Chapter 8

Oxygen Steelmaking Furnace Mechanical Description and Maintenance Considerations

K. J. Barker, Manager of Technology—Steelmaking and Continuous Casting, USX Engineers and Consultants, Inc.
J. R. Paules, Manager, Technical Services, Berry Metal Co.
N. Rymarchyk, Jr., Vice President, Sales and Engineering, Berry Metal Co.
R. M. Jancosko, Exec. Vice President, Vulcan Engineering Co.

8.1 Introduction

The intent of this chapter is to provide a mechanical description of the basic oxygen furnace (BOF), as well as the maintenance of certain BOF components. The components covered in this report include basically all components of the BOF vessel and the trunnion ring up to the trunnion pins. Excluded areas are probes, couplings, bearings, foundations and the various drive units. The BOF components covered are: top ring and lip ring; cone, barrel, bottom shells and transition knuckle sections or flanges; brick retainer rings, slag shields and taphole assembly; working and safety refractory linings; vessel support system; trunnion ring, trunnion blocks and trunnion pins; cooling system for the vessel or trunnion ring; and oxygen lances.

This chapter is an abridged version of *AISE Technical Report No. 32, Design and Maintenance of Basic Oxygen Furnaces,*[1] with the addition of Section 8.5 which addresses oxygen lance design, and Section 8.6 which addresses sub-lance design.

8.2 Furnace Description

8.2.1 Introduction

This chapter is established to provide a description and preliminary design considerations for the manufacture and supply of BOFs. Basic oxygen furnaces are so called by virtue of the refractory and the additives used in their steelmaking processes. The processes referred to in this chapter are those which involve the treatment of a mixture of steel scrap and molten iron, generally transported from the blast furnace to the BOF. The steel scrap and hot iron are charged into the BOF vessel and oxygen is injected in one of many different methods into the furnace for purposes of producing a steel melt of specific chemical and physical properties.

The processes involved share one common operating factor; the injection of oxygen into the furnace is the agent for decarburizing the molten hot iron and generating the reaction heat required to melt the scrap.

For purposes of this chapter, the terms used will be consistent with the following descriptive definitions. A BOF installation consists of the basic oxygen furnace, furnace support foundation, furnace tilt drive and controls, furnace water cooling system, fume exhaust and cleaning system, oxygen injection system, auxiliary furnace bottom stirring system, process additives system, scrap and hot metal charging system, molten steel delivery and slag disposal system, furnace deskulling system, and other auxiliary steelmaking requirements such as sampling, refractory inspection and relining systems, process computers, etc.

An operating BOF, Fig. 8.1, consists of the vessel and its refractory lining, vessel protective slag shields, the trunnion ring, a vessel suspension system supporting the vessel within the trunnion ring, trunnion pins and support bearings, and the oxygen lance.

The BOF vessel consists of the vessel shell, made of a bottom, a cylindrical center shell (barrel), and a top cone; reinforcing components to the cone, such as a lip ring and top ring; auxiliary center shell and top cone flanges for bolted-on top cones; auxiliary removable bottoms for bottom reline access, or for individual bottom reline of bottom-blown vessels; and a taphole. This list is not intended to be either restrictive or comprehensive, e.g., top cone flanges are not universal.

BOF vessels can be one of the general classifications presented in Fig. 8.2. These are top-blown vessels, in which the oxygen is injected above the hot metal bath by means of a retractable lance; top-blown vessels, in combination with bottom stirring, the latter usually by introducing metered amounts of inert gas at specific locations under the hot metal bath—the introduction of the inert gas is either through porous plugs or tuyeres; bottom-blown vessels, in which the oxygen is injected under the molten metal bath through tuyeres arranged in the bottom of the vessel, and usually carrying pulverized additives; bottom-blown vessels utilizing a calculated source of heat energy provided by hydrocarbon fuel, in a very similar arrangement as the bottom blown vessel; and combination-blown vessels, in which the oxygen is introduced under the bath through tuyeres

