

**DESIGN, PERFORMANCE ANALYSIS, AND
MANUFACTURING OF PARABOLIC TROUGH SOLAR
COLLECTOR USED FOR THERMAL LOADS**

By

Eng. Mohamed Rashed Helmy AbdelMagid

**A Thesis Submitted to the Faculty of
Engineering at Cairo University in Partial
Fulfillment of the Requirements for the Degree of
MASTER OF SCIENCE**

In

MECHANICAL POWER ENGINEERING

**FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Thesis Title: DESIGN, PERFORMANCE ANALYSIS, AND
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USED FOR THERMAL LOADS.

Keywords: Parabolic trough collector, Intercept factor, Optical efficiency,
Shading factor, End loss factor.

Summary: This thesis presents a detailed study on Parabolic Trough Solar Collectors applied with a water desalination unit using a multi-effect distillation technique. Thermal design procedures were implemented to determine the full dimensions of the collector. Then, optical and thermal losses from the collector were investigated taking into consideration the shading effect and the end loss factor. Also, transient thermal performance of the collector was studied throughout the annual seasons. It was found that the best performance will be achieved in May during which the desalination unit can be solar operated for seven hours daily, producing 15 m³/day of distillate water. Finally, the construction, manufacturing, and assembly steps of the parabolic trough collector were introduced.

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Table of Contents:

List of Tables	iv
List of Figures.....	v
Nomenclature.....	ix
List of Abbreviations.....	xii
Abstract.....	xiii

1. CHAPTER 1: INTRODUCTION

1.1. Potential of solar energy in Egypt.....	1
1.2. Solar energy applications.....	2
1.3. Solar energy for thermal loads.....	3
1.4. Multi-Effect distillation.....	3
1.5. Parabolic trough collector.....	5
1.6. Parabolic trough collector solar tracking system.....	6
1.7. Thesis outline.....	7

2. CHAPTER 2: LITERATURE REVIEW

2.1. Introduction.....	9
2.2. Optical error analysis.....	10
2.2.1. Theoretical and experimental studies.....	11
2.3. The commercial parabolic trough collectors	16
2.3.1. Luz collectors.....	16
2.3.2. EuroTrough collectors	17
2.4. Effect of parabolic trough orientation.....	18
2.4.1. Single axis tracking.....	19
2.4.2. Experimental studies.....	20
2.5. Incidence angle modifier, Shading, and End losses.....	27
2.6. Conclusion and scope of work.....	33

3. CHAPTER 3: MODELING THE PTC SYSTEM

3.1.	Introduction.....	35
3.2.	Sizing the Parabolic Trough Collector.....	37
3.3.	The project layout.....	38
3.4.	The intercept factor at normal incidence calculations.....	39
3.5.	The thermal performance of the PTC.....	40
3.5.1.	Solar irradiance absorption.....	41
3.5.1.1.	Weather data.....	41
3.5.1.2.	Incidence angle.....	42
3.5.1.3.	Incidence angle modifier.....	42
3.5.1.4.	Peak optical efficiency.....	42
3.5.1.5.	Shading factor.....	43
3.5.1.6.	End losses.....	43
3.5.2.	Modeling the receiver tube thermal losses.....	44
3.5.2.1.	Assumptions.....	44
3.5.2.2.	Energy balance components.....	45
3.6.	Modeling of the storage tank.....	53
3.6.1.	Energy balance on the storage tank.....	54
3.6.1.1.	Storage tank thermal losses.....	55
3.7.	The present case study.....	58
3.7.1.	Shading effect.....	58
3.7.1.1.	Calculating the critical tracking angle.....	59
3.7.1.2.	The shading factor.....	61
3.7.2.	End losses effect.....	62
3.7.3.	The simulation program.....	64
3.6.3.1.	Forristall code verification.....	64
3.7.3.1.	EES code customization.....	64
3.7.3.2.	EES code flow chart.....	65

