VIMSCAN - Visual Modeling Software For Assembling Nodalization Networks Of Thermalhydraulics Analysis Codes

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Abstract

Described in this paper is VIMSCAN, a general software used to assemble nodalization network diagrams in graphic mode and to generate corresponding input data files for thermal hydraulics analysis codes such as CATHENA and RELAP5. VIMSCAN provides analysts with powerful nodalization network and data management environments by employing database and visually graphical modeling technologies.

1. Introduction

CATHENA and RELAP5 are the thermal-hydraulic analysis codes mostly used in Canadian nuclear industry and abroad for the purposes of CANDU and pressurized water reactor nuclear power plant design and safety audit. These two codes are also used for thermal-hydraulic analysis in non-nuclear engineering areas. To use these codes, users have to prepare suitable input data files by nodalizing the systems to be analyzed, especially when the systems are very complicated. In present practice, preparation of the input data files and nodalization diagrams are done separately. Therefore, except for inconveniences, there are some potential disadvantages, for example, inconsistency between the input data file and its nodalization diagram, and inefficient model data management. Presented in this paper is a general computer program VIMSCAN that can be used to assemble nodalization network diagrams and to generate corresponding CATHENA and RELAP5 input data files. This is different from some input model builders that create visualization (i.e. nodalization diagram) of the input model specified in the input data file. Conversely, VIMSCAN creates input data files according to the nodalization diagrams assembled visually. By employing database and visually graphical modeling technologies, this program provides analysts with powerful nodalization network and data management environments, and helps reduce the effort of nodalization and input data file creation greatly.

This paper describes methodologies of the VIMSCAN program, applications for the thermal hydraulics analysis codes, and some conclusions.

2. Methodologies for major functions

The methodologies adopted in the program consist of three aspects: visual nodalization, model database and input data file creation.

2.1 Visual nodalization method

Visual nodalization is to set up system model in windows graphical mode through assembling basic nodalization elements – connections, junctions, and components such as pipes, annulus , volumes, reservoirs, tanks, junctions, pumps, valves, separator, resistances, heat exchangers, accumulators, branches, mixers, heat constructions, and so on. Shown in Figure 1 is a nodalization diagram assembled for a core pass between the reactor inlet and outlet headers. In other words, what Figure 1 displays is a nodalization network editor by which the elements in the nodalization diagram can be added, deleted and modified. Parameters and data related to the elements, e.g. components and connections, are inputted and modified through dialog boxes, see Figure 2 and Figure 3 respectively for instance. The connections are set up by drawing lines between components, see Figure 1. The component type can be selected from the tools bar on the left of the visual modeling window in Figure 1.

