OCTREE

The SC/Tetra Preprocessor controls the size of the mesh 3-dimensionally by an Octree. Generally, it starts with a cube (root octant) that completely surrounds the entire model domain. The cube is then divided into eight cubes recursively to create a set of sub-cubes that fill up the entire model region. Each sub-cube is called an octant. This is the basis of octree. Surface and volume meshes are created based on the size of the octants. [12]

Figure 2 shows an octree used to mesh the domain of the selected open-pit mine. The size of the octants is smallest at the Pit boundary and gradually increases vertically upwards. Small size elements at the pit bottom capture the flow pattern more accurately than larger size elements. For the selected model domain, the smallest octant size used at the Pit boundary is 11.92m and the largest octant size used at Free Atmosphere boundary is 190.76m. The selection of the smallest octant size is based on the average width of the smallest feature at the Pit surface and the requirement of greater resolution.

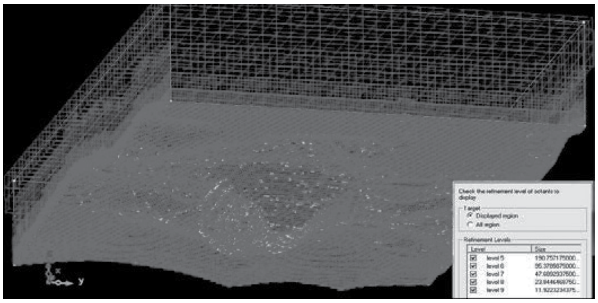

Figure 2. Octree and its refinement level for the model.

MESH ELEMENTS AND QUALITY

In general, basic 3-Dimensional mesh elements are of four types. Figure 3 displays these 4 types of element. Tetra elements extensively form volume mesh; Prism elements form layers at the roughness boundary and resolve boundary layers most efficiently. Velocity and thermal boundary layers are developed respectively due to the presence of roughness and thermal gradient at the stationary walls. Pyramid elements are used as transition elements in between two different types of elements, for example, Tetra and Prism; and Hexa elements are mostly used in Structured Grids and have the highest accuracy of solution.

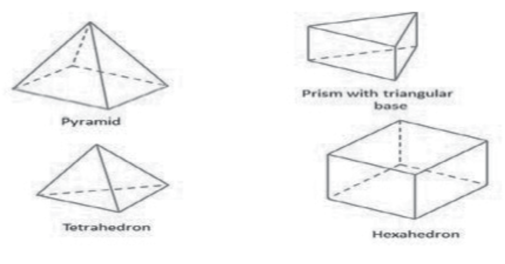

Figure 3. Basic three-dimensional elements.

For the selected model domain, volume of this geometry is meshed with Tetra elements, and a few layers of Prism elements are inserted at the Pit boundary to capture the roughness and the heat flux, and to develop the appropriate velocity and thermal boundary layers. The quality of the mesh elements in SC/Tetra are defined by h-ratio and shape factor respectively for the tetrahedral and the hybrid elements. The "h-ratio" is the ratio of the radii of the inscribed circle and the circumscribed circle of a triangle. The ratio of 0.5 resembles the best triangle shape (equilateral triangle), and it approaches to zero as the shape worsen (skewed triangle). [13] The quality of Hybrid elements such as Prism elements are defined by shape factor. The best shape factor is one (1.0) and approaches to zero as the shape of a prism worsen.

MESHING IN FACETED MINE GEOMETRY

Intersecting Surfaces

Intersecting surfaces are generated when multiple vertices are present inside the same octant. Figure 4 presents such Intersecting Surfaces at the Pit boundary of the model geometry. When Intersecting Surfaces are present in a model, a Volume Mesh cannot be created, because it results in overlap/collision in between the Tetra elements. Therefore, all intersecting Surfaces must be removed by strategic Merging of Nodes of the involved triangles.

Volume Meshing with Tetra Elements

A volume Mesh is created only after all the Intersecting Surfaces are removed. Auto Execution in SC/Tetra creates Volume and Surface mesh and Prism Layer consecutively. The initial mesh of the model domain is presented in Figure 5. The quality of the Tetra elements in terms of h-ratio is given in Figure 6; a number of very low quality elements with a low h-ratio are observed.

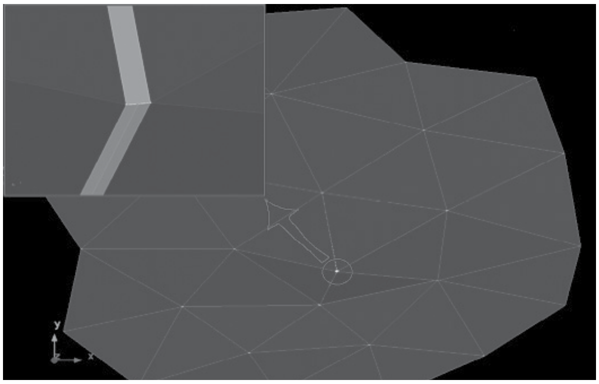

Figure 4. Intersecting surfaces and its enlarged view.

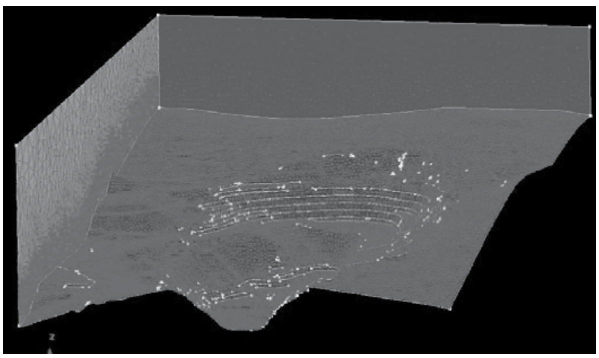

Figure 5. Volume meshed pit with Tetra elements.