OTTAWA December 24th, 1941.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1138.

Some Practical Considerations of the
Use of Side-Blow Converters
in the Present Emergency.

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BUREAU OF MINES
DIVISION OF METALLIC MINERALS

ORE DRESSING AND
METALLURGICAL LABORATORIES

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
MINES AND GEOLOGY BRANCH

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Some Practical Considerations of the Use of Side-Blow Converters in the Present Emergency.

The side-blow converter, known also as a "Baby Bessemer" or "Tropenas", is used to produce metal for steel castings of various sizes and classifications. Now that electric furnace capacity is limited, additional steel foundry capacity can be obtained by equipping grey iron foundries with side-blow converters. Steel made by this method could be used to advantage in many applications, thus releasing the electric furnace for the specific applications for which it is so pre-eminently satisfactory.

The side-blow converter process consists in melting mixtures of scrap steel and pig iron in a cupola operated in the same way as in grey iron practice; transferring the molten metal to a cylindrical vessel lined with refractory material, open at the upper end for the escape of the gases; then blowing air at or over the surface of the molten metal. The oxidation of the silicon, manganese and carbon contained in the metal furnishes the heat for the refining process. At the end of the operation the blown metal contains approximately 0.08 per cent each of silicon, manganese, and carbon. The metal is deoxidized by additions of silicon and manganese, and sufficient amounts of each of these elements are added to provide the desired content in the final product. Carbon may be increased by the carbon content of the alloys, or by the use of recarburizers. Molten iron from the cupola is frequently used for this purpose.

The chemistry and thermal reactions of the side-blow converter process are not given here, as they are readily available in the metallurgical texts dealing with steel-making processes.

The converter installation consists (in addition to a cupola) of a cylindrical vessel made in two pieces, both constructed of heavy steel plate, the shell and bottom section being fitted with a short funnel-shaped top-piece clamped to the shell which is removable to facilitate lining. The vessel is supported by two trunnions mounted on standards so that it can be rotated to any position desired for charging and pouring the metal. The air required for the operation is supplied by a positive-pressure blower through a hollow trunnion into the tuyere box mounted on the shell of the vessel. Essentially, the installation requires a vessel and its supporting standards, the tilting mechanism and motor, and the blower and motor. In addition, a hood to remove smoke, gases and sparks produced during the blowing operation is necessary.

Side-blow converters are generally referred to as of 1-ton or 2-ton capacity, have 5'0" or 5'6" diameter shells with 13 to 13½ inches of lining. The tuyeres, five to seven in number, are 15 to 17 inches above the bottom. The tuyeres are 1¼ inches in diameter.

The adaptability of the converter process has long been an established fact. Until quite recently, however, the ease of control of other processes was a limiting factor in new installations of converters. Two recent developments which are helping to increase their use are, first, the improved methods of desulphurization which permit production of converter steel with lower sulphur contents than easily possible previously, and, second, the adaptation of "electric eye" control. This scientific instrument control for automatic indication of cycle temperatures and accurate determination of the end-point of the blow makes training of operators easier and establishes the operation on a definite routine.

Desulphurization.

In making steel, the sulphur content must be held quite low for most grades of steels, except in some cases where sulphur is desirable and required for certain purposes. Formerly, difficulty was occasionally experienced in obtaining cupola metal with a sulphur content sufficiently low that the steel produced from it would meet the requirements. The process for removal of part of the sulphur, known as desulphurizing, is accomplished by treating the molten iron with crude sodium hydroxide, crude sodium carbonate or fused sodium carbonate. The amount used is approximately 15 to 20 pounds of desulphurizer per ton of metal treated. The most convenient compound to use is Purite, which is available in two-pound briquettes. These briquettes melt slowly on the surface of the molten iron, causing a violent boiling action in the bath and forming a highly fluid slag. Sulphur and entrained oxide impurities are removed from the iron and absorbed by the slag. The operation requires that the slag be removed after the reaction is completed.

The process of desulphurizing may be carried out by either of two methods: (1) batch desulphurizing, or (2) continuous desulphurizing.

Probably for the average converter process where the operations are at irregular intervals the better method is the batch type. This method makes use of a standard crane-type ladle. Iron from the cupola is tapped out into the ladle until it is partially filled, then part of the required amount of desulphurizer is added. During the time the ladle is being filled the remaining portion of the desulphurizer is added. The reaction is allowed to continue until the boiling action ceases, then the slag is removed as completely as possible. The metal is then ready for transfer to the converter.

