Insertion of Prism layers in this filtered geometry is very successful due to absence of vertices and ridges. For the selected domain, 99.99% of the Pit boundary area is inserted with 3-layers of Prism elements without any holes.

SIGNIFICANCE OF GOOD QUALITY MESHING

Convergence in Solution

Good quality meshing helps the Solver to converge a solution. Occasionally, a single bad element is enough to cause extensive divergence in solution. Figure 12 shows velocity min/max plot of a steady state analysis of the meshed pit with bad tetra elements and holes in the prism layers. Extensive fluctuations in velocity values represent a poor quality meshing of the domain.

Figure 13 shows velocity min/max plot of a good quality mesh of the same geometry with the similar boundary conditions. A steady state is reached at the 628th cycle. Almost linear pattern of the plot (Figure 13) at the final stage indicates a good convergence and a very low fluctuation in the residuals.

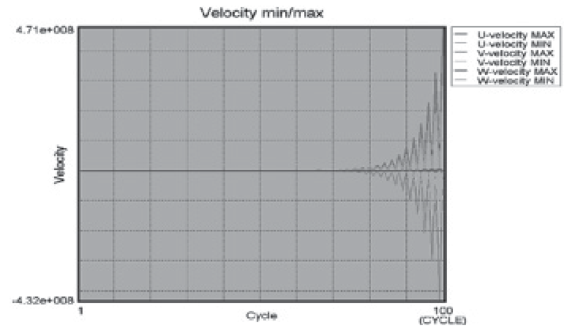

Figure 12. Velocity Min/Max plot of poorly meshed pit.

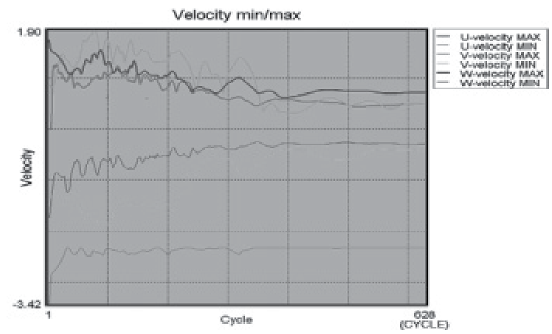

Figure 13. Velocity Min/Max plot of good quality mesh.

Boundary layer formation: Prism Layers

It has been stated previously that the prism layers are significantly important at the roughness boundary. To examine the significance of prism layers, a simplified pit was simulated twice with similar boundary conditions. However, in one mesh, no prism layers were inserted, and in the other, there are 5 layers of prism elements at the Pit boundary. For both the mesh, initially a steady state condition is reached using only an inlet velocity. These steady boundary conditions are then used as input to the transient simulation. In the transient simulation, a Heat Flux quantity of 160 W/m^2 was provided from the Pit boundary. Figure 14 shows the contours of 'magnitude of velocity' plot of these models utilizing two different meshes along the same plane of Y = 869.275m. This figure displays the velocity magnitude contours after 2 hrs. of simulation.

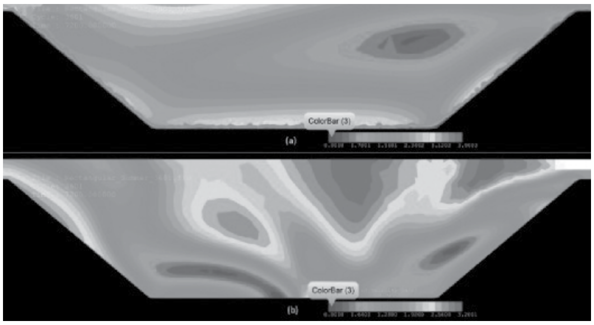

Figure 14. Magnitude of velocity contour plot of (a) No Prism Mesh and (b) Pit Boundary prism mesh.

The velocity contour plot of the model domain with prism layers displays an excellent velocity boundary layer formation and its stratification near the Pit Boundary. The model without the prism mesh represents a lack of accuracy in resolving the roughness and the heat flux at the Pit boundary, resulting in a poor velocity boundary layer formation at the Pit boundary.

Figure 15 shows a temperature plot for both the meshes. In the model with no Prism mesh, the temperature at the Pit boundary reaches a value of 94.02OC, while in the model with prism mesh, the maximum temperature reached at Pit boundary is 75.7OC. Figure 15 plots the temperature contours.

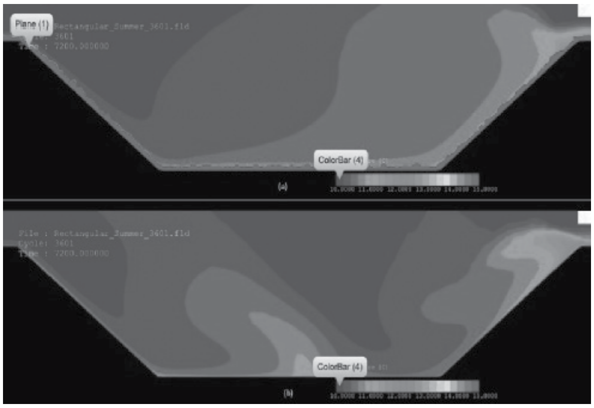

Figure 15. Temperature contour plot of (a) No Prism Mesh and (b) Pit Boundary prism mesh.

The model domain with prism mesh evidently accounts for the heat flux at the Pit Boundary better than the model domain without prism mesh, as shown in figure 15. Absence of the prism layer not only affects the formation of a thermal boundary layer at the heat source (Figure 15(a)); it simultaneously affects the thermal convection inside the volume of the model domain. This results in an inaccurate temperature rise/drop inside the volume of the model domain, and as such an inaccurate estimation of buoyancy flow. Completely different flow regimes (Figure 14 (a), 14 (b)) are resulted due to the inaccurate estimation of the thermal buoyancy.

CONCLUSIONS

The vertices and the ridges at the mine topography must be removed for a good quality mesh. Insertion of good quality prism layers at the roughness boundary