SEGMENTED RADIUS SOLAR COLLECTOR (SRSC)

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New solar collector design to be analyzed with computer software and compared to experimental testing. The Segmented Radius Solar Collector (SRSC) uses a series of curved reflective panels to focus light.

Objective

- Model optical design with software
- Experimentally determine efficiency for segmented radius device

Background

Solar energy is converted to thermal energy. Industrial parabolic troughs heat molten salts and synthetic oils to produce steam for electrical power generation, 300 - 550 ºC.

Methods

- Improve optical design, decrease focal region.
- Measure temperature change of water to calculate energy transferred and efficiency.
- Removed panel pairs to confirm software findings.

Figure 1: The SRSC reflects light with a series of curved panels onto a collector rod that has water flowing through at a known flow rate, with monitored input and output temperatures.

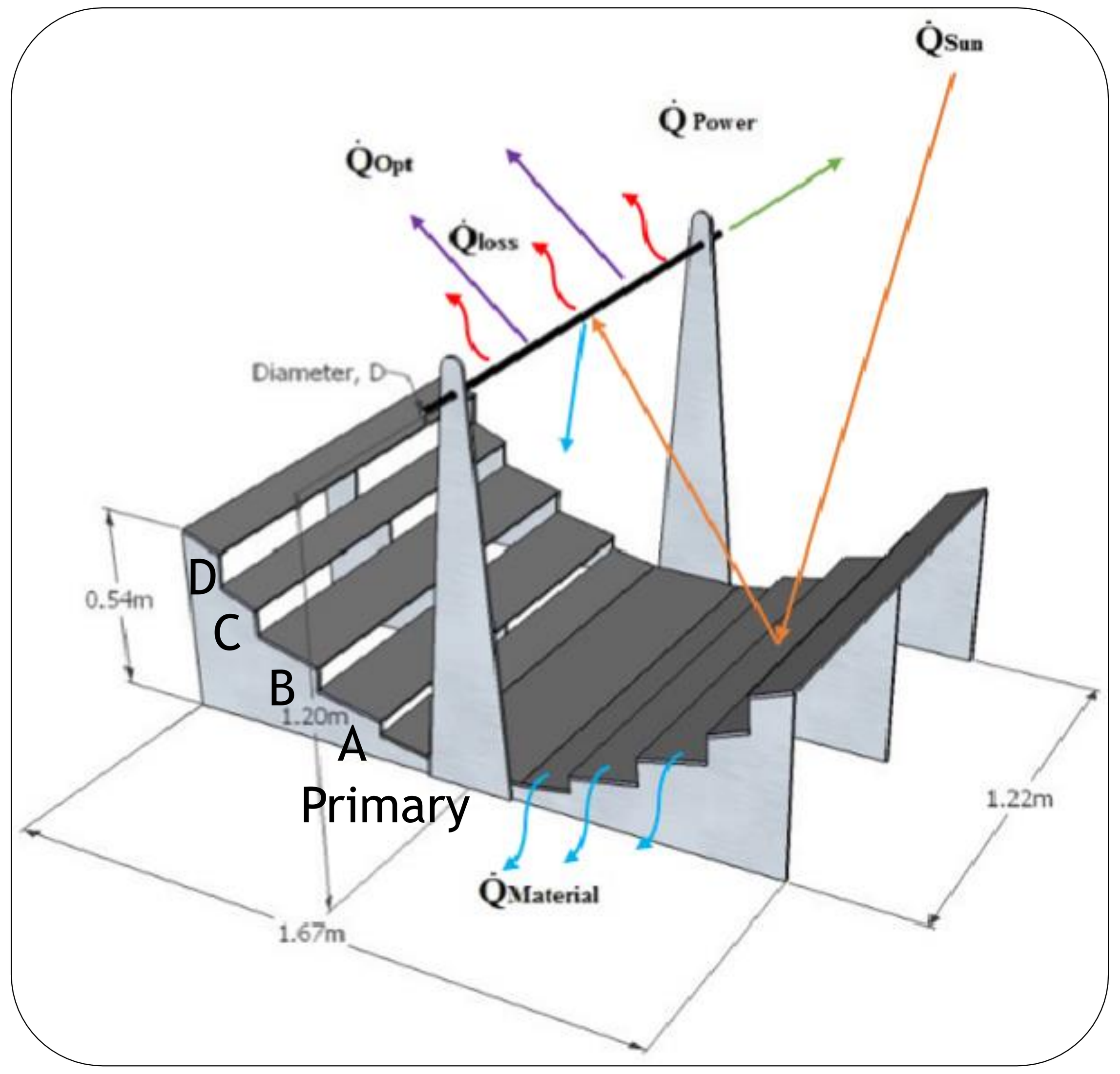

Figure 2: The SRSC implements a series of reflective panels which theoretically reduces the optical losses by creating a common focal region.

