This is an interesting paper that should be accepted for oral presentation at ISTEGIM2019. However, major revisions should be brought to the final version according the following remarks:

Main remarks:

- In the first paragraph of page 1, how do you define the performance of the micro-channels ?

An additional phrase added,

Here we consider the microchannel performance (based on thermal efficiency and pressure losses) for two different types of perturbators, Wire-net [1, 2, 3] and the S-shape.

- What is the CFD tool that was used ? Please provide information on the CFD model settings (grid density, discretization schemes, boundary conditions,...)

Three-dimensional, ideal gas, steady CHT simulations were carried out to investigate the effect of thermal efficiency and pressure losses for various inlet mass flow rates in ANSYS Fluent. Turbulent K-ω shear stress transport turbulent model was utilized for all the CHT models and collectors simulations. The free microchannel simulations were conducted using laminar models. The -epsilon model is not accurate in the near-wall region. On the contrary, the K- model is appropriate for the near-wall turbulent flows. Both conventional models are mixed to take the advantage of both models. The microchannel thermal efficiency, ε, % is calculated using the relation,

|  |  |
| --- | --- |
|  | (1) |

|  |  |
| --- | --- |
|  | (2) |

where being the hot and cold fluid capacity rates, and are the inlet and outlet temperatures of the counter-flow channels. is the microchannel mass flow rate at hot and cold inlet. The microchannel pressure losses, ∆P, % were calculated using the relation,

|  |  |
| --- | --- |
|  | (3) |

Where, is the inlet and outlet total pressure drop and is the absolute pressure at the inlet.

Two types of geometrical symmetry exist in a plane that is parallel to the inlet flow direction (see Fig.1a). cylindrical collectors with wire-net microchannel is shown in Fig.1a. The primary symmetrical domain (see Fig.1b) is along half of the secondary collector diameter. Besides, the secondary symmetrical domain is at the centre of the wire-net compact heat exchanger (see Fig.1c). It is computationally expensive to carry out a Conjugate Heat Transfer (CHT) analysis by holding the primary symmetry (see Fig.1b). Similarly, periodic boundary conditions were implemented in the plane that is perpendicular to the inlet flow direction. A periodicity exists in half of the microchannel foil thickness on every hot and cold side alternatively. Thus, the counter-flow arrangement is simplified into a single hot and cold microchannel with partition foil above it, as shown in Fig.1c.

- How was the numerical model simplified ? How can this be seen in Fig. 1 c, e?

Two types of geometrical symmetry exist in a plane which is parallel to the inlet flow direction. The primary symmetrical domain (see Figure 1b) is along half of the secondary collector diameter, and the secondary symmetrical domain is at the center of the wire-net compact heat exchanger (see Figure 1c). It is computationally expensive to carry out a CHT analysis by holding the primary symmetry (see Figure 1b). Similarly, periodic boundary conditions were implemented in the plane that is perpendicular to the inlet flow direction. A periodicity exists in half of the microchannel foil thickness on every hot and cold side alternatively. Thus, all hot and cold microchannels were simplified into a single hot, and cold microchannels with partition foil above it, as shown in Figure 1c.

- In the section "Microchannel performance", second line: how is defined the thermal efficiency ?

The microchannel thermal efficiency, ε, % is calculated using the relation,

|  |  |
| --- | --- |
|  | (1) |

|  |  |
| --- | --- |
|  | (2) |

where being the hot and cold fluid capacity rates, and are the inlet and outlet temperatures of the counter-flow channels. is the microchannel mass flow rates at hot and cold inlet. The microchannel pressure losses, ∆P, % were calculated using the relation,

|  |  |
| --- | --- |
|  | (3) |

Where, is the inlet and outlet total pressure drop and is the absolute pressure at the inlet.

- Show the collectors in Figure 1.

Cylindrical collectors with wire-net microchannel is shown in Figure 1a.

The primary and secondary collector mesh model is depicted in Fig. 4 a & b, respectively.

- In Figure 1b, it is not clear what is the 2nd symmetry. please explain it in the text.

The primary symmetrical domain (see Fig. 1b) is along half of the secondary collector diameter. Besides, the secondary symmetrical domain is at the centre of the wire-net compact heat exchanger (see Fig. 1c). It is computationally expensive to carry out a CHT analysis by holding the primary symmetry (see Fig. 1b). Similarly, periodic boundary conditions were implemented in the plane that is perpendicular to the inlet flow direction. A periodicity exists in half of the microchannel foil thickness on every hot and cold side alternatively. Thus, the counter-flow arrangement is simplified into a single hot and cold microchannel with partition foil above it, as shown in Fig.1c.

