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ABSTRACT

Kinetic parameters and feedback reactivity coefficients of a research reactor at different burn-up were analyzed to investigate safety performance. For this purpose reference operating core of Pakistan Research Reactor-1(PARR-1) and proposed core utilizing Low Enriched Uranium (LEU) high density fuel (U_3Si_2-Al) with best performance were chosen. For searching of equilibrium core with best performance different core configurations were studied utilizing LEU fuel of the existing density of PARR-1 and higher densities of 4.0 and 4.8 U g/cc (U_3Si_2-Al) and performance was investigated for each core.

Effective delayed neutron fractions and prompt neutron generation times were calculated at different burn-up for reference operation core of PARR-1 and proposed core utilizing WIMSD/4 and CITATION codes. Effective delayed neutron fraction is larger for proposed core than reference operating core of PARR-1 while prompt neutron generation time is smaller for proposed core. β_{eff}/Λ is decreasing by factor of 0.276/full power day for reference operating core and 0.374/full power day for proposed core with burn-up. It is observed that β_{eff} strongly depends on the core size and is bigger for smaller cores and smaller for larger core while prompt neutron generation time is smaller for hard spectrum.

Rossi-Alpha (β_{eff}/Λ) for critical reactor was measured experimentally by noise analysis technique at PARR-1 reference operating core at 35.26 full power days burn-up. The auto power spectral density of the linear channel is taken and used to find out the break frequency by non-linear least square fitting method, which leads to β_{eff}/Λ = 161.45 s^{-1}. The measured and calculated values for Rossi-Alpha are in good agreement within 0.235% of error.

Study of feedback coefficient of reactivity reveals that fuel temperature coefficient is more negative for proposed core and moderator temperature and density coefficients for reference operating core of PARR-1 are more negative. Feedback coefficients are more negative with *equilibrium xenon concentration. Taking the xenon free cores at beginning of burn-up cycle and equilibrium xenon concentration at other burn-up steps, fuel temperature coefficient of reactivity is 16.98 % and 5.85 % more negative at 35.26 full power days burn-up comparatively at BOC for reference operating core of PARR-1 and proposed core respectively. At same conditions moderator temperature coefficient is 25.93 % and 15.44 % more negative while moderator density coefficient is 7.44 % and 5.38 % more negative for reference operating core of PARR-1 and proposed core, respectively.*

Steady state thermal hydraulic analysis shows that reference operating core can be safely operated at 10.0 MW, with 1.41 safety factor to onset of nucleate boiling (ONB) and minimum margin to burnout is 4.2 while proposed core limited to 9.0 MW with 1.36 safety factor to ONB and minimum margin to burnout is 3.61.

Fast reactivity ramp insertion transient analysis reveals that proposed core is limited to 1.4 $ per 0.5 sec due to limiting condition of clad temperature while reference operating core is safe to reactivity ramp of 1.5 $/0.5 sec. Fast ramp reactivity insertion at different burn-up simulation shows that increase in burn-up decreases peak power, energy released and clad temperatures. Increase in prompt neutron generation time with burn-up results in sluggish response of reactor to reactivity. Feedback reactivity coefficients become more negative with burn-up which also mitigate the severity of transients and contribute in improvement of safety of a research reactor with burn-up.