THE FARC FUEL ARCHIVE OF VVER

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ABSTRACT

The principles of organisation are explained and the structure of the FARC fuel archive for VVER reactors is circumscribed. The objective of archive is accumulation of fuel data, data storage and obtaining the fuel using characteristics. The working version of fuel archive on 01.07.98 is realised, in which the data tables for fuel assemblies for 169 VVER-440 cycles and 35 VVER-1000 cycles are stored.

There are two different versions of fuel archive - for VVER-440 (FARC) and for VVER-1000 (FARC1000). A structure of some tables and the texts of programs for them differ.

There are codes ensuring filling database from of data files, sent by a nuclear power stations.

The algorithms and codes for checking integrity, reasonableness and reliability of fuel archive data are developed.

All assembly's data are stored for 360-degree maps. If the data are presented for 30-, 60- or 120- degree sectors, they are automatically transformed in 360 degrees.

The code development of data retrieval from archive and their processing is carried out in accordance with setting the concrete tasks. Examples are calculations of the utilisation coefficient of nominal power and characteristics of control rods.

The main approaches to finding correlation between conditions of maintenance fuel assemblies and depressurisation of fuel elements are formulated.

Tools Visual FoxPro produces the database for PC in the WINDOWS environment. All information is stored in the DBF format tables.

The FARC fuel archive intends for accumulation of fuel data for the VVER reactors, their storage and obtaining the fuel using characteristics. The working version of fuel archive on 01.07.98 is realised, in which the data tables for fuel assemblies for 169 VVER-440 cycles and 35 VVER-1000 cycles is stored.

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VVER-1000 (FARC1000). A structure of some tables and the texts of programs for them differ.

For operation of archive the appropriate software ensuring filling database by means of data from files, sent by a nuclear power station is created.

The possibility of input file preparation by the BIPR-7 program data is realised.

Structure of archive.

The database is created by Visual FoxPro for PC in the WINDOWS environment. All informative data is stored in the associated tables in a format DBF. In the database at the description of each table there are comment for the table and a description of each field of the table - field name, comment for the given field and header of this field used as archive.

There are the following main tables (enumeration of fields stored in the database is given not for all tables):

- The power nuclear station characteristics (table AE)
- The used fuel assembly characteristics (table FASS440 and FASS1000)
- The characteristics of depressurised assemblies (table UNGERM)

The auxiliary information (table MG).

It contains of vectors of correspondences of the cell numberings in various geometry and number of adjacent cells for maps with various numbers of cells.

The characteristics of cycles (table RUN)

- Brief name of power nuclear station
- No of block
- No of cycle
- Date of beginning of cycle, dd.mm.yyyy
- Date of end of cycle, dd.mm.yyyy
- Cycle length, days.
- Number of assemblies in 360 degree map

- Symmetry of map at data representation by power nuclear station, degrees
- Symmetry of map for stored data, degrees
- Number fuel assemblies, loaded from storage in the given cycle
- Average fuel burnup (for all assemblies), MWdays/kgU
- Average swapped fuel burnup, MWdays/kgU.
- Maximum burnup in swapped fuel, MWdays/kgU
- Minimum burnup in swapped fuel, MWdays/kgU
- Number of the loaded assemblies in a 360 degree symmetry
- Number of swapped assemblies in a 360 degree symmetry
- The wordy comment - for any explanations
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Data for used fuel assembly - assembly characteristics for every cycle (table ASS_RUN)

- Brief name of power nuclear station
- No of block
- No of cycle
- No of fuel assembly
- The type of fuel assembly
- No of cycle for given fuel assembly,
- No of fuel assembly in prior cycle in a symmetry sector of current cycle
- Unique number of assembly
- Factory number of assembly
- Relative power fuel assembly at the beginning of cycle
- Relative power fuel assembly at the end of cycle
- Burnup at the end of cycle, MWdays/kgU
- Burnup at the beginning of cycle, MWdays/kgU. It is entered at presence of the prepared input data together with finite burnup
- Burnup at the beginning of cycle, MWdays/kgU. It is calculated by finite burnup of the previous cycle
- Flag of the assembly unloading
- Flag of belonging to the control rod assembly: W - workgroup, R - control rod, not concerning to workgroup,
- Flag of the assembly inloading from storage

Monitoring of data.

