The Experience of Mathematical Modelling of Radioactive Nuclei Mass Transport Dynamics by Parallel Computer Code

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The code TARUSA-10 was developed to describe complex generation and mass-transport processes of radioactive nuclei for nuclear reactor systems. Supercomputer (MBC-1000 "Beta") lets get almost unlimited resources to approximate any solution obtained by the numerous method. Although this task is very suitable for the vector processor but unfortunately this one is not available at MBC-1000.

Main points of the mathematical model are:

1. The nuclear reactor unit is presented as a sum of space zones (number of zones is unlimited)
2. For every nucleus in any radioactive decay chain (number of chains is unlimited) in any zone at any time moment there is the density function (solution).
3. Any nucleus may be included in radioactive decay chains.
4. For every nucleus in any zone at any time moment the source term may be calculated.
5. Any connections between zones are presented by especial parameters (mass-transport coefficients for any nucleus) to describe different chemical, physical, mechanical and decay processes in zones, individual for any nucleus.
6. Moreover there is the time dependence for mass-transport coefficients (dynamic processes)
7. The forecast time interval is presented by finite number of time-step intervals. Mass-transport coefficients are constant values in these time-step intervals.
8. Beginning conditions are defined for this task

Thus the large-scale first order differential linear equation system for the density functions is to be resolved. The supercomputer processor is 64 bit one. Large integer lets us take so little time-step to approximate the density function for the high precision. Besides we can make so long-time forecast for the density function. This function for all nuclei and for all zones at every time moment is presented as vector-function. For the every time-step interval the resolved operator for the large-scale linear system is calculated. The high precision fine-time-step method to get this operator is used. Thus we can move step by step along time scale to resolve this task.

For this task the simplest but so effective parallel method was used. Number of the fission product decay chains in library at this moment is 164. Mass-transport between chains is not available. This independence lets us calculate by parallel method every radioactive chain by one processor. Thus about 164 processors may be use to resolve this task. The efficiency of this parallel process is about 1.

Moreover the parallel solver for the super-big task is applied to get resolved operator.

The example of a practical task solution with number of differential equations about 10^6 is presented.

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