problem. Other DSAF tests show that prefiring an experimental 98% alumina castable refractory to 2957°F (1625°C) reduces the corrosion rates by 75% as compared to material prefired to only 2732°F (1500°C). Coatings used to seal the pores of the refractory were ineffective at reducing corrosion rates by Illinois No. 6 slag, but may be effective for more basic slags.

Slag viscosity testing showed that there can be considerable variation in the temperature below which the slag does not flow well for basic slags which tend to freeze rapidly. However, adding 10% calcia to a high-calcium Rochelle slag substantially reduced the freezing temperature of the slag. Alumina and silica additions had little effect. Additions of calcia, alumina, or silica to a lignite slag had little effect on the flow properties of a lignite slag, although the alumina addition may increase its propensity to freeze quickly upon cooling. However, the freezing temperature is still too low to make a 10% addition effective in causing the slag to freeze on the refractory in a combustor system, which would decrease the corrosion rate of the refractory.

5.0 RECOMMENDATIONS FOR FUTURE WORK

Based on the data developed during the Combustion 2000 Project, we conclude that the HITAF concept offers a higher-efficiency technology option for coal-fired power generation systems than conventional pc firing. Higher-efficiency technology options are important to the power generation industry in order to conserve valuable fossil fuel resources, reduce the quantity of pollutants (air and water) and solid wastes generated per MW, and reduce the cost of power production in a deregulated industry.

A number of accomplishments have been achieved as a result of the bench- and pilot-scale work summarized in this report, as well as the work completed to date in support of the Combustion 2000 Program. On the basis of results and observations from both activities, the EERC believes that further development and evaluation of the high-temperature heat exchangers and materials related to their successful use are warranted. Specific activities to be considered are summarized in the following paragraphs.

New high-density castable refractory and castable ceramic formulations were developed in cooperation with commercial vendors. These new materials are more resistant to the erosive/corrosive properties of slag than those initially evaluated. In addition, higher curing temperatures were successfully applied to high-density castable refractories, resulting in improved resistance to slag erosion/corrosion. However, further development of these materials for use in high-temperature furnace applications with emphasis on their resistance to slag erosion/corrosion is necessary before commercial application will be possible.

Partial success was achieved with respect to casting ceramic tiles in near net shapes, limiting the need for machining and thus reducing stress cracking. However, further development of ceramic component fabrication methodology with an emphasis on casting near net shapes to eliminate machining requirements is necessary to eliminate RAH tile stress cracking and reduce the cost of RAH ceramic tiles.

Bench-scale tests successfully demonstrated the use of additives to modify slag properties. Specifically, additives were successfully used to increase and decrease slag viscosity for acidic and basic slags. Bench-scale tests with an alumina additive were successful in reducing refractory corrosion. During pilot-scale tests, limestone added to the pulverized fuel was successfully used to prevent slag screen plugging and control differential pressure. On the basis of these observations, further development of coatings that can be applied to refractory or ceramic surfaces to effect the desired changes in heat transfer or improve the resistance of these materials to slag erosion/corrosion is warranted.

Bench-scale tests have been used to identify a high-temperature window in which the products of coal combustion are much less corrosive toward the alloy MA-754 used to fabricate tubes for the RAH panel. This information indicates it would be appropriate to determine the potential to operate the RAH panel without fireside ceramic tile protection at furnace exit temperatures comparable to those found in conventional pc-fired boilers. This information would be very valuable in determining the potential application of the MA-754 alloy to repowering projects.

The pilot-scale SFS has been successfully operated in support of the high-temperature heat exchanger development effort firing lignite, subbituminous coal, or bituminous coal. CAH tube bank performance has been problem free when these fuel types are fired, resulting in process air temperatures of nominally 1300°F (705°C). Successful operation of the RAH panel when the same fuels are fired has also been demonstrated, resulting in process air temperatures of 1700° to 2000°F (927° to 1094°C). Therefore, further development and testing of the high-temperature heat exchanger are warranted. Specific activities should address 1) investigation of alternative alloy and ceramic materials that will permit operation of the RAH panel at temperatures higher than these observed to date for process air temperatures of >2000°F (>1094°C), 2) corrosion testing of alloy materials for fireside applications, 3) integrated operation of the CAH tube bank and RAH panel with a turbine, 4) integrated operation of the CAH tube bank and RAH panel with a fuel cell, and 5) cofiring biomass in the high-temperature SFS and documenting overall system performance as well as specific efficiency losses that may occur relative to the performance of the CAH tube bank and the RAH panel.

On the basis of work completed to date, the HITAF concept appears to offer a higher-efficiency technology option for coal-fired power generation systems than conventional pc firing. Concept analyses have demonstrated the ability to achieve program objectives for emissions (10% of New Source Performance Standards, i.e., 0.003 lb/MMBtu of particulate), efficiency (47%–55%), and cost of electricity (10%–25% below today's cost). Higher-efficiency technology options for new plants as well as repowering are important to the power generation industry in order to conserve valuable fossil fuel resources, reduce the quantity of pollutants (air and water) and solid wastes generated per MW, and reduce the cost of power production in a deregulated industry.

Possibly more important than their potential application in a new high-temperature power system, the RAH panel and CAH tube bank are potential retrofit technology options for existing coal-fired boilers to improve plant efficiencies. Therefore, further development of these process air-based high-temperature heat exchangers and their potential for commercial application is directly applicable to the development of enabling technologies in support of the Vision 21 program objectives.