Development of a Mesh Handling System for the SPACE pilot code

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1. Introduction

The SPACE pilot code, which is under development as a hydraulic solver of nuclear power plant system, is required to handle a variety of complicated geometry encountered in reactor systems. The mesh systems can be divided into two types; structured mesh system and unstructured mesh system. The structured mesh system is simple to apply but is less flexible than the other. The unstructured mesh system is more complicated than the structured mesh system. But it is more flexible to model complex geometries. Therefore, both of the two types of mesh systems are utilized in SPACE to allow code users simplicity as well as flexibility. In this paper, the geometrical approach used in SPACE, and the C++ class design of mesh handlers are briefly introduced.

2. Base Mesh System

The SPACE code has two sets of mesh system, one from structured mesh system and the other from unstructured mesh system. CBaseMesh is a C++ class designed to define the data and functions that is common both in the structured and unstructured meshes. CStructuredMesh and CUnStructredMesh are derived from the CBaseMesh. Therefore, CStructuredMesh and CUnStructredMesh have their own specific data and functions, as well as the common attributes defined in the base class.

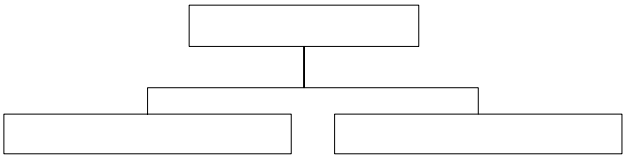

Figure 1 Hierachy of Mesh Classes

3. Structured Mesh System

The CStructuredMesh class is used to make the structured hexahedron cell both in Cartesian and cylindrical coordinate system. Fig. 2 shows an example of Cartesian mesh block generation.

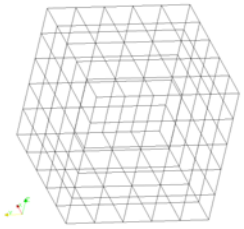

Figure 2 3D-Structured Mesh

4. Unstructured Mesh System

The CUnStructuredMesh class is defined to handle unstructured meshes. CUnStructuredMesh does not directly produce unstructured meshes, but handle the mesh data given in the Gambit[1] neutral file format. In the unstructured 3-dimensional mesh system, the calculational domain can be divided into hexahedron, tetrahedron, pyramid, or wedge (prism) shaped cells. All the geometrical property of the various types of cell and face, i. e., volume of cell, face area, centroid, and so on, are calculated by the member functions of CUnStructuredMesh. The detailed calculation algorithms are in the reference[2].

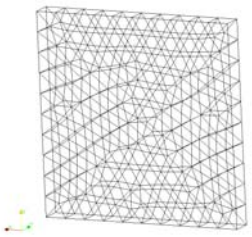

Figure 3 2D-Unstructured Mesh

5. Multi-Components Mesh

CStructuredMesh and CUnstructuredMesh inherit the common attributes from CBaseMesh. Therefore the objects instantiated by those derived classes are able to merge to an object representing a multi-block system, as shown in Fig. 4. C++ operator overloading is used to define the two-block merge operator, ‘ +’ . The following example shows the usage of the ‘ +’ operator.

```
CStructuredMesh     m1;
CUnStructuredMesh   m2;
CUnStructuredMesh   m3;
…….
CUnStructuredMesh   m;
…….
m = m1 + m2 + m3;
```

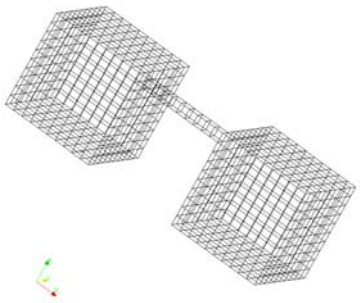

Figure 4 Multi-Component Mesh

6. Test Results

As shown in Figs. 5 through 7, the SPACE mesh handler is able to generate various types of Cartesian, cylindrical and unstructured mesh blocks, and to construct multi-block systems with more complex geometry. Fig. 5 is an example to make a 'H' type pipe system, and Fig. 6 represents an 'U' type one. In order to test the mesh connectivity, hydrostatic pressure build-up tests are performed. The entire system is initially filled with liquid, and remained until it is hydrostatically stabilized. Every boundaries are treated as wall. The test results show a good agreement with the theoretical pressure distribution, implying that the multi-block systems are well connected as intended. Finally, Fig. 6 shows that the SPACE hydraulic solver simulates properly the hydrostatic pressure in cylindrical mesh block, as well.

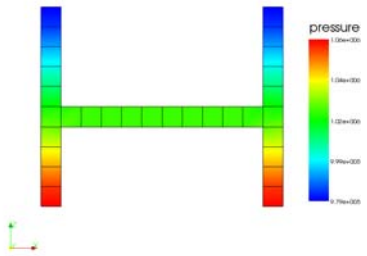

Figure 5 Static pressure distributions in 'H' pipe system

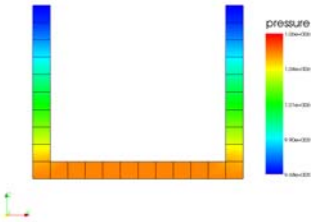

Figure 6 Static pressure distributions in 'U' pipe system

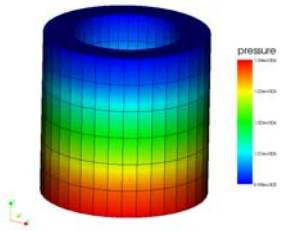

Figure 7 Static Pressure distributions in a cylindrical mesh block

7. Conclusion

The SPACE hydraulic solver mesh handler provides a flexible way to generate one-dimensional and multi-dimensional, structured, unstructured and cylindrical block meshes, and to construct more complex systems by linking the already generated simple blocks. Hydrostatic pressure build-up test results show that various types of block meshes and the multi-block connection approach work properly. In the near future, capability of the SPACE mesh handler will be enhanced to link a face to multi-faces between two block meshes.

Acknowledgment

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REFERENCES

[1] Gambit User Guide
[2] E. J. LEE, "Geometrical Approach to the Grid System in the KOPEC Pilot Code", KNS Spring Meeting, May, 2008.
[3] Davies D. E., Deborah J. Salmond, 1985, ".Calculation of the Volume of a General Hexahedron for Flow Predictions", AIAA Journal, Vol. 23, No. 6, pp954-956
[4] OpenFOAM, April 2007, "Open Field Operation and Manipulation CFD Toolbox" User's Guide, Version 1.4.