TASK 3.3 – HIGH-TEMPERATURE HEAT EXCHANGER TESTING IN A PILOT-SCALE SLAGGING FURNACE SYSTEM

1.0 INTRODUCTION

The U.S. Department of Energy (DOE) projects that from 1995 to 2015, worldwide use of electricity will double to approach 20 trillion kilowatt hours. This growth comes during a time of concern over global warming, thought by many policy makers to be caused primarily by increases in carbon dioxide (CO_2) emissions through the use of fossil fuels. Government regulations now being negotiated in global treaties may force electric utilities to reduce CO_2 emissions or be forced to buy CO_2 credits from nations producing less CO_2 per capita. Unless coal-fired power plants are made more efficient, utilities may be forced to turn to more expensive fuels to avoid buying the credits.

One way to improve the efficiency of a coal-fired power plant is to use a combined cycle involving a typical steam cycle along with an indirectly fired turbine cycle using very high-temperature but low-pressure air as the working fluid. At the heart of an indirectly fired turbine combined-cycle power system are the very high-temperature heat exchangers that can produce clean air at up to 2600°F (1427°C) and 250 psi (17 bar) to turn an aeroderivative turbine. The overall system design can be very similar to that of a typical pulverized coal (pc)-fired boiler system, except that ceramics and alloys are used to carry the very high-temperature air. This design makes it especially suitable as a boiler repowering technology. With the use of a gas-fired duct heater, efficiencies of 55% can be achieved, leading to reductions in CO_2 emissions of 40%, as compared to today's coal-fired systems.

To support the development of this type of power system, the University of North Dakota Energy & Environmental Research Center (EERC) has designed, constructed, and operated a 3.0-million-Btu/hr (3.2×10^6 kJ/hr) slagging furnace system (SFS). Operational experience has shown that the SFS works very well and is well suited for testing very high-temperature heat exchanger concepts. Test results have shown that a high-temperature radiant air heater (RAH) panel designed and constructed by the United Technologies Research Center (UTRC) and used in the SFS can withstand temperatures of over 2000°F (1094°C). To support the pilot-scale work, the EERC has also developed laboratory- and bench-scale equipment to determine the corrosion resistance of possible refractory and structural materials and develop methods to improve corrosion resistance.

To expand this development effort, the EERC requested funding from the National Energy Technology Laboratory (NETL) in the amount of $400,000 to perform approximately 3 weeks of tests in the EERC pilot-scale SFS to determine the effects of heat exchanger design, coal type, and coal additives on heat exchanger efficiency and material lifetimes in a slagging coal-fired environment. In addition, the EERC used laboratory- and bench-scale methods to test new refractories and ways to increase their corrosion resistance.