Reactor-Boiler and Auxiliaries - Course 433

AUXILIARY CIRCUITS

In addition to the main reactor systems which are primarily responsible for the production and transfer of heat, a number of auxiliary systems are generally present to support the main systems or serve special purposes. Some of these are present to remove heat caused by radiation capture, others to control the chemistry of main systems and still others for safety reasons.

Some of the most common reactor auxiliary systems will be briefly described in this lesson.

Reflectors and Reflector Cooling

The reflector was defined in an earlier lesson as a material surrounding the reactor core which prevented neutron losses by bouncing (or reflecting) neutrons back into the core. We have since studied moderators and learned that a moderator must be able to slow neutrons down quickly without capturing too many. In general, materials which make good moderators, also make satisfactory reflectors, but the requirements are not so stringent. For example, light water cannot be used as a moderator with natural uranium because of its neutron capture, but it is satisfactory as a reflector. Other materials which may be found as reflectors include heavy water, carbon (graphite) and in special cases, beryllium. If water is used, it must, of course, be contained in a vessel around the core, and the materials used to make the vessel must be acceptable for reactor core construction as discussed in an earlier lesson. This is sometimes simplified by making the moderator vessel bigger than the fuel core, so that the outer part of the moderator in the vessel acts as a reflector.

If a separate reflector is used, a method of cooling is required, since the capture of radiation in the reflector material causes heating. The heat removal system will depend upon the material chosen for the reflector. A liquid reflector can be circulated through a heat exchanger and cooled in a manner similar to a moderator system. A solid reflector material such as graphite must be cooled by circulating a coolant in embedded pipes or by blowing a gas coolant over the graphite blocks.

Shield Cooling

Due to the radiation released in a reactor, both at the time of fission and as the fission products decay, a heavy shield is required to protect personnel. The main part of this shield is often a thick concrete wall. As the radiation is stopped by the shield, the energy of the radiation is changed to heat. At the inner surface of the shield where the radiation is most intense, the heat produced would cause excessive temperature if some method of cooling is not supplied.

As well as producing stresses which could lead to mechanical failure, high temperatures in a concrete shield will drive out retained water, and hence reduce the shield's effectiveness.

The most common cooling system is to embed pipes near the inner surface of the shield, and use a pump to circulate water through the embedded pipes and a heat exchanger.

Demineralizer Systems

In any of the systems where water is recirculated, there is likely to be a demineralizer or chemical control auxiliary circuit. This is normally a small parallel circuit containing one or more ion exchange columns and possibly a filter. An exception to this is the chemical control equipment for the boiler system which will be discussed in a later lesson. The purpose of a filter is obviously to filter out particulate matter down to some acceptable size of particle. Various types of filters can be purchased depending upon the degree of filtering required. As a general rule, the cost increases (either due to initial cost or more frequent replacement) as the size of particle which must be removed, is reduced. A filter is normally located up-stream from the ion exchange columns to prevent plugging of the columns.

The action of an ion exchange column will be described in more detail in lessons you will take later in chemistry, and for the present, we will only describe the general results obtained. Some materials may dissolve in the system, and exist in the in the form of individual molecules. These can obviously not be filtered out by mechanical means, but can effect the chemistry of the system. This can include such things as corrosion products from the system components, or products formed from gases which are picked up from the air. For example, under some conditions, nitrogen from the air can lead to the formation of nitric acid which is very harmful to most systems and must be removed. This type of impurity is very effectively removed by ion exchange columns. After a period of time, a column may become so loaded with impurities, that it cannot remove any more. The column is then said to be spent and must be replaced. In some cases, columns can be "regenerated", in which case replacement with a new column is not necessary.

Dousing and Containment Systems

One of the main considerations in analysing the safety of a nuclear station is the question of whether or not large amounts of radioactive material could escape from the site following a major (even if almost impossible) accident. Various systems have been used to help ensure that any major activity release will remain on the site. One of the methods which has been used in a number of nuclear stations in the U.S.A., is to construct a containment shell around the whole reactor building. This is large, often spherical building, which is evident in pictures of some American stations. This approach is very expensive, since the shell is very large and must be constructed to stand whatever pressure is considered to be maximum in a major accident.

In the Canadian program, a different approach to the containment problem has been adopted. This approach is based on the following factors:

1. In a heavy water moderator and water cooled reactor, the pressure surge following an accident is due , almost entirely, to steam formation.

2. The initial release of steam will occur before any significant fuel failures and will, therefore, contain very little radioactive material.

Based on these factors, a method is used which will control the pressure below that which would damage the normal building required. A relief system may be supplied which will vent the initial burst of non-radioactive steam and then return to the sealed condition.

A large supply of water from a reliable source (such as a large storage tank) is then sprayed into the area which contains the steam. This water spray condenses the steam, and hence lowers the pressure. This dousing action has led to the name dousing system for this equipment.

The system will typically include a water storage tank, large lines with power operated valves, and spray nozzles or tanks in the area where a steam leak may occur. One of the important considerations in the design of this type of system is the need for testing. Since it is a safety system, some assurance of reliability is required, and at the same time, there is a high probability that it will never be operated in the life of the station. Long idle periods can lead to valves sticking, etc, so it is normal to test the valves at regular intervals, say once or twice a year. This means that two valves have to be installed in each line so that any valve can be tested without releasing the water.

ASSIGNMENT

1. What is the purpose of a reflector?
2. Why is it necessary to supply cooling to the inner part of the bulk shield?
3. An ion exchange column will act effectively as a filter. Why then is a filter often installed up-stream of the ion exchange column?
4. Give two examples of things an ion exchange column might remove from a water circuit.
5. What is the purpose of a dousing system?

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