- In Figure 2a, what is the value of Uin?

Uin = 5 m/s

- Please improve the quality of Figure 2b. The caption of Figure 2a should be detailed: explain the two parts of this figure

Fig.2 (a) depicts the non-dimensional velocity contours for plane microchannels and microchannels with wire-net. The non-uniform velocity distribution in plane microchannels (without wire-net) adversely affects the CHE performance as mentioned by Yang et al.[4] due to the least resistance from the inlet to the outlet. This reduces the benefits of counter-flow passages since the maximum velocity gradients lie at two extreme inlets (see Fig.2, (b)). However, the microchannels with wire-net have a homogeneous velocity distribution that retains the counter-flow effects (see Fig.2, (a)). This effects are similar to the conventional grid turbulence theory [5] where a grid generates turbulence that is nearly homogeneous and isotropic, and this is the idealized model assumed in most of the turbulence theory [6].

- The sentence "This steepness increases the working range..." at the end of page 1 is not clear. Please develop and explain.

As the steepness decreases, the microchannels can work at high mass flows with higher efficiency and thereby the number of microchannels required will decrease. As the result, heat exchanger becomes more compact and cost-effective.

- The paragraph beginning by "CHT simulations..." on page 3 is not enough detailed and thus very difficult to understand. Please give more information on the higher order turbulence models used in the simulations.

This paragraph is removed

- There is too much infomartion in Figure 3. It should be separated in several figures with more detailed description. The quality of Figures 3a, b, c, d, e and f should be improved, the sclaes are not visible. What are the black circles and lines inf figures 3a, b and c ?

Since it’s an extended abstract I didn’t add much details into it. I believe the content is too much for this abstract. So I removed it.

- Just below figure 3, it is stated that "the flow separation is strong for normal configuration": how is it evidenced?

This section is deleted

- Which vorticity study are you talking about in the same paragraph? Is there some figures to support to conclusions about the presence of the strong small vortex?

This section is deleted

- Globally, this section "Microchannel performance" is rich of information but not enough structured: it should be developed and structured and the conclusions should be supported by more detailed explanations. The last paragraph dealing with the turbulence production term is really not clear.

It’s one among the production term which shows the influence of Reynolds stress impact on the mean velocity gradients in the flow direction. Shows how the turbulent Reynols stress uv influences the flow in wire-net microchannels. The rest s-shape part is removed.

- In the section "Collector performance", primary and secondary collectors should be more clearly defined and shown in a figure.

Added primary and secondary collector pictures, see Figure 4 (a,b)

- The quality of Figure 4 should be improved. Please use scientific notation for the legend in figures 4b and 4c.

Added

- In the first paragraph of page 5, what do you mean by "Microchannel performance features" ?

Characteristics from the CHT analysis, mainly pressure drop and thermal efficiency.

- Please detail the "free-slip boundary condition" used in the computational analysis.

Wall with zero shear. No rare fraction effects.

- The paragraph just below the equation is not clear.

Equation shows the model equation to calculate accurately the inertial and viscous coefficients with large temperature variations. The accuracy of predicting the porous medium characteristics was presented in my paper [1]. The paragraph shows the primary and secondary collector performance based on reduced order model.

- What do you mean by Lambda2.velocity ?

It’s the vorticity criteria implemented to calculate the strength of vortices in the collectors.

- The last part of this paragraph is really difficult to understand: coud the recirculation zone be represented in the commented figures ? Where is the collector bed ? What do you mean by "remain steady enough to dissipate the integral vortex"?

The picture shows the cross-section (vorticity plot) of the cylindrical collector. Flow direction is show with an arrow for all three configurations. Microchannels are placed perpendicular (right) to the flow direction. Collector bed is at the opposite side of the inlet.

- How is defined the collector flow maldistribution?

For secondary collectors, its defined as the deviation from the idealistic CHT inlet mass calculated using eqn,

For primary collectors, its defined as the idealistic secondary collector mass flow calculated using,

- First line of page 6: where is it shown that "The small collector height primary collector has profoundly influenced the flow distribution as well as the turbulence characteristics"?

Kindly see Figure 5, where different hieghts of the trapezoidal primary collectors are mentioned. Based on the collector height the distribution is affected as well.

The primary trapezoidal collector inlet distributes the flow to 16 secondary collectors and then to 60 microchannels. The maldistribution is depicted in Fig.4, (a). Collector flow maldistribution strongly depends on the secondary flows in the primary collectors. Parametric study on different primary collector heights is shown in Figure Fig.6, (a). As the collector height increases, the maldistribution decreases and the optimum collector height is found to be at 100 mm. The velocity contour of minimum and maximum collector heights is represented in Fig.6, (b & c) respectively. As the height increases, the velocity near the secondary collector inlets decreases, and the recirculation strength also decreases. The highest turbulence production for the maximum height configuration is near the primary collector outlet. The small collector height primary collector configuration has profoundly influenced the flow distribution as well as the turbulence characteristics.

