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Innovations at the MT-25 microtron aimed at applications in photon activation analysis

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Microtron is a high frequency cyclic accelerator of electrons with fixed frequency and constant magnetic field. Electrons are accelerated in a cavity resonator by high frequency energy supplied by high pulse power of a magnetron, orbit within an accelerating chamber in circular trajectories with gradually increasing diameters, gaining gradually higher energy, and can be extracted from individual orbits to achieve required beam energy. The accelerated electron beam can be converted into high energy photon radiation - bremsstrahlung - on a target made usually of tungsten. Microtron can thus be used as an effective source of high energy photon radiation for use in photon activation analysis (PAA). With a suitable secondary converter, microtron can be used also as a neutron source suitable for neutron activation analysis.
In 1981, microtron MT-22 built at the Czech Technical University in Prague in collaboration with JINR Dubna started operation. After ten years of operation, MT-22 was replaced by a new, chamberless microtron MT-25. In 2003, MT-25 was made over to the Nuclear Physics Institute, ASCR (NPI) and its modernization started aimed at upgrading microtron parameters such as the mean accelerated electron current, quality of the beam and irradiation fields, and attaining better long-run operation stability and reliability. MT-25 delivers highly monoenergetic electrons within the energy range 6 - 25 MeV with the maximum mean beam current 25 microA. Stable operation of MT-25 at a 20 microA mean electron current (at >20 MeV energy) started in 2006, and its utilization for PAA on a larger scale has been re-established. Several, mainly geochemical and cosmochemical studies have been carried out or are underway.
Until recently, PAA analyses could be carried out only in the offline regime, i.e., in assay of elements providing by photoactivation radionuclides with sufficiently long half-lives. Currently, installation of an automated system for rapid sample transport between the beam position and detector in the short time, online irradiation regime is being completed which will provide substantial extension of the analytical range of IPAA. The system has been designed as a pneumatic tube system driven by three vacs and controlled by a commercially available modular programmable controller. The irradiation chamber has been designed as a rotation device with the axis of rotation perpendicular to the axis of the beam. The system enables special operations, such as multiple irradiation-counting cycles, counting sample either in a transport/irradiation vial or its manual removal from the vial before counting, etc. An important part of the system is a four-way switch (router) placed above a detector shielding.
Operation of the microtron MT-25 has so far been controlled manually. For a routine operation, especially for repeated short-time irradiations, it is desirable to run microtron in a continuous stable regime with minimum fluctuations of the electron beam energy and current between irradiations of individual samples. Also for this purposes, a new fuzzy control system for the microtron MT 25 has been designed and optimized. The control system is based on a Mamdani-type fuzzy regulator using an operator description and a mathematical model of the microtron. The system allows controlling the energy and the current of accelerated electrons at required values. The fuzzy controller was tested with the aid of the mathematical model with satisfactory results and its optimization was performed with the help of a genetic algorithm. The optimization was performed in two phases, the first one aimed at maximizing speed of the control process and minimizing the control error, and the second one at minimizing the control overshoot. A real control system has currently being tested with encouraging results.
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