marching procedure until the steady state is reached. The incremental unknowns (IU) were introduced by Temam [24]. In these new numerical schemes the large scale component Y for the unknown and its small scale component Z are treated differently.

Consider a discretized approximate solution on N equally spaced grids to be $U = \left(Uh(ih)\right)_{i=1..N}$, where $h = \frac{1}{N}$. We split U into two components Y and Z by the means of a matrix of passage noted S, which gives:

$$U = S\begin{pmatrix}Y\\Z\end{pmatrix}, \quad and \quad \begin{pmatrix}Y\\Z\end{pmatrix} = S^{-1}U \quad (8)$$

Based on the above consideration the relationship between variables at two successive time steps is given by

$${}^{t}SS\begin{pmatrix}Y^m\\Z^m\end{pmatrix}+\Delta t\,{}^{t}SAS\begin{pmatrix}Y^{m-1}\\Z^{m}\end{pmatrix}={}^{t}SS\begin{pmatrix}Y^{m-1}\\Z^{m-1}\end{pmatrix}+\Delta t\,{}^{t}SS\begin{pmatrix}F_Y^m\\F_Z^m\end{pmatrix}$$

Many new schemes can be designed by using the IU principle. Its Crank-Nicolson like scheme is written in the following form:

$$\left({}^{t}SS+\Delta t\,{}^{t}SAS\right)\begin{pmatrix}Y^m\\Z^m\end{pmatrix}=\left({}^{t}SS\right)\begin{pmatrix}Y^{m-1}\\Z^{m-1}\end{pmatrix}+\Delta t\,{}^{t}SS\begin{pmatrix}F_Y^m\\F_Z^m\end{pmatrix} \qquad (9)$$

3.4 Result and Discussion

The boundary conditions, the pre-simulation time period (warm-up), the size of the physical domain, the simulation time step, the grid refinement, the convergence errors and the required computer run time are important simulation parameters, which have to be chosen very carefully in order to accurately predict temperature and moisture content profiles in mortar slab under different sort of weather data.

In this subsection we present the results of the linear 1D problem. The boundary conditions and the initial conditions, as well as the geometry remain the same. The situation under study is one-dimensional heat and mass transfer in a homogeneous porous mortar of thickness L similar to the tests problems used by Lefebvre and Izequierdo [1998], with the initial and boundary conditions for both temperature and moisture content:

$w(x, t = 0) = 0.07\ kg/kg\ ;\ T(x, t = 0) = 20°C$
$w(x = 0, t) = 0.031\ kg/kg\ ;\ T(x = 0, t) = 5°C$
$w(x = L, t) = 0.025\ kg/kg;\ T(x = L, t) = 23°C$

The temperature and the moisture content were monitored at the positions $x = 0.125L$ (near the cold end). The sensitivity of the computed result was checked by running two different space girding n=200 and n=300 in conjunction with two different time steps $\Delta t = 0.1$and 1 s. The results obtained with these time and space grid sizes did not show any differences neither in convergences nor in accuracy for both temperature and moisture content except that with $\Delta t = 1s$ convergence toward the steady state is reached in fewer computation steps. We can safely conclude that the results presented in this paper are grid free solutions. The accuracy of the numerical method used to solve this problem is compared to the exact solution.

The temperature decay profiles near the cold end obtained with the different models are plotted in figure 2, figure 3 and figure 4 along with the analytical linear solution for comparison purposes. The moisture results at these same locations are presented in figure 5 and figure 6.

A perfect matching between the computational results of the incremental unknown scheme and the analytical solution is obtained. The influence of taking into account the phase change rate is not that significant for the temperature evolution. However, as presented in figure 6 results of the moisture content decay show clearly that the evolution is strongly affected by the presence of the phase change rate.

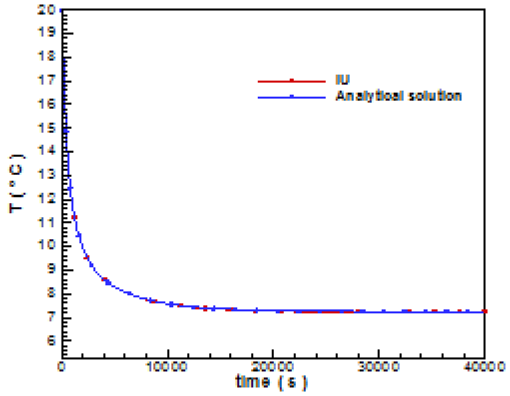

Figure 2: Evolution of temperature at $x = 0.125L$ of the mortar slab (Philip and DeVries's model).