- It is not clear which section of the exchanger is represented in figure 5d.

It’s the cylindrical cross-section of the secondary collector. See Figure 4a as well.

- What is the collector height ?

Height of the trapezoidal primary collector

- In the section "Experimental testing", more explanation should be given on the experimental setup and on the measurements done. How was determined the critical Reynolds number. Please explain Figure 6a more in detail.

Test bench for microchannels with S-shaped perturbators are depicted in Fig.7a. The microchannels were tested for a regime of mass flow rates. It was found that the critical Reynolds number has shifted to lower Reynolds number. Deviation of laminar friction factor to turbulent friction factor (from Blasius profile) occurred at Re=180, see Fig.7b. ﻿This is in good agreement with several studies conducted by Shah and Wanniarachchi [12], Heggs et al. [13], Focke et al. [14] and Liu and Tsai [15] on corrugated plate heat exchanger microchannel geometries. For Shah, the Reynolds critical was less than 200, while Heggs suggested that the flow is never laminar after Re= 150. The rest authors suggested the Reynolds critical is in between Reynolds number 300 and 400. The length scale (roughness, perturbators size) of the microchannels disturbances determines the turbulent transition. If the length scale is too small, the turbulent transition occurs at the conventional Reynolds number. When length scale increases, the critical Reynolds number reduces to smaller Reynolds number.

- The CFD pressure losses are said to be in good agreement with experimental data in figure 6c, but it is not obvious for high temperatures: please explain.

High temperature testing part is removed. Low-temperature testing aimed for Pressure drop studies is only presented. I have added it.

- A general conclusion is missing.

Other remarks and typos:

- All the authors' names should be in the same format (upper or lower case)

- Please define all the acronyms

Its defined at the very beginning. Only two, CHT and ROM.

- 3rd line of introduction in page 1: "enhances "

- 4th line: critical Reynolds

- Can you provide some references for the S-shape perturbators, as done for the wirenet ones ?

[4] N. Tsuzuki, M. Utamura, T. LamNgo, Nusselt number correlations for a microchannel heat exchanger hot water supplier with s-shaped fins. appl. Therm. Eng., 29:3299–3308, 2009.

- page 1, line 5 of second paragraph: "the microchannels with wire-net have more a homogeneous velocity distribution"

the microchannels with wire-net have more ~~a~~ homogeneous velocity distribution"

- page 1, line 6 of second paragraph: "These effects are similar..."

- change "mass flow" in "mass flow rate"

changed

- line 4, page 2: "...term are well-balance."

Modified

- define all the parameters used in the definition of the turbulent production term on page 3

This section is removed

- S-shape instead of s-shape on page 3

Replaced

- end of page 3: "...for the S-shape perturbator is lower (see Fig.3g)

Section is removed

- First line below figure 4 on page 4: "The modelling is performed in three different stages:"

modified

- On page 5, change "mediums" in "media"

changed

- Page 5, line 12: "...global parameters such as pressure drop, thermal efficiency, and turbulent viscosity are determined..."

modified

- Define all the parameters used in the equation on page 5

Its defined in nomenclature

- Just under the equation, Danish is the firstname of the author of the reference cited.

Modified

- 5th line under the equation: change "idealist" in "ideal"

modified

- 13th line under the equation: Fig.4,c instead of Fig.5,c

modified

- Caption of Figure 5: remove the capital letter to Height

modified

- The first sentence of the section "Experimental testing" is grammatically incorrect.

Modified.

- The sentence "Five pressure taps near the microchannel inlets and one pressure tap at the collector inlet" has no verb!

Five pressure taps were installed near the microchannel inlets, and the remaining one was placed at the collector inlet.

- Last sentence of this paragraph: "The comparison between CFD and experimental results is depicted..."

The section is removed.

- No verb in the sentence "High temperature testing of the entire heat exchange model". Is it the title of a sub-section?

Section is removed

- At the end of page 6, the reference Munson et al is not under the right format.

This section is removed.

- Upper legend of Fig.6,b: various

- To what refer m1, m2, m3...in this figure?

6 different mass flows—See Figure 8.

- Check the format of ref [1]

Corrected

- Year is missing in ref [4]

Corrected

- 9th edition in ref [5]

- Give only the initials of authors' firstname in ref [11]

- ref [12]: 6th edition

removed