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Aksenova A.E., Chudanov V.V., Goloviznin V.M.,
Pervichko V.A., Popkov A.G., Varenkov V.V.

The interactive Postprocessor VV-2D for scientific and engineering applications

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Аннотация

В работе описывается интерактивный пакет программ предназначенный для обработки и визуализации результатов научных и инженерных расчетов. Рассматриваются основные характеристики и возможности пакета.

Aksenova A.E., Chudanov V.V., Goloviznin V.M., Pervichko V.A., Popkov A.G., Varenkov V.V. The interactive postprocessor VV-2D for scientific and engineering applications Preprint NSI–3–94. Moscow: Nuclear Safety Institute, January 1994. 20 p.

Abstract

In this paper an interactive postprocessor program intended for processing and visualizing scientific and engineering computational results is described. Main features and potentialities are considered.

The interactive Postprocessor VV-2D for scientific and engineering applications

A.E. Aksenova, V.V. Chudanov, V.M. Goloviznin,
V.A. Pervichko, A.G. Popkov, V.V. Varenkov [1]
Nuclear Safety Institute
Russian Academy of Sciences
52, Bolshaya Tulskaya, Moscow, 1131991, Russia
12 January 1994

Abstract

In this paper an interactive postprocessor program intended for processing and visualizing scientific and engineering computational results is described. Main features and potentialities are considered.

During mathematical modeling of physical processes it is important to have a convenient and powerful tool for data visualization and manipulation. Potentialities of personal computers and interactive computer graphics provide a possibility to make easer an observing and understanding of calculated results.

Postprocessor VV-2D (Variables Viewer) is an interactive plotting computer program for visualizing and processing results of one- and two- dimensional scientific and engineering calculations. Data and graphic images are treated in postprocessor as some objects with their names, attributes and values. In connection with advanced man-computer interface it gives a basis for higher level data manipulations.

Postprocessor VV-2D was developed as a special graphic module of the RASPLAV code [1] and intended for visualizing results of numerical modeling severe accidents subsequences at Nuclear Power Plants. However developed architecture of the package provides a possibility to use the postprocessor as independent graphic tool. Structure of input data and the set of developed utilities make it possible to use VV-2D for wide range of scientific and engineering applications. Now VV-2D (version 2.0) is available on personal IBM PC compatible computers.

This paper contains description of main postprocessor functions, graphic objects which postrocessor deals with, possibility of data transfer from computational programs to VV-2D format and some other items.

Fig.1 shows main postprocessor's functions with input and output data flows.

1 WHAT CAN BE DONE BY POSTPROCESSOR

The user of postprocessor VV-2D manipulates with the following types of objects:

- variable: scalar, vector, matrix, text;
- graphic object: curve, counter lines, vector field, curvilinear mesh, map of region, surface, cavity;
- screen: a set of graphic objects on screen of display;
- film: sequence of screen images.

At the beginning of the session all variables are concentrated in input (*.SDF) file. On the basis of input file the user in dialog can select needed variables into current list and than use them as arguments for plots. Variables (all or some part, for all or selected time moments) can be combined into output list and saved on disc. Generally, variables may be taken from input file, inputted directly in postprocessor

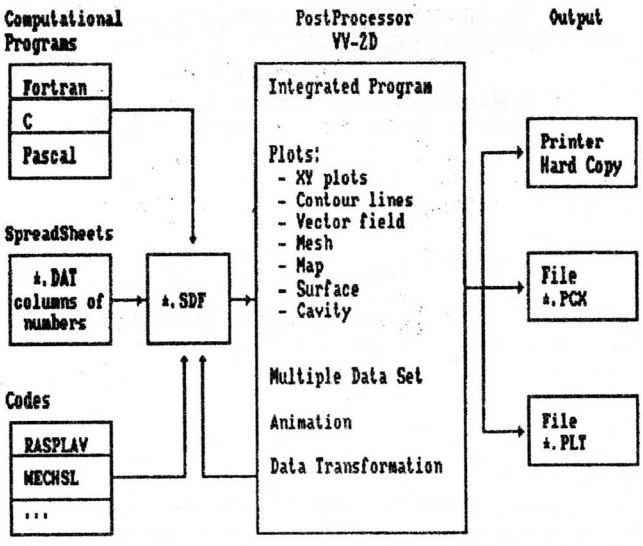


Figure 1: Schematic diagram of main postprocessor's functions with input and output data flows.

as columns of numbers, read from text (ASCII) files containing columns of numbers, or calculated by formula expressions.

User forms in dialogue various graphic objects, defines their formats, colors, screen positions. In accordance with type of graphic object there are different possibilities of plot examination. For example, for CURVES the coordinates of current point are displayed. For CONTOUR LINES the coordinates of current point and two one-dimensional plots with function distribution along $x = const$, $y = const$ are drawing. There is ZOOM command for detailed view of graphics.

User can create some set of graphic objects on the screen to reflect essence of processes in convenient way.

User can define a sequence of time moments to see FILM, i.e. an evolution of graphic objects in time.

Graphic objects of the same type are linked in lists. Work with all lists is organized via the advanced interactive procedures.

Any time graphic objects presented on the screen may be printed on printer. There is a possibility to output screen images to files in PCX format or to form PLT files for quality output on printer or plotter.

2 FEATURES

Postprocessor VV-2D has many useful features, which include:

- Integrated. Postprocessor is an integrated program for data manipulation and plotting. It combines XY plots with 2D contours, vector fields, meshes, maps of regions, and surface visualization together with data manipulation into one program. Postprocessor is easy to use.
- Interactive. You control the program through simple menus using mouse and keyboard arrow keys.

- Windows. You can use a number of windows at the same time to create different plots (one plot per window). Windows may be of different sizes, and they may be overlapped or superimposed upon each other to create composite plots. You can set different plotting attributes in different windows. You may specify the background color of a window, and whether or not it has a header and border. You can resize, reposition, or delete windows.

- Multiple DataSets. You may create and display plots from more than one set of data at a time. You may plot a separate set of data in each window, or use the same data set for all windows.

- Non-Rectangular Grids. Your data points may be arranged in a rectangular grid (i.e. straight rows and columns) or non- rectangular grid (curved rows and columns).

- Data Manipulation. You can alter your data and/or create new data using FORTRAN - like expressions.

- Zoom. You can repeatedly zoom into any portion of the plot and return to a full view. Zooming is very easy - just use the mouse to draw a box around the area of the plot that you want to enlarge.

- Examine. You can examine the values of variables at any location in a 1D or 2D plot by simply selecting the location with crosshair using the mouse. For 2D plots you can see also two additional 1D plots which show distribution of values along horizontal and vertical lines of crosshair.

- Flexible. You have interactive control over nearly all the characteristics of the plots: colors, markers, axes, texts, placement, size etc. You can specify the settings for plot characteristics in one or more files customized to your plotting needs.

