ICREN-01/2013 **February 16-17, 2013 Constantine, Algeria**
First International Conference on Renewable Energies and Nanotechnology impact on Medicine and Ecology

Numerical Study of the Effect of diameter intern ant extern on the Establishment of the Turbulent Regime in a Coaxial Exchanger

Nada. BENAYAD [a], Nadir.BELLEL[a].

[a]*Energy Physics Laboratory, Department of Physics, University Mentouri of Constantine. Algeria*

Abstract

This work aims to study the effect of changing diameter intern and extern on the length and temperature of the establishment of a turbulent flow in a coaxial heat exchanger with a counter current flow. The study is based on a numerical simulation using fluent software. For better illustration, this study presents a mathematical model governing a flow in the presence of a heat transfer (continuity equation, Navier-Stokes equation and energy equation).

Keywords: coaxial exchanger, fluid velocity, diameter, fluent, length of establishment.

1. Introduction:

In industrial plants, it is often necessary to provide a large amount of heat to the system. In most cases, heat is transmitted through a heat exchanger. An estimated 90% share of energy transfers carried out by the heat exchangers in the industry. The types of exchangers that currently exists in the industry: the coaxial heat exchanger tube (which, we will begin our study) **[1, 2].**
It is of the double pipe with hot water flowing in the central tube while cooling water flows in the annular space.
The main purpose of calculation of heat exchangers is to satisfy the duality between heat transfer and pressure drop that is to say, be a compromise between maximizing the transfer and minimizing the loss by limiting always optimize investment costs and other iterative. In our study follow the numerical approach to validate and better illustrate the results. Our aim in this study is shown the effect of inlet temperature of the fluid on the establishment of turbulent flow in a coaxial heat exchanger.
Flows considered in this work are three-dimensional, permanent, a turbulent incompressible Newtonian fluid. They are governed by equations expressing the transport of mass, momentum and energy presented below; the fluid properties are assumed constant exchanger is adiabatic and without phase change. Most flows of practical importance are turbulent. Various methods are then applied to turbulent flows redesigned to solve physical demand.
In the present work, we will try to apply the known model of turbulence which is the model (K-epsilon) to study three-dimensional turbulent flow in a coaxial heat exchanger. The latter gives a more realistic description of turbulent interaction phenomena by following the evolution of each parameter by the turbulent transport equations **[3, 4.5].** The parallel flow heat exchangers are devices geometrically simple we will expose their properties in detail because, in making important calculations, they provide interesting information and physical form a kind of reference models for other exchangers.

Our work involves the following steps:

• The effect of changing diameter intern on the length and temperature of the establishment of a turbulent flow in a coaxial heat exchanger with a counter current flow.
• Same study but this time for the effect of changing diameter extern in on the length and temperature of the establishment of a turbulent flow in a coaxial heat exchanger with a counter current flow.

Nomenclature

D : Tube diameter m
L_{estab} : length of establishment the tube m
T_{estab} : Temperature of establishment the tube K

Indices / Exhibitor:
c : hot
f : cold
int : Central or inner tube.
ext : Outer tube or annular space.

1.1 Numerical validation: In our study we treat the simplest type of tubular heat exchangers is the coaxial heat exchanger tube. [2] The hot fluid enters the heat exchanger with temperature T_{ce} and exit with T_{cs}, The cold fluid enters with T_{fe} and exits with Tfs. Two Operating modes are possible [6, 7.8]:

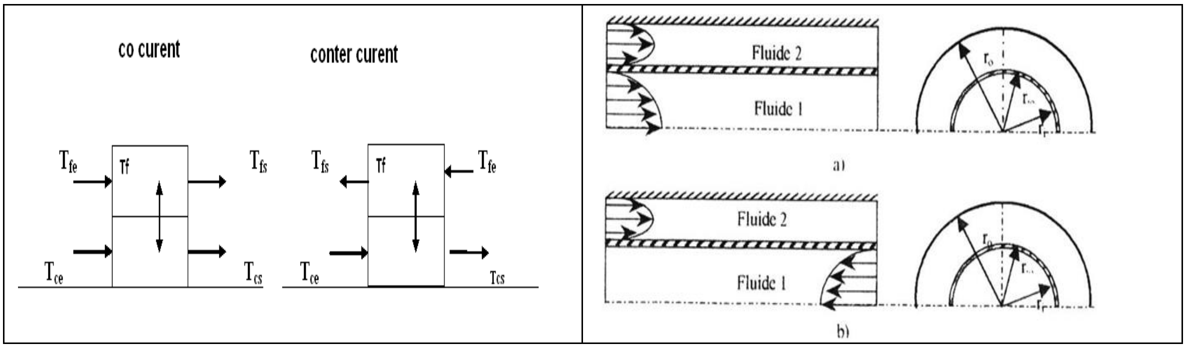


Fig 1: The two commonly used modes.

Mathematical modeling:
Transport equation: The equations governing the turbulent flow are:

Continuity equation:

$$\frac{\partial U_i}{\partial X_i}+\frac{\partial}{\partial x_i}\left(\overline{U}_i+u'_i\right)=0 \quad (1)$$

Reynolds equation. :

$$\overline{U}_j\frac{\partial \overline{U}_i}{\partial x_j}=\frac{1}{\rho}\frac{\partial}{\partial x_j}\left[-\underbrace{\rho\overline{u'_i u'_j}}_{tensiondeReynolds}-\overline{p}\delta_{ij}+\underbrace{\mu\left(\frac{\partial \overline{U}_i}{\partial x_j}+\frac{\partial \overline{U}_j}{\partial x_i}\right)}_{tensiondeN-S}\right] \quad (2)$$

Transport equations of turbulent kinetic energy k **and its dissipation rate** ε **:**

$$\frac{Dk}{Dt}=\frac{\partial k}{\partial t}+\overline{U}_j\frac{\partial k}{\partial X_j}=\frac{\partial}{\partial X_j}\left(\frac{\nu}{\sigma_{k,L}}+\frac{\nu t}{\sigma_{k,t}}\right)\frac{\partial k}{\partial X_j}+\nu t\left(\frac{\partial \overline{U}_i}{\partial X_j}+\frac{\partial \overline{U}_j}{\partial X_i}\right)\frac{\partial \overline{U}_i}{\partial X_j}-\varepsilon \quad (3)$$

The constants of the standard model are those given by Launder and Spalding (74) [6, 7.8] they are assembled in Table1 next:

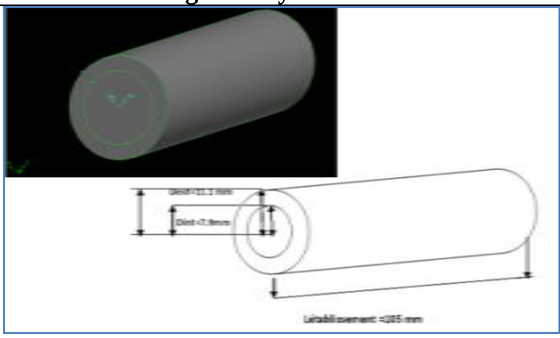
$C\mu$	$C\varepsilon 1$	$C\varepsilon 2$	$\sigma_{k,L}=\sigma_{k,t}$	$\sigma_{\varepsilon,L}$	$\sigma_{\varepsilon,t}$
0.09	1.44	1.92	1.0	1.0	1.3

Table 1: Constants standard data model by Launder and Spalding (1974).

Simulation software based on finite volume solves the equations of motion of turbulence exposed.

Simulation Software: The software simulation is performed in Fluent, using equations in the preceding paragraphs. It allows the resolution of the equation system and publishing the results in specific files [6]. The study was performed on a coaxial exchanger whose parameters are grouped in the following table. The geometry considered is shown in the figure below, these conditions are summarized in the following table

