Table 2

Comparison of solutions for different grids between the present work and the work of Iwatsu (2004), for $Re=10^3$, $R_i=0$, $P_r=1$ and $A=1$, where $R_i=Gr/Re^2$ is the Richardson number.

	Iwatsu (2004)			Present work		
	41×41 nodes	61×61 nodes	161×161 nodes	42×42 nodes	62×62 nodes	162×162 nodes
$\overline{Nu}$	5.805	5.736	5.708	5.807	5.705	5.695
$\lvert\psi\rvert_{max}$	9.96×10^{-3}	9.71×10^{-3}	9.64×10^{-3}	9.57×10^{-3}	9.55×10^{-3}	9.56×10^{-3}
$\lvert\psi\rvert_{min}$	2.51×10^{-7}	1.59×10^{-7}	1.29×10^{-7}	5.87×10^{-7}	1.56×10^{-7}	1.21×10^{-7}

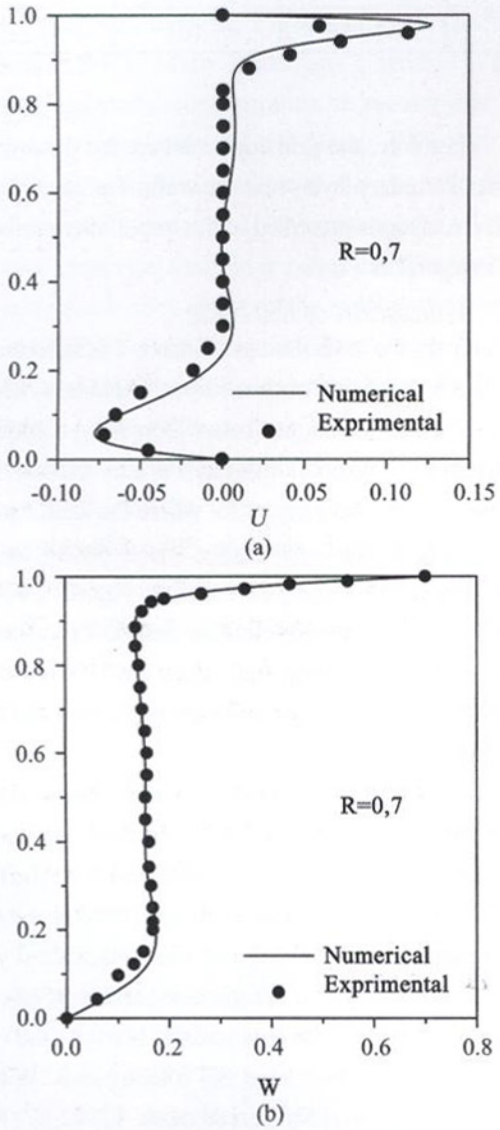

Fig. 2. Radial and azimuthal velocities distributions at R=0.7 : Comparison between the numerical results and the experimental data of Michelson (1986), for Re=1000 and $A=H/r_c=1$.

4. 3. Steady and oscillatory solutions with and without magnetic field

The study carried out is characterized by the graphic visualization of iso-contours of the dimensionless stream function ψ , defined as $U=\frac{1}{R}\frac{\partial\Psi}{\partial Z}$, of isotherms, the temporal evolutions of U, V, and θ. In this work, we are interested in the critical point for which the flow becomes oscillatory. For that, we have made a series of experiments simulations, by increasing progressively the value of Grashof number Gr, and we examine the behaviour in time of the numerical solutions at some monitoring points selected.

For each value of the Hartmann number Ha, we detect the critical Grashof number Gr_{Cr}. Generally, the beginning of the oscillations appears suddenly when Gr is slightly increased from the steady state (Figs. 3a-b) close to the critical state. The value of Gr_{Cr} corresponds to the amplitude of oscillation of largest dimensional velocities (Wakitani, 2001).

At low Grashof number, the flow presents a unicellular mode. When the Grashof number is increased, the separation of the main cell occurs in the medium of the cylinder and gives rise to secondary cells. Figure 4a presents the steady flow structure for $Gr=0.7\times10^6$. According to this figure, we can see a secondary cell at middle height of the cylinder. The flow becomes oscillatory for $Gr=0.8\times10^6$, and the flow structure for this value presents two contrarotating cells (Fig. 3a). The application of the magnetic field has an effect to stabilize the fluid flow. When the magnetic field is applied (Ha =10), the flow structure is constituted of two recirculation