- Printing. You can print a plot at any time or you may print the plot to a file to be sent to a plotter. Prior to printing you can interactively position and scale the plot. Plots may be sent also to the files in PCX or PLT (for quality printing or plotting) formats.

- Animation. If your data file consists of variables corresponding to several time moments it is possible to visualize *"animated"* picture. In this case the series of plots is displayed for selected time moments. In this connection VV-2D can be considered as 3D viewer (two spatial coordinates plus time).

- Element evolution. There is a possibility to select some element of vector or matrix and to plot its value as function of time. You can mark, for example, any point of computational region and observe temperature or some other function evolution in this point.

- Data Input. You can input data from the following sources:

  - from SDF - files, created by computational programs on C and FORTRAN languages;
  - from any text files with regular data structure;
  - through keyboard in dialogue;
  - through data manipulation with existing data.

Postprocessor can be used as independent graphic tool like well known packages GRAPHER or SURFER, i.e. VV-2D can be used without any special input files and all data can be formed by post-processor itself.

3 MAIN DEFINITIONS

3.1 Variable

The simplest type of object which postprocessor dealing with is variable. Variable is the kind of titled data of numerical or text type.

3.1.1 Structure of variable

Name	—	Brief name (key name)
Full Name	—	Full name (commentary)
Type	—	Type of variable (FLOAT, INT, TEXT)
Nx	—	X dimension
Ny	—	Y dimension
Discr	—	key of discretization

1 — Node of calculation mesh
2 — Center of cell
3 — Center of vertical edge
4 — Center of horizontal edge

3.2 Graphic object (GRAPH)

Graphic object is a function of variables (VAR) and set of parameters.

3.2.1 Types of graphic objects

- CURVE(X,Y) — plots dependence Y(X). It is possible to build spatial and time dependences. You may observe several curves as one graph (in common axes). Values X_i, Y_i are one dimensional numeric arrays (i - number of curve). Data can be taken from calculation program, read from disk or inputted by means of Postprocessor itself (as table or formula). Main characteristics of CURVE: argument X name, functions Y name, its minimum and maximum values, color, labels, thickness. There are ZOOM and auto scaling regimes. Graph can be send to printer.

- TOPO(F,X,Y) — outputs on the screen contour lines of F(X,Y). It is possible to build contour lines and filled lines of constant level. Levels can be defined manually or automatically. In addition the line colors, labels, style, thickness are defined.

- FIELD(Fx,Fy,X,Y) — builds vector field distribution. X, Y are coordinates; F_x, F_y are vector components.

- MESH(X,Y) — draws curvilinear quadrangle mesh.

- MAP(I,J) — displays region map showing the physical medium location in indexes space.

- CAVITY(X,Y) — plots sequence of curves on one graph for several time moments.

- NUMBER(X) — draws number (scalar value with its short name).

- TEXT(X) — draws text string.

3.2.2 Graphic operations

Select	—	select current graph.
View	—	draw current graph on the screen.
Edit	—	edit graph parameters.
Create	—	create new graph.
Move	—	move and resize graph on the screen.
Zoom	—	view fragment of graph.
Print	—	print graph image.
Read	—	read graph parameters from disk.
Write	—	write graph parameters to disk.
Default	—	set some default graphics parameters.

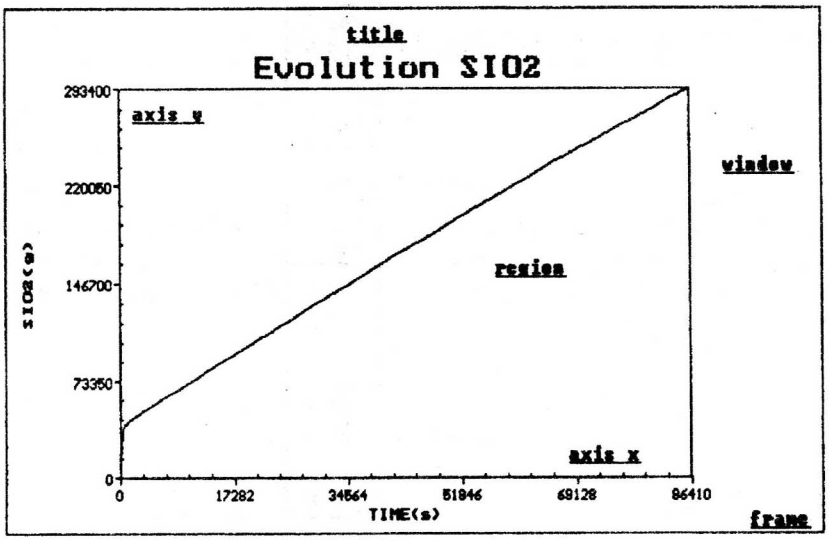


Figure 2: Stucture of plot.

3.2.3 Structure of graphic object (GRAPH)

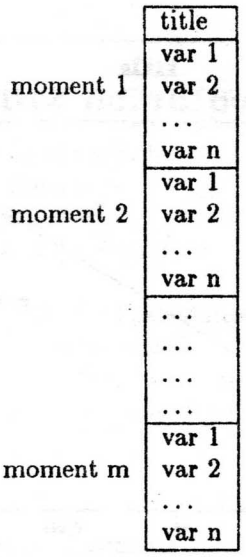
Graphic objects consist of following components:

WINDOW, REGION, FRAME, TITLE, XAXES, YAXES, Y2AXES, SYMMETRY, GRID.

- WINDOW. A rectangular zone of screen including region, frame, title, XY axes. Parameters are the size, color, fill style.
- REGION. A rectangular domain located inside window. Graph is drawing in region limits. Parameters are the size, color, fill style.
- FRAME. Graphic image can be outlined by frame. Frame parameters are the size, color.
- TITLE. Consists of three strings. Parameters are the font color, size, direction, location.
- AXES. There is a possibility to build axes inside graph window. Axes may be of linear or logarithmic scale. It is possible to define two independent Y - axes (Y1 - axes and Y2 - axes). Parameters are the size, axes titles, numerical values, tics, colors.
- SYMMETRY. Allows to observe symmetrical picture of plot relative to X - and Y - axes.
- GRID. Region may be covered by rectangular grid. Parameters are the type, color, style.

4 CONNECTION WITH CALCULATION PROGRAM

Connection with calculation program is realized via a special data file containing full information about all its data. It is the so called SDF (Self Descriptiveness Format) file [2]. Structure of SDF - file:



The file of this kind is formed by computational programs on FORTRAN and C languages using the special utilities library. For data exchange between programs written on different languages and between different types of computers the special text format (SDT) is used, which can be converted from/to SDF-file.

The set of utilities supports transformation of any text file with regular structure into SDF - file.

SDF-file contains the set of variables for different time moments.

