OPTIMIZATION OF SOLAR COLLECTOR GEMOTRIC PARAMETERS USING A HEURISTIC OPTIMIZATION METHODS

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PAPER HIGHLIGHTS

- Introduction
- Heuristic optimization methods
  - Random search method
  - TLBO method
- Results comparison od Random search and TLBO method
- Conclusion

INTRODUCTION

- A popular field of research in the past few tears is the efficiency of solar energy use.
- The development of design and production technology of flat solar collectors is with the goal of increasing their efficiency, decreasing the cost of production and other undesirable effects, which presents a very attractive research direction.
- In this paper the benefits of using TLBO method over the Random search method are presented.

HEURISTIC OPTIMIZATION METHODS

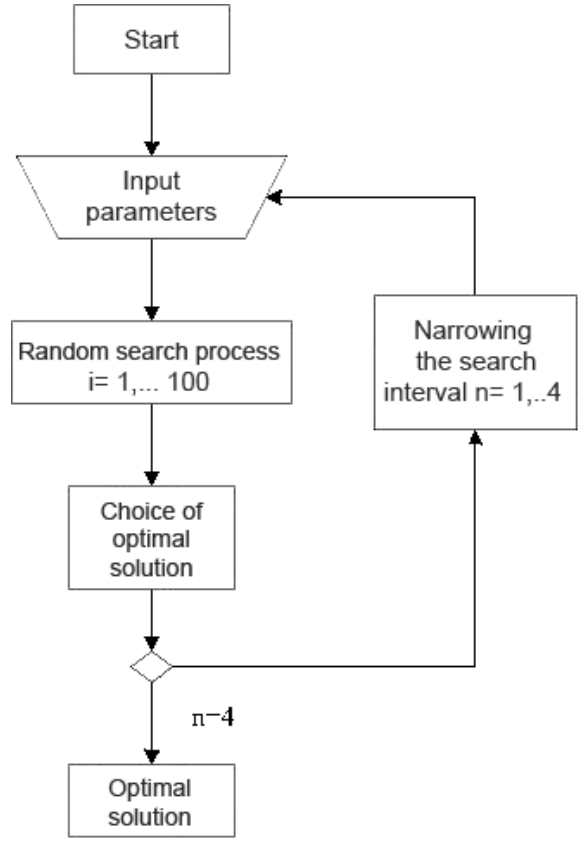
RANDOM SEARCH METHOD

- Random search method is one of the oldest heuristic optimization methods.
- The method is based on narrowing the given search interval when the goal function achieves an extreme value.
- The steps are repeated until a satisfactory solution is achieved.
- This method can, in theory, work with an infinite number of variables and with an infinite number of constraints.

HEURISTIC OPTIMIZATION METHODS

RANDOM SEARCH METHOD

- The start of the algorithm operation consists of the input of variables and de-termining constraints.
- With the introduction of variables, the search interval is de-termined.
- After that, the method is processed, followed by the choice of optimal solution in that interval, in order to finish the step with a narrower interval.



Basic algorithm for random search

HEURISTIC OPTIMIZATION METHODS

TLBO METHOD

The algorithm consists of two key phase- Teacher and Learner phases.

