Supplementary Materials

(Detailed description of the numerical analysis model)

1. Shear-stress transport (SST) k-ω model

In the shear-stress transport (SST) k-ω model to predict the flow of rim seal is as follows, the turbulent kinetic energy k and the specific rate of dissipation ω are calculated using the following transport equation.

$$\frac{\partial}{\partial t}(\rho k)+\frac{\partial}{\partial x_i}(\rho k u_i)=\frac{\partial}{\partial x_j}\left(\Gamma_k\frac{\partial k}{\partial x_j}\right)+G_k-Y_k+S_k$$

$$\frac{\partial}{\partial t}(\rho \omega)+\frac{\partial}{\partial x_j}(\rho \omega u_j)=\frac{\partial}{\partial x_j}\left(\Gamma_\omega\frac{\partial \omega}{\partial x_j}\right)+G_\omega-Y_\omega+D_\omega+S_\omega$$

G_{k} : the production of turbulence kinetic energy.

G_ω : the generation of ω, $G_\omega=\alpha\frac{\omega}{k}G_{\mathrm{k}}$

Γ_k and Γ_ω : the effective diffusivity of k and ω.

Y_k and Y_ω : the dissipation of k and ω due to turbulence.

D_ω : the cross-diffusion term.

S_k and S_ω: user-defined source terms.

2. Species transport model

The local mass fraction of each species, Y_i, is predicted through the solution of a convection-diffusion for the i^{th}, species. This conservation equation takes the following general form.

$$\frac{\partial}{\partial t}(\rho Y_i)+\nabla\cdot\left(\rho\vec{V}Y_i\right)=-\nabla\cdot\vec{J}_i+R_i+S_i$$

R_i : the net rate of production of species i by chemical reaction.

S_i : the rate of creation by addition from the dispersed phase plus any user-defined sources.

$\vec{J}_i$: the diffusion flux of species i, which arises due to gradients of concentration and temperature.

The mass diffusion in turbulent flows is as follows.

$$\vec{J}_i=-\left(\rho D_{i,m}+\frac{\mu_t}{Sc_t}\right)\nabla Y_i-D_{T,i}\frac{\nabla T}{T}$$

$D_{i,m}$: the mass diffusion coefficient for species i in the mixture.

$D_{T,i}$: the thermal (Soret) diffusion coefficient.

Sc_t : the turbulent Schmidt number. $Sc_t=\frac{\mu_t}{\rho D_t}$, where μ_t is the turbulent viscosity and D_t is the turbulent diffusivity.

Reference

1. ANSYS Fluent. 15.0 Theory Guide.