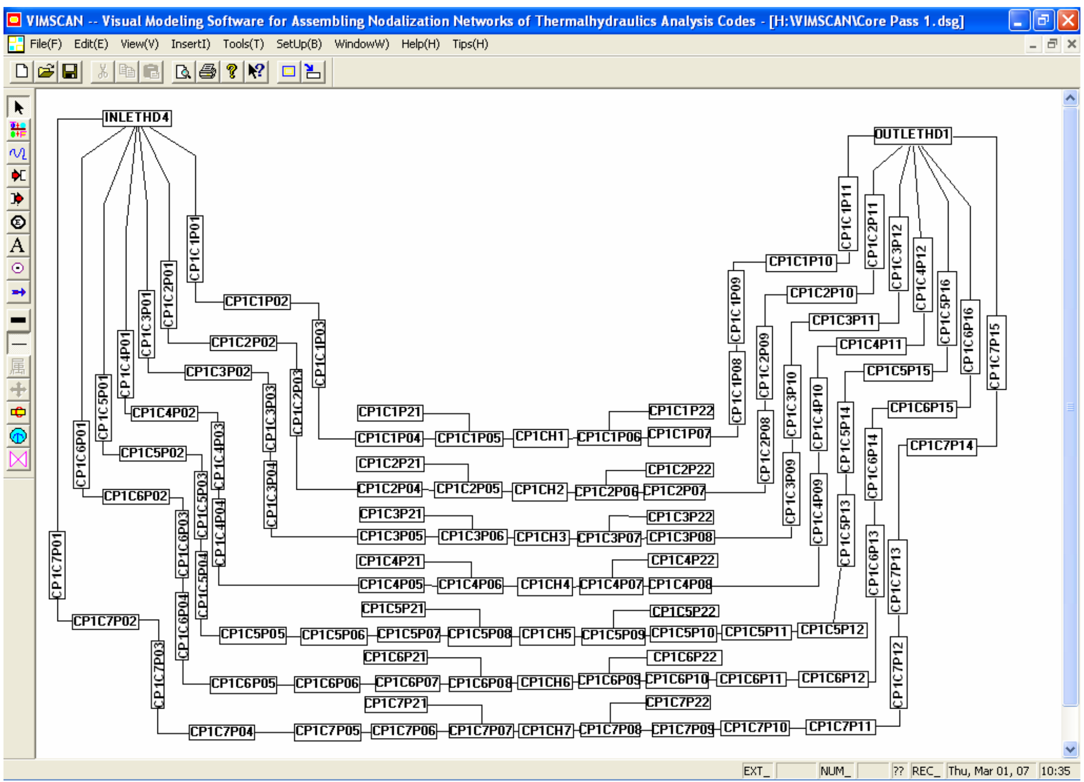

Figure 1 Example of assembling nodalization diagram

System model modules, system control modules, control parameter groups and boundary conditions, general tables, control systems, reactor kinetics, and so on are set up and edited by using the similar dialog boxes to Figure 2 or Figure 3.

Sometimes, it is more practical to use more than one nodalization diagram to express a complex and large-scale systems. In this case, combination of the nodalization diagrams are completed through a workspace called project, see Figure 4. That is, analysts can combine or integrate any nodalization diagrams to generate the desired input data file by adding or deleting nodalization diagram file names into or from the project. Generation of the input data files are described in Section 2.3.