Factor Description	Role	Energy Factor (W)	Equation (W) [1]
Energy Source from the Sun	Source	Q_{Sun}	$q_{Sun}A_{SRSC}$
Light Absorbed into Panels	Material Loss	Q_{Panel}	$q_{Sun}A_{SRSC}\varepsilon_{SS}$
Light Reflected From Collector Rod	Material Loss	Q_{RRefl}	$q_{Sun}A_{SRSC}(1-\varepsilon_{SS})\ (1-\varepsilon_{Th})$
Convective Cooling on Collector Rod	Loss	Q_{RConv}	$hA_R(T_R-T_\infty)$
Conductive Cooling on Collector Rod	Loss	Q_{RCond}	$kA_{Re}(T_R - T_{Al})/L$
Radiative Cooling on Collector Rod	Loss	Q_{RRad}	$\sigma A_R T_R^4$
Energy Transferred into Heat Transfer Fluid	Power	Q_{HTF}	$mC_p\ (T_2 - T_1)$
Light Missing Collector Rod	Optical Loss	Q_{Opt}	Q_{Opt}

Table 1: Energy factors which sum to the total available energy provided by the sun. Thermal losses are minimal at the experimental ranges.

Optical Model

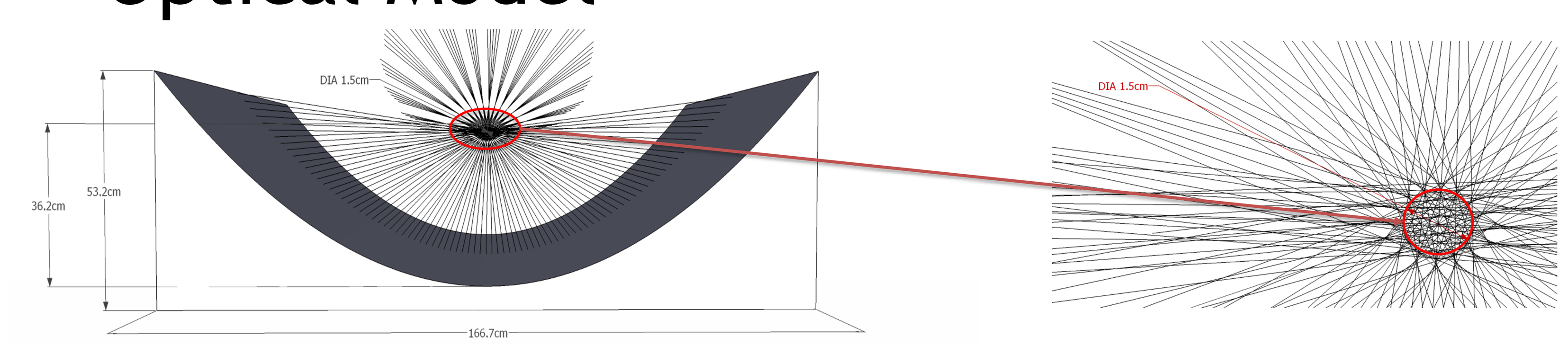

Figure 3 (a): Parabolic model simulated light pathways to form a 1.5 cm focal region to compare to the SRSC models.

