

The potential of structural ceramics in advanced energy conservation applications has not been realized because little research has been conducted on the joining of ceramics. In 1982, DOE initiated long-term, generic applied research and development in the area of ceramic attachments for high-temperature applications. Subsequent research defined the current limits of room-temperature strengths of brazed ceramic-ceramic joints. Brazes were developed for silicon carbide (SiC-SiC) and alumina (Al_2O_3-Al_2O_3) with acceptable room temperature strengths and toughness. These brazes will allow ceramic components to be used economically in large operational systems such as high-temperature heat engines and heat exchangers, or in any other application requiring resistance to high temperatures, stresses, or oxidizing atmospheres. This project has been transferred from EUR to the Office of Transportation Systems for subsequent applications development. In a complementary effort, highly refined finite element mathematical models were developed to obtain an understanding of stresses and fracture mechanisms in ceramic-metal joints. These models were experimentally validated for rectangular and cylindrical joint geometries, and a three point flexure test geometry has been developed to experimentally validate adhesion models for zirconia-nodular cast iron braze joints. This research has been transferred to the DOE Ceramic Technology for Advanced Heat Engines Project for further applications development.