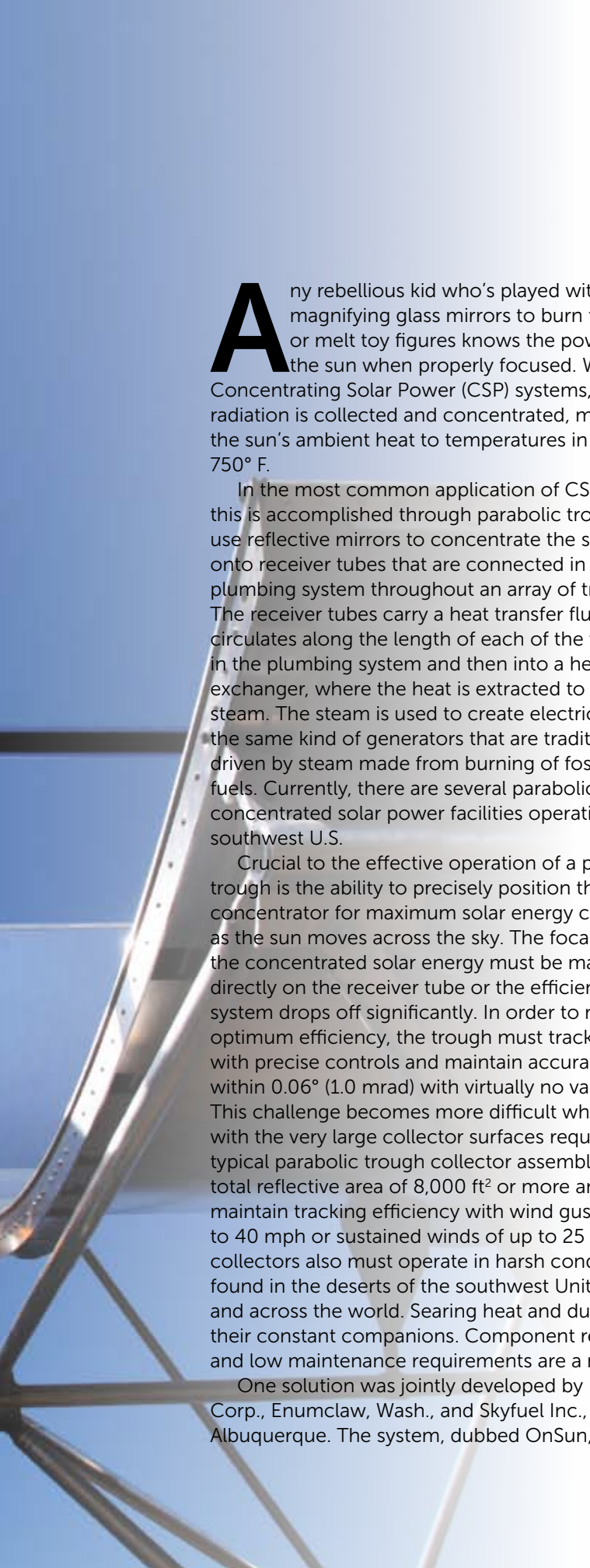
Positioning parabolic troughs

How to precisely orient troughs to capture maximum solar energy.

Paul J. Heney/Editorial Director



Any rebellious kid who's played with magnifying glass mirrors to burn twigs or melt toy figures knows the power of the sun when properly focused. With Concentrating Solar Power (CSP) systems, solar radiation is collected and concentrated, multiplying the sun's ambient heat to temperatures in excess of 750° F.

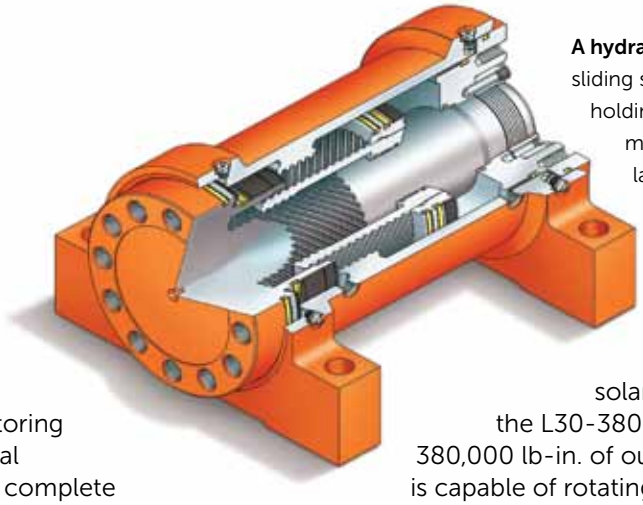
In the most common application of CSP today, this is accomplished through parabolic troughs that use reflective mirrors to concentrate the sunlight onto receiver tubes that are connected in a vast plumbing system throughout an array of troughs. The receiver tubes carry a heat transfer fluid, which circulates along the length of each of the troughs in the plumbing system and then into a heat exchanger, where the heat is extracted to make steam. The steam is used to create electricity using the same kind of generators that are traditionally driven by steam made from burning of fossil fuels. Currently, there are several parabolic trough concentrated solar power facilities operating in the southwest U.S.