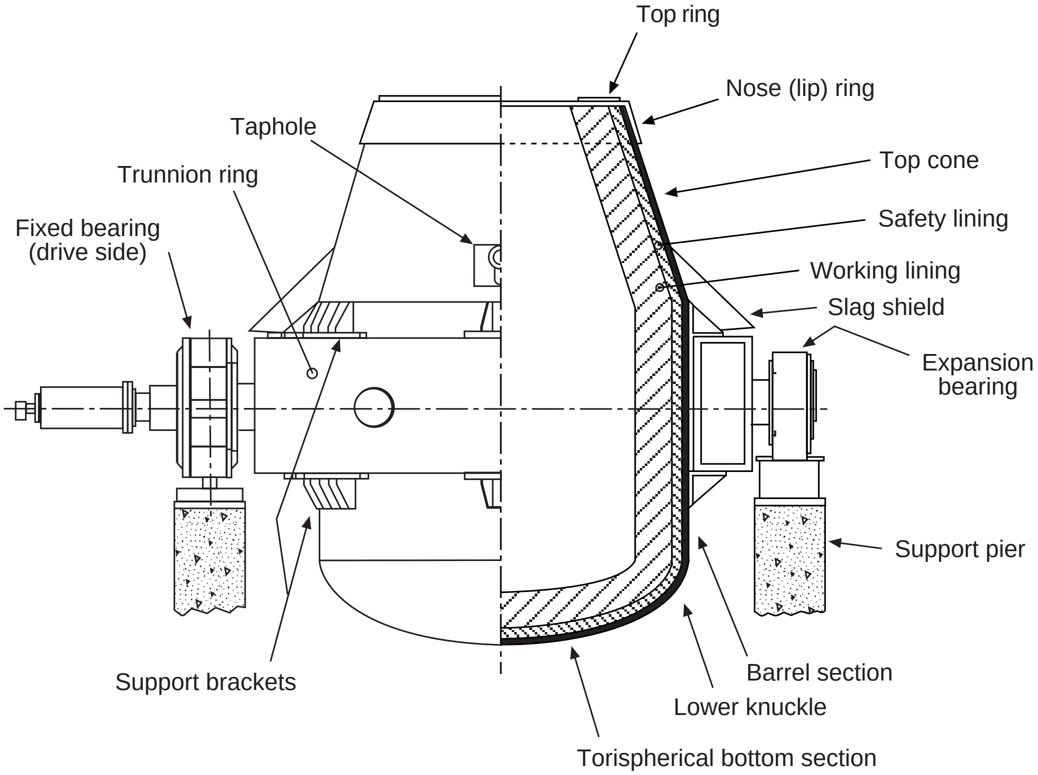

Fig. 8.1 BOF configuration.

