APCS for NPP on the basis of home-grown technologies

M N Mikhailov
“NIKIET” JSC, Moscow, Russia

Abstract. The report summarizes the history of the development of domestic APCS, including the Soviet period. It is noted that the USSR-located NPPs were equipped only with automatic process control systems (APCS) of domestic production. In the 90s Russia undertook gradual transition to development of software and hardware tools using imported hardware components almost completely. In addition, various systems and software and hardware facilities, which were developed in the course of revision of the documentation received under license contracts, became widely used in the NPPs of WWER type. In the area of RBMK modernization, the strategy was adopted aimed at on development and implementation of domestic hardware and software tools in the systems important to safety. The author states that recently a policy has been adopted in the industry focused on intensive development of the domestic hardware and software tools and systems for the NPP APCS.

1. History of development

The evidences from domestic and foreign experience shows that such complex area as control systems and facilities of nuclear power plants is developed rather evolutionary than revolutionary.

The initial stages are characterized by application of systems which have rather simple structure and performed functions. The civil nuclear technology uses sensors, electro-measuring instruments, electron tubes, magnetic amplifiers, electro magnetic relays, analog recorders and other devices of general purpose industrial grade mainly as hardware components. Of course, the special attention was given to the reactor control and safety systems which were developed using the unique engineering solutions and facilities [1].

Increase of the reactor capacity and their basic parameters and safety requirements in combination with the need to improve the control effectiveness result in gradual increase of the nuclear power plant (NPP) automation degree, and also in development of the special hardware and software.

For the first time in the domestic practice in respect to NPP, “Carat” IT system was developed in the beginning of the 60s of the past century for the second power plan unit of Beloyarskaya NPP. Specifics of control of the power plan unit with the channel reactor required operative implementation of calculations of power distribution by the reactor core channels and predetermined the need for the process control computer (PCC) as the system core. “Carat” system was implemented on the basis of one of the first domestic PCC of UM1-NH type. Hereafter, this experience was used in respect to the nuclear power plant units with RBMK-1000 reactors for development “SKALA” IT system (figure 1) on the basis of V-ZM PCC complex with redundant basic computer, redundant devices for communication with the facility and general peripheral devices [2].
Several IV-500 information and computing machines were put into operation in a series of the power plant units with WWER-440 reactors, but these machines performed only the functions of information collection and calculation of separate performance indicators due to their small computational capabilities. From the late 70s, the NPPs with WWER reactors were equipped with “Complex-Uran” IT system, and later with “Complex-Titan” on the basis of SM-2M computing machines (figure 2).

It must be noted that the NPP on the territory of the USSR were equipped only with automatic process control systems (APCS) of domestic production. At that, these systems were developed and produced using only domestic components and software. At that, it was not observed any significant disadvantage in general characteristics and indicators as compared with the similar systems of the foreign NPPs except some indexes, for example, the normal-mode ratio.

2. Current situation
The modern NPP APCS is the integration of all recent developments in certain devices (sensors, actuators, apparatus, software, etc.) as well as in the systems in whole.

It must be understood that the economic problems in Russia in the 90s resulted in almost total stagnation of the nuclear power industry and crash of the electronics manufacturing industry, but it became possible to purchase import components, equipment and software. All of this resulted in gradual
transition to development of software and hardware tools using import hardware components almost completely.

Besides, the systems and the software and hardware suites developed by processing of the documentation received under license contracts became widely used in the NPPs of WWER type. The remarkable example of such approach is the standard software and hardware tools of several generations (TPTS, TPTS-E, TPTS-EN, TPTS-NT, TPTS-SB) manufactured (see figure 3) under the design documentation developed by “VNIIA” FSUE according to the domestic standards on the basis of the license for Teleperm ME platform of Siemens [3]. The elements with improved reliability produced by the leading manufacturers in the world are used as the hardware components.

Also, it is important to stress that the import software and hardware suites incorporated in the safety control systems (according to NP-001-15 terminology), for example, the suites of AREVA, have been already installed or purchased for implementation at several domestic NPPs of WWER type, for example, at Kolskaya, Leningradskaya and Novovoronezhskaya NPP. Various import software are prevalent in the upper block level systems classified as important to safety. At the present time, some efforts are made to obtain the open codes of the corresponding software products and to certify them as regards information security. The example is PORTAL program platform. Also the domestic facilities are gradually being developed, first of all, for the systems important for safety. The example is the above mentioned TPTS-SB apparatus.