Variable is numeric or text data together with attributes: brief name, full name, dimension, size, discretization keys.

Moment is a set of variables belonged to the same time moments.

Now there are special converters from some output data files produced by severe accident analysis codes such as the WECHSL [3] or CORCON [4] ones. In this case the cavity shape data and set of integral values are converted to SDF - files.

5 START OF SESSION

VV-2D is a menu-driven package. The user is offered a list of options which can be selected with the arrow keys in the cursor key pad or with mouse. To accept the selected option press ENTER key on the keyboard or left button on the mouse. To cancel chosen option or return to the previous level of the menu tree press ESC key on the keyboard or right button on the mouse.

When you log in, VV-2D checks whether the mouse is installed on your computer. If you don't have a mouse, you can go on entering commands from the keyboard. However,in this case your capabilities in constructing domains and handling files will be substantially reduced.

The main menu appears at the top of the screen. The bottom line is used for short prompts and error messages.

The menu-dialogue has three-like form. For example, ITEM1/ITEM2/.../ITEMN means to choose menu item item1 - you'll see a submenu, in which you should choose menu item item2 and so on.

When postprocessor starts, it reads PP.CFG file which contains working directory and filenames stored at the end of previous session. Besides that, there are *.MEM files with last time environment inside VV-2D. So, when you quit the package and then start it, you have the some variables, graphics, lists etc. as though you didn't leave postprocessor.

6 EXAMPLE FOR FIRST-TIME USER

The aim of this section is to provide a sample data processing that will show the first-time user of postprocessor how various menu items function and interface with each other. The user will be taken through a number of steps. The first step is SDF-file reading where the input data will be read. The next step is manipulations with lists of variables where variables can be created, deleted or modified. The third step is connected with various graphic objects which can be created, formatted, colored, repositioned or

resized. The fourth step shows the way to have several graphic objects on one screen. The fifth step presents means for film-making — a sequence of screen images for different time moments. Finally, we will explain you how to print a screen image at any time or send it to PCX-file.

6.1 File manipulations

In work with VV-2D several types of input files are used: main data file (SDF - file) containing full information about all its variables, last time environment configuration (MEM - file), main configuration file (PP.CFG), ASCII - files containing columns of numbers. And set of output files to store plots formats, numeric data and graphic output files. All operations with input and output files are performed through file box window:

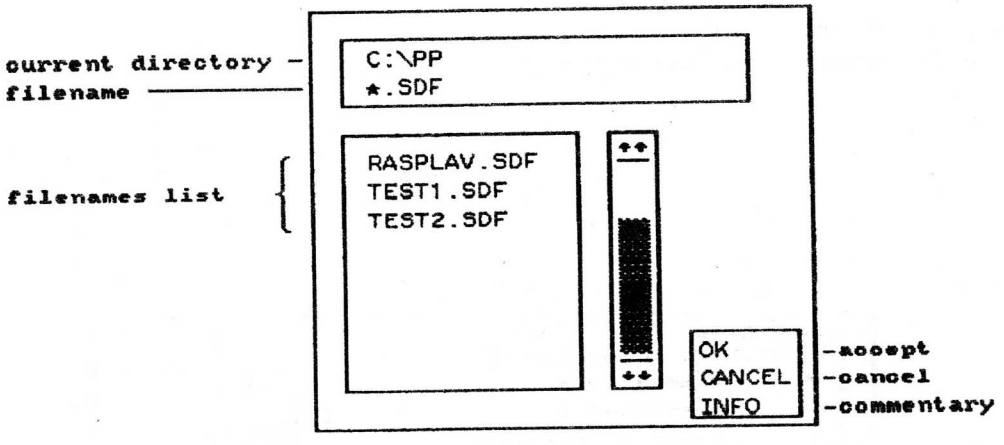


Figure 3: File Box.

A filename dialog box appears after you choose a file command.

Dialog box contains text boxes and command buttons. You enter information in text boxes; you point to a command button and click the left mouse button to execute or abort the command.

You can enter information in a text box by typing it, although in most cases you can enter information more quickly and easily by using the Microsoft Mouse.

The commands of menu item FILES are used to read, write or delete files and quit the package. You can read and write files of SDF - format. Operation DELETE can be used for files of any types. SDF - files are created by numeric programs with the help of special postprocessor utilities or by the VV-2D.

When you choose command READ, WRITE, or DELETE, a file directory box appears.

The file directory box lists the following:

- The name of the current drive or directory (on the current directory line);
- The last file read or written (on the filename line);
- All files within the current directory that correspond to the mask on the filename line.

You can view all of files contained in a file directory box by using the scroll bar along the right edge of the box. To use the scroll bar point to the solid-colored portion of the scroll bar and click the left mouse button.

6.2 List of variables

There are three lists of variables in VV-2D:

- Input list of variables (variables from input SDF - file);
- Output list of variables (variables for output SDF - file);
- Calculation list of variables (internal variables).

You can do the following variables operations:

- Create new variable;
- Delete variable;
- Modify values of variables by reading data files, editing through tables or by formula's transformations.

Variables are also used for graphic output.
Most variable operations call variables dialog box.

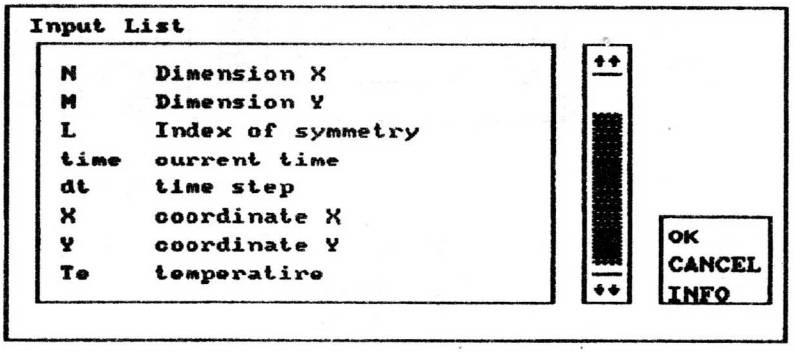


Figure 4: Variable box.

It is similar to file-box, but here you haven't directory and filename lines at the top of box. Central part of variable dialog box is occupied by list of variables. Variables in the list consist of two parts — brief name and full name. You always have current highlighted variable. You can use cursor up and cursor down keys to change the current variable. You can scroll list in window through vertical scroll-bar on the right of the list. You can use Microsoft Mouse to choose a variable: point to the variable and click left button of mouse.

It should be noted that input variables list contains the same set of variables for different time moments. So, we can view variable in such manner only for certain time moment. To see or select time moments choose menu item INPUT/MOMENTS/SELECT. You can do it through dialog box like variable dialog box. But here instead of variable names you'll see a list of time moments in form time=0000.000, where time is the key variable here. You can change it in menu item INPUT/BASE_VAR.