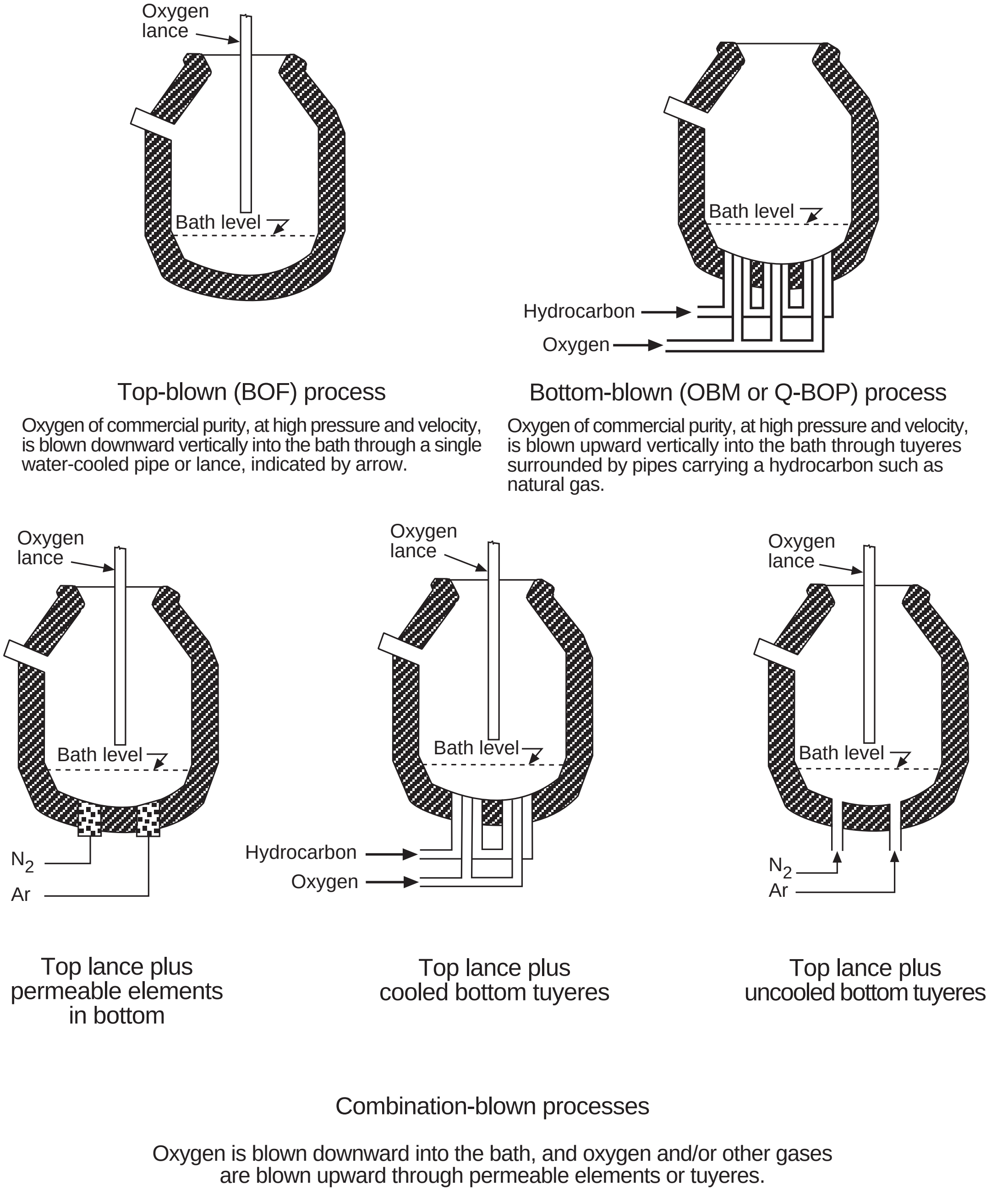

Fig. 8.2 General BOF vessel classifications.

in the bottom of the vessel, as well as above the bath through a lance—the oxygen blown through the bottom usually carries pulverized additives. Fig. 8.3 presents commercially available bottom stirring processes.

8.2.2 Vessel Shape

The shape of the vessel has an influence on the efficiency of the steelmaking process inside. This is particularly the case when the oxygen to the steel bath is supplied only from the top (top blowing). Fig. 8.4 shows a variety of shapes and sizes which were used in North America during the

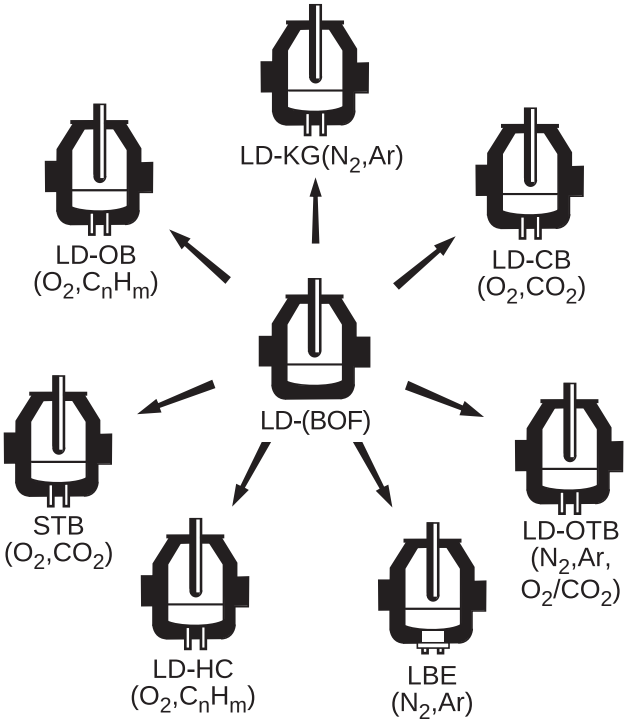

Fig. 8.3 Commercial variations of bottom stirring practices.

period of 1954–1973. Although many factors would influence the shape of the vessel, an approximate rule of thumb which has yielded favorable designs relates to the specific volume of the vessel. In conjunction with the rate of oxygen blowing, Fig. 8.5, and with hot metal composition as controlling factors, operating experience has shown that in general when the specific volume is in excess of 26 cubic feet per net ton of processed steel, Fig 8.6, the yield loss due to slopping is highly reduced.

Except for the case of a greenfield site installation, the optimum vessel shape for the particular application is usually determined by factors other than the oxygen blowing efficiency. The height clearance and the distance between trunnion pin bearing centers are two common factors which limit vessel volume increase in a vessel replacement project.

8.2.3 Top Cone-to-Barrel Attachment

There are generally two methods for the attachment of the top cone of a vessel to its cylindrical section, namely welding or bolting. Welded top cones can be either corner welded or welded with a rounded knuckle. In each case, the inside surface of the shell must be free from offsets because of stress concentrations. Corner welded transitions are more susceptible to cracking than rounded knuckle transitions.

Bolted top cones, on the other hand, necessitate outfitting both the cone and the top of the cylindrical center section with adequately heavy flanges and elevated temperature-resistant bolts and nuts.

The taphole on BOFs built in the U.S. has been placed mostly in the cone section. The centerline of the taphole usually falls on the intersection of the refractory linings of the top cone and the cylinder. In vessels with a top cone knuckle, most of the tapholes fall partly within the knuckle area. In other countries, there are numerous vessels where the tap nozzle is actually located in the top cylinder of the center shell. This is done to utilize the properties of the molten steel flow which are associated with the angle of the tapped molten steel jet, the ferrostatic head, and the control of the