In [4], the APCS of the Belorusskaya NPP is considered. The power plant units of the Leningradskaya NPP-2 of NPP-2006 project were selected as the prototypes of the Belorusskaya NPP units. At that, the Belorusskaya NPP APCS has some outstanding features; in particular, the triggering part of engineered safety feature actuation system for Belorusskaya NPP meets all requirements of the
regulatory documentation to the systems of this class and supplied by the Russian manufacturer (VNIIA) while the Leningradskaya NPP-2 uses AREVA hardware and software tools.

The APCS has standard structure (see figure 4). But, the Belorusskaya NPP APCS will have a variety of advantages, such as APCS implementation using only Russian hardware and software tools, and also increase of standardization degree due to application of uniform equipment for high levels of control.

Figure 5 shows the power unit control post for the modern NPP of WWER type.

Figure 4. APCS structure in Belorusskaya NPP.

Figure 5. Power unit control post for the modern NPP of WWER type.

In the area of RBMK, the strategy was adopted at modernization focused on development and implementation of domestic hardware and software tools in the systems important to safety. Although the import components are used for hardware, but the domestic equivalents are also may be used upon
their availability. The structure of the main control systems for the power plant units of RBMK-1000 type is given in figure 6.

Figure 6. The structure of the main control systems for the power plant units of RBMK-1000 type.

The main system is the integrated monitoring, control and protection system (IMCPS). Its key feature is implementation of deterministic safety principles, and namely: two shutdown systems each of which can independently switch the reactor into pre-critical condition and maintain it with no single point of failure or personnel error; two independent equipment set for information processing and output of emergency and control signals with three channels in each set; variety principle both for equipment sets (each set has its own designer and manufacturer) and for shutdown systems (different reactivity introduction devices and drivers, different designers, manufacturers, etc.).

The safety control systems for manufacturing systems (SCS-M) are based on the same hardware and software tools as the IMCPS. The computer systems may be designed and implemented as the independent systems as well as as a part of other control systems. The uninterrupted power supply systems (UPS) included in the main systems are used as the support systems. Main control rooms and emergency control rooms (MCR and ECR) are modernized or designed completed with other systems.

The domestic software is used within all above mentioned control systems. One of the critical complex components is KROSS program developed by NIKIET itself.

It is necessary to point out that the particular attention is paid to the verification issues regarding absence of undocumented features both for hardware and software of RBMK control systems.

The crucial element is the testing site which is designed for research, development and engineering (including acceptance testing of prototype equipment units), functional tests of the supplied equipment and following author’s supervision of the systems during the whole life time at the NPP.

Figure 7 shows the main control room at the NPP of RMBK type.
The approach mentioned above for RBMK is also adopted for the APCS of the power plant unit with BREST-300 reactor. In particular, it was developed the table simulator for the reactor plant control systems which is in operation now (see figure 8). It provides mastering of hardware as well as software.

Finally, the software mastered on the testing facility is transferred into the real devices.
3. Conclusion

Sum up, it may be said that recently, there was adopted the strategy in the industry focused on intensive development of the domestic hardware and software tools and systems for the NPP APCS including their certification for supply to the foreign markets as a part of cooperation under the supervision of RACS JSC.

References

[1] Zinkin A N, Lysikov B V et al. 2002 Experience in designing and development of monitoring, control and protection systems for the reactor plants of different Experience in Nuclear reactor designing: Book of science and technology conference reports (Moscow) pp 121-135

[2] Adasko V I, Desyatnikov I I, Dolkart V M 1991 Information systems of NPP power units with RBMK-1000 reactors. Designing experience and development prospects Electric engineering 9 pp 53-60

[3] Kishkin V E, Narits A D 2015 Evolution of hardware and software tools of the automatic control level for the nuclear and thermal power plant APCS BGUIR reports 2 pp 13-15

[4] Akimov N N, Bibikov V V, Koltsov V A, Lotov V N 2015 Automated process control system in Belorusskaya NPP BGUIR reports 2 pp 9-12