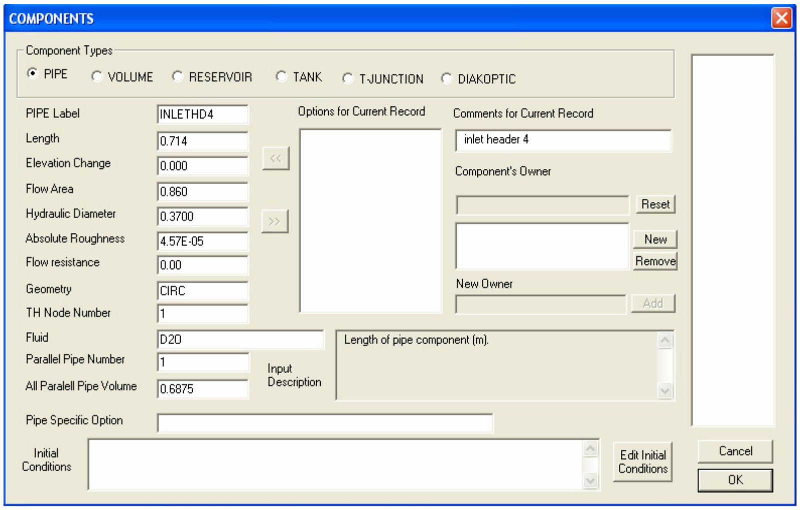

Figure 2   Example of component data editor dialog box

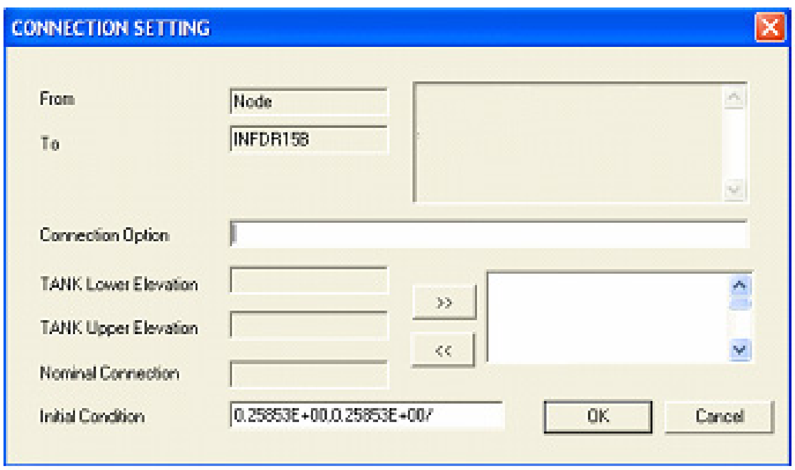

Figure 3   Example of connection data editor dialog box

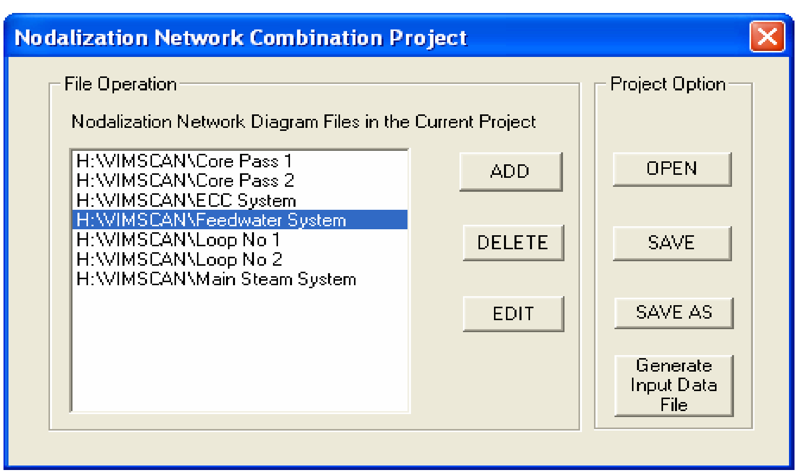

Figure 4   Workspace window for combining nodalization networks

2.2 Model databases

The program employs three input and output databases, which relationships are described in Figure 5. The first database is generated based on the nodalization network diagrams described in Section 2.1. When opening or saving a nodalization network diagram file, a database containing all data information of the diagram is generated automatically, this is the data source for the input data files of the thermal hydraulic analysis codes. As an example, part of the database corresponding to the nodalization network diagram shown in Figure 1 is presented in Figure 6 where the database is opened by Microsoft Access.

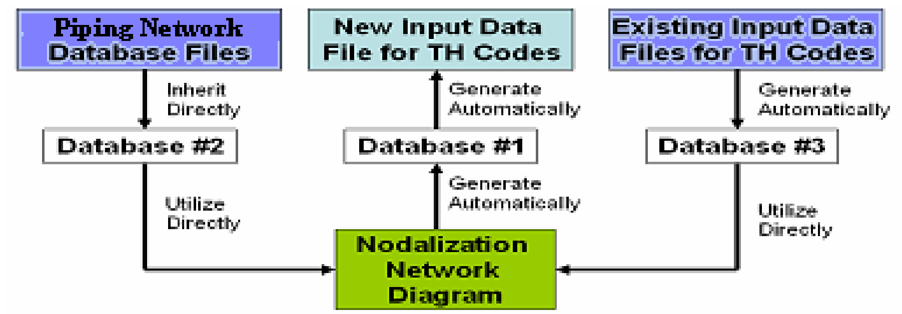

Figure 5 Databases Employed in VIMSCAN

The second database is created by the piping network code CATNIP, from which all geometric data relevant to the nodes in the nodalization diagrams can be derived directly. Therefore, when setting up the system nodalization diagrams, analysts can utilize the existing piping network databases to save much effort of keyboard inputting lots of data.

The third database is created by the program from the existing input data files of the thermal hydraulic analysis codes. This database is very necessary for setting up nodalization network diagrams for the existing input data files, especially the data information regarding component characteristics, connections and initial conditions. This is the case when analysts need a satisfactory nodalization network diagrams for input data files edited before in text formatting.

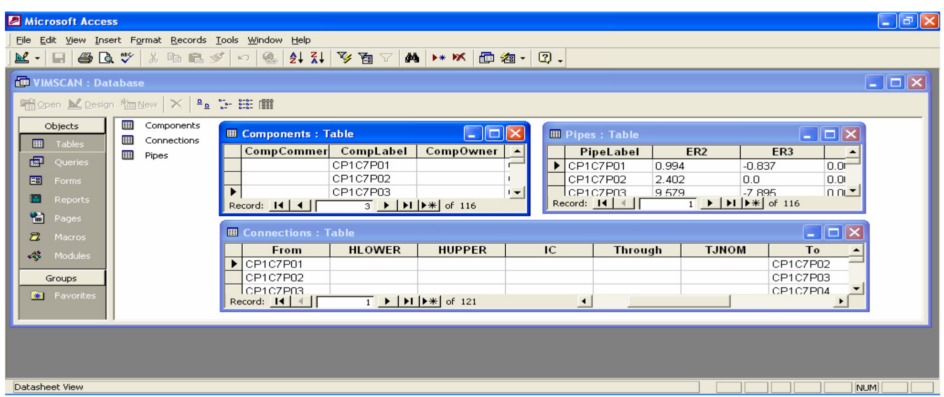

Figure 6 Example of VINSCAN Database

In real application practices, all these databases are invisible. What the analysts need to access directly are the nodalization network diagrams and files colored in Figure 5.

