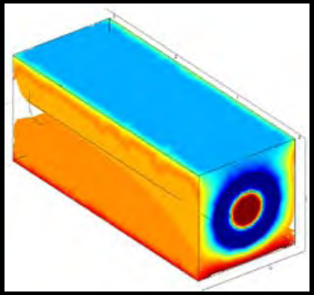
Presented at the COMSOL Conference 2008 Boston



Universidad Pontificia Bolivariana

Comsol and MatLab integration to optimize Heat exchanger using Genetic algorithms technique

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Introduction

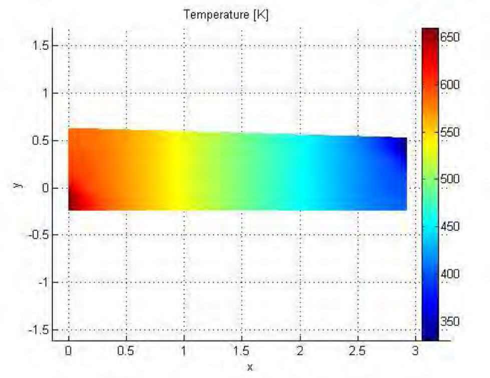
[0.5 min.]

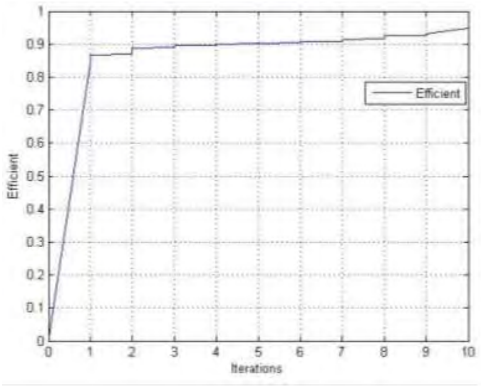
- An optimal fin design and optimization process to get an efficient heat exchanger has been developed.
- **Genetic algorithms** technique and **finite elements** method worked together to find the best geometric configuration for heat exchanger.
- We designed our own genetic algorithm code named **GA7** and adapted it to Comsol Multiphysics.

Content

[0.5 min.]

- Objetives.
- Optimization problem.
- Genetic algorithms technique.
- Comsol and MatLab GA Integration
- Mathematical models.
- GA7 design process.
- Results.
- Conclusions.
- Future works.





Objetives

[1 min.]

- Develop **optimization software** for energetic systems.
- Create **MatLab and Comsol Multiphysics integration** to improve applications for both programs.
- Apply **Genetic algorithms** technique for thermodynamical analysis.
- Identify numerical analysis to develop future works on Hydrogen Fuel cell systems.

Optimization problem

[1.5 min.]

- Behavior prediction of **physical phenomena** is of interest to improve different systems and devices frequently used in engineering applications.

- Numerical approach has taken **advantage of computers development.** Several kind of systems, process and devices have been improved.

- **Genetic Algorithms** (GA) have proved to be a complete approach for solving optimization problems.

Optimization problem

[0.5 min.]

- **Geometric dimension**, type of heat transfer surface and materials all change according to design requirements.

- Heat flux must be maximized to **transport as much energy as possible** through the heat exchanger geometry. MatLab and COMSOL integration seeks the best geometric dimensions to optimize flux in two-stream counter flow heat exchanger.

Genetic Algorithms technique

[0.5 min.]

- Genetic algorithms (GA) have received considerable attention regarding their **potential as an optimization technique**.
- GA have been successfully applied for **engineering optimal search**.
- Thermodynamical systems must be optimized in order to increase efficiency, reduce cost and offers a cleaner solution.

Genetic Algorithms technique

[1 min.]

