Mathematical models and simulations of an integrated downer–regenerator FCC unit are presented. The models describe the steady-state nonisothermal behavior of the interdependent heavy oil cracking downflow reactor and catalyst regeneration fluidized-bed reactor. The models are rooted in four-lump cracking reaction kinetics and complete combustion kinetics for the regenerator reactions. Simulations results for the downer-type unit are partially validated against data collected in a 0.1–0.3 b/day pilot plant that was operated in the high-severity mode. The results are fairly reasonable especially in regard to predicting the performance of the cracking reactor.