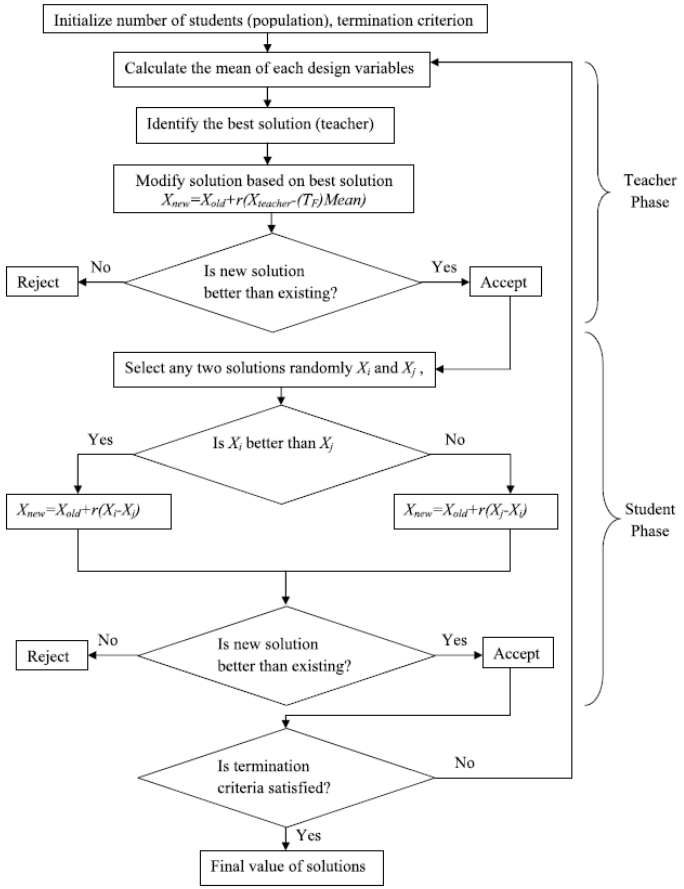
In the beginning the number of students is defined, which represents the total number of potential solutions.

From this group the best value which can become the teacher can be separated.

The best solution in an iteration is the teacher for the next iteration.

HEURISTIC OPTIMIZATION METHODS

TLBO METHOD



Structure of Teaching-Learning-Based optimization

HEURISTIC OPTIMIZATION METHODS

TLBO METHOD – TEACHER PHASE

The first phase of the algorithm is the Teacher Phase, which directly influences convergence.

Each teacher strives to increase the quality of his students. The new iteration value can be determined according to the following expression.

$$X_{\text{New}} = X_{\text{Old}} + r_i \left(X_{\text{Teacher}} - T_{\text{F}} X_{\text{Mean}} \right)$$

HEURISTIC OPTIMIZATION METHODS

TLBO METHOD – LEARNER PHASE

The basic working principle of this phase is the interaction between students.

In the vase that Xi> Xj where these are values of two randomly selected students in the algorithm, the following equation is used.

$$X_{\text{New}} = X_{\text{Old}} + r\left(X_{\text{i}} - X_{\text{j}}\right)$$

The second case is when Xi< Xj and then the algorithm uses the following expression.

$$X_{\text{New}} = X_{\text{Old}} + r\left(X_{\text{i}} - X_{\text{j}}\right)$$

Random value r is in the interval between 0 and 1, and the new value is adopted only if it has a better value than the previous one.

COMPARISON RESULTS OF RANDOM SEARCH AND TLBO METHODS

For the purposes of this paper authors used mathematical model, parameter intervals and constants from their previous research [10].

Efficiency optimization using TLBO on models of flat solar collectors with circular cross-section pipes, and rectangular cross-section pipes.

Compared to previous research of these authors, the analysis omits the flat solar collector with a square cross-section.

COMPARISON RESULTS OF RANDOM SEARCH AND TLBO METHODS

GOAL FUNCTIONS

For optimization of solar collectors with rectangular cross-section pipes:

$$F' = \frac{\frac{1}{U_L}}{W_f\left[\frac{1}{U_L\left[\left(W_f - W_o\right)F + W_o\right]} + \frac{1}{C_b} + \frac{1}{2\left(W_i + H_i\right)H_{fi}}\right]}$$