Function, variables and initial values

Initial Population

Chromosomes cost

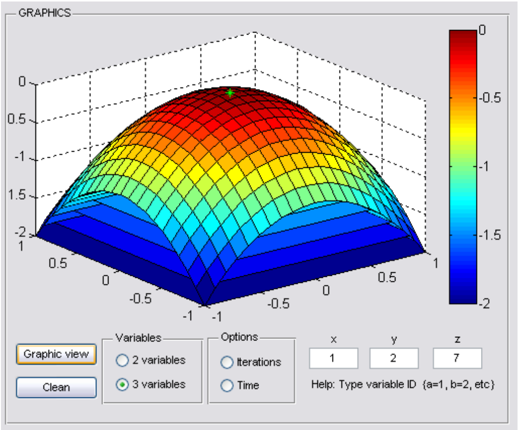
Pair Selection

Cross

Mutation

Convergence

End



Genetic Algorithms technique

[1 min.]

- Continuous function optimization.
- **Does not require derivation process**.
- Can jump out of local maximum.
- Works with **randomly data**.
- Successful use on **parallel computational systems**.
- Hybrid processes of optimization.

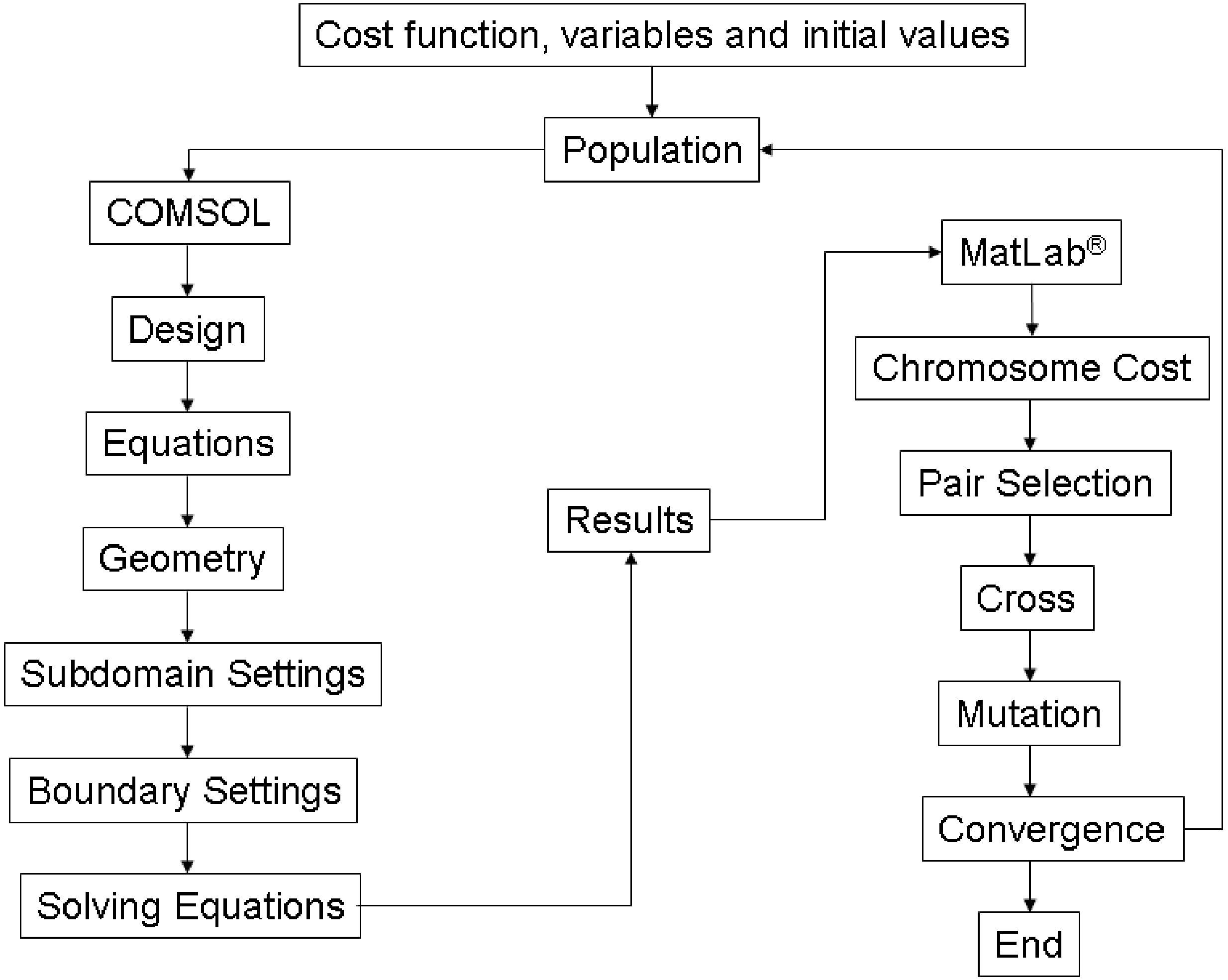
Comsol and MatLab Integration

[1 min.]

- Governing equations for solids and fluids are solved with COMSOL Multiphysics model.
- **2D counter flow heat exchanger** simplified model is analyzed.
- GA7 seeks for best variables for fitness function.
- Comsol and MatLab integration is controlled by **GA7 software**.

Comsol and MatLab Integration

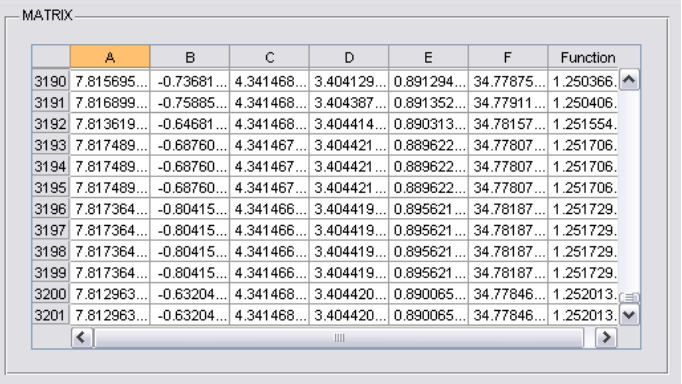
[1.5 min.]



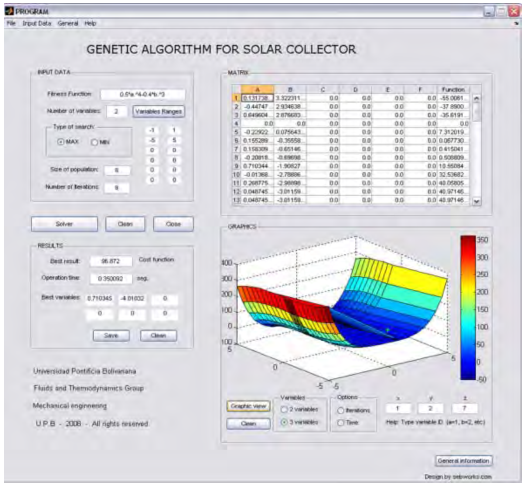
GA7 design process

[1 min.]

- Research.
- MatLab programming.
- Validation.
- Sophistication.
- Graphical interface design.
- **Applications.**


