#3861

A glimmer of hope for PC-based dynamic fluid-flow analysis

By Landruff Trent

AIVC

As many PC users know, the recent explosive increase in RAM size, clock speed, available languages, and file I/O capability brought about a corresponding increase in the number of cost-effective application programs for desktop machines, particularly technical/scientific micro software. Now, for example, there is a large family of cost-effective programs dealing with structural and design analysis, circuit analysis, material properties, stress analysis, heat transfer, optics, project management, artificial intelligence, expert systems, and the like whose problems could, until recently, only be solved on a large mini or on something like a 7600 or Cray. One type of analysis (no doubt there are others) has not seemed to keep pace with the explosion, however. The out-of-step family member is the dynamic analysis of fluids on a multidimensional basis.

■ Marching to a different drummer

There are many reasons why the multidimensional analysis of fluid dynamics has not kept pace with the explosion, and I will try to touch on a few. First, fluid dynamics phenomena are difficult to model from "scratch" (with no end-user programming) even on a large computer. They also call for a considerable number of innovative input/output schemes. And there is too much grunt work involved in dealing with "what-if" situations. It follows, then, that what is difficult for a big "number cruncher" is a seeming nightmare for a 16- or 32-bit, 640K-RAM desktop machine with 20 megabytes of storage.

MICROCOMPACT ... LOOK(S) LIKE A GOOD STARTING POINT FOR MULTIDIMENSIONAL FLUID-FLOW DYNAMICS ON A PC, AS WELL AS BEING ONE OF THE FEW ... GAMES IN TOWN THAT DOES ANYTHING ORIGINAL

To model fluid flow dynamics accurately, one must use a mesh and a large number of node points (points on a part that is laid over the grid points on the mesh). In the absence of an off-the-shelf applications program, the analyst must have a knowledge of programming to write a program that can create the mesh, another program to create the node points, and some means of validating and verifying that the programs work. The small amount of RAM (640K) available on a desktop machine makes these tasks almost impossible, however, because it limits the analyst to 4000 node points or to solving only two-dimensional problems, thereby producing results that are outside the 5% realm of acceptable accuracy. The small amount of available storage (20 megabytes) also limits the analyst, even given the most innovative schemes for pulling things into and out of memory. And the calculations involved in evaluating the phenomena at node points (such as for turbulent flow, which goes wherever it wants) partially defeat one of the primary reasons applications programs exist — to circumvent problems, to allow you to "take it out of the box and run it."

For the above reasons, commercial software authors shied away from all-out efforts to create new and complete software for fluid dynamics problems. Instead, they preferred to market subsets of programs used on the large machines. Although these subsets succeeded in covering a small, narrow portion of the problem, they were generally just stop-gap measures. Areas of application were few and too specialized, accuracy was bad, and cost-effectiveness was almost zero. But take heart! There is a glimmer of hope, I think. That glimmer is a program called Microcompact, which comes closer to being a genuine applications program than any I have seen yet. Incidentally, it also incorporates a pretty neat heat-transfer applications program.

Marketed by Innovative Research, Inc., Microcompact is designed around your basic everyday 640K PC (with a few special items, of course). It caught my eye because:

- It is one of the few "games in town."
- It covers several approaches to a solution.
- It is priced in the realm of reality.

- It has an acceptable learning curve.
- It is menu-driven (to me, preferable to command-driven).
- It gives you some flexibility in tailoring the problem you are solving.

■ A new approach

The solution approach used by Microcompact is an outgrowth of a numerical solution methodology described in a book called *Numerical Heat Transfer and Fluid Flow* (S. V. Pantankar, Hemisphere Publishing Corporation, New York, 1980). By way of detail, Microcompact provides the calculational procedure for solving any number of partial differential equations for dependent variables like velocity components, temperature or enthalpy, chemical concentrations, and turbulence parameters. Momentum and continuity equations are solved by the Simpler algorithm, with the velocity components being stored on a staggered grid. Microcompact also allows nonuniform grid spacing and two-dimensional modeling in Cartesian, axisymmetric, or polar coordinate systems.

The operational details of the program are divided into two parts: invariant and adaptive. The invariant part provides the basic solution procedures applicable to all problems of like sort while the adaptive part allows end-user innovation through minimal programming. If the programming feature scares you, take heart. Microcompact offers loads of examples to help you through the rough spots.

■ Type and turbulence

Microcompact is best described as an "open architecture" type of program. By that, I mean it allows you, through its adaptive part, to customize by adding, subtracting, or paralleling hardware and/or software. And, if you are worried about how Microcompact handles turbulent slow phenomena, rest easy. It allows you to choose from three model options depending on how sophisticated you and/or your model are:

- Mixing-length model,
- k–ε model (k = turbulence-generated kinetic energy, ε = k dissipation rate), or
- Reynolds-stress model.

These options cover solutions that range in complexity from algebraic input (mixing length) to Reynolds stress (solving eight simultaneous differential equations). The approach that has received the lion's share of the attention, though, is the middle-of-the-road or compromise k–ε model.

■ Stepping out

Microcompact has some other pertinent features that make it look like a good starting point for multi-dimensional fluid-flow dynamics on a PC, as well as being one of the few, if any, games in town that does anything original. They are:

- Grid points — Microcompact can accommodate 4000 grid points (e.g., 50 × 80) with acceptable accuracy, and all with only 640K RAM.
- Fluid types — Fluids considered are incompressible or, in the extreme, mildly compressible.
- Execution time — Time is proportional to the number of grid points (generally 30 min. for 4000 grid points).
- Graphics — Use Micrographics, a companion program.
- Applicability—Microcompact is applicable for IBMs, clones, look-alikes, act-alikes, and compatibles. Nothing is available yet for the Macintosh family and others.
- Gas and/or liquid flow — Microcompact can accommodate all but free-surface phenomena.
- Cost — $2500.

If Microcompact has any real drawback besides its inability to produce acceptable three-dimensional accuracy with only 640K of RAM and 4000 grid points, it lies in hardcopy file output. You need an EGA board/screen, but no screen dump or file dump is yet available. However, Hewlett-Packard says its laser printer has drivers that can do the job. Alternatively, you can use an eight-pen plotter and change all the pens once (since a maximum of 16 pens are employed in the Microcompact file output), or take a snapshot of the screen itself, using a 35-mm or Polaroid camera.

In future issues of *Menu*, I will attempt to give you updates on Microcompact, as well as evaluation results of other scientific and engineering programs for the PC. In the interim, call me at the ME/ESD Software Information Center, Ext. 29259. ☑

