Azimó Heliostat Module

Abstract

Azim6 Heliostat Module introduces revolutionary design concepts that will change the future of the concentrated solar energy market. The heliostat design is innovative through ease of manufacturing, optimal structural modularity, and the ability to withstand harsh outdoor conditions with ease of maintenance. The principle that sets this heliostat module apart from other comparable products is our ability to maximize efficiency by minimizing resources used. The basis of the small, innovative design involves four mirrors mounted to a bar with motors individually controlling the tilt of each surface and a revolving base attached to the ground allowing for a substantial range of motion. This allows the module to effectively track the sun throughout the day while reducing the number of motors and subsequently the cost. Cost also is significantly reduced through 3D printing technologies that allow most of the system to be made from ABS plastic opposed to a costly aluminum structure. The design is practical for hassle-free maintenance with the ability to detach each mirror and motor assembly from the module individually. Plastic covers are used to protect the system from the wear and tear of sand and other outdoor elements, allowing for a 20-year minimum lifetime. This design is cost effective, has a long lifetime, and meets the performance specifications laid out by the customer in an efficient and innovative way.

Product Functionality

The Azim6 Heliostat consists of four reflective surfaces that are attached to an injection molded ABS support system. The support system is divided into two sections that contain a 12V DC motor that controls the rotation of two reflective surfaces around the horizontal x-direction. Each section can be removed from the module if needed to for repair or cleaning. The support for the reflective surfaces is held by an ABS truss structure that connects to a center rod. The rod is held in place by the base that is bolted to a concrete floor from three flanges. The base also contains a belt system that allows for the rotation of the entire heliostat module around the vertical z-direction. The motors in this heliostat module are controlled by a Raspberry Pi Zero W microcontroller that is attached to one of the flanges of the base of the system. Each motor and the controller are covered by baffling to prevent system malfunction from external conditions.

Cost Breakdown

Energy Consumption:	Totole	\$0.30
Assembly Labor:		\$5.50
Manufacturing Labor:		\$23.75
Raw Materials:		\$18.48
OTS Parts:		\$103.57

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- Reflective surfaces and
- ABS structure allows for repair.

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Support System

The support system utilizes a simple T-bar design alongside vertical support shafts to help reduce beam deflection and vibrational oscillation due to the weight of the reflective surfaces. This system is made from injection molded ABS to keep cost and weight low, capitalizing on small heliostat design.

Reflective Surface

The reflective surface is made from glass mirrors that are made to ASTM C1036 standards and high-quality silver. The reflective surface is connected to a support backing made of ABS to allow for sufficient strength and drive down module cost.

Control/Actuation

Actuation of the system is controlled using two axes of rotation: one that is the main shaft rotating about its primary axis, while the reflective surfaces rotate to keep the azimuth oriented properly. The Azim6 heliostat module is controlled using 12-Volt DC motors and a Raspberry Pi Zero W microcontroller.

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N1) Innovation through Small Heliostat Design

N13) Minimum Factor of Safety

N15) Wind Speed Resistance

N6) Heliostat Module Shade Percentage

N12) Washability

N14) Operational Lifetime

N16) Thermal Input Power

N17) Solar Concentration

N4) Tracking Error

N5) Number of Axes for Sun Tracking

N9) Automated Tracking

N11) Price of Parts

N2) Collection Area

N3) Number of Heliostats in Module

N7) Receiver Mounting Height

N8) Module Cost Limit

N10) % of Reflecting Area to Module Area

N18) Maximum Heliostat Distance

Customer Needs Mapping

M1) Heliostat with lowest weight

M13) Factor of Safety >= 2

M15) Withstand Windspeed of 90 mph

M6) Shade percentage = 0%

M12) Based on fluid volume

M14) 20 years

M16) 1MW

M17) 1000 suns

M14) $\alpha \le 0.5^{\circ}, \beta \le 0.5^{\circ}$

M5) 2 axes

M9) Most tracking features

M11) \$ of individual parts \leq \$ of OTS parts

M2) $\le 1 \text{ m}^2$

M3) 4-16 heliostats

M7) 0m - 100m

M8) \$100/m²

M10) %

M18) 100m





F1) Constructed from lightweight ABS plastic F13) Factor of Safety >= 2 for materials used F15) Structural factor of safety supports 90 mph

F6) Heliostats are arranged linearly

F12) 4 gallons water per day per heliostat

F14) 10-year lifetime with one replacement

F16) 756 modules based on 1370 W/m² at noon

F17) 1031 modules for 0.97 optical efficiency

F4) Maximum tracking error: $\alpha \le 0.5^{\circ}$, $\beta \le 0.5^{\circ}$

F5) 180 degrees of freedom in 2 axes

F9) Raspberry Pi Zero W 2 controller

F11) Machined vs. OTS parts carefully selected

F2) 4 mirrors with total area of 1 m^2

F3) 4 heliostat design

F7) Receiver mounted at height less than 100m

F8) OTS parts $\leq 100/m^2$

F10) 3180% reflective surface to modules area

F18) 100m between heliostat and target tower