SIMPLE is the acronym for Semi-Implicit Method for Pressure-Linked Equations.

1. SIMPLE is well-suited to solving numerical models of incompressible flow. A key ingredient of SIMPLE is its insistence on mass conservation at each iteration toward the final solution.

2. The equations for $u$, $v$, and $w$ are obtained from the $x$, $y$, and $z$-direction momentum equations. Usually the finite volume method is used to derive the discrete equations when SIMPLE is used.

3. The equation for $p$ is obtained from the continuity equation.

4. Discrete equations for $u$, $v$, $w$, and $p$ are solved sequentially. For example, to solve the $u$ equation, the current values of $v$, $w$ and $p$ are assumed to be known – only $u$ is allowed to change.

5. At the end of one iteration of SIMPLE, the local velocity components for each cell are adjusted so that mass conservation for each cell is maintained. The solution algorithm is a sort of organized tug-of-war between the momentum equations and the mass conservation equation (continuity).

6. Numerical solution of the flow field requires outer and inner iterations.
   (a) One outer iteration involves the sequential solution of the $u$, $v$, $w$, and $p$ equations, i.e., one iteration of the SIMPLE algorithm.
   (b) Inner iterations are the iterative solution to each of the linearized $\phi$ equations. The equations are linearized in the sense that other $\phi$ variables are frozen, and any other non-linearities are frozen. The $\phi$ variables are $u$, $v$, $w$, $p$ and other scalars such as turbulence quantities, temperature, species concentration, etc. The linearized $\phi$ equations are solved by an iterative method instead of a direct method (i.e., a variant on Gaussian elimination) because
      • the system of equations is large and sparse,
      • the linearized equations have coefficients that depend on the other $\phi$ variables. It doesn’t make sense to reduce the residuals too much since the coefficients will change on the next outer iteration.
   (c) Stable and efficient solution of the coupled, nonlinear system of equations involves balancing the work done by the inner and outer iterations. Control of the inner and outer iterations involves several additional user-adjustable parameters.
      • Under-relaxation parameters for each $\phi$ field
      • Residual tolerances for iterative solution of each $\phi$ field
- Upper limits on the number of iterations for the inner solver for each \( \phi \) field.

The goal is to approach the minimum number of inner iterations that are necessary for stable outer iterations. In other words, excessively accurate solutions to the linearized

7. Convergence is obtained when the normalized residuals for all of the \( \phi \) variables are reduced below the tolerance. For hard problems, convergence may require modifications to the default solution parameters for the CFD code.

(a) Adjust the solution parameters for inner iterations of the \( \phi \) equations. For incompressible flow, the solution of the pressure equation is critical. A more stable solution can sometimes be obtained by putting more effort into solution of the pressure correction (or pressure) equation – tighter tolerance or an increase in the maximum number of allowable iterations.

(b) Use of a pseudo-transient simulation for steady problems: treat the initial guess as the initial condition for a transient problem. Adjust the time step of the pseudo-transient so that a stable solution is obtained, but ignore the transient results: only the steady-state solution is of interest.