Status and Perspective of the Pre/Post Processing for Thermal-Hydraulic Code

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1. Introduction

The governing equations for the thermal-hydraulic solver can be obtained through several steps of modeling and approximations from the basic material transport principles. The volume averaging process gives rise to the concept of the volume porosity.

Considering the structural complexity of the reactor internal design, one can imagine how much efforts should be put to get the proper porosity data. Personal experience tells that over one man-year of efforts are not enough to develop a reasonable input preparation report for a reactor because of the notorious error-prone tedious calculations. To overcome this problem, any one can imagine that the utilization of a CAD system will be very much helpful. But, some efforts have to be exercised to evaluate the capability of the present day CAD system for this type of application. Even if the evaluation is affirmative, some efforts have to be devoted to develop the necessary procedure for the porosity calculation.

In this paper, the CAD system, Pro/Engineer[1] is utilized for this purpose. Detailed review tells that, sole Cad system is not enough but a mesh generator is also necessary. A post-data processor may be combined to further enhance the capability.

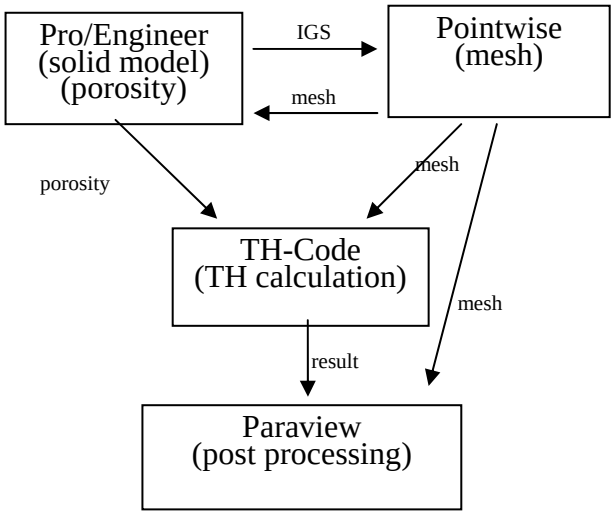

Figure-1. Data Processing Flow

2. Overall Description of Data Processing System

As shown in Figure-1, Pro/Engineer(Pro/E) is adopted as a solid modeler. Using the Pro/Engineer one can model the thermal-hydraulic system such as reactor vessel as shown in Figure-2. It shows the general view of the reactor vessel. It includes the very complex reactor internals. Pro/Engineer supplies not only the solid modeling capability but also the very powerful geometry evaluation tool which is called Pro/Toolkit. It is a user Application Program Interface (API) to Pro/E. Through it, one can access almost all the Pro/E functions. The API Pro/Toolkit is used to develop the batch process for handling multitude of basic cells.

Pointwise[2] is a mesh generation software. It accepts the solid model from Pro/E in IGS format to generate the mesh data. The mesh data are sent back to Pro/E for calculation of porosity for individual mesh cells and faces. These information, mesh and porosity, are sent to the TH calculation code. Mesh data are also given to Paraview[3] which is a post-processor. It is given the TH code calculation results as well. And any calculation results can be visualized in user selected form by Paraview.

Figure-2. Reactor Model

3. Interaction between Pro/Engineer and Pointwise

In general, Pro/Engineer generates solid model and produces the IGS file for Pointwise. Pontwise generates mesh data based on the IGS file produced by Pro/Engineer. Mesh data are supplied to Pro/Engneer for calculating the porosity for individual cells and faces.

Some complications are arisen from the fact that reactor vessel including the internals are not the simple tank but comprising the complex flow passage. The reactor barrel divides the flow direction between the

downcomer and upper plenum. The cavity between the barrel and the baffle also divides the flow passage. Such physical barriers should be specially treated before the any mesh process is applied.

This can be achieved by developing the simplified enveloping model. Figure-3 shows such a model for reactor vessel. It envelopes the exact rector vessel shown in Figure-2. But it encompasses the flow passages. This can be shown in Figure-4, which presents the individual blocks that model certain parts of the rector vessel.