COMPARISON RESULTS OF RANDOM SEARCH AND TLBO METHODS

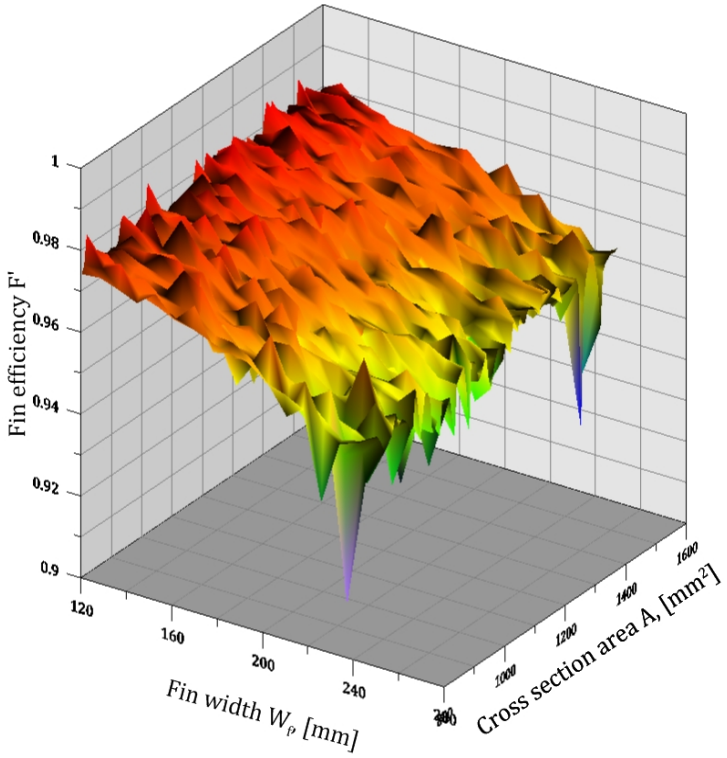
GOAL FUNCTIONS

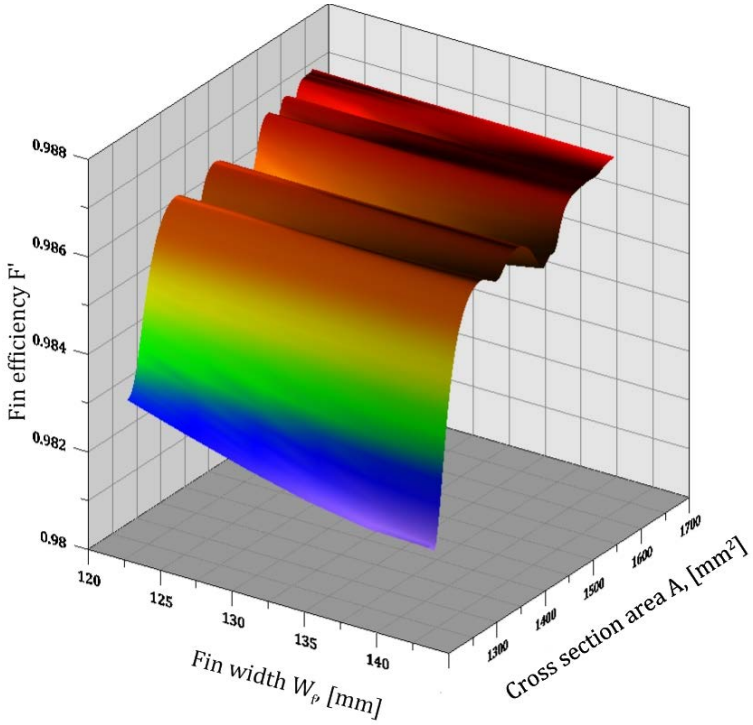
For optimization of solar collectors with circular cross-section pipes:

$$F' = \frac{\dfrac{1}{U_L}}{W_f\left[\dfrac{1}{U_L\left[\left(W_f - D_o\right)F + D_o\right]} + \dfrac{1}{C_b} + \dfrac{1}{\pi D_i H_{fi}}\right]}$$

