Crash-free Technology for Continuum Flow Computations Using «LEGAK» Code on Multiprocessor Computer Systems

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A crash-proof computational procedure assumes that computations are actually carried out during a single run, i.e. without any user's interference.

A crash-proof procedure development includes the following:

- development of computation techniques for time-dependent continuum flows with an ability to calculate flows with severe distortions of interfaces;
- development of the procedure of applying the techniques above: the methods of dividing a physical problem decision region into mathematical sub-regions and the types of computational grids used for various flow phases.

The area of LEGAK code applications [1,2] includes computations of complex 2D axially symmetric heterogeneous flows with consideration of a variety of physical processes: hydrodynamics, elasticity-plasticity, viscosity, HE detonation, radiant heat conductivity, etc.

A variety of physical materials in the systems under study and severe distortions of interfaces are the distinctive features of those problems.

An ability to support crash-proof computations was one of the main requirements taken into consideration during the code development, this feature is of especial importance for parallel computations on multiprocessor computer systems.

For computation of severely strained flows, LEGAK code rejects the Lagrangian representation of interfaces both during the computational process and at initial time. In such case, cells containing several materials occur (the so-called mixed cells). For calculation of such cells mass and volume concentrations of materials are taken into consideration, as well as other values characterizing each of the materials (internal energy e_i per unit mass of a material given, sonic speed c_i, etc.; see [1.2]). For calculations of cells containing several materials special algorithms and computation models are used.

The Lagrangian phase computations are carried out, in essence, by linear interpolation (equal DivU operators for components) to find the velocity of the interface not determined explicitly.

For computation of convection flows of mixed cell during the second phase, the special donor-acceptor algorithm is used that restricts the numerical diffusion, so that an interface appears to be localized within one cell.

The idea of our approach to the use of concentrations for determination of interfaces is actually the basis for the crash-proof procedure of computations in Lagrangian-Eulerian variables by LEGAK code. The concentration values are always used to determine interfaces, except for those cases, when it is certainly possible (with regard to the flow behavior in some sub-regions) to determine some interfaces by Lagrangian grid lines. For this reason, some interfaces that will be severely strained during the computational process are not Lagrangian even initially and determined by the concentration values on the grid not coinciding with the

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material boundaries; on the contrary, other interfaces may either remain Lagrangian during the whole computational process or change their representation during more late phases of flows.

Since the computational grid lines are not tied down, generally speaking, to interfaces, there is an ability to carry out computations using good quasi-orthogonal grids.

Of course, such an approach to developing a crash-proof procedure requires a noticeably more refined grid and larger time and memory resources to provide the precision of computations equal to that of Lagrangian methods.

On the other hand, application of homogeneous algorithms allowed a rather simple and quick parallelization of the code to reduce times of computations and use multiprocessor distributed-memory computer systems.

The paper describes the fundamentals of LEGAK code [1], its implementation in the code complex of the same name [3], the principles of this complex parallellization and the main features of the approach to the crash-proof procedure development for some classes of problems belonging to the code application area.

There are some examples of computations of various problems having the distinctive feature, such as severe distortions of interfaces.

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