4. CHAPTER 4: RESULTS AND DISCUSSION

4.1.	Introduction.....	67
4.2.	The intercept factor and concentration ratio.....	67
4.2.1.	Geometrical effects on the intercept factor.....	68
4.3.	The peak optical efficiency.....	70
4.4.	Shading factor.....	70
4.5.	End loss factor.....	73

4.6.	The Parabolic Trough Collector Length.....	77
4.7.	Overall solar system simulation results.....	77
5.	CHAPTER 5: DESIGN AND CONSTRUCTION OF PTC	
5.1.	Concentrator Structure.....	86
5.1.1.	Trough structure assembly.....	91
5.1.2.	Main supports.....	94
5.1.3.	The whole structure.....	97
5.1.4.	Optical testing of the PTC.....	97
5.2.	Heat collecting element.....	98
6.	CONCLUSIONS AND RECOMMENDATION FOR FUTURE WORK	
6.1.	Conclusions.....	100
6.2.	Recommendations for future work.....	101
	REFERENCES.....	102
	APPENDIX A: Intercept Factor Matlab Code.....	105
	APPENDIX B: Shading Width Matlab Code.....	107
	APPENDIX C: Thermo-physical Properties of HTF.....	109
	APPENDIX D: The properties of the PTSC components	110
	APPENDIX E: The modified Forristall Code.....	113
	APPENDIX F: The working drawings.....	133

List of Tables

Table 2.1: Percentage of measurements of flux falling within multiples of a given standard deviation. [6].....	13
Table 2.2: Error sets used in optical analysis. [16].....	15
Table 2.3: Main Characteristics of the Luz Parabolic Trough Collectors..	16
Table 2.4: Orientation angle effect on the yearly collection efficiency.....	27
Table 2.5: IAM for different solar collectors. [21],[22],[23],[24],[25].....	29
Table 3.1: Heat flux definitions. [30].....	45
Table 4.1: Values of the geometric and error parameters.....	67
Table 4.2: Shade factor results calculated through the annual seasons.....	73
Table 4.3: Sample of end loss factor calculations in 1st January.....	74
Table 4.4: Number of operating hours and the desalination plant output..	82

List of Figures

Fig. 1.1: Worldwide annual solar-electric power output per unit collector area [1].....	1
Fig. 1.2: Economic potential of most active countries in CSP in MENA region [4].....	2
Fig. 1.3: Solar Energy Usage.....	2
Fig. 1.4: Schematic diagram of MED.....	4
Fig. 1.5: Different MED configurations [5].....	4
Fig. 1.6: Parabolic Trough Collector.....	5
Fig. 1.7: Schematic of photo-sensor tracking.....	7
Fig.1.8: Solar tracking module.....	7
Fig. 2.1: Description of optical errors associated with PTC [12].....	10
Fig. 2.2: Solar acceptance angle [13].....	11
Fig. 2.3: Front and rear views of third generation (LS-3) collector [17].	17
Fig. 2.4: Front and rear views of EuroTrough collector [17].....	18
Fig.2.5: Schematic drawing illustrates the situation of perfect tracking..	18
Fig. 2.6: Single axis and double axis tracking.....	19
Fig. 2.7: North-South and East-West horizontal axis tracking.....	19
Fig.2.8: Direct irradiance for a single axis tracking surface, (47 N latitude, 13 Jul) [18].....	20
Fig. 2.9: Direct irradiance for a single axis tracking surface, (47 N latitude, 10 Jan) [18].....	21
Fig. 2.10: Monthly maxima of the direct irradiance on single axis tracked surfaces [18].....	21
Fig. 2.11: Monthly direct irradiation for single axis tracked surfaces.....	22
Fig. 2.12: Schematic representation of a horizontal PTC with width (w) and length (l) [19].....	23
Fig. 2.13: Daily tracking angle variation with the different orientation angles [19].....	25
Fig. 2.14: Daily incidence angle variation with the different orientation angles [19].....	26
Fig. 2.15: The relation between IAM and incidence angle for different collector types [21],[22],[23],[24],[25].....	29
Fig. 2.16: IAM versus incidence angle [26].....	30
Fig. 2.17: The shading effect.....	31
Fig. 2.18: Shading effect through the day [27].....	31