6.3 Graphs

You have an opportunity to view dependency of variables in different graphic forms:

text	—	some text on the screen;
number	—	number in a window;
curve	—	up to 8 curves with axes and texts in a window;
topo	—	counter lines;
field	—	vector fields;
mesh	—	curvilinear mesh;
map	—	map of regions;
surf	—	surface;
cavity	—	cavity.

If you choose menu item GRAPH you will see all these words in submenu items. Each type of graphic objects has its own list. So you can create some number of graphs with different formats, but the same type.

Formats of graphs include:

- position on screen and size;
- colors for different parts of image;
- type-dependent information (for example, number of curves for CURVE or values of levels for CONTOUR LINES).

6.4 Screen

User can create some set of graphic objects on screen to reflect essence of processes in convenient way. This set is organized as a list of graphic objects which have been created before in menu item GRAPH. The screen list contains only names of graphs. So, if you change something in graph format (for example, color or position) — the screen view have been changed too. It should be noted, that graphs may overlap each other and as a consequence, some of graphs may be hidden by other graphs.

You can modify the screen list in the same manner as you do it with variable lists. Choose menu item SCREEN/LIST and you'll see the current set of graphs.

Choose menu item SCREEN/VIEW to see all graphs in the screen list on one screen. If you start VV-2D first time you'll see only one graph: text time=0 in the frame. To have more images on the screen choose menu item SCREEN/INSERT. You'll see submenu with names of graph types. If you choose one of them, for example, SCREEN/INSERT/GRAPH you'll see a list of graphs of this type. Choose one of it. After clicking of OK button you have this graph in the screen list. Check it in SCREEN/LIST menu item. And then choose SCREEN/VIEW menu item to see new screen.

6.5 Film

User can define sequence of time moments to see FILM: subsequent evolution of graphic objects on screen.

It can be useful when you want to watch some evolution of your model. Make in GRAPH and SCREEN menu items all graph images you want to see. Color them, place in different places of the screen. Then choose menu item FILM/VIEW. Now you see the same graphs for subsequent time moments included in input SDF - file — this is some kind of animation.

Time moments are arranged in the list. You can modify it in menu item FILM/EDIT in the manner used for other lists.

You may set the time of screen refresh in menu item FILM/EFFECTS/DELAY.
Menu item FILM/EFFECTS/STOP sets the flag for waiting key pressing on keyboard after each cadre.

6.6 Graph printing and plotting

Any time you have some graph images on the screen you may print full screen by pressing f <Ctrl>P on the keyboard.

There are menu items PRINT for all graph types. When you choose them you see the appropriate graphs. You can choose some rectangular region of the screen with help of mouse:

- point to some place on the screen and click left mouse button, so you have marked one of the corner of rectangular;
- move mouse in some other place (you see changing rectangular during movement) and click left mouse button — you have marked other corner of rectangular.

Press key combination <Ctrl>P on keyboard to print selected rectangular region.

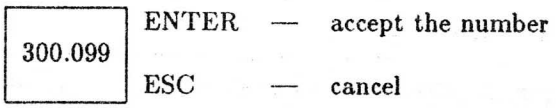
7 DATA INPUT AND EDITING

Numeric parameters can be defined in the following forms:

- 1.Number
- 2.Table
- 3.Analytical expression (formula)

7.1 Number

Current value of the parameter is displayed on the screen. You can edit it and renew by pressing ENTER key or left button on the mouse. Attempts to enter invalid characters produce a signal. In this situation user can either press ESC key to quit the procedure (with restoring old value of the parameter) or press ENTER key to try it again.



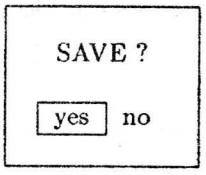
7.2 Table

Using of tables makes it possible to look through or correct one, two or three columns with the numbers.

Values of the array elements are displayed in the windows. There is a column with element numbers on the left. Above these windows the number of elements and the array names are displayed.

There is a graph with the dependence of array values and indexes if the table includes one column. This graph is drawn on the right. The marker on the graph indicates position of the current element. Any changes in the array elements will be immediately displayed on the plot.

If no changes have been made since entering the editing procedure, ESC key can be used to immediately quit it. Otherwise user is asked whether to save or abandon the changes.



The answer is selected with the Left Cursor and Right Cursor keys and accepted by pressing ENTER key. Hitting ESC key brings user back to the editing procedure.

Editing keys:

←, →, ↑, ↓	move inside the array
HOME	jump to the element's first character
END	jump to the element's last character
PgUp, PgDn	display previous/next page in windows
Ctrl-HOME	jump to the first element of array
Ctrl-END	jump to the last element of array
Tab, Ctrl ←, Ctrl →	toggle between columns
ESC	quit

Example. The table of two columns.

	Name 1	Name 2
1	1.11+01	9.11+00
2	2.22+01	6.22+01
3	3.33+01	3.33+01
4	4.33+02	8.33+02
5	5.33+03	5.33+03
6	6.33+04	1.00+04
7	7.77+03	7.11+03
8	8.77+01	3.01+01
9	9.77+02	9.99+02
10	1.77+03	9.99+03

7.3 Formula expression

The user is prompted to enter a formula as a text string containing specified arguments on which the function depends. Arguments that may be used are taken from the current list. This list is formed from the variables of input SDF - files and during the work inside postprocessor.

All spaces are ignored.

Symbols of arithmetic operations:

- \+ add;
- \- subtract;
- * multiply;
- / divide;
- ^ raise to power. Only positive numbers are allowed to be raised to power.

The list of permitted functions (in upper or lower case):

SIN(x)	—	trigonometric sine
COS(x)	—	trigonometric cosine
TG(x)	—	trigonometric tangent
ABS(x)	—	absolute value
EXP(x)	—	e^x
LN(x)	—	$ln(x)$
SQRT(x)	—	$\sqrt{x}$
HI(x)	—	Heaviside function $HI = \begin{cases} 1, & \text{if x > 0} \\ 0, & \text{if x < 0} \end{cases}$
MIN(x1,x2,...,xn)	—	minimum of variables x1,...,xn
MAX(x1,x2,...,xn)	—	maximum of variables x1,...,xn

Detected syntax errors produce diagnostic messages and correct formula is expected. Pressing of ESC key causes exit without changing of the parameter.

$\sin^2(x) + \cos^2(x) + 300.99$

ENTER — accept formula

ESC — cancel

8 FUTURE PLANS

1.Adaptation of the package for workstations. 2.Development of interface libraries and utilities for data transfer from calculation programs. 3.Expansion of graph object types: histograms, circle diagrams.

4.Development of variables manipulation modules: integral and differential operations, calculation of extreme values, data processing in selected subregions. 5.More advanced user interface: colors, prompts, HELP-system.

9 KEY WORDS

SDF — Self Descriptiveness Format of files. Can be created by means of special postprocessor utilities.