The algorithms and control programs for checking integrity, reasonableness and reliability of data brought into the fuel archive are developed. The balance of number of the inloaded and unloaded assemblies is checked. The errors are fixed, if the following facts made clear:

A. One fuel assembly

1. Equality to zero of finite burnup
2. If the assembly cycle = 1, and number of the prior assembly > 0
3. The extremely large finite burnup for fresh assemblies
4. The assembly cycle > 1 for fresh assemblies and fuel assembly not from storage. If the fuel assembly inloads from storage, No of prior cell should be = -1
5. No of prior cell exceeds the number of cells in reactor.

B. Fuel assembly pair

1. Type mismatch of fuel assembly during reloading
2. Duplication of prior numbers of assemblies
3. Duplication of current numbers of assemblies
4. The extremely large deviation from the average change of burnup for cycle in assemblies located in symmetric cells. The symmetric cells in 30-degree sector are considered. The average burnup change is calculated in view of real coefficient of symmetry. The burnup change is calculated for one day to ensure a uniform criterion for matching. From average value the minimum and maximum ones are removed.
5. Mismatch of initial and finite burnup in the previous cycle
6. Decrease of burnup between cycles
7. Violation of the cycle order for one fuel assembly

All assembly data are stored for 360-degree maps. If the data are represented for a 30, 60 or 120-degree sector, they are automatically translated into 360 degrees.

The development of programs for data retrieval from archive and their processing is carried out in accordance with setting the concrete tasks. There are examples of computations of using the nominal power factor of and characteristics of unloading control rods.

The fuel archive allows atomising researching correlation between the facts fuel assembly depressurisation and following features of conditions of maintenance these fuel assemblies:

1. burnup depth;
2. presence of significant increases in linear fuel pin power after fuel reloading;
3. belonging the fuel assembly to control group or to the its nearest environment.

The approach to research the depressurisation of the symmetric fuel assemblies is developed. A consideration of the assembly symmetry was in absolute identical conditions (from the simulation point of view) gives the additional information for speculation.

The algorithms for researches of simultaneous influence of the several factors - for 2-nd and 3-rd example - are not yet developed.

Control group of fuel assembly.

The developed algorithms assume a separate researching the fraction of depressurised fuel assemblies, included in workgroup, and/or at which one of the assemblies of workgroup is in the nearest neighbourhood. This fraction should be compared to the similar value calculated for all fuel assemblies.

Burnup depth.

When studing the depth of the burnup of the depressurised fuel assemblies of them are divided into groups within the 5%-interval of burnup. The fraction hitting in this group is compared to the similar value calculated for all fuel assemblies. The interval of burnup can vary.

Besides the average depths of burnup depressurised fuel assemblies and all remaining ones are compared.

Depressurisation of symmetric fuel assemblies.

The failure of the symmetric fuel assemblies testifies that the failure reason is lurked in operating conditions, since the probability of casual coincidence for failure of two symmetric fuel assembly is very small.

The program for the report generation with the characteristics of the depressurised symmetric fuel assemblies and their environment is written.

The presence of a significant amount of such assemblies could be a serious basis for doubts in accuracy of the power density computation and their leaps in indicated cells.

Increase of linear power.

There is supposition, according to which integrity of the fuel pin provided under monotone decrease of linear power of fuel pins in accordance with burnup. The violation of monotonicity can happen after fuel reloading. The cases were noticed, when in depressurised fuel assemblies such monotony violation happened.

Check of correlation of depressurisation and increasing linear load at fuel pins should be carried out as follows:

1. The base is filled by appropriate data necessary for calculating leaps of linear power.
2. The fraction of failed fuel assemblies is calculated at which the leaps of linear power happened under transition from cycle to cycle.
3. This fraction is compared to the similar value calculated for all fuel assemblies.