A convenient slag skimming tool can be made by using green, hard wood, two-inch planks cut to sections of suitable width by six or eight inches deep, fastened to a handle made from ususl bar stock. The wooden skimmer can be used for satisfactory slag removal without becoming coated with metal, a disadvantage of steel plate skimmers, and when unfit for further service it is easily replaced.

The continuous process of desulphurizing is better suited to installations where operations are carried out on a large scale throughout the day, when a supply of metal must be available at all times. The metal is desulphurized continuously while filling a receiving or reservoir ladle.

The efficiency of this desulphurizing process has been increased by the recent development of the elongated, U-shaped, teapot spout, insulated and covered, receiving ladle. The ladle has an insulated lining between its steel shell and its inner brick or monolithic lining and is fitted with a refractory-lined cover. The insulated lining and cover help in conserving the heat of the metal and prevent an excessive drop in temperature. The ladle is placed with its long axis at a right angle to the cupola spout in such a position that it receives the molten metal at the end remote from the teapot spout. While the ladle is being filled, the metal is treated with desulphurizing compound. Usually the flow of metal from the stream and the violent boiling of the compound are sufficient to carry on the reaction, but it may be hastened and accomplished more thoroughly by stirring or agitating the metal in the ladle with a green wood pole. When the reaction is complete, the slag must be removed. The ladle has an opening fitted with a spout, on the rear side of the ladle a short distance below the top. The slag is removed by turning the ladle backwards and allowing the fluid slag to run out. In continuous operation, the removal of this slag should be done at definite intervals, followed by additions of desulphurizing compound. The amount of compound required depends upon the amount of sulphur in the molten metal, the sulphur content desired in the finished metal, and the temperature of the molten metal, but is approximately the same as used in the batch process. With hot cupola metal, the reduction of sulphur is accomplished more satisfactorily.

Lining.

The converter lining may be either silica brick or a rammed-in ganister monolithic lining.

The silica brick used for lining may be either standard shapes (nine-inch straights and arches interspersed to form the desired circle) or shapes made up especially for lining converters. The converter special shape bricks are usually made in two sizes so that an inner and an outer (next to the shell) circle of brick are used. The inner circle of brick can be removed and replaced when repairs are necessary. The tuyere section is made in either one complete shape or in two half-sections. In using silica brick, the customary allowances for expansion must be made. Care must be taken in the preliminary drying of the lining or the brick will spall and crack, especially the large tuyere shapes. Before starting operations, the lining should be inspected and any cracks patched to prevent trouble due to "run-outs" of metal during the blow.

The ganister lining is possibly the most used in America. The ganister used is obtained from a siliceous rock crushed and screened to 1/8 inch and fines. It should not be confused with foundry ganister, the name given to crushed brick salvaged from cupola repair jobs. The ganister is mixed with 10 per cent high-quality fireclay and moistened with sufficient silicate of soda (water glass) solution or molasses water to give a good bond. For best results, the lining material should be mixed in a mill of the regular foundry type where a combination of plows and mullers revolve in a stationary pan, and then stored covered with damp gunny sacking for 24 hours before using. The material is rammed in to form the proper depth of bottom. A substantial wooden form, conforming to the cross-section of the desired holding capacity of the vessel, about eighteen inches in height and fitted with a lifting ring, is placed on the bottom, and the material for the side wall is rammed in around it. This form can be raised from time to time until the lining is completed. The tuyeres are formed by using pieces of pipe, of the proper dimension (usually 1¼ inches outside diameter), fastened in a wooden holding device which in turn is clamped in the wind box. Upon the completion of the lining, the wooden pipe-holding device is removed and the pipes are removed. The nose-piece of the converter is lined in the same way, using another wooden form made to follow the desired contour. The two pieces are assembled and clamped together, the inner joint having more ganister rammed in to make a smooth-finished job and prevent metal from leaking through when the vessel is turned down.

The lining whether brick or ganister must be thoroughly dried out, either by a coke fire or a gas torch. About two hours before the first blow, the lining should be heated up as hot as possible, preferably with two oil torches introduced through the backing plate of the wind box and extending through the tuyeres. Successful blows are very dependent upon having the lining of the converter brought to almost incandescent heat. With continuous operation, the lining will lose very little of its heat. However, if it is necessary to delay operating for some time, it is necessary to heat the lining again.

The lining of the vessel becomes eroded in time and has to be repaired. The slag and burned sections are chipped out sufficiently to expose the original material, and then patching with the ganister mix may be done to restore the original contour of the vessel.