COMPARISON RESULTS OF RANDOM SEARCH AND TLBO METHODS

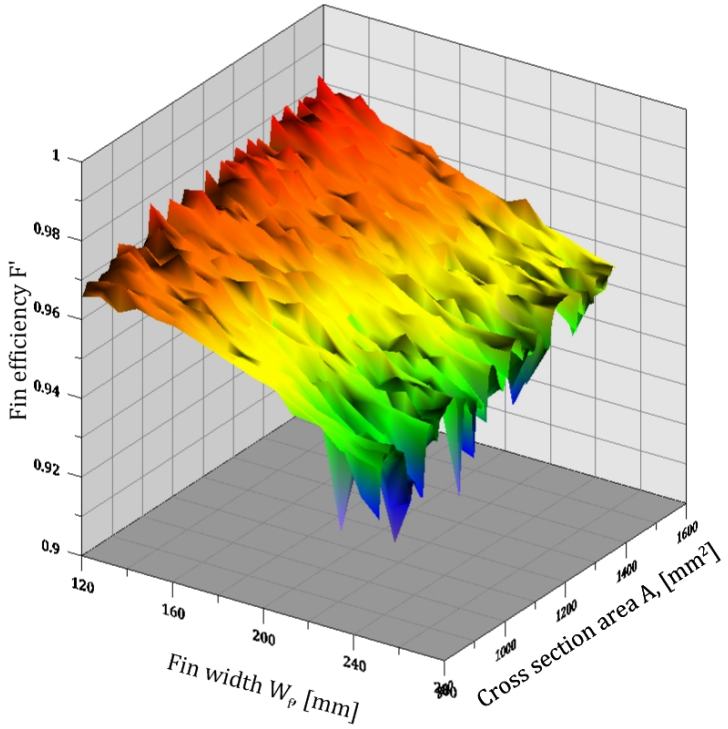
RESULTS COMPARISON FOR RECTANGULAR PIPES

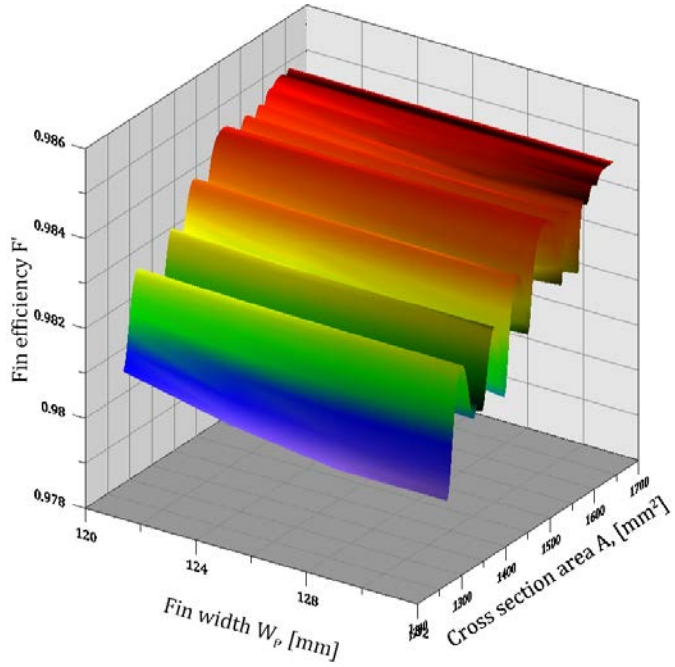




COMPARISON RESULTS OF RANDOM SEARCH AND TLBO METHODS

RESULTS COMPARISON FOR CIRCULAR PIPES





CONCLUSION

In this paper optimization of the efficiency factor as a function of rib pipe geometry for flat solar collectors was conducted.

With random search method, it can be seen that the collector with rectangular cross section pipes has the greater efficiency factor than the circular cross-section pipe collector.

Optimization using TLBO also shows a larger factor of efficiency for the rectangular cross-section, however the difference is notably smaller than with random search method.

From the given diagrams it can be concluded that TLBO has a far quicker convergence to the optimal solution.

THANK YOU FOR YOUR ATTENTION