Variable — numeric or text data. Attributes of variable are: the short name, full name (commentary), dimension, size, discretization key.

Graph — graphic dependence of variables. Type of graphs are the following: one dimensional spatial- and time dependencies, contour lines, vector fields, mesh, map of region.

File Variable — variable is belonged to input SDF - file.

Calculating Variable — variable is created directly by means of postprocessor.

List of Input Variables — list of variables from SDF - file.

List of Current Variables — includes file and calculating variables. This list of variable used in branch GRAPH.

List of Output Variables — list of variables for writing to SDF - file. Includes file and calculation variables.

Screen — combination of several graphs on one screen.

Film — Sequences of identical pictures belonged to different time moments.

10 WHAT HARDWARE YOU NEED

IBM PC 286/386/486
640 K of memory
Display Adapter EGA, VGA
Matrix/Laser Printer
Microsoft Mouse
Disk operation system (DOS), version 3.0 or later.

11 LIST OF FILES

PP.EXE	—	Executive File
PP.CFG	—	Main postprocessor's configuration file.
PRNT.CFG	—	Printer's configuration file.
.SDF	—	SDF - files of input and output data.
.MEM	—	Current status configuration file.
.DAT	—	ASCII - files containing columns of numbers.
.GR1	—	Contains TEXT attributes.
.GR2	—	Contains NUMBER attributes.
.GR3	—	Contains CURVE attributes.
.GR4	—	Contains TOPO attributes.
.GR5	—	Contains FIELD attributes.
.GR6	—	Contains MESH attributes.
.GR7	—	Contains MAP attributes.
.GR8	—	Contains SURF attributes.
.GR9	—	Contains CAVITY attributes.

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[4] Cole R.K., Kelly D.P., Ellis M.A. CORCON–MOD2: A Computer Program for Analysis of Molten–core Concrete Interactions. NUREG/CR–3920, SAND84–1246, 1984.

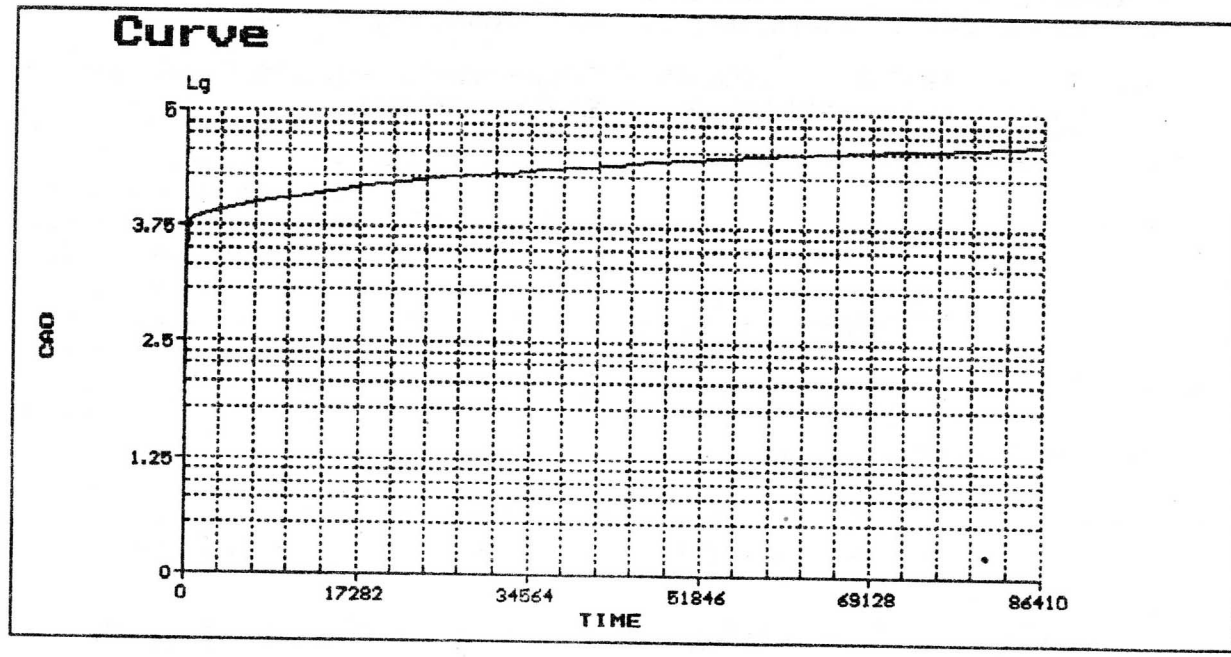

Figure 5: Example of XY plot. Logarithmic Y-axes.

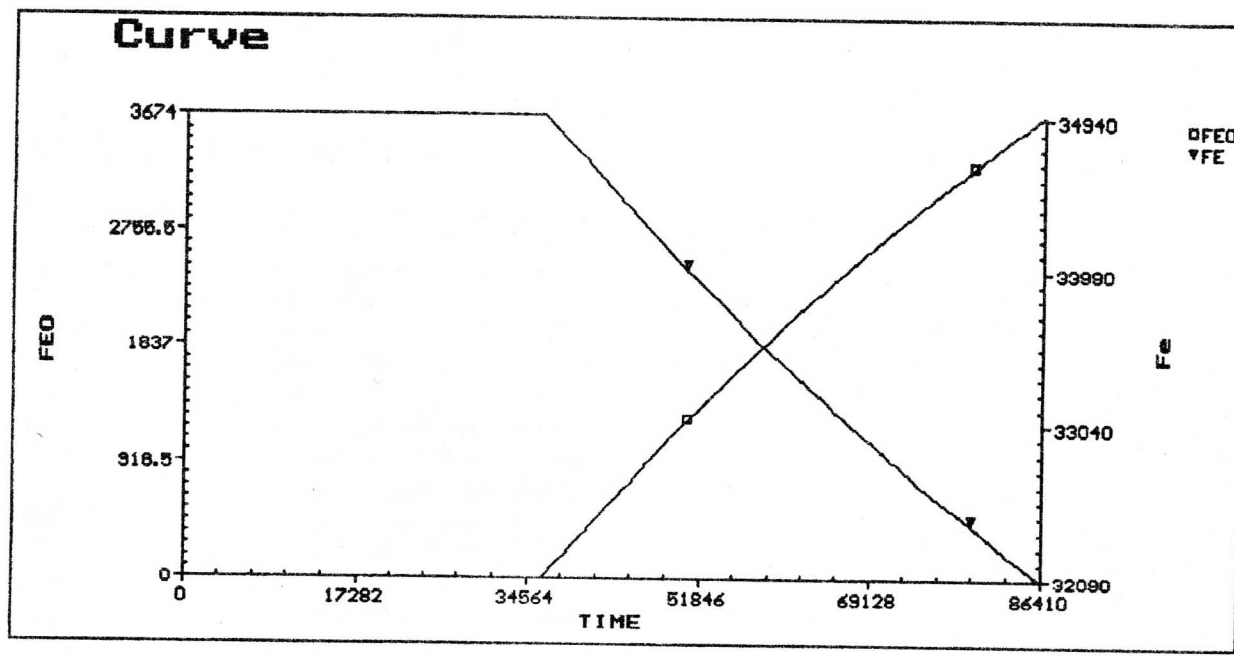

Figure 6: XY plot with two Y-axes for two different scale values.