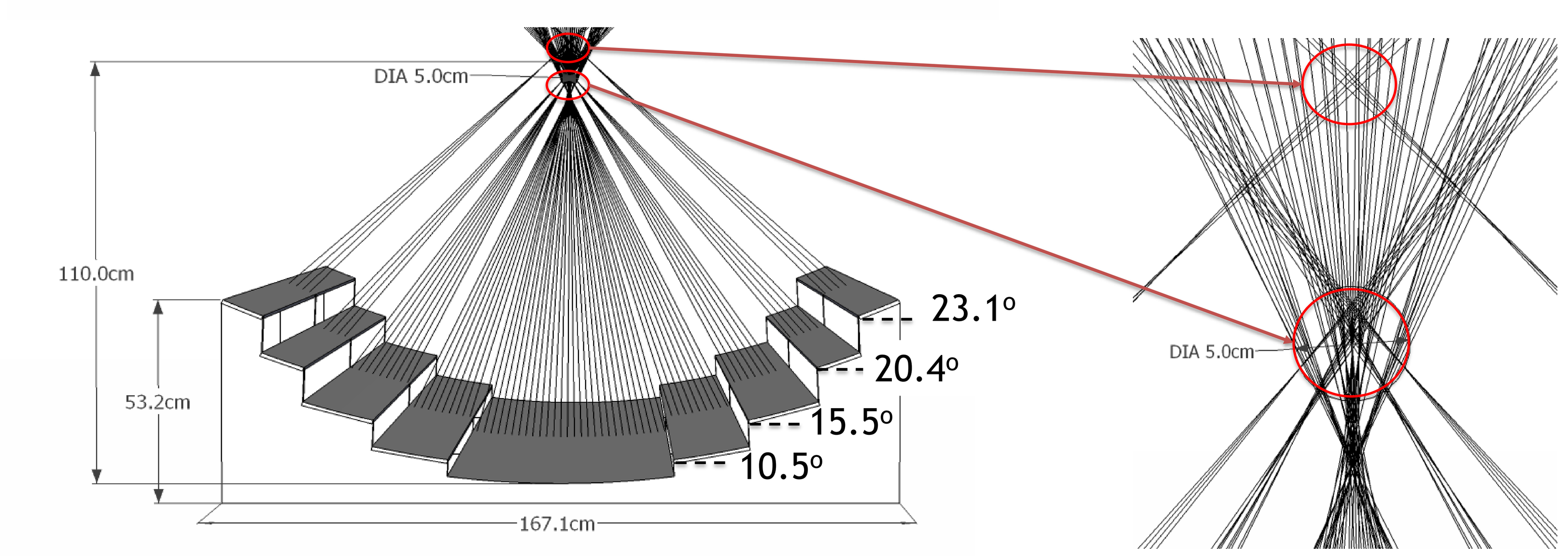

Figure 3 (b): SRSC device simulated light pathways to form multiple focal regions with a 5.0 cm width.

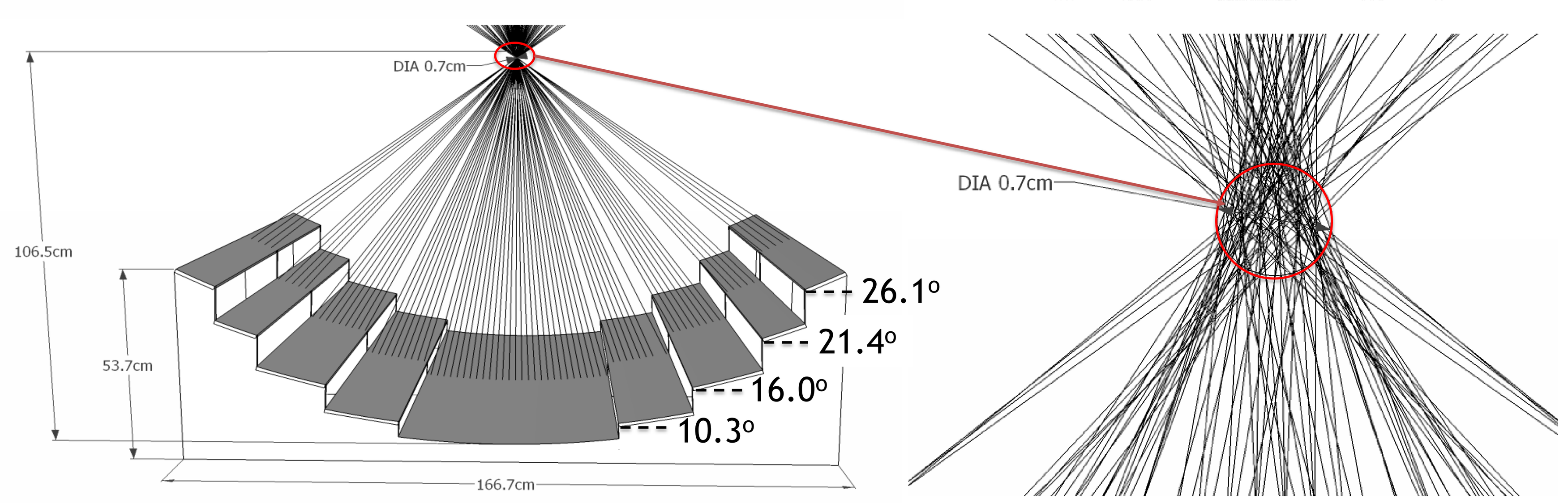

Figure 3 (c): Modified SRSC model simulated light pathways to form a single focal region of 0.7 cm.

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Flow Rate 0.8 L/min		Efficiency	Power (W)	Area (m^2)
Panels	Primary panel	33%	200	0.65
Panels	(A)	31%	310	1.12
Panels	(A, B)	32%	430	1.53
Panels	(A, B, C)	29%	470	1.77
Panels	(A, B, C, D)	28%	500	1.98

Table 2: Efficiency decreases as panel pairs are added. *Figure 2* shows the corresponding panel pairs.

Scale Up Parameters

Collector Width to Focal Distance

- w = Collector Width (m)
- f_d = Focal Distance (m)

$$\frac{w}{f_d} = 1.55$$

Collector Width to Radius of Curvature

- R = Radius of Panel Curvature (m)

$$\frac{w}{R} = 0.77$$

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Sources

[1] Welty et. Al. Fundamentals of Momentum, Heat, and Mass Transfer. 5th ed. John Wiley and Sons. 2008