Determining the Oxygen Content of Steel By Neutron Activation Techniques

by F. C. Burns

Fast and accurate means for determining the elemental oxygen content of steel are required by today's steelmakers. One of the techniques that has been developed to meet these requirements is the fast neutron activation method, which is based on the measurement of gamma rays emitted by elemental oxygen when exposed to a neutron flux.

Basically, this testing method depends on a system consisting of three components: a neutron generator, a gamma-ray scintillation detector, and a pneumatic transfer system. In the neutron generator, deutrons are accelerated to a potential of 150 kev and are permitted to strike a tritium target, thus forming a compound nucleus (see Fig. 1). This nucleus decays into an alpha particle and a 14-Mev neutron.

The 14-Mev neutron, on striking an oxygen-16 atom in the sample, forms a second compound nucleus. This second nucleus instantly decays to a proton and a radioactive nitrogen-16 atom. The latter decays with a half-life of 7.4 sec, emitting a beta particle and a 6-Mev gamma ray.

By counting the number of 6-Mev gamma rays emitted by any steel sample after irradiation by 14-Mev neutrons, and by using a suitable detecting system, the oxygen content of the steel can be determined.

The system

In Fig. 2 is shown a diagram of an automatic fast neutron activation device for oxygen detection. Although the neutron generator itself measures only 3x8 ft, the necessary protective shielding causes the entire system to fill 144 sq ft of space.

In the operation of this system, the weighed and cleaned sample is shot—by means of a pneumatic transfer system—into the neutron flux provided by the generator. The sample is irradiated for 20 sec, and then is automatically returned to a gamma-ray detector. The counter is activated automatically when the sample arrives, and the gamma radiation of the sample is counted for 20 sec. The count is then printed out by the analyzer.

Next, the same procedure is followed for analyzing a standard sample. A comparison of the count from the standard and the count from the sample gives the oxygen content of the sample. The standard can be almost any metal with a known oxygen content.

With this analytical system, only two elements can cause interference: fluorine and uranium. Therefore, the technique can be applied to almost all common types of steel and steel alloys.

The size and shape of the sample can vary widely. Sample weights, for example, can range from 1 to 100 g. The only restriction on the sample's shape is that it be the same as the standard used.

Prior to analysis, samples must be thoroughly cleaned. Oxygen in residual surface iron oxide can cause erroneous testing results.

The accuracy and repeatability of this technique depend on the oxygen content of the sample. If the oxygen concentration is only 10 ppm, accuracy of ±25% and repeatability of ±20% can be expected. However, if the concentration is 500 ppm, accuracy of ±5% and repeatability of ±1% are obtained.

Summary

A fast neutron activation technique has been developed for determining the elemental oxygen in steel samples. With this analytical method, large, representative samples of steel can be analyzed in as little time as 1 min.

Since samples are tested nondestructively, it is a simple matter to check the results of a reading—either immediately or at a later time.

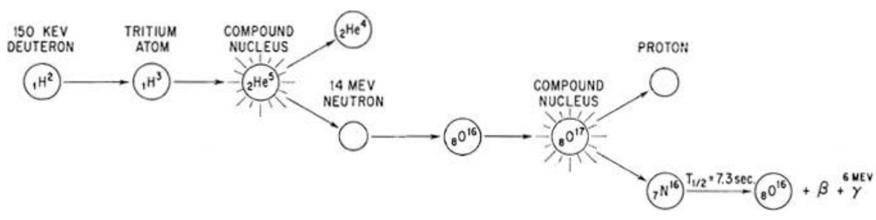

Fig. 1—Reactions inside of the neutron generator.

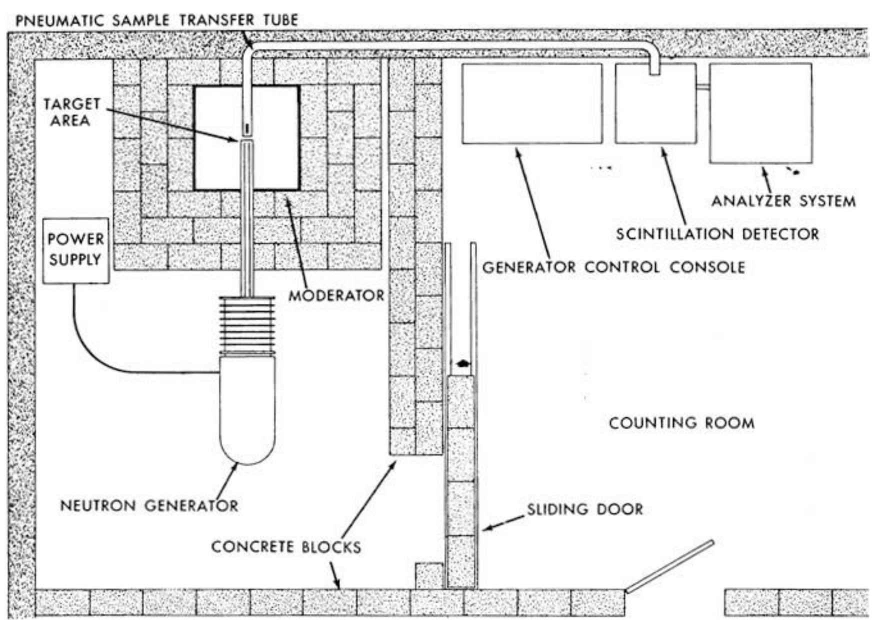

Fig. 2—An automatic fast neutron activation device for oxygen detection.

F. C. BURNS is a research nuclear chemist at the US Army Materials Research Agency, Watertown, Mass. This paper was presented at the 47th National Open Hearth and Basic Oxygen Steel Conference in Pittsburgh.