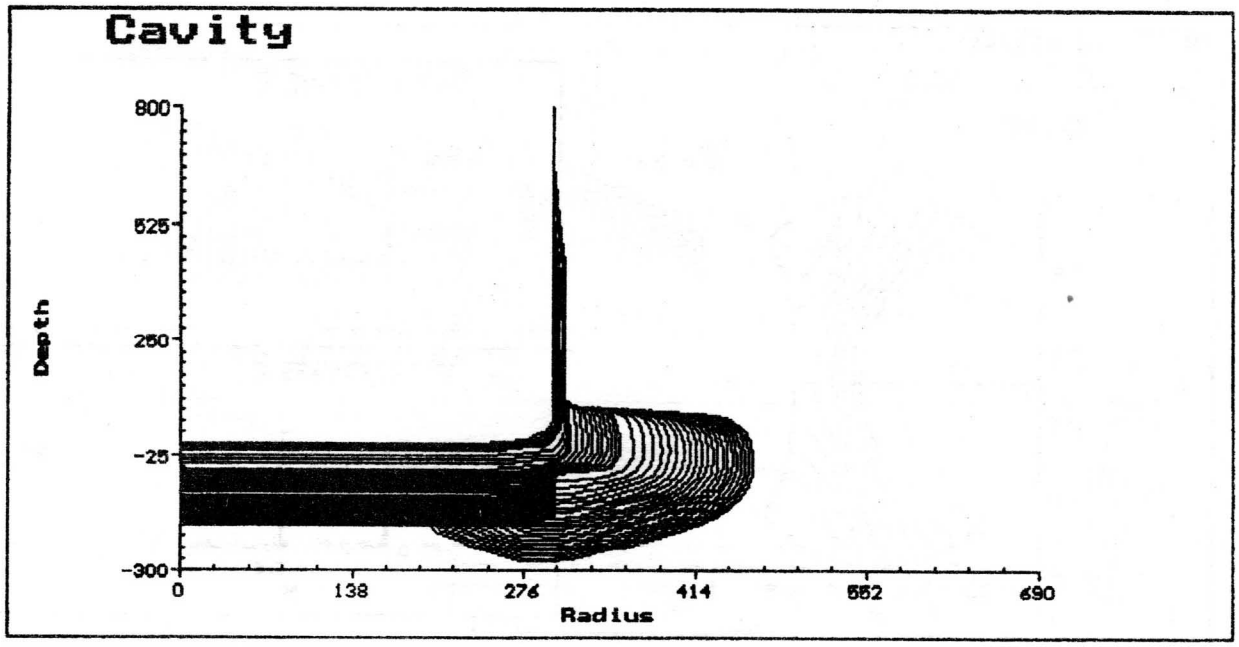

Figure 7: Cavity plot. Shown free boundary position for several time moments.

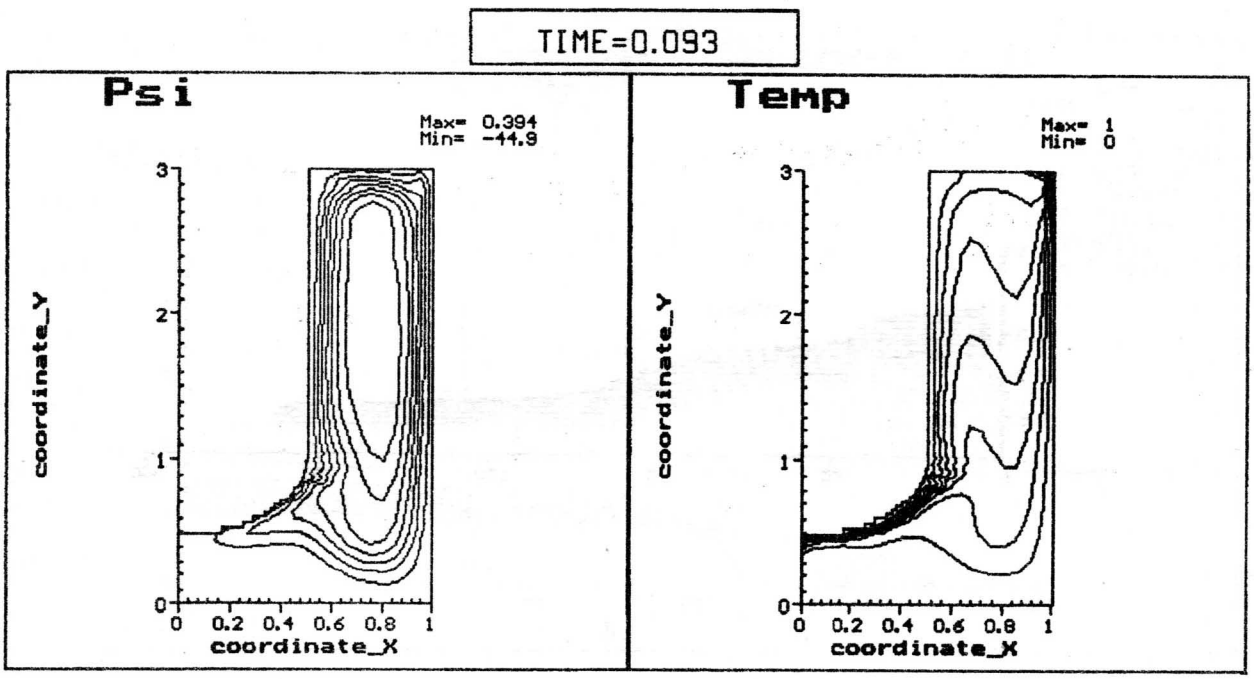

Figure 8: Contour lines of constant level for two functions F1(X,Y), F2(X,Y).