Fig. 2.19: End losses from the receiver tube.....	32
Fig. 2.20: End loss versus incidence angle [28].....	32
Fig. 3.1: Schematic for the overall plant.....	36
Fig.3.2: P & I Diagram.....	36
Fig. 3.3: Top view of the whole site.....	38
Fig. 3.4: Heat transfer model.....	46
Fig. 3.5: Receiver tube support.....	53
Fig. 3.6: Schematic for the solar field.....	54
Fig. 3.7: Thermal resistances associated with the storage tank.....	55
Fig. 3.8: 3D model of the whole plant.....	58
Fig. 3.9: Schematic showing the PTC orientation and main dimensions with respect to the site fence.....	59
Fig. 3.10: PTC simplified geometry used to calculate the aperture shaded area.....	59
Fig. 3.11: Geometric sketch illustrates end loss and end win.....	63
Fig.4.1: The effect of receiver diameter and rim angle on the intercept factor.....	68
Fig. 4.2: Effect of receiver diameter on the captured energy.....	69
Fig.4.3: Variation of aperture shaded area with time, (21 st Feb.).....	71
Fig.4.4: Variation of aperture shaded area with time, (21 st August).....	72
Fig.4.5: Daily variation of the end loss factor.....	75
Fig. 4.6: Representation of the receiver un-illuminated length throughout the day.....	76
Fig. 4.7: Initial variation of collector outlet temperature. (21 st Feb.).....	78
Fig. 4.8: Variation of storage tank temperature. (21 st Feb.).....	79
Fig. 4.9: Initial variation of collector outlet temperature (21 st May).....	79
Fig. 4.10: Variation of storage tank temperature. (21 st May).....	80
Fig. 4.11: Initial variation of collector outlet temperature. (21 st August).....	80
Fig. 4.12: Variation of storage tank temperature (21 st August).....	81
Fig. 4.13: Variation of storage tank temperature (21 st Nov.).....	81
Fig. 4.14: Variation of captured energy by the collector (21 st Feb.).....	83
Fig.4.15: Variation of captured energy by the collector.(21 st May).....	83
Fig.4.16: Variation of captured energy by the collector.(21 st Aug.).....	84
Fig. 4.17: Variation of captured energy by the collector (21 st Nov.).....	84
Fig. 4.18: The amount of absorbed, loss, and useful energies through the annual seasons.....	85
Fig.5.1: ReflecTech Mirror Film.....	86

Fig. 5.2: 3D model of the torque tube structure with the parabolic ribs and the supporting longitudinal bars assembled.....	88
Fig.5.3: The used laser cutting machine.....	89
Fig. 5.4: The parabolic rib. a) The assembled rib, b) The connection between the two parts, c) Exploded view of the assembly point, and d) The location of the supporting longitudinal bar.....	90
Fig.5.5: The PTC structure.....	91
Fig. 5.6: The longitudinal bars.....	91
Fig. 5.7: Fixation of the longitudinal bar with the parabolic rib.....	92
Fig. 5.8: Al. sheets Installation on the ribs.....	92
Fig. 5.9: Fixation of Al. sheet with the bar.....	92
Fig. 5.10: View from inside the hollow longitudinal bar.....	92
Fig. 5.11: Fixation points of the Al. sheet with the longitudinal bars.....	93
Fig. 5.12: The concentrator structure as well as the bases of the receiver tube supports.....	93
Fig. 5.13: The concentrator structure in site.....	94
Fig. 5.14: The three concrete bases supporting the pylons.....	94
Fig. 5.15: The three bases aligned with the N-S axis orientation.....	95
Fig. 5.16: One of the four structure main supports.....	95
Fig. 5.17: The upper loading base of the ball bearing assembly with the main support.....	95
Fig. 5.18: The ball bearings with the driving shaft.....	96
Fig. 5.19: The spacing between the two units where the tracking mechanism will be installed.....	96
Fig. 5.20: The two units of the PTC with N-S axis orientation.....	97
Fig. 5.21: The reflected rays on the receiver tube nearly at noon.....	98
Fig. 5.22: The reflected rays on the receiver tube afternoon and before the sunset.....	98
Fig. 5.23: The absorber tube with the glass glazing, metal bellow, and the getter.....	99