MATRIX

	A	B	C	D	E	F	Function
3190	7.815695...	-0.73681...	4.341468...	3.404129...	0.891294...	34.77875...	1.250366.
3191	7.816899...	-0.75885...	4.341468...	3.404387...	0.891352...	34.77911...	1.250406.
3192	7.813619...	-0.64681...	4.341468...	3.404414...	0.890313...	34.78157...	1.251554.
3193	7.817489...	-0.68760...	4.341467...	3.404421...	0.889622...	34.77807...	1.251706.
3194	7.817489...	-0.68760...	4.341467...	3.404421...	0.889622...	34.77807...	1.251706.
3195	7.817489...	-0.68760...	4.341467...	3.404421...	0.889622...	34.77807...	1.251706.
3196	7.817364...	-0.80415...	4.341466...	3.404419...	0.895621...	34.78187...	1.251729.
3197	7.817364...	-0.80415...	4.341466...	3.404419...	0.895621...	34.78187...	1.251729.
3198	7.817364...	-0.80415...	4.341466...	3.404419...	0.895621...	34.78187...	1.251729.
3199	7.817364...	-0.80415...	4.341466...	3.404419...	0.895621...	34.78187...	1.251729.
3200	7.812963...	-0.63204...	4.341468...	3.404420...	0.890065...	34.77846...	1.252013.
3201	7.812963...	-0.63204...	4.341468...	3.404420...	0.890065...	34.77846...	1.252013.



