Abstract
This work deals with a numerical simulation of a Taylor-Couette flow (TCF) problem based on the finite-volume method using Fluent software. We investigate the effect of the inner cylinder on the flow behaviour when it is submitted to both rotation and periodical radius variation with the upper and lower end-walls and outer cylinder are maintained stationary. The basic system with a height $h=200\text{mm}$, a ratio of the inner and outer radii $\eta=0.9$, an aspect ratio corresponding to the cylinder height reported to the gap length ratio, $\Gamma=40$ and a ratio of the gap to the radius of the inner cylinder is $\delta=0.1$. The motivation, in addition to its connection with the classical Taylor-Couette system, is to assess the response of this new modeling controlling technique flow, in terms of the critical value of the Taylor number, $T_c$, for the first instability. The variation of the inner cylinder cross-section is carried out using the dynamic mesh program realised with an UDF/User Defined Function, constructed to modify the shape of the grid cells and to ensure the desired deforming motion. We note that the amplitude variation substantially affects the conditions of apparition of the first mode of instability (Taylor vortices) corresponding in the nominal case to $T_c = 41.3$ and advanced to $T_c = 17.66$ When the deforming amplitude is fixed at $\varepsilon = 5\%$. For then more, a considerable decrease in the friction coefficient, around 40%, is registered.

The Taylor–Couette flow is a viscous, incompressible fluid flow evolving in an annular space of two coaxial cylinders rotating around their common $z$ axis. This apparatus is widely used in many industrial and researching processes found in chemical composition, mechanical tribology and nuclear engineering. In 1890, M. Couette [1] was the first to investigate this class of flows, he was interested in measuring the dynamic viscosity of the fluid. Lord. Rayleigh [2] studied the behavior and the stability of the inviscid rotating flows. G.I. Taylor[3] investigated analytically and experimentally the flow between two concentric cylinders and successfully determined the stability of the fluid contained between the rotating cylinders. A. Bouabdallah [4] presented a theatrical and experimental study for various regimes of transition from laminar to turbulent. Previously the effect of circular cylinder cross section variation on the near wake behavior measurements by H. Oualli and al. [5]. Subsequently, in 2010, A. Lalaoua and al. [6] used Fluent software to make a prediction of the Taylor-Couette flow subjected to a radial deforming outer cylinder. In the present study, we consider a flow control strategy capable of spatially localizing the Taylor vortices between two concentric rotating cylinders. To this end, we proceed by actuating the geometry of the TCF to affect the vortices appearing in the radial direction along the length of the apparatus. Particularly, we are interested in investigating the impact of a pulsatile radial motion of the inner rotating cylinder on the Taylor vortex flow (TVF) in an infinite length.
cavity. We conduct numerical simulations using a finite-volume approach. It is found that a destabilization of the TVF results from the interplay of the imposed oscillating radial flow and the flow resulting from the Taylor instability.

We briefly describe the numerical procedure used to solve the problem. The grid is generated using the Gambit program and saved on a structured quadrilateral grid. The volume of the annular gap is constructed on 120×120×7 cells shown in fig.1. The deformation of the inner cylinder diameter is executed using the dynamic mesh program. The Taylor-Couette device is in its classical configuration as stationary outer cylinder and rotating inner cylinder. The flow structure for $T_{c1}=41.33$ corresponding to the appearance of the first instability given in the fig.2.b. This numerical result is in a good agreement with the experimental value reported by A. Bouabdallah, fig2.a equal to $T_{c1}=41.2$ for the same geometrical conditions. Therefore the deviation between our results and the experiment is evaluated to less than 0.3%.

The variation of the first critical Taylor number $T_{c1}$ with the amplitude of deformation is seen in fig. 3. For amplitude of $\varepsilon = 0.1\%$, the first critical Taylor number $T_{c1}$ increases from 41.2 to 42. This tendency reverses completely when $\varepsilon$ exceeds 0.1% and the critical Taylor number decreases rapidly until $T_{c1}=17.66$ for $\varepsilon=5\%$, after which the rate of decline moderates.

When the inner cylinder diameter is superimposed to a periodical motion with an amplitude, the circular cells shown in the natural case are squeezed in the gap leading to a pattern of an elongated

---

**Fig. 1. 3D-grid with quadrilateral**

**Fig. 2. a)Experiment results, A. Bouabdallah  b)Presents results**

**Static pressure**

**Fig.3 Critical Taylor number $T_{c1}$ and $T'_{c1}$ versus deforming amplitude rate $\varepsilon$ of the radius of the rotating inner cylinder**
shape as shows at fig.1.a. This observation remains valid when the amplitude of the deformation is increased. For $\varepsilon = 1\%$, the cells shape shifts completely from circular to an oval one.

Fig. 4. Onset of the Taylor vortices versus amplitude deforming rate $\varepsilon$ near the threshold $Tc_1$ and $T'c_1$.

Fig. 5. shows the evolution of the friction coefficient $C_\ell$ versus the axial position $z$ on the wall of the outer cylinder for $r = R_2$. We note that the same behaviour as for the nominal case, for the values and the evolution of the friction coefficient for this small excitation amplitude, $\varepsilon = 0.1\%$. For the average amplitude, the tendency completely shifts and the coefficient of friction reduces up to 35% at the borders of the cylinder and decreases drastically to become close to zero at the mid height of the cylinder. We can notice also, the appearance, of an “energetic sink” for the coefficient of friction. When we consider the high amplitude value, $\varepsilon = 5\%$, we note that the coefficient of friction $C_\ell$ is decreased to over 34%, compared with its nominal value, with the difference that the “energetic well” vanishes and this value is found on the whole high of the cylinder. In the first step of this study, we considered the Taylor–Couette flow system with a rotating inner cylinder while the outer cylinder is at rest. In the second step, the inner cylinder is forced radially to increase and decrease alternatively.
It comes out the following mains results,

- The technique of deformation delays the first instability appearance on a narrow range of the deforming amplitudes before a complete reversal of this behaviour beyond the threshold amplitude value of $\varepsilon=0.1\%$.
- As the amplitude is increased, the critical Taylor number $T_{c1}$ reduced considerably from $T_{c1}=41.3$ to the value of $T'_{c1}=17.66$ compared with nominal case.
- Besides, it is noted that the radial vibration motion reveals a remarkable result of a drastic reduction of the friction coefficient, approximately 35%, compared with nominal case with the appearance of an “energetic sink” for the coefficient of friction which becomes null at the mid high of the outer cylinder. As future work, we attempt a numerical approach of the second instability characterized by the onset of the azimuthal wave subjected to controlling.

**Keywords:** Fluent package CFD, Radial deforming cylinder, Taylor-Couette flow, Dynamic pressure, Taylor vortices, Laminar-turbulent transition regime.

**REFERENCES**