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Construction & building

Telescope gets thermal system

While innovative, adaptive optics will provide the sharpest views ever taken of the solar surface, these images could be distorted if the thermal system in the telescope is not managed correctly. Therefore, obtaining precise optical performance will require close control of the telescope's thermal environment.

Faithfully rising each morning for uncountable generations, our familiar sun remains a master at hiding the significant secrets of its fundamental physics. Its behaviour can have major effects on our everyday life on Earth. Solar flares and coronal mass ejections can negatively affect or even completely shut down radio communications, GPS satellite availability and the power grid.

Scientists, in their ongoing quest to learn more about Earth's nearest star, are continually creating new models to explain its nature and predict its behavior. As the complexity and sophistication of these models grow, they require increasingly advanced solar telescopes with resolutions beyond the capabilities of current installations, even those in space, for validations.

The telescope

To meet this need, the National Solar Observatory (NSO) is constructing the Daniel K. Inouye Solar Telescope (DKIST) at an elevation of 10,000 ft (3,048 m) on the Haleakalā volcano summit in Maui, HI, USA. NSO is funded by the National Science Foundation under a cooperative agreement with the Association of Universities for Research in Astronomy, Inc. All research here is based in part on data collected with the DKIST, a facility of the NSO.

This entails closely matching the surface temperature of the observatory dome's exterior to the ambient air temperature in order to eliminate any density differential in the air that would degrade the optical path.

Temperature control

Maintaining the precise dome temperature in the extreme weather environment atop the volcano requires high-pressure coolant to circulate throughout a network of sheet heat exchangers that are mounted onto the observatory structure. In selecting a suitable pump for this task, the NSO set high operating specifications, including a wide temperature range, and also called for an extremely tight delivery schedule in order to keep the construction timeline on course.

Construction

To provide solar scientists with a telescope capable of observing the sun at

The telescope will provide the sharpest views ever taken of the solar surface.

LeEllen Phelps, NSO Thermal Systems Manager, signals that the pumps passed all required factory-acceptance tests.

the required high resolution, a collaboration of 22 institutions, headed by the NSO, National Science Foundation (NSF) and Association of Universities for Research in Astronomy (AURA), joined together to build the world's largest solar telescope.

The $344 m DKIST will allow for observations with unprecedented spatial, spectral and temporal resolution via sub-second spectroscopic and magnetic measurements of the solar photosphere, chromosphere and corona. Its location on Haleakalā was selected for its reliable, clear daytime atmospheric viewing conditions. Construction at the DKIST site began in January 2013, and full operational capability is scheduled for 2020.

Accuracy

When telescopes operate with such high resolution, all factors affecting performance must be managed to ensure maximum equipment accuracy. One of those factors is the control of all observatory and telescope thermal surface environments, which is overseen by LeEllen Phelps, NSO Thermal Systems Manager. Phelps manages the design, equipment acquisition and construction of all facility thermal systems at the DKIST.

"It is critical that we control the thermal environment of every optic, every instrument and every path that the optical train passes through," explained Phelps. "To do this at the required precision, we must install numerous thermal-management systems throughout the structure. Our goal is to maintain the instruments and facility at a uniform temperature matching that of the ambient air within ±2°C (±3.6°F). Only so much of that degradation can be compensated for in the optics of the telescope."

Controlled environment

One important thermal environment which must be controlled is the exterior surface of the telescope enclosure. The dome presents more than a quarter acre of surface area whose temperature must be precisely regulated to closely match the ambient air. Any temperature differentials between the ambient air and the building surfaces create what scientists call "seeing," which is a density differential within the air that degrades the optical path and results in image distortion.

Coolant system

According to Phelps, the pumps are the heart of the coolant-distribution system that manages the thermal environment of the observatory exterior. "We will use pumps to circulate ten different temperatures of closed-loop heat-transfer fluid to cool different components of the observatory, including the exterior, to a very precise temperature that follows whatever the ambient temperature happens to be at a given time. Several closed loops will circulate coolant a few degrees below the ambient temperature to keep the exterior skin temperature at a state constantly matching ambient conditions even with the sun hitting the surface and with varying wind conditions."