Mathematical Models

[1 min.]

- Fin analysis:
  - Heat equations for solids
  - Fin efficiency (Fitness function)

- Heat exchanger analysis:
  - Navier Stokes equations.
  - Energy equations for solid and fluids
  - Heat transfer rate (Fitness function)

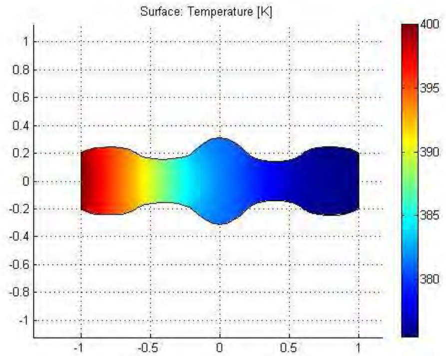
Results: *Fin optimization*

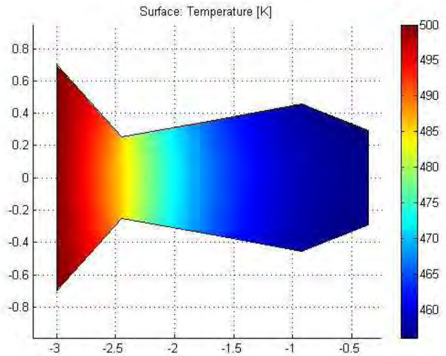
[0.5 min.]

- For the following boundary conditions:

Variable	Magnitude	Units
Convective coefficient	30	W/m^2k
External temperature	400	k
Boundary temperature	290	k

We defined two different geometric configurations:



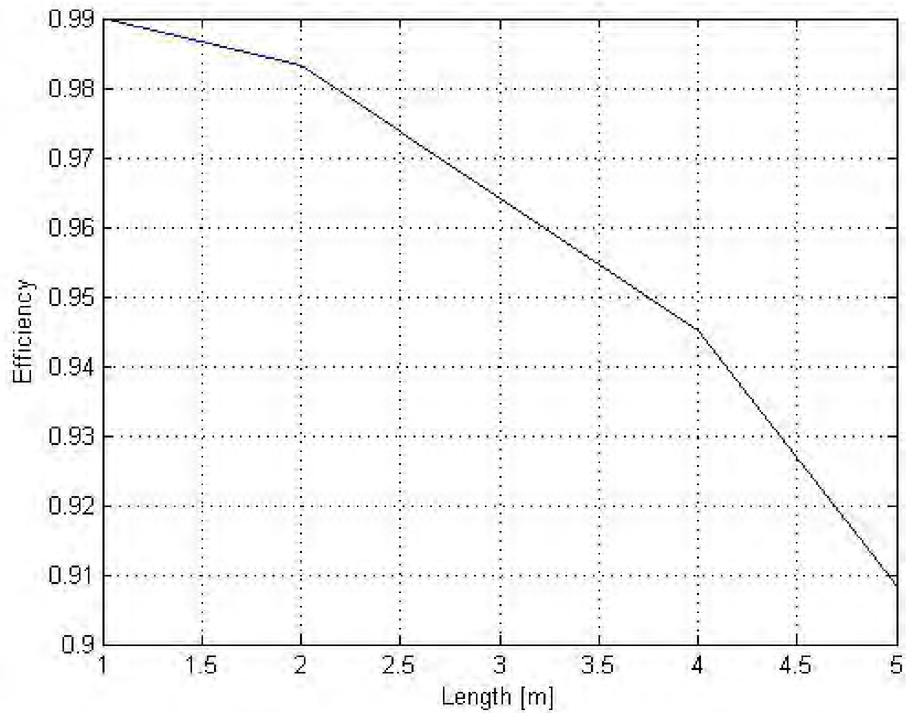


Results: *Fin optimization*

[0.5 min.]