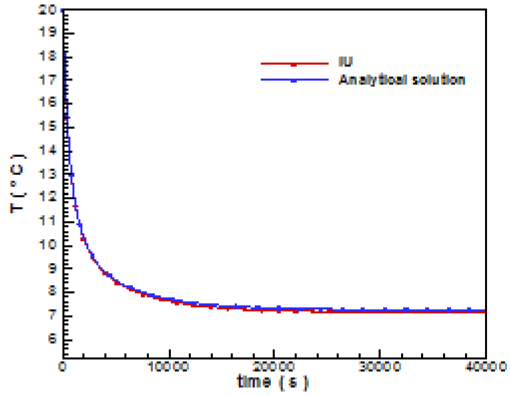

Figure 3: Evolution of temperature at $x = 0.125L$ of the mortar slab (Luikov's model).

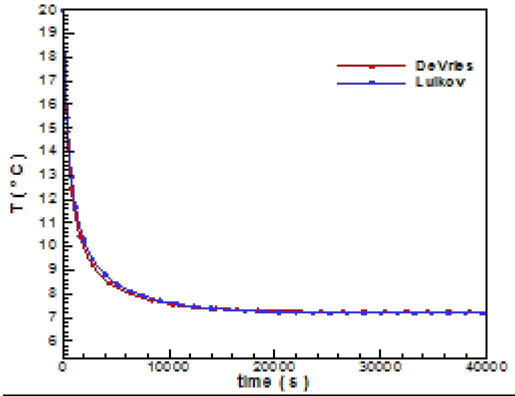

Figure 4: Evolution of temperature at $x = 0.125L$ of the mortar slab (Philip and DeVries and Luikov's model).

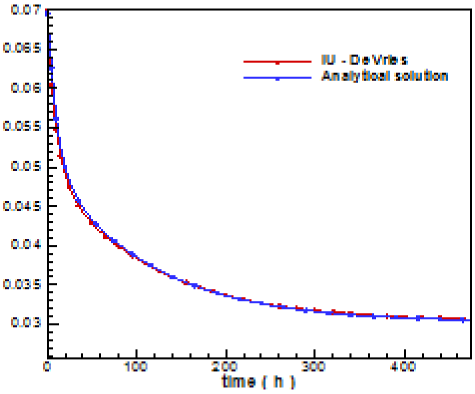

Figure 5: Evolution of the moisture content at $x = 0.125L$ of the mortar slab (Philip and DeVries's model).

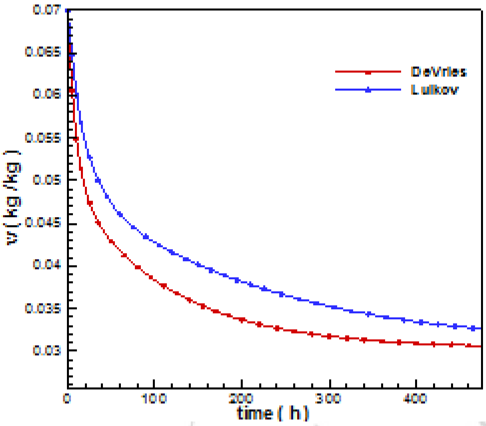

Figure 6: Evolution of the moisture content at $x = 0.125L$ of the mortar slab (Philip and DeVries and Luikov's model).

4. Conclusion

Numerical experiment was conducted in order to assess the impact of the phase change rate on time variation of temperature and moisture content in a homogenous porous material also compared the results obtained with analytical solution to that obtained using the incremental unknown schemes. The stationary 1D heat and moisture transfer problem as formulated by Philip and DeVries and Luikov is solved with analytical solution and IU method. The 1D linear test problems show that solution of the water content in the porous material is greatly affected when phase change rate taken into account while the transient temperature solution remains mainly identical for both models. These remarks should be taken into account when predicting the water content and temperature evolution during thermal processes of porous material. For the water transport two phenomena take place. First, the increasing product temperature leads to an increase of partial vapor pressure of water, and therefore the partial vapor pressure for water in the region close to surface is higher than in the center. Due to the pressure differences, the water vapor moves both to the centre and to the surface.

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