

A Scalable Turntable Tool for Parabolic Mirror Construction

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The parabola is the only geometric shape that will collect incoming parallel rays and focus them to a single point. Parabolic reflectors are used in satellite receivers, solar collectors and other applications.

Construction of these shapes is often problematic and dependent upon the wavelength being focused. In microwave applications, a parabola of chicken wire can suffice, while in astronomy parabolic mirrors that are ground to 1/10th of a wavelength of light are commonplace. The visible spectrum sits between from 400 nanometers (ultraviolet) and 800 nanometers (infrared) with the mean being 600 nm (yellow). The peaks sensitivity of the eye is at 555 nm (green). For solar collectors the mean wavelength is much longer, around 800 nm.

Unlike their flat solar-cell counterparts, parabolic mirrors can capture a significant amount of the solar spectrum in the infrared region, where the band gap of most semiconductors forbids energy harvest. This, when combined with their high collection efficiency (over 90%) makes them an excellent addition to the solar energy arsenal.

Machining a surface to a tolerance on the order of a wavelength of light (500nm or 1/2 micron) is out of the reach of most technologies, including CNC machine tools, due to the discrete steps of position and stair-stepping artifacts that appear in the final work. However, spinning pools of liquid form a perfect parabola and these have been used for astronomy applications for some time.

These turntables must spin at a uniform speed, typically 40 RPM. They must be very flat, free from vibration and therefore balanced. The containers that sit on the turntable must be tall enough to contain sloshing of the fluid during startup and rigid enough to prevent out of control oscillation of the kind often seen in clothes washers during an unbalanced spin cycle. The container, like the turntable must be balanced and not contain an excess of mass at any angular station. If a spinning liquid is carefully solidified, the resulting shape is a perfect parabolic form, which can be used directly, or used as a form for casting secondary shapes and molds.

Geometric Calculations

The focal length of a parabola is given by the equation:
Where p is the focal length in a system of units consistent with the measure of x or y

Spreadsheet Study

A prototypical parabolic collector three feet in diameter can collect 657 watts of power

on a sunny day. The tool to make any number of these dishes is just the cost of the casting material, modeled below for plaster of paris and foam filler.

The focal length of any parabola from the square one shown here with short focus at 9" to those of infinite focal length can be constructed simply by varying the RPM of the drive from 42 RPM to 0 RPM.

A Simple Turntable Design

An effective turntable should satisfy the following design goals:

Ease of Manufacture

Accuracy of Dimension

Material Cost

Manufacturing Cost

Balance and Stability

Portability

Powered with Off-The-Shelf Hardware

A simple turntable design has been done that satisfies these seven goals. An exploded view is shown below:

The dimensions, material specifications and weight of each piece will now be furnished in turn. All dimensions are to ± 0.005 " unless otherwise specified.

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