the geometry



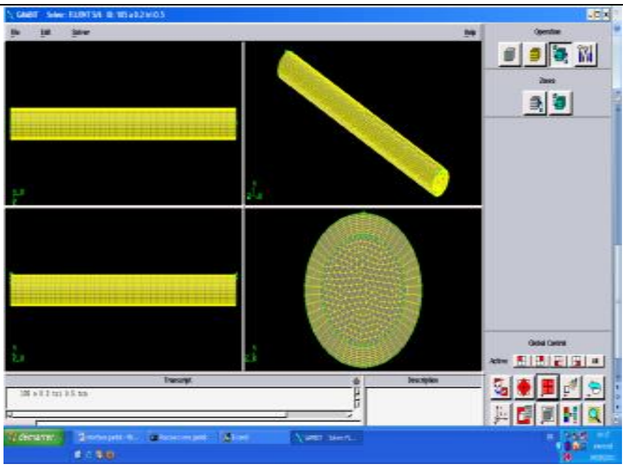
The conditions at the entrance

geometry	**Cylindrical.**
Flow regime	**Turbulent.**
Speed of the cold fluid (m/s)	**0.4**
Speed of hot fluid (m/s)	**0.3**
Hydraulic diameter cold(mm)	**3.2**
Hydraulic diameter hot (mm)	**7.9**
cold fluid	**water**
hot fluid	**water**

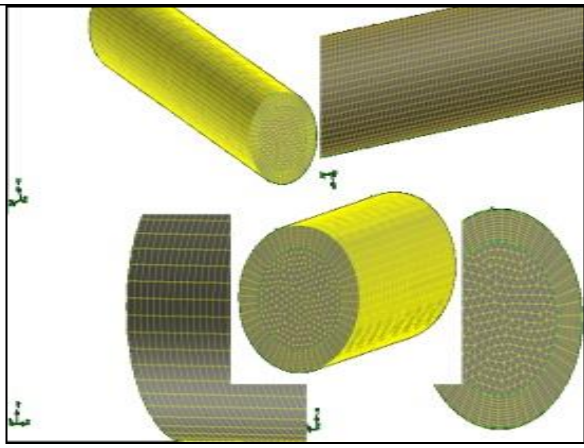
Fig 1: physical and geometrical parameters of the water exchanger water

Meshing: The construction of geometries with mesh generation and the incorporation of boundary conditions are performed by the processor GAMBIT. The tetrahedral mesh structure was adopted for the central tube and structured hexahedral mesh was adopted for the annulus. For better accuracy of results, a mesh dependence test must be performed for different numbers of cells.

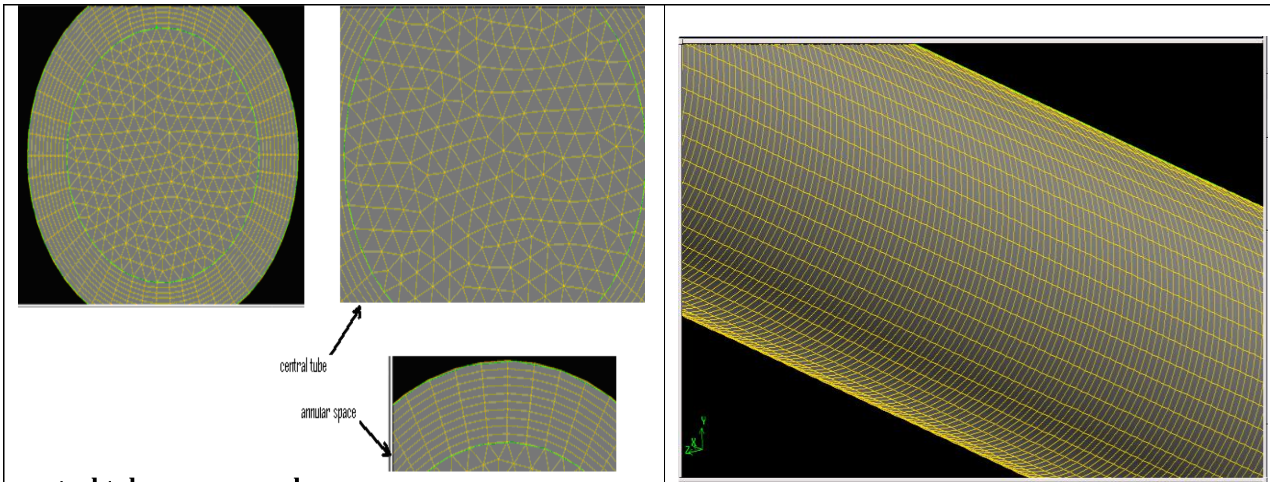
In the present work for this geometry and the study was done with a mesh composed of 243,140 cells.



interface GAMBIT



exchanger coaxial mesh different profiles



central tube , annular space **Lateral surface.**

Fig2: The detail of the mesh...