With intermittent practice the necessary patching of the lining can be done when convenient. In continuous practice, an additional shell is advantageous, which, having been previously lined and dried out, can be used to replace the one in service. In one converter installation operating continuously for sixteen hours, three shells are in use, one mounted on the trunnions in service, one being dried out ready for service, and one being repaired.

Cupola Metal.

A satisfactory chemical composition of cupola metal for side-blow converter steel-making is carbon 2.75 to 3.00 per cent, silicon 1.20 to 1.50 per cent, manganese 0.50 to 0.60 per cent, phosphorus and sulphur 0.06 per cent or less, depending on specification limits. The metal temperature should be 2750° F. or higher.

Operation.

The operation is commenced by turning down the vessel to receive the cupola metal, which, while in the ladle, has had all slag removed from its surface. The converter is turned up until the surface of the metal is level with the bottom of the tuyeres as observed through the wind box door. The converter should then be at an angle of between 4 and 10 degrees from horizontal towards the front as indicated by the pointer mounted on one of the trunnions on the protractor mounted on the standard. The wind box backing plate is clamped in place and the blast (from 2 to 5 pounds pressure, as shown on a gauge on the operating platform or 'pulpit') is turned on. If the vessel lining and the cupola metal are quite hot, the flame should come up almost immediately, accompanied by a large volume of smoke and scintillating sparks. During this first period of the blow the flame is not very clear. The next period, known as the 'manganese' period, has the flame becoming intensely whie with sharply defined outlines, accompanied by a turbulent boiling action in the vessel causing considerable slag to be emitted. It is necessaryto lower the pressure to possibly 2½ pounds for a minute or so until the reaction quiets down. During the third period, the carbon period, the flame is not so clearly defined, becoming flickery with feathery edges and with a different colour. When the reactions of oxidation of the metalloids are about complete, by listening to the rhythmic sound of the blast one will hear given a peculiar sound effect similar to a sigh, and the flame, which has been at the normal size, now goes "up for the last time." This flame is long, the longest of the whole blow, and although thin is quite intense in its brightness and also has the feathering edges or fingers. As soon as this flame starts dropping, the blast is shut off and the vessel is turned down. The predetermined amounts of silicon and manganese are then added. A convenient method of making these additions is by the use of a silico-manganese alloy--preheated if necessary--which does not lower the temperature of the metal as much as would the necessary larger additions of the ferro-alloys. The metal temperature is usually over 3000° F. The metal is then tapped out into the ladle.

It is customary to use a slag skimmer in the mouth of the vessel to hold back the slag until the ladle is almost filled. If the slag is thin and fluid, it may be thickened by adding silica sand. If there is much slag in the vessel, it may be partially skimmed out before tapping. After the metal is tapped, the converter is turned completely down, to drain off any slag remaining in the vessel. An inspection is then made of the lining and the tuyeres and repairs are made if necessary. The converter is now ready to receive metal for the next blow.

Time of Operation.

The time required for the actual blowing operation will vary somewhat under different conditions, but is usually 12 to 15 minutes from turn-up to turn down. The total cycle of charging the converter, blowing, deoxidizing, tapping, and slagging should be about 25 minutes. The actual time cycle depends on the chemistry of the cupola iron, temperature of metal at start of blow, temperature of vessel at start of blow, blower and power characteristics, and facilities for handling metal to and from the converter.

Limitations of Side-Blow Converter Process.

In common with other methods of steel-making, certain limitations are to be found in the side-blow converter process. One is the necessity of using materials of low phosphorus content in the cupola, as no satisfactory method exists for phosphorus reduction in furnaces lined with acid (siliceous) materials. Another limitation is the rather high melting losses, both in the cupola (3 to 6 per cent) and in the converter (10 to 15 per cent).

In the converter process, successful operation is due in large part to the training and judgment of the operator. With the decline in the use of converters in the past few years, experienced operators are not as available as formerly. However, this difficulty has been partially offset by the introduction of electric-eye control, which materially shortens the period of time required for the training of operators.

Concluding Remarks:

The advantages of the converter process for the production of light and medium castings are: (a) the cheapness of the installation; (b) flexibility in operation, for metal may be produced at intervals throughout the day; and (c) the high temperature and excellent fluidity of the steel produced.

Wartime conditions demand changes in thought as well as in manufacturing processes. It would seem that steel manufacturers should seriously review their procedures in the light of changed conditions. Any such review should not overlook the possibilities of the side-blow converter.

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