

## TABLE OF CONTENT

CHAPTER 1 .....	1
INTRODUCTION .....	1
1.1 Energy Scenario .....	1
1.2 Solar Energy.....	2
1.3 Solar Air Heater .....	3
1.3.i Limitations of Solar Air Heaters.....	3
1.3.ii Importance of Artificial Roughness.....	5
1.3.iii Artificial roughness as protrusions/dimples .....	5
1.4 Optimization of influencing parameters .....	6
1.5 Metaheuristic Optimization Techniques .....	6
1.5.i Firefly algorithm .....	6
1.5.ii Particle-swarm optimization.....	7
1.5.iii Differential evolution .....	7
1.5.iv Teaching-learning-based optimization .....	8
1.5.v Ant colony optimization .....	11
1.5.vi Grass-hopper optimization algorithm .....	12
1.5.vii Whale optimization algorithm .....	13
1.5.viii Grey wolf optimization.....	14
1.5.ix Dragonfly algorithm .....	16
1.6 Motivation.....	17
1.7 Research objectives.....	18
1.8 Thesis Organization .....	18
CHAPTER 2 .....	20
LITERATURE SURVEY .....	20
2.1 Application of Artificial Roughness .....	20
2.2 Parametric Optimization of Solar Air Heaters.....	23
2.3 Research Gap .....	25
CHAPTER 3 .....	27
DIMPLES IN ZIG-ZAG AND STRAIGHT-LINE PATTERN .....	27
3.1 Introduction.....	27
3.2 Application of metaheuristic algorithms.....	28
3.3 Example 1-Dimples in a Zig-Zag Pattern .....	29
3.3.i Single-objective optimization .....	30
3.3.ii Multi-objective optimization .....	32
3.3.iii Hypothesis Testing: <i>t</i> -test .....	33

3.3.iv Results and Discussion .....	34
3.4 Example 2- Dimples in a straight-line pattern .....	35
3.4.i Single-objective optimization .....	37
3.4.ii Multi-objective optimization .....	39
3.4.iii Results and Discussion .....	40
3.5 Performance Comparison.....	40
3.6 Conclusions.....	41
3.7 Summary .....	43
CHAPTER 4 .....	45
PROTRUSIONS IN V-NOTCH PATTERN.....	45
4.1 Introduction.....	45
4.2 Experimentation test rig .....	46
4.3 Parametric selection .....	50
4.4 Data Reduction.....	50
4.5 Validity test.....	51
4.6 Error analysis .....	51
4.7 Metaheuristic optimization .....	52
4.8 Results and Discussion .....	53
4.8.1 Correlations.....	60
4.8.1.i Correlation for Nusselt number (Nu).....	60
4.8.1.ii Correlation for friction factor .....	63
4.8.2 Performance comparison .....	65
4.8.3 Optimization .....	67
4.8.3.i Single objective optimization .....	67
4.8.3.ii Multi-objective optimization .....	69
4.8.3.iii Validation of optimization results .....	71
4.9 Conclusions.....	72
4.10 Summary .....	73
CHAPTER 5 .....	74
SEMI-CAPSULE PROTRUSIONS IN STAGGERED PATTERN.....	74
5.1 Introduction.....	74
5.2 Experimental Setup and Conduction .....	76
5.2.i Data Reduction .....	78
5.2.ii Data validation test .....	79
5.2.iii Uncertainty test.....	80
5.3 Metaheuristic optimization .....	80
5.4 Results and discussion .....	81

5.4.i Influence of Reynolds number ( $Re$ ).....	81
5.4.ii Effects of comparative protrusion tallness ( $e_c/D_h$ ) .....	82
5.4.iii Influence of comparative pitch ( $p/e_c$ ) .....	84
5.4.iv Protrusion angle ( $\alpha_p$ ) influence .....	86
5.4.v Thermohydraulic Performance Index (THPi).....	87
5.5 Statistical correlations .....	88
5.6 Performance Comparison.....	93
5.7 Optimization .....	95
5.8 Conclusions.....	99
5.9 Summary .....	100
CHAPTER 6 .....	101
CONCLUSIONS, LIMITATIONS AND SUGGESTIONS FOR FUTURE WORK	101
6.1 Introduction.....	101
6.2 Overall Conclusions of this Research Work .....	102
6.2.i Problem 1 .....	102
6.2.ii Problem 2.....	102
6.2.iii Problem 3.....	103
6.3 Comprehensive comparison of the performance across the three problems....	103
6.4 Limitations .....	104
6.5 Suggestions for Future Work .....	104
References:.....	106