The boundary conditions:

The specification of boundary conditions is performed according to the problem addressed. Note that the space mesh is assumed as fluid....

Table 2: the boundary conditions in GAMBIT.

Region	**Geometry (cylindrical exchanger)**
entry	**Velocity inlet**
output	**Out flow**
Wall	**Wall**

3. Results and discussion:

3.1 Study of the effect of change speed of the hot fluid on the establishment of the regime:

The experimental data used in this study are: diameter inern = 7.9 (mm) , diameter extern = 11.1 (mm) are colored red in the results on the table. Here we have used a numerical study, we varied the values of diameter intern around the value 7.9 at most and at least send the effect of this change on the length and temperature establishement.

Effet de diametre interne (du tube centrale) :

With a study similar to previous one but this time varying the diameter extern around the value 11.1mm we obtain the following results:

For the fluid water - water and the same conditions of temperature input and speed hot and cold by changing the internal diameter of the heat exchanger and keeping the external diameter = 11.1mm = constant (real internal diameter = 7.9mm)

The results are shown in the following table: The results provided by the software:

Dint (mm)	3.9	6	7	7.9	8.5	9	10.2	10.7	10.9
Dext (mm)	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.1
L étab (mm)	70	90	100	100	190	100	450	120	/
T étab (K)	292	297	301	304	308	313.7	315.5	319	/

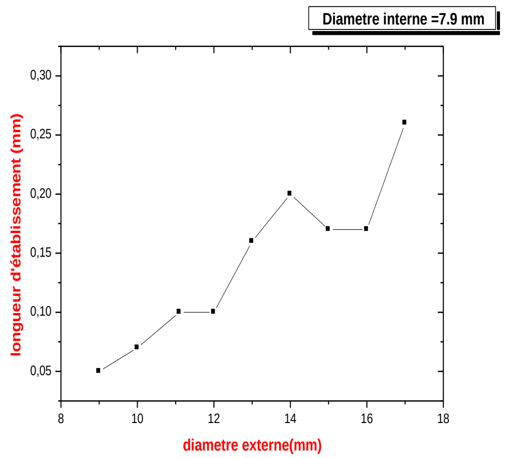
Effect of external diameter: water to water heat exchanger with internal diameter = 7.9mm = constant and changing the external diameter:

The data software to draw the curves:

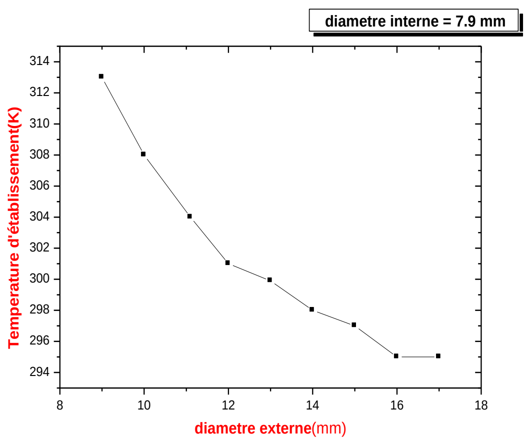
D ext (mm)	9	10	11.1	12	1. 1 3	14	15	16	17	18
D int (mm)	7.9	7.9	7.9	7.9	.9	7.9	7.9	7.9	7.9	7.9
Letab (mm)	50	70	100	100	160	200	170	170	260	/
Etab(K)	313	308	304	301	299.9	298	297	295	295	/

The results are shown in the following lines:

Effect of internal diameter

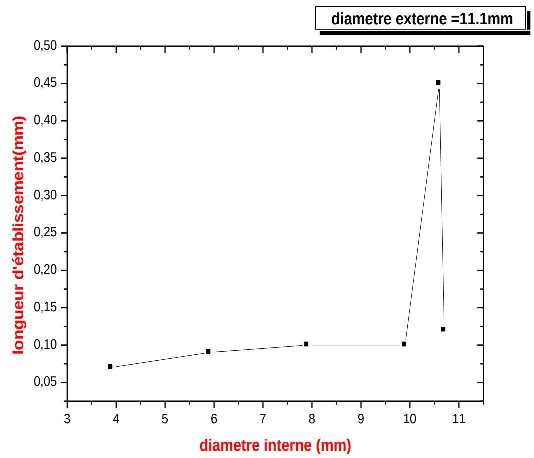


$L_{estab}=f\ (d_{ext})$

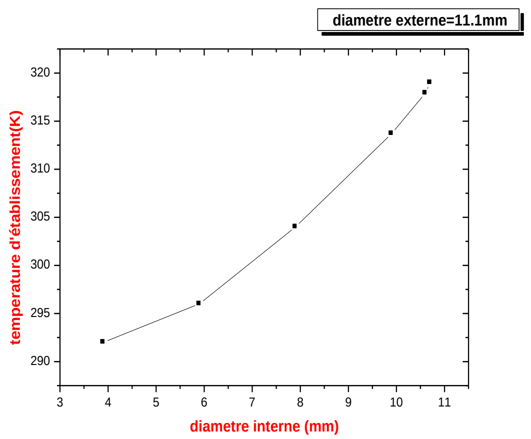


$T_{esab}=f\ (d_{ext})$

Effect of external diameter



$L_{\ estab}=f\ (d_{int})$



$T_{\ estab}=f\ (d_{int})$

Discussion of the results :

We observe on this figure:

Effect of change in internal diameter:

On the lengueur of establishment:

We note that the higher the internal diameter increases more lengueur setting increases, but it increases gradually to a diameter interval (3.9,9) mm and has a peak dint = 10.2mm, then it désend after this value.

On The temperature of establishment :

We note that the higher the internal diameter increases as the temperature increases settlement arguably varies a proportional manner.

Effect of change in external diameter:

On the lengueur of establishment:

We note that the more external diameter increases more lengueur setting increases. But increases in a progressive manner for the range of diameter (9.12) mm and there has been a more rapid increase in the interval (12,17) mm and a small dimunition in the interval (14,15) mm then it remente another time

On The temperature of establishment:

We note that the higher the external diameter is increasing the temperature of establishment decreasing arguably varies from invercement proportional manner.

4. Conclusion :

Diameter intern:

On the lengueur of establishment:

¬ We note that the higher the internal diameter increases more *lengueur of* establishment increases, but it increases in a gradual manner

on The temperature of establishment :

¬ We note that the higher the internal diameter increases as the temperature of establishment increases settlement arguably varies a proportional manner.

External diameter:

On the lengueur of establishment:

¬ We note that as the external diameter increases more lengueur of establishment increases, but it increases in a gradual manner.

on The temperature of establishment :

We note that as the external diameter is increasing the temperature of establishment decreasing arguably varies from invercement proportional manner.
So for a good length of establishment and temperature of establishment we must be a balance between the intern diameter and extern diameter, although précisaement we propose to édtudier ratio Din / Dext for each tubular heat exchanger.

References

[1] J. Padet.Echangeurs thermiques d'Editions MASSON 1994.
[2] A. Bontemps, A. Garrigue, C. Goubier, J. Huetz, C. Marvillet, P. Mercier, R. Technologie des échangeurs thermiques Vidil Editions Techniques de l'Ingénieur
[3] J. CrabolTransferts de chaleur (Tome 2) éditions Masson 1990.
[4] P.Tobaly.Echangeurs de chaleur.IUT de St Denis Licence Professionnelle Module Ingénierie des systèmes multi techniques .14 mars 2002.
[5] **:** M. MOUSSA, J. MARIE PERRIERCORNET. Échangeur de Chaleur: échangeur tubulaire et Échangeur à surface raclée, JEAN CASTAING LASVINOTTES 2002.
[6] Y.JANNOT, P.MEUKARM. Simplified estimation method for determination of thermal effusively and thermal conductivity with a law cost hot strip .measurement science and Technologies, vol.15, pp.1932-1938, 2004.
[7] H.JOHN LINHARD IV. H.JOHN LIENHARD V. A heat transfer text book third edition version 1.23 dated January 2005.
[8] J.F.SACCADURA. Initiation aux transferts thermiques, paris 4 éme tirage 1993.
[9] H.JOHN LINHARD IV. H.JOHN LIENHARD V. A heat transfer text book third edition version 1.23 dated January 2005.