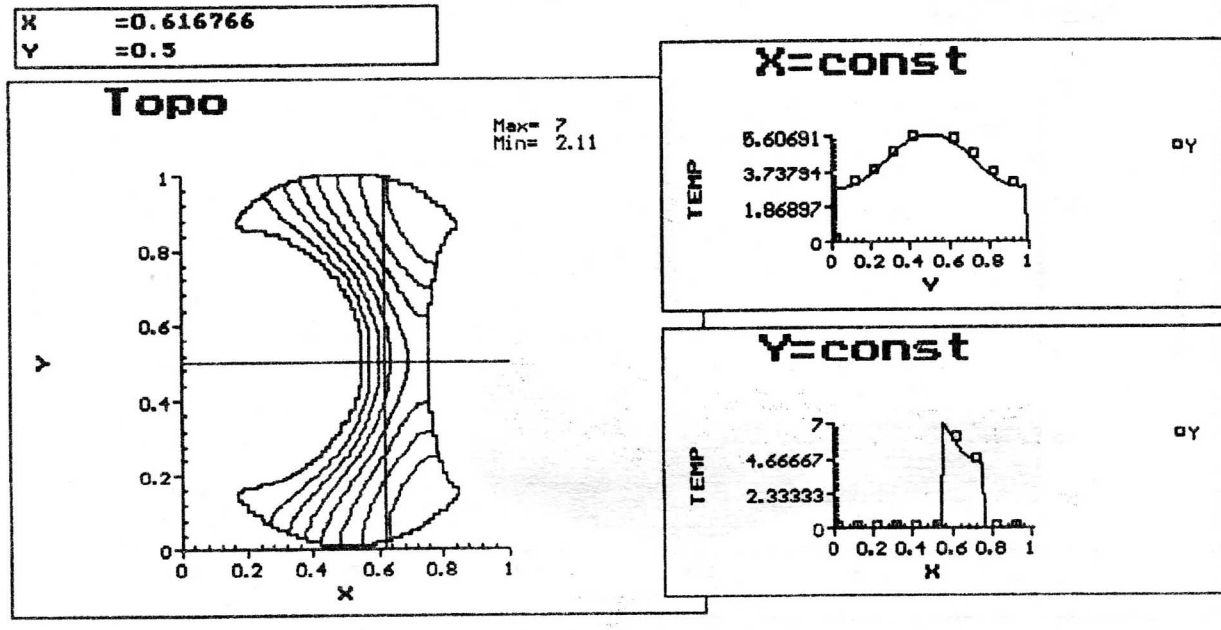

Figure 9: Contour lines with two distribution in horizontal and vertical direction.

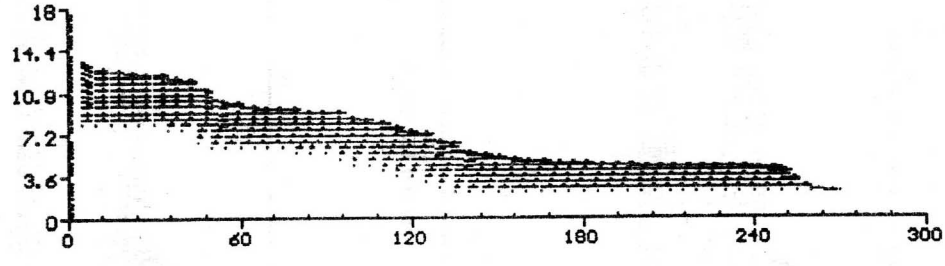

Figure 10: Field of velocities.

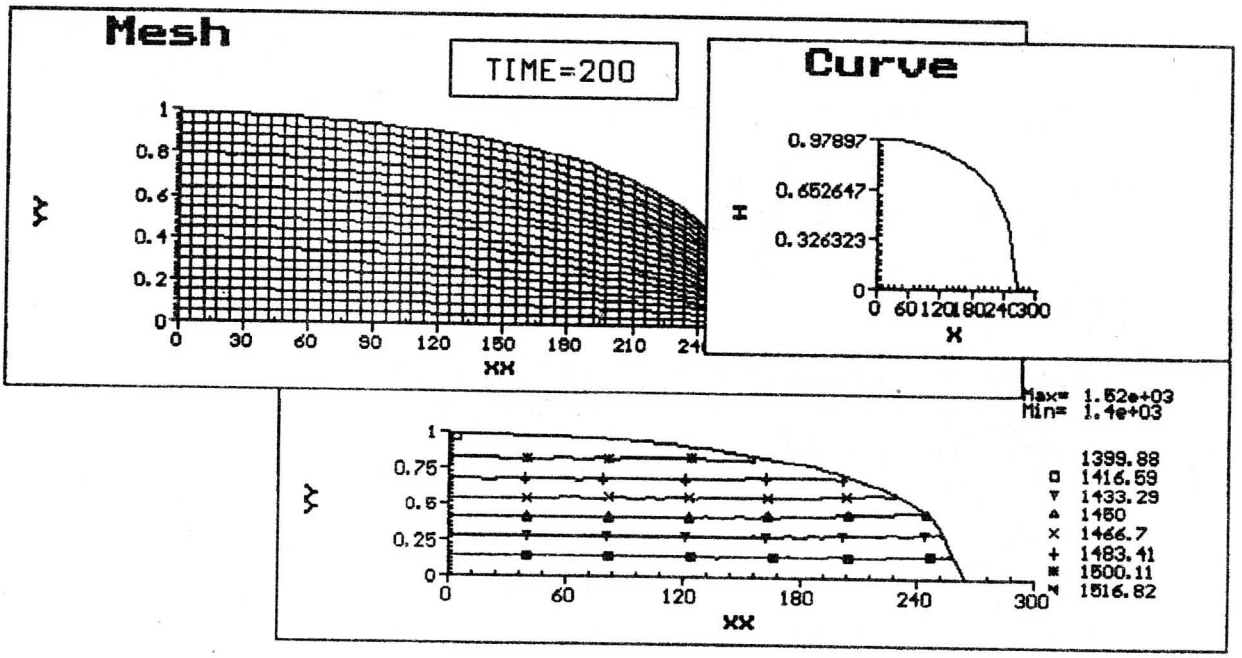

Figure 11: Combination of three graphs on one screen.

