NREL FACTS

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NREL Facilities

High-Flux Solar Furnace

...concentrating sunlight for industrial applications

On top of a high, barren mesa above Golden, Colorado, researchers at the National Renewable Energy Laboratory (NREL) have achieved a world-record concentration of 50,000 suns at the High-Flux Solar Furnace. The heat generated at the facility can be used to process a variety of materials, providing a clean alternative to very costly laser furnaces or conventional furnaces that burn fossil fuels.

In more than eight years of operation, NREL research with the High-Flux Solar Furnace has shown that concentrated sunlight can be used in manufacturing processes for the automotive, aerospace, defense and electronics industries. The solar furnace also has proved effective at decontaminating hazardous wastes.

How the Solar Furnace Works

The 10-kilowatt solar furnace has three principal components: a heliostat, a primary concentrator and a refractive secondary concentrator. The heliostat is a large (32 square meters) flat mirror that tracks the sun as it moves from east to west and reflects the sunlight onto the primary concentrator. The primary concentrator is made up of 25 curved mirror facets, each measuring roughly 0.5 square meters, that reflect the sunlight a second time and focus it at a target area inside the test building. The primary concentrator reduces the beam of sunlight to a 10-centimeter diameter and concentrates it to approximately 2,500 suns at the focal point. Special optical devices can be placed at the focus to significantly increase the concentration. Reflective secondary concentrators can deliver 20,000 suns; refractive secondary concentrators can achieve 50,000 suns.

A solar furnace enables the user to very rapidly heat the surface of a sample. In some cases, the temperature rise exceeds thousands of degrees Celsius per second. For high-temperature coatings on metals and ceramics—where it is advantageous to heat only the surface of the material without affecting the base material—a solar furnace can be ideal.

NREL/PIX03272

Inside the Test Building

The test building can accommodate a number of researchers and their experiments. The building is equipped with computers and data acquisition tools, video monitors of the outside equipment, sophisticated instruments to monitor solar radiation and other atmospheric data, and automated devices that enable researchers to control the heliostat, primary concentrator, focal point and the power of the concentrated sunlight.

Applications

Materials Processing and Advanced Materials Manufacturing—The solar furnace's ability to selectively heat the surface of a sample have led to studies of phase transformation hardening, cladding, thin-film deposition and rapid thermal tempering. Metal, ceramic and composite materials can be treated to obtain higher-value materials with desired properties such as superconductivity or greater resistance to corrosion, friction and oxidation. NREL and Brush Wellman Inc., a leading ceramics/electronics manufacturer, have jointly investigated using high solar flux to metallize ceramics for electronic components. Researchers

have recently demonstrated the ability to produce fullerenes and nanotubes, unique materials with exciting new applications that require temperatures above 3000 degrees Celsius for formation.

Ultra-Accelerated Weathering—All materials break down by varying degrees when exposed to ultraviolet light. However, materials used in various solar power systems, which must endure years of ultraviolet exposure, need to be very durable. Solar researchers use the process of accelerated weathering to investigate how materials will hold up over time. While conventional methods allowed scientists only a five-fold acceleration in weatherization, NREL's High-Flux Solar Furnace has demonstrated a 100-fold acceleration, allowing researchers to study the results of 20 years of weatherization in 2-1/2 months.

Detoxifying Hazardous Wastes—Solar furnaces are well suited to the destruction of hazardous wastes. Focusing a beam of concentrated light onto hazardous wastes breaks down numerous toxic chemicals, including dioxin and polychlorobiphenyls (PCBs). The ultraviolet portion of the solar radiation breaks the bonds holding together the hazardous components. Researchers can destroy gaseous wastes in a solar reactor that serves as a kind of "solar incinerator." These processes involve temperatures around 700 degrees Celsius and fluxes equivalent to 500 or more suns.

Partnerships

Among the private and public sector partners that have used NREL's High-Flux Solar Furnace for collaborative research:

- Texas Instruments: defining the optimum operating parameters to form spherical silicon crystals.
- MER Corporation: novel methods of synthesizing fullerenes, a stable form of carbon only discovered in the 1980s. Fullerenes may have exciting, new commercial applications in semiconductors, superconductors, high performance metals and medical technologies.
- Defense Nuclear Agency/Northrop-Grumman: the response of optical materials to intense pulses of light.

NREL/PIX06975

- DOE Hydrogen Program: thermal and thermochemical decomposition of water to produce hydrogen.
- DOE Concentrating Solar Power Program: testing of prototype high-temperature thermal receivers.

National User Facility

In July 1993, NREL's solar furnace was designated as a National User Facility, opening it nationwide to industry, university and government scientists interested in using it for technology development. In the future NREL will focus on increasing the facility's role as a National User Facility, with a goal of accommodating new users to explore a wide variety of advanced solar concepts.