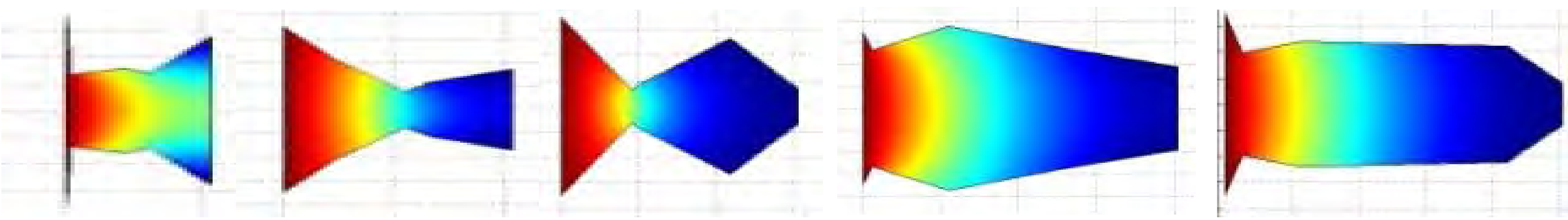
- Length effects on Efficiency value:

Length (m)	Efficiency
1	0.99
2	0.9834
3	0.964
4	0.9452
5	0.9082



Results: *Fin optimization*

- Length effects on Efficiency value and shape:



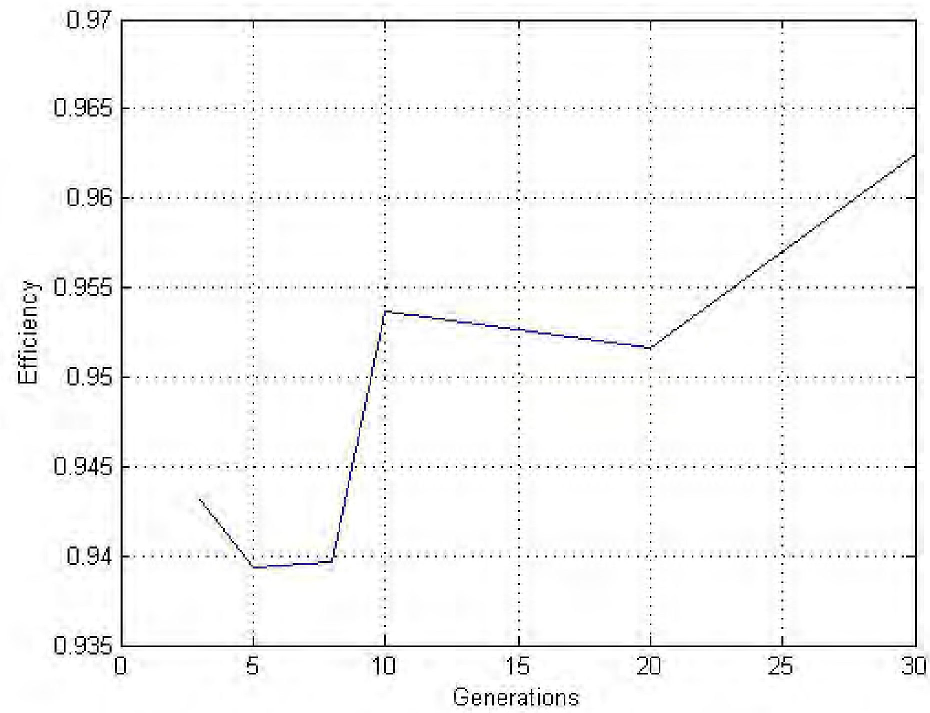
1 2 3 4 5

Results: *Fin optimization*

[0.5 min.]

