## ⑥ Continuity Equation in $(\xi, \eta, \varsigma, t)$ coordinates

Using operator (3.3), the continuity equation (2.12) becomes

$$\frac{\partial H_\theta}{\partial t} + mn\left[\frac{\partial}{\partial \xi}\left(\frac{H_\theta u}{n}\right) + \frac{\partial}{\partial \eta}\left(\frac{H_\theta v}{m}\right)\right] + \frac{\partial}{\partial \varsigma}\left(H_\theta \Omega\right) = 0$$

dividing by $mn$ gives

$$\boxed{\frac{\partial}{\partial t}\left(\frac{H_\theta}{mn}\right) + \frac{\partial}{\partial \xi}\left(\frac{H_\theta u}{n}\right) + \frac{\partial}{\partial \eta}\left(\frac{H_\theta v}{m}\right) + \frac{\partial}{\partial \varsigma}\left(\frac{H_\theta \Omega}{mn}\right) = 0} \qquad (4.5)$$

Similarly the flux form of the material derivative becomes

$$\boxed{\frac{H_\theta}{mn}\frac{\mathcal{D}A}{\mathcal{D}t} = \frac{\partial}{\partial t}\left(\frac{H_\theta A}{mn}\right) + \frac{\partial}{\partial \xi}\left(\frac{H_\theta u A}{n}\right) + \frac{\partial}{\partial \eta}\left(\frac{H_\theta v A}{m}\right) + \frac{\partial}{\partial \varsigma}\left(\frac{H_\theta \Omega A}{mn}\right)}$$

(4.6)

Where $A$ is any fluid property (scalar or vector)