2.3 Generation of input data files

Input data files for thermal hydraulics analysis codes are created completely according to the input data format requirements defined in the code manuals, for example, References [1], and based on the databases that are generated automatically from the nodalization network diagrams, see Section 2.2. The generated input data file could cover systems expressed by one or more nodalization network diagrams through using the project method described in Section 2.1.

2.4 Model data management

To perform effective model data management, design of the program adopts the following conventions.

- Modification of any model data can only be completed through the nodalization network diagrams corresponding to the created input data file, unless modification to the input data file itself is done manually and forcibly.
- Information on properties of the nodalization network diagram files is written into the input data files for propose of consistency check if necessary. Such check can be done by the program itself.
- Save the nodalization network diagram as the only file that expresses the systems to be analyzed, and other files such as database and input data ones are derivative.
- Access and use the nodalization network diagram files by authorization and password protection.

3. Main features of the VIMSCAN program

The major functions and the methodologies of the program are presented in the above sections. Described below are the main features of the VIMSCAN program:

- A standard Windows multiple-documents application suitable for Windows NT, 2000 or later operating systems.
- Developed under Visual FORTRAN 6.0 Developer Studio and all source codes are C^{++} based, therefore, it is beneficial to possible incorporation with thermal hydraulic analysis source codes that are FORTRAN-based.
- The nodalization network diagram saved as chart file with small size. For example, the file size for the core pass nodalization diagram shown in Figure 1 is only 57 KB.
- The assembled nodalization network diagrams can be copied and then pasted into other application files for documentation, e.g. Microsoft Word and PowerPoint.
- General file functions for graphic applications, such as New, Save, Save As, Page Setup, Print, and so on.
- Basic graphics edition functions for components in the nodalization network diagram, like Insert, Cut, Copy, Paste, Delete, Select, Move, Property Setting, Dimension and Alignment Adjustments, etc.

4. Applications

The developed VIMSCAN program is applied into creating nodalization network diagrams of a CANDU system and corresponding input data files for the thermal hydraulics analysis codes such as RELAP5 and CATHENA. These diagrams cover a wide range of systems, from reactor core passes to the emergency core cooling (ECC) systems. The nodalization network diagram shown in Figure 1 is an example of them. All data and known conditions are derived from the existing thermal hydraulics analysis code input data files that were edited manually before and in text formatting mode, for instance, the RELAP5 input data file of the CANDU HPECC system in Reference [2]. That is, databases are first generated based on the existing input data files and then are used during creating nodalization network diagrams, refer to description of the third database in Section 2.2. After completing the nodalization network diagrams, new input data files are generated by the program. By comparing the new input data files with the original ones, the consistencies of the data contents in the files have been demonstrated. Therefore, it has been proven that the presented visual nodalization modeling methodologies are feasible and the developed software is reliable.

5. Conclusions

In summary, the VIMSCAN software can be used to effectively generate nodalization network diagrams and to reliably create the relevant input data files for thermal hydraulics analysis codes such as CATHENA and RELAP5. The software can provide analysts with convenient and efficient environments for editing nodalization networks, creating input data files of thermal hydraulics analysis codes, and managing the corresponding model data.

Based on the current VIMSCAN program, it is feasible to develop visualization of result post-processing. For using the thermal hydraulics analysis codes that adopt Parallel Virtual Machine (PVM) [3], it is also feasible to develop visualization of the transient simulation, i.e. dynamical display and control of the calculation processes by employing PVM to realize data exchanges between VIMSCAN and the thermal hydraulics analysis codes.

6. References

[1] Nuclear Safety Analysis Division, "RELAP5/MOD3.3 Code manual Volume II: User's Guide and Input Requirements", NUREG/CR-5535/Rev 1, Vol. II, December 2001.

[2] Z. Cui, M. McIntyre, et al, "Applying RELAP5 to Waterhammer Analysis of CANDU HPECC Piping System", 28th Annual Conference of the Canadian Nuclear Society, St John, 2007.

[3] Hernandez M. J., "Database Design for Mere Mortals: A Hands-On Guide to Relational Database Design", 2nd Edition, ISBN: 0201752840, Addison-Wesley Developers Press Reading, Massachusetts, March 2003.