Nomenclature

Symbol	Quantity
A_{aperture}	Aperture Area, m^2
a	Accommodation Coefficient
b	Interaction Coefficient
c	Specific Heat, kJ/kg.K
C	Concentration Ratio
D	Receiver Diameter
d_D	Distance between the two units
d_r	Displacement of the receiver from the focus
d^*	Universal non-random error due to receiver dislocation
f	Focal Length
f	Friction Factor
h	Heat Transfer Coefficient, $\text{W/m}^2.\text{K}$
k	Thermal Conductivity, W/m.K
$k(\theta)$	Incidence Angle Modifier
L	Collector Length, m
l	Un-illuminated Length of the receiver, m
l_{win}	Illuminated length of the second receiver, m
m	Oil mass, kg
n	Day number of the year
Nu	Nusselt Number
Pr	Prandtl number
$\dot{Q}_{\text{absorbed}}$	Solar irradiance absorbed by the receiver tube, W/m^2
$\dot{Q}_{\text{heatloss}}$	Solar irradiance loss by the receiver tube, W/m^2
\dot{Q}_{Load}	The steam generator load, W
\dot{Q}_{useful}	The useful energy carried by the heat transfer fluid, W
$q'_{12\text{conv}}$	Heat flux by convection from the receiver to the HTF, W/m

$q'_{23\text{cond}}$	Heat flux by conduction in the receiver tube, W/m
$q'_{3\text{SolAbs}}$	Heat flux absorbed by the receiver tube, W/m
$q'_{34\text{conv}}$	Heat flux by convection from the receiver to the glazing, W/m
$q'_{34\text{rad}}$	Heat flux by radiation from the receiver to the glazing, W/m
$q'_{45\text{cond}}$	Heat flux by conduction in the glass glazing, W/m
$q'_{5\text{SolAbs}}$	Heat flux absorbed by the glass glazing, W/m
$q'_{56\text{conv}}$	Heat flux by convection from the glazing to ambient, W/m
$q'_{57\text{rad}}$	Heat flux by radiation from the glazing to the sky, W/m
$q'_{\text{cond,bracket}}$	Heat flux loss in the supporting brackets, W/m
q'_{heatloss}	Heat flux loss from the receiver tube, W/m
Ra	Rayleigh Number
Re	Reynolds Number
t	Time, hrs
T	Temperature, K
T_6	Ambient Temperature, K
T_7	Effective Sky Temperature, K
U	Overall Heat Transfer Coefficient, W/m ² .K
W	Total Aperture Width, m
W_{eff}	Un-shaded Aperture Width, m
X	Shading Width, m

Greek Letters

Φ_r	Rim Angle
Φ	Latitude angle
σ	Stefan-Boltzmann constant
σ	Standard deviation of random errors
σ^*	Universal parameter for random errors
β	Tracking angle error
β^*	Universal parameter for tracking error
γ	Intercept Factor
θ	Incidence Angle

δ	Declination angle
ω	Hour angle
γ_s	Solar azimuth angle
ψ	Orientation angle
ζ	Tracking angle
ρ	Mirror reflectivity
τ	Glazing transmissivity
α	Receiver absorbtivity
η_o	Optical efficiency
ε	Emissivity