- Generation effects on Efficiency value:

Generations	Efficiency
3	0.9431
5	0.9393
8	0.9397
10	0.9537
20	0.9516
30	0.9625

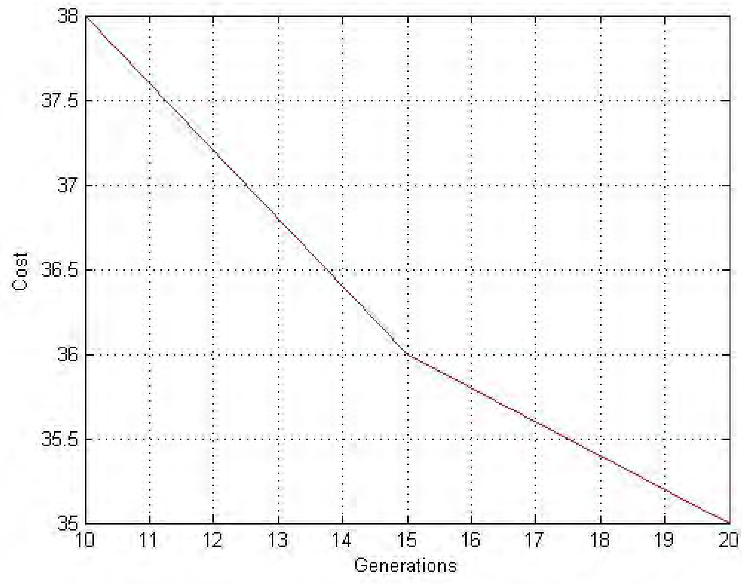


Results: *Fin optimization*

[0.5 min.]

- Cost minimization through iterations:

Area/Efficiency	Efficiency	Iteration	Cost (US$)
6.21E-04	0.8049	10	38
5.85E-04	0.8136	15	36
5.72E-04	0.8325	20	35

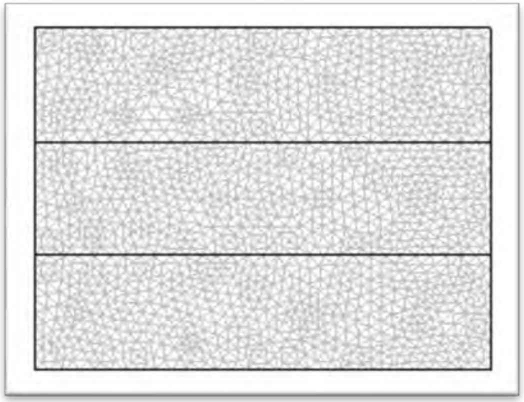


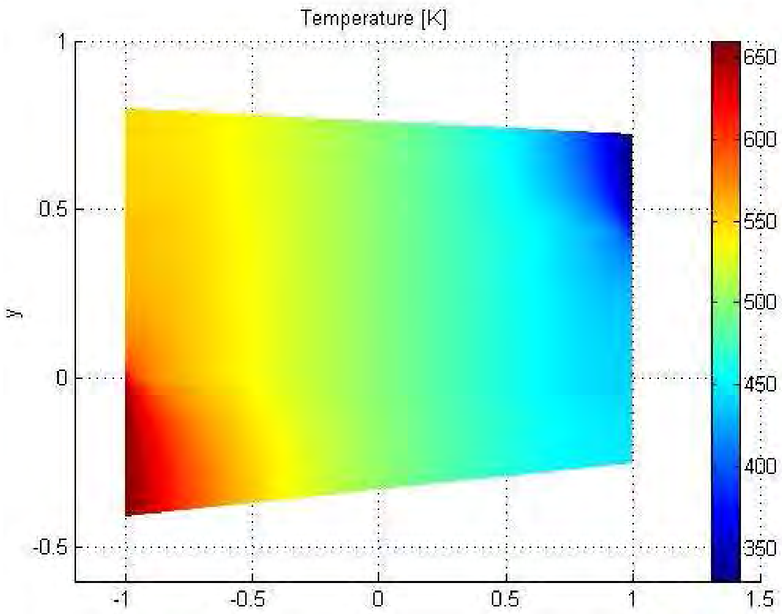
Results: *Heat Exchanger optimization*

[0.5 min.]