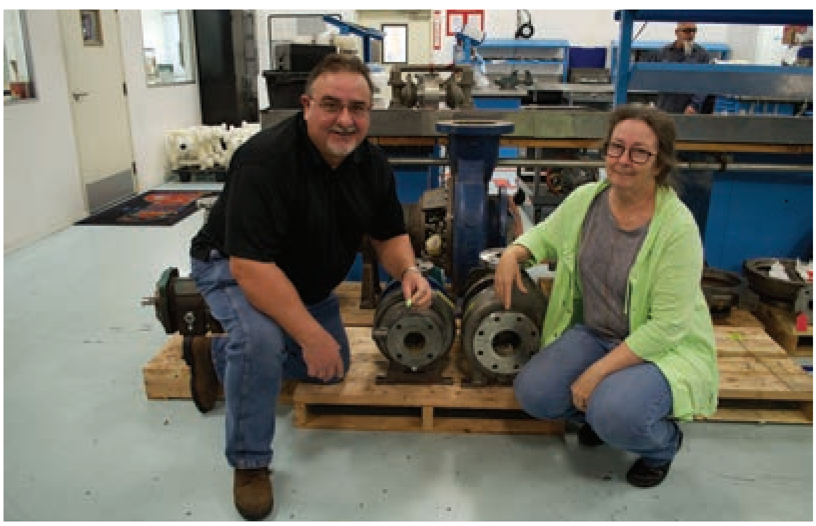
Pumps used for this purpose must meet strict specifications. "In this application, we are using an ionic brine for the heat-transfer solution in a regime of low temperatures that are much lower than what conventional HVAC pumps could handle without freezing up and having issues," said Phelps. "It's mostly the low temperatures in some of the cooling regimes that determined the most important pump-specification parameters. Energy efficiency was also an important factor because of the high cost of power on Maui."

Meeting deadlines

From the onset, the NSO set a tight construction schedule. Thermal-system component selection and acquisition were no exception.

After a competitive-bid process, the pump contract was awarded to James, Cooke & Hobson, Inc. (JCH), a major industrial equipment distributor based in Albuquerque, NM, USA, with offices in Arizona, New Mexico, Texas, California and Nevada.

JCH Sales Engineer Dean Newbold was assigned as lead on the project, but knew immediately that meeting the deadlines would be a challenge. At that point Newbold contacted Griswold Pump Company, Grand Terrace, CA, USA, for assistance. Griswold is a centrifugal pump manufacturer from PSG, a Dover company, based in Oakbrook Terrace, IL, USA.



Griswold 811 Series pumps ready for shipment to Hawaii.

Griswold worked closely with Newbold by building, testing and delivering 26 811 Series ANSI Centrifugal Pumps in nine different sizes and configurations, including some with a low-flow configuration. NSO staff personally monitored pump testing to measure suction pressure (psi), discharge pressure (psi), power (HP), speed (rpm), flow (gpm), fluid temperature (°F) and vibration.

Reliability

The 811 Series offers many design innovations that deliver long-term operational reliability, including:

- A fully open impeller with rear adjustment capability and twice the wear area of enclosed models for superior handling of solids, corrosives and abrasives
- Back pump-out vanes that reduce hydraulic loads and seal-chamber pressure, resulting in smooth, stress-free operation
- Standard bronze labyrinth oil seals that keep outside contaminants from entering the lubrication media, which significantly extends bearing life
- Extra-heavy casings that incorporate a standard Class 300 wall thickness that extends casing life even when used with corrosive or erosive fluids.
- Heavy-duty shaft that minimizes vibration and shaft deflection, resulting in optimized pump life, and bearings that are sized for a 10-year life span ●

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The DKIST will study solar phenomena such as superheated plasma loops.