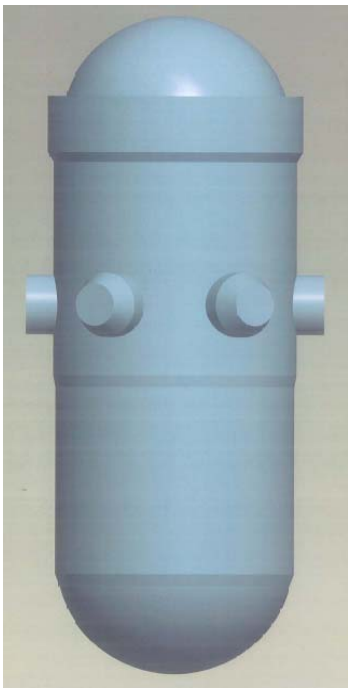

Figure-3. Simplified Model

The exploded view of the reactor vessel in figure-4 shows the blocks of the reactor vessel more clearly. Surfaces that represents the division of the flow passage such as the barrel outside surface should be treated as solid wall that does not allow any flow. But rest of the faces and/or surfaces will be given surface porosities that allow flow. Each blocks are given to Poinwise through IGS file format for mesh generation. The mesh generated for the downcomer at the nozzle level are shown in Figure-5. Pointwise can generates various type of meshes such as tetrahedral, hexahedral, prism or pyramid including.

The mesh data generated by Poinwise are processed to generate the file for vertex data and cell connectivity data. This file is fed to the Pro/Toolkit application program for the porosity calculation.

4. Conclusion and Further Works

Mesh handling procedure that can estimate the cell and face porosity has been developed successfully. If it is applied to the parts (of Pro/E) it can be used for any nodal code. For this purpose, development of the code that can handle unstructured staggered scheme is strongly recommended. Final test of this procedure will be performed after combining that with thermal-hydraulic code such as SPACE in the near future.

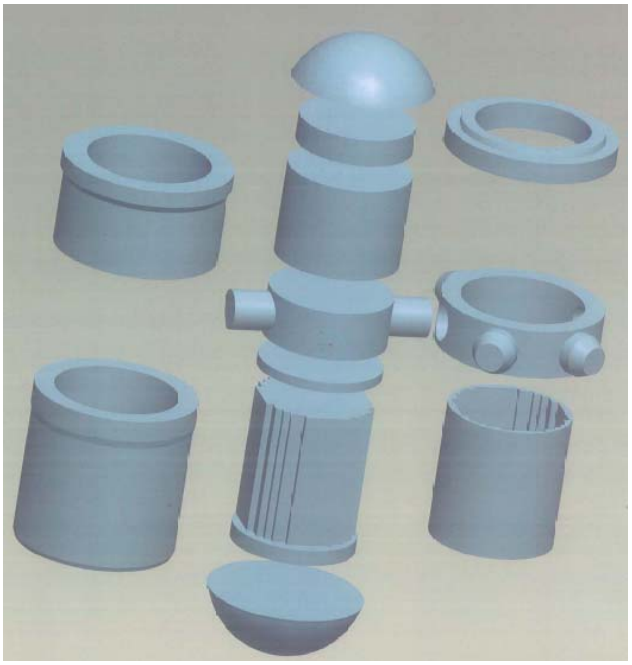

Figure-4. Exploded view of simplified reactor model

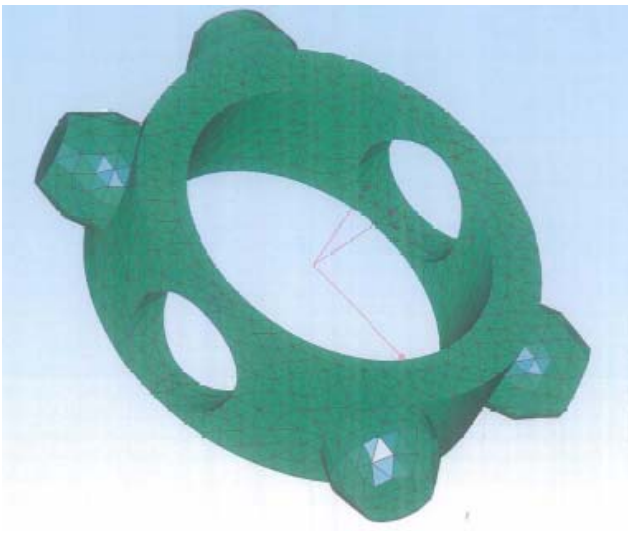

Figure-5. Mesh for Downcomer at Nozzle Level

REFERENCES

[1] http://www.proengineer.com/
[2] http://www.pointwise.com/
[3] http://www.paraview.org/.