- We defined the following boundary conditions.

Variable	Magnitude	Units
Cold Temperature	330	k
Hot Temperature	660	k
Cold velocity	0.5	m/s
Hot velocity	0.25	m/s
Outlet Pressure	0	Pa



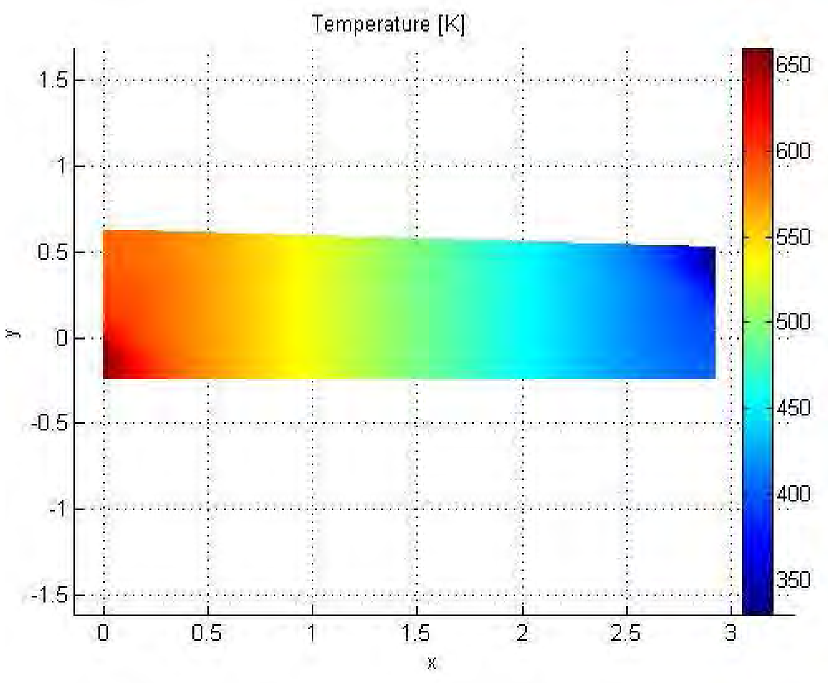


Results: *Heat Exchanger optimization*

[0.5 min.]

- Length effects over Heat exchanger optimization:

