PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Advanced Research Combustion Technologies

09/2007

CIRCULATING MOVING BED COMBUSTION PROOF-OF-CONCEPT

Description

Beginning in 2001, joint funding from the U.S. Department of Energy's (DOE) Office of Fossil Energy, through DOE's National Energy Technology Laboratory (NETL), and major energy systems supplier ALSTOM Power has advanced research and development of a novel circulating moving bed (CMB) combustion system. The CMB technology is expected to provide significant advantages for advanced power generation, for both conventional pulverized coal and fluidized-bed combustion boilers. Commercial deployment of the new CMB system will improve performance efficiency and enable progress toward environmental and cost goals, for new power plants as well as for retrofits.

CMB technology involves a new method of solid fuel combustion and heat transfer. Fuel and over-fire air (OFA) are introduced to the combustor and burned in a bubbling bed region at very high temperatures, approaching 2,000 °F. The hot gas from combustion flows upward through the combustor and is recuperated (exchanged) with a flow of high-density solid particles falling downward. Upon reaching the bottom of the combustor, the solids are fluidized and transferred through standpipes to a moving bed heat exchanger (MBHE). There, an energy cycle working fluid, such as steam or compressed air, removes excess heat from the cooled solids, which are transported back to the top of the combustor to renew the process. Fly ash is removed from the combustor and processed through a cyclone, while flue gas emissions such as sulfur dioxide are controlled primarily by a cleanup system such as a flash dry absorber (FDA).

The CMB technology can be readily adapted to CO_2 capture via a carbonate capture process. The CMB technology also enables advanced power generation systems such as chemical looping gasification that can cost-effectively produce hydrogen and capture CO_2. In addition, the MBHE can be used for oxygen-fired CFB applications to replace the fluid bed heat exchanger and avoid potential recarbonization problems.

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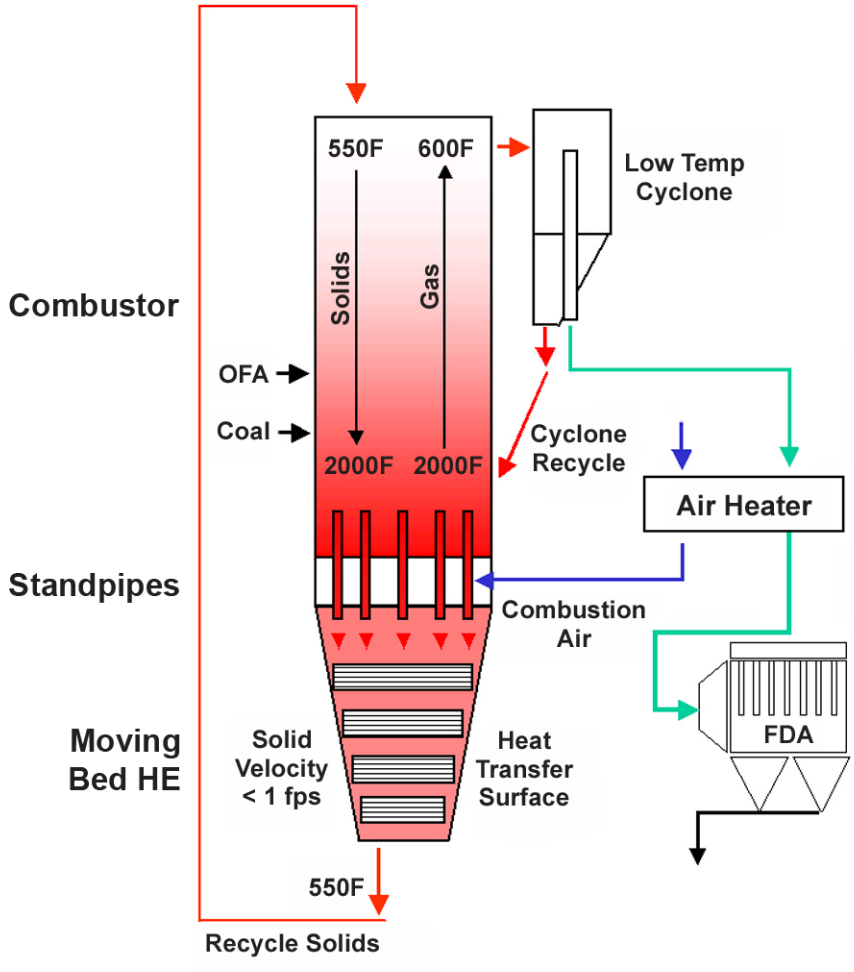
PROJECT DURATION

Project Phase I
09/28/01 to 03/31/03

Project Phase II
04/01/03 to 12/31/07



CMB combustion system operates at very high temperatures

Goals

The overall objective of the CMB proof-of-concept project is to continue development of the CMB technology to identify the technical, design, and performance criteria that need to be met to result in a commercial CMB system. To date, tests have been conducted at a scale sufficient to provide the design data for scale-up to a demonstration plant. Specific objectives are:

- Develop CBM technology and components unique to the CBM system;
- Accelerate MBHE technology development for CBM and other applications;
- Conduct an extended duration MBHE slipstream test at an existing coal power plant; and
- Enable a full-scale MBHE technology demonstration to be conducted by the end of the decade.

Accomplishments

The project objectives have been achieved through a series of experiments conducted in ALSTOM Power's Multi-use Test Facility (MTF). The MTF was modified to operate under commercial-scale CMB conditions. Pilot-scale tests using the modified MTF confirm the following:

- High heat transfer rates in the combustor and MBHE were achieved, and combustion performance was very good;
- Bed ash agglomeration is controllable and can be avoided over the range of commercial CBM boiler temperatures;
- Emissions were close to state-of-the-art levels, and can be further optimized to meet DOE and industry emission targets for the year 2010; and
- Mechanical systems worked well, and no technical obstacles were identified to impede continued CMB development.

Design of a demonstration plant was deferred to a follow-on CMB development program. However, many key inputs were developed during the course of the proof-of-concept project.

COST

Phase I Project Value
$2,797,468
DOE/Non-DOE Share
$1,688,000 / $1,109,468

Phase II Project Value
$6,826,095
DOE/Non-DOE Share
$4,119,276 / $2,706,819

Total Project Value
$9,623,563

DOE/Non-DOE Share
$5,807,276 / $3,816,287

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Benefits

This project is expected to benefit the power industry by developing a cost-effective CMB process, providing highly efficient, high-temperature Rankine steam cycles for both greenfield and retrofit applications. Specific benefits of the CMB process include:

- Significant reductions in CO_2 emissions and all criteria pollutants including mercury;
- Reduction in the size of the required heat transfer surface areas by about 60 percent as a result of the enhanced heat transfer rates;
- Significant cost savings of over 30 percent compared to conventional technology; and
- Flexibility of operation and ability to fire a wide range of fuels.

The CMB system also is considered a crosscutting technology — one that enables hydrogen production and CO_2 capture in other advanced power generation systems such as chemical looping gasification. Potential future applications will utilize CMB combustion systems:

- As a low-cost circulating fluidized bed (CFB);
- For oxygen-fired CFB applications to replace the fluid bed heat exchanger (FBHE), to avoid recarbonization problems; and
- For conventional CFB applications used to replace the FBHE — an important path for early field testing of the MBHE.