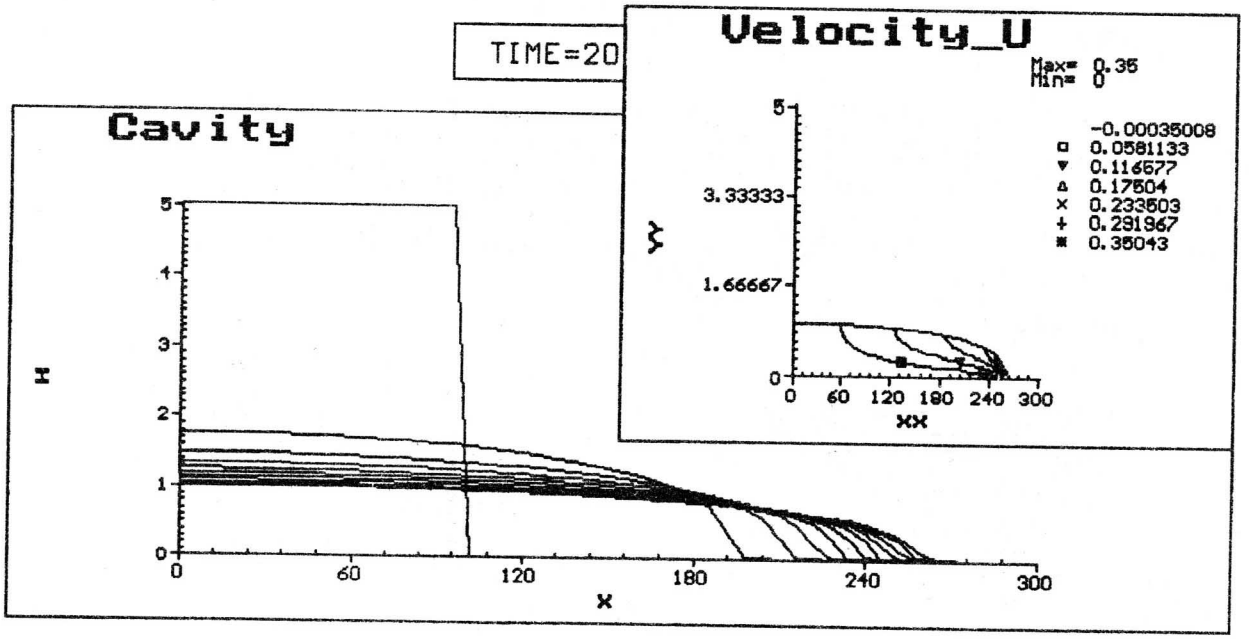

Figure 12: Combination of two graphs on one screen.

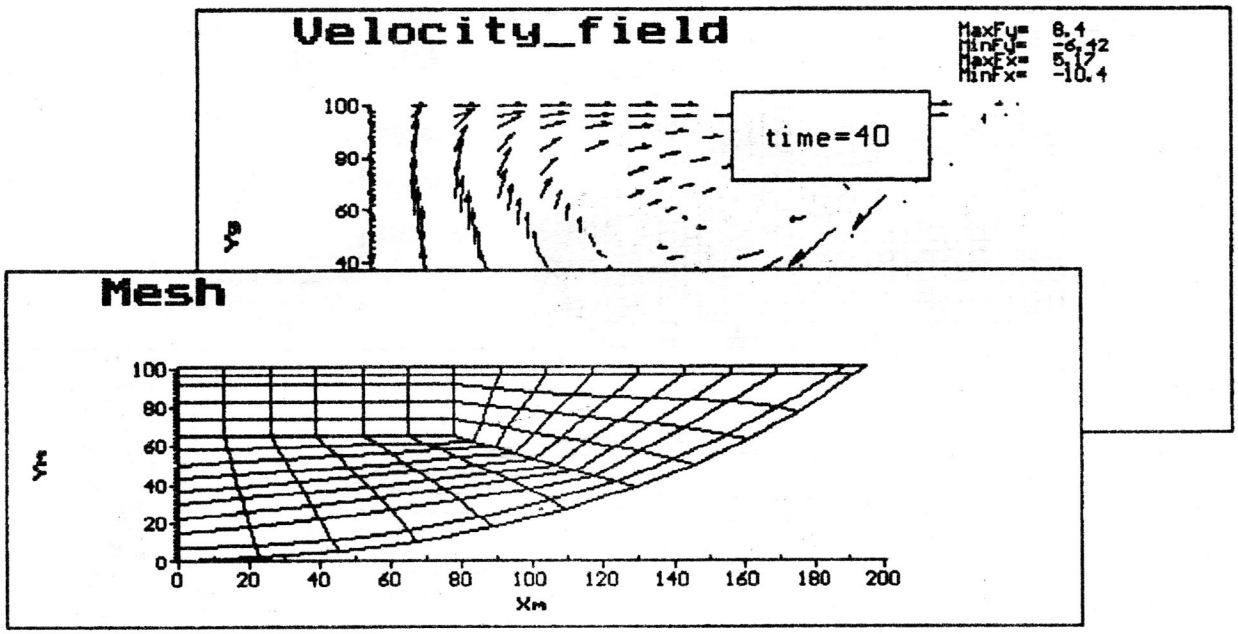

Figure 13: Mesh, velocity field and time combination.

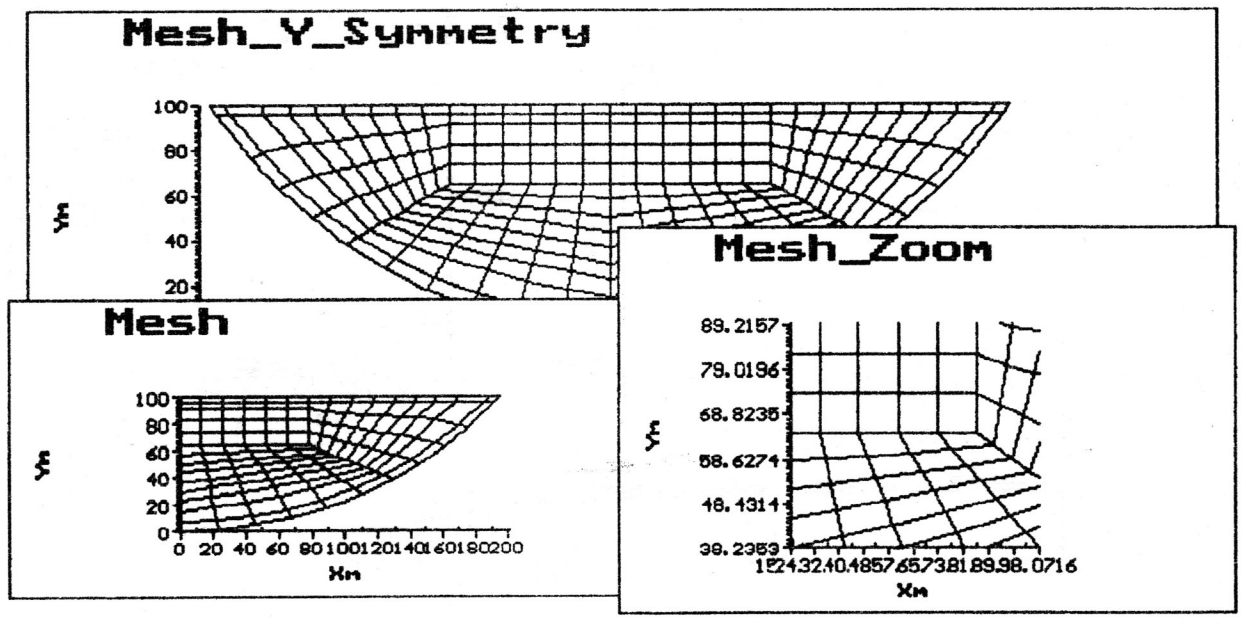

Figure 14: Mesh, symmetrically reflected mesh, zoomed mesh.