Crucial to the effective operation of a parabolic trough is the ability to precisely position the concentrator for maximum solar energy capture as the sun moves across the sky. The focal point of the concentrated solar energy must be maintained directly on the receiver tube or the efficiency of the system drops off significantly. In order to maintain optimum efficiency, the trough must track the sun with precise controls and maintain accuracy to within 0.06° (1.0 mrad) with virtually no variation. This challenge becomes more difficult when dealing with the very large collector surfaces required. Each typical parabolic trough collector assembly has a total reflective area of 8,000 ft^2 or more and must maintain tracking efficiency with wind gusts of up to 40 mph or sustained winds of up to 25 mph. The collectors also must operate in harsh conditions found in the deserts of the southwest United States and across the world. Searing heat and dust are their constant companions. Component reliability and low maintenance requirements are a must.

One solution was jointly developed by Helac Corp., Enumclaw, Wash., and Skyfuel Inc., Albuquerque. The system, dubbed OnSun, is an integrated tracking, control, and drive system for large solar power systems. OnSun is comprised of two major subsystems. First is a helical hydraulic actuator with a sliding spline design. The large contact surface of the helical gearing allows the L30 actuator to provide increased holding torque of up to 1.8 million in.-lb, eliminating the requirement for an external holding brake mechanism found on competitive drive systems. The second subsystem is a sun-tracking control system, SkyTrakker, developed by SkyFuel. Delivered as a compact, pre-fabricated package, the integrated OnSun sun tracking system allows for rapid field installation and system start-up.

Solar energy collection is most efficient at the equator, where gross thermal power/solar power is approximately 1,000 W/m^2 of direct solar radiation. Dependent on geographical location, 6 to 8 solar collector assemblies are required for each MW of electricity to be generated, and each collector assembly requires an individual tracking, control, and drive system. A modest 25 MW solar field will have as many as 200 collector assemblies, each with a drive system that consumes the very same electricity that is being generated. To minimize this energy consumption, the OnSun system uses a variable frequency drive control for the hydraulic pump motor that minimizes startup currents and reduces parasitic power consumption by 50%.

The Heat Transfer Fluid is circulated through a mechanically coupled continuous loop system that traverses through multiple collector assemblies so synchronous coordination of the movement of each collector is vital. With state-of-the-art communications capability, SkyTrakker provides system health monitoring to ensure reliability and system life. High-speed remote monitoring and control are provided using field network communications between SkyTrakker and the control room. Both an RS-485 optically isolated wired network and 2.4 GHz wireless RF network communications are provided. Heat Transfer Fluid



A hydraulic actuator with a sliding spline design provides holding torque of up to 1.8 million in.-lb, due to the large contact surface of the helical gearing.

temperature-monitoring capability is provided for high temperature and freeze mode protection. Both remote and local monitoring of the HTF is provided for dual safety operation. In addition, complete monitoring of each SkyTrakker operation is available using a USB connection for field maintenance and debugging operations.

As a better alternative to the complex, and inefficient task of actually tracking the sun's position to maintain optimum collector efficiency, SkyTrakker controls the movement of the collector assembly by determining the desired collector position based on the sun's precisely known position in the sky relative to the exact location of the collectors on Earth. This ensures that the collector is always in the best position, even if cloud cover blocks the sun momentarily. As soon as the cloud or other obstruction clears, the collector is in precise alignment to resume maximum thermal efficiency and there is never a "hunt" mode due to the collector being off position. A solid-state digital inclinometer is used to ensure the tracking accuracy is maintained to within 0.05°.

The most precise and accurate positioning algorithms and controller would be of little value without a drive system capable of responding with accuracy to the minute positioning commands generated. The sun is in continual motion as it tracks across the sky each day and maximum solar efficiency is only attained when the collector is properly focused. The very large surfaces of the collector assembly require a support structure. Even with state-of-the-art space frame type designs, these structures weigh in at several thousand pounds. Additionally, the large surface area of the collector acts as a sail in even a slight breeze.

The OnSun drive system uses a helical sliding spline hydraulic rotary actuator, the Helac L30 series actuator. The L30 series and its predecessors have been in volume production for 25 years with more than 100,000 units delivered to military, mining and heavy equipment customers for use in extreme operating environments. Customized specifically for the concentrated solar power market, the L30-380 generates 380,000 lb-in. of output torque yet is capable of rotating the collector assembly in precise 0.1° increments through the entire 240° of total rotation.

The L30 series helical rotary actuators use a low hydraulic displacement to drive through their rotation cycle, which facilitates the use of a small pump and motor to supply the high-pressure fluid to the actuator. The self-contained hydraulic fluid system is charged with multifunctional gear oil that ensures long gear life for both the pump and actuator. Strict fluid cleanliness standards are used during the production of the drive unit to ensure that the fluid used is of the highest possible cleanliness standards. As part of this process, each component is thoroughly cleaned prior to assembly and then the completed actuator is subjected to a computer controlled cycle test where the fluid is analyzed for particulate size and quantity. The actuator is flushed with fresh ultra-clean fluid until the cleanliness standard is achieved. This eliminates the need for filters, and an associated preventative maintenance headache, thereby contributing to overall reduced cost of operation for the entire solar collector field. Coupled with a small electric motor, with support for 110 Vac and 220 Vac single and three-phase power input, is a single gear pump that provides the hydraulic pressure needed to drive the actuator in the both the low-speed tracking as well as high-speed stow modes.

The OnSun system is designed for rapid field installation based on the low number of parts that are involved as well as quick installation and assembly features incorporated into the design. The drive system is delivered as a compact, pre-fabricated package that allows for rapid field deployment. The SkyTrakker controller is a single board design that offers ease of connection and configuration. SPE

SkyFuel Inc.
www.skyfuel.com

Helac Corp.
www.helac.com