2.9 Fast reactors

An alternative to the thermal reactor strategy is to strive to attain criticality using, primarily, fast neutrons. Various fuels and combinations of fuels can provide the required self-sustaining reaction. Highly enriched uranium (over 20% ^{235}U) is possible and in this process ^{238}U produces several isotopes of plutonium including ^{239}Pu and ^{241}Pu by neutron capture. Then the ^{239}Pu and ^{241}Pu undergo fission and produce heat in the same way as ^{235}U or ^{233}U. The ^{238}U is referred to as the *fertile* material while, like ^{235}U or ^{233}U, the ^{239}Pu and ^{241}Pu are referred to as *fissile* materials. An alternative is the fertile thorium, ^{232}Th, that yields fissile thorium.

While fast reactors could use enriched uranium, they are more efficiently fueled with fissile plutonium or a mixture of uranium and plutonium. In the latter case the ^{238}U will produce more plutonium. A reactor in which the net change of plutonium content is negative is called a *burner* fast reactor while a reactor in which the plutonium content is increasing is termed a *fast breeder reactor* (FBR). Commonly fast breeder reactors are cooled using liquid metal (sodium, lead or mercury) rather than water and so are referred to as *liquid metal fast breeder reactors* (LMFBR). Almost all the commercial fast reactors constructed to date are LMFBRs and hence the focus on this type in the pages that follow.

The advantage of a fast reactor is that it makes much better use of the basic uranium fuel, indeed by an estimated factor of 60. Moreover, since an FBR breeds new fuel there are subsequent savings in fuel costs since the spent fuel can be reprocessed to recover the usable plutonium. Examples of LMFBRs are the French-built Phenix (and Superphenix) and the Russian BN-600 reactor that has been generating electricity since 1980 (see section 4.8). However, as described in section 7.6.3, the safety issues associated with these fast reactors are much more complex than those with thermal reactors.