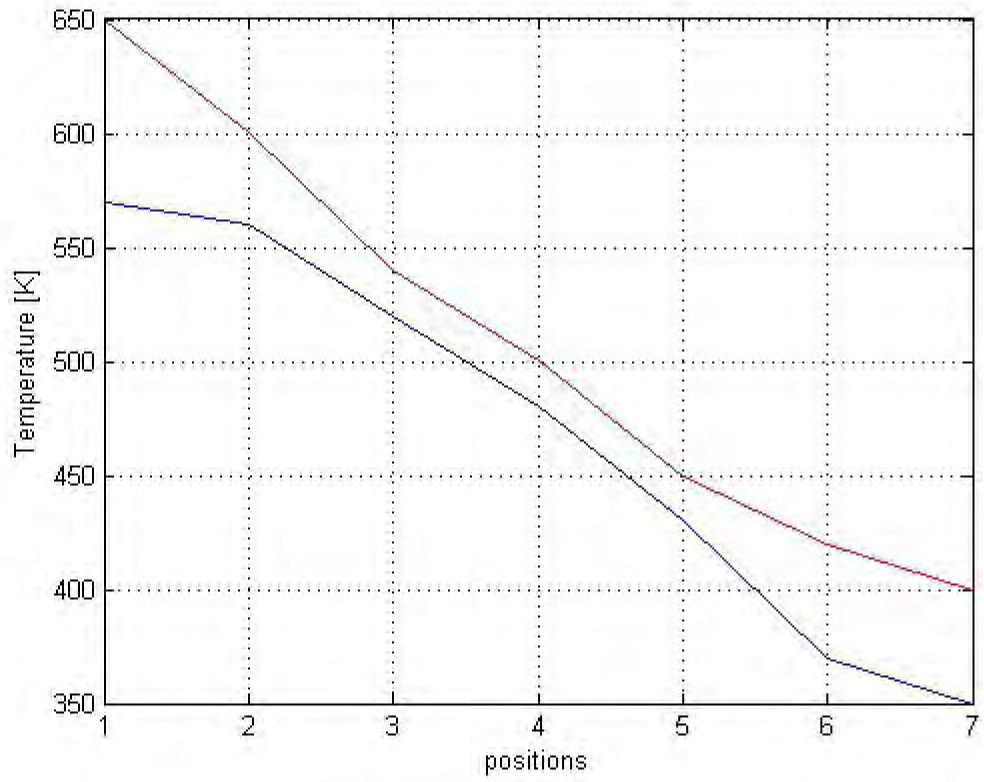
Variable	Magnitude	Units
Hot flow entrance	0.4262	m
Hot flow exit	0.4703	m
Tube width	0.4515	m
Cold Flow entrance	0.4175	m
Cold flow exit	0.3847	m
Heat Flux	674.533	W



Results: *Heat Exchanger optimization*

[0.5 min.]

- Temperature distribution through length:



Conclusions

[1 min.]

- COMSOL Multiphysics and GA optimization software integration is a **great solution for function of high level of sophistication**.

- Optimal design of a heat exchanger is not just minimization of pressure difference as much as possible. **Efficiency can be augmented by employing extended surfaces around heat exchanger geometry**.

Conclusions

[1 min.]

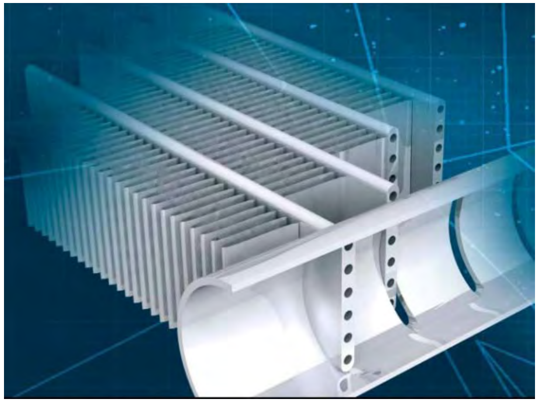
- Adding fins will increase pressure drop, but it will reduce construction cost by increasing overall heat transfer coefficient and reducing required area.
- Pumping cost, heat transfer, minimal area and fastest solution should be considered in the optimization of efficiency and effectiveness of heat exchanger.
- GA7 supports function with 6 variables with great results and reasonable operation time.

Future Works

[0.5 min.]

- 3D geometries and other phenomena like chemical reactions in applications such as fuel cells and microheat exchangers and micro mixers.

- Multiobjetives functions.



Acknowledges

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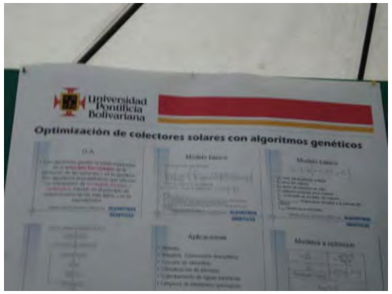
The entire team wants to acknowledge the support of the **Universidad Pontificia Bolivariana** during this research.

New challenges will come.



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