L-D AND BASIC LINED SIDE BLOWN CONVERTER(*)

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In view of the increasing importance of the L-D process as a means of bulk steel production, it was decided to design and test a small L-D converter. Unfortunately when designing this converter it was appreciated that its capacity must be limited by the lifting facilities available. After due consideration it was agreed that the maximum capacity must be limited to about 200 lbs.

Description of the plant:

Cupola: The cupola used for the experiments is a modified cupolette which has a capacity of plant 10 cwt. per hour. The existing height of the cupola is 8' 6" and hearth dia. 14" inside. The tuyers two in number are of 3" dia. and arranged at the height 1' 6" from the bottom. Arrangement for poking through tuyers have been provided.

Converter:

The basic lined L-D type converter has been designed and fabricated in the College of Mining and Metallurgy. The vessel has a concentric opening in a truncated cone top and is put on two stands which are fixed on a foundation. The converter body can be tilted to any angle for the purpose of filling and pouring. The vessel has got the following dimensions:

Height of the cylindrical portion	..	10"
Dia. of the cylindrical portion	..	16"
Height of the conical portion(nose)	..	6.7"
Height of the conical portion(bottom)	.	7"
Dia. of the conical portion (nose)	..	12"
Dia. of the conical portion(bottom)	..	14"

The nose can be detached when required for lining. The pea size magnesite is raised by putting a former which gives a lining of 2" thickness on all sides and 3" in the bottom.

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The experiments were conducted by lancing high purity oxygen from the top through a water cooled lance having a jet of ½" dia. and another one with ¼" dia. Water is flown through the lance so that there will be a protection of the injecting pipe. The lance is hung by a steel rope which is passed through a pulley, fixed on a cantilever type of hinge and can be rotated to the sides. The rope is guided and opened by a gear wheel which is moved by hand.

Four ingot moulds of cast iron were cast to study the ingot defects and rimming action of the steel. The moulds are of 12" height and average square dimension is 3½".

Assessment of Thermal Requirements:

As part of their metallurgical calculations the students were required to prepare a thermal balance sheet under assumed conditions. These calculations demonstrated that unless the vessel was preheated to at least 400°C., there was serious likelihood of insufficient heat being generated to permit satisfactory teeming of the metal. Indeed this fact was realised when on the second trial the metal was blown dead soft, since some difficulty was experienced in teeming in into ingot form.

One most serious difficulty experienced, which would not be encountered in a full scale plant, was the inability to obtain sufficient superheat on the metal supplied from the cupola. In spite of obtaining better quality of coke, the metal ex-cupola never exceeded 1300°C., which left insufficient margin of safety.

Some notes on the L-D Experiments:

No. LD/1 ... 19-9-59

The cupola and converter worked satisfactorily, the ¼" diameter lance being used, but owing to excessive sloping and the leaking of the lance, it was decided to stop the blow after six minutes oxygen injection. The following results were obtained:-

Analysis	C	Si	S	P	Mn
Molten metal	3.0	2.45	0.28	0.37	0.7
Blown metal	2.7	0.18	0.09	0.35	0.06

No. LD/2 Thursday, the 24th September 1959.

Owing to a scaffold in the cupola the experiment was abandoned.

No. LD/3 Friday, the 25th Sept.,1959

The cupola worked very satisfactorily, although there was little superheat on the metal supplied to the converter. It was estimated that the metal temperature was 1350°C maximum.

During the blowing, the oxygen was maintained at 50-60 lbs.per sq.in., but the position of the lance was varied from between 5 and 8 inches above the surface of the metal. There was considerable slopping during the oxygen injection and one rather large ejection from the converter. About 8 minutes elapsed before the commencement of the carbon flame. Considerable difficulty was experienced in teeming the finished metal owing heat losses consequent to delays after tapping. The following samples were taken during the course of experiment:

Sample No.	C	Si	S	P	Mn	Remarks
LD/3/1	3.4	0.83	0.096	0.274	0.235	Taken 8 min. after commencement of the blow, before the development of the carbon flame.
LD/3/2	2.8	0.69	0.056	0.157	0.11	Taken after blowing for 15 minutes.
LD/3/3	2.6	0.17	0.045	0.063	0.015	After 20 min. blowing.
LD/3/4	0.35	0.044	0.04	0.045	0.01	Sample prior to tapping after 28 min. blowing.

The composition of the slag showed the following variations during blowing:

Duration of blow.	CaO	SiO_2	MgO	MnO	Fe_2O_3	P_2O_5
8 mins.	36	30.4	4.5	0.8	10.9	0.5
20 mins.	24	34.0	8.2	2.8	13.0	11

Further lime additions were made during the course of blowing.

No. LD/4: This time the lance used had the nozzle of $\frac{1}{4}$" dia. and the blow continued for 28 minutes at an oxygen flow of 10 cu.ft/min. at 40 lbs/sq.in. at which point the experiment had to be discontinued owing the lance leaking, after the first slagging. The analysis of finished metal was:

C	Si	S	P	Mn
2.4	0.8	0.04	0.05	0.07

Conclusions:

1. In spite of difficulties owing to high heat losses associated with a small unit, it was demonstrated that good quality steel can be produced by the L-D converter from ordinary grades Indian pig iron and when making higher carbon steels, by careful observation of the flame, the carbon can be caught on the drop.

2. The diameter of the lance, the pressure of impingement of the oxygen and the thickness of the slag covering controls the relative rates of C and P removal. The distance between the tip of oxygen lance and the surface of slag and metal can be adjusted to vary the actual pressure of impingement.

3. A low pressure of impingement and a thick slag covering favours dephosphorisation, whilst a thin slag and high pressure of impingement accelerate removal of carbon.

4. The process can be employed to dephosphorise ordinary grades of Indian pig iron, so as to produce a product suitable for the manufacture of ingot moulds, rolls and similar high duty castings.

5. By careful control of the pressure of impingement and the intermittent feeding of lime during the blow resulted in very satisfactory desulphurisation.

6. It is considered that the adoption of a basic-lined, side blown converter offers a greater control of impingement pressure and slag thickness, which together with the higher heat increment due to a higher percentage of CO_2 in the exit gases, merits further investigation and development.

BASIC-LINED, SIDE-BLOWN CONVERTER

In view of the difficulties encountered with operation of the L-D Converter, chiefly owing to lack of superheat of the metal ex-cupola and small capacity of the converter, it was decided to design and construct a basic lined side blown converter. It was found, by calculation, that more heat could be obtained due to the combustion of CO above the metal.

Description of the Side Blown Converter:

The side blown converter designed was a D shaped vessel having a holding capacity of about 4 cwt. To prevent excessive oxidation it was decided to have a metal depth of at least 10". The vessel was mounted on two supports, so that it can be tilted to about 90°, which enables the angle of impingement and slag thickness can be varied.

One special feature of this converter is the tuyere arrangement. As shown in the diagram, three rows of tuyeres ($\frac{1}{2}$" dia.) have been provided, with two tuyeres in each row. The bottom row of tuyeres at (A) are horizontal and can operate with oxygen or air. The second row (B) is at an angle of 30° to the horizontal and operate on oxygen. The axis of these tuyeres meet about the middle of the metal surface. The third or the uppermost row (C) supply extra oxygen or air for the combustion of CO above the metal surface, thus generating extra heat in the converter.

This tuyere arrangement permits the blowing at a slight angle of impingement when the converter is in the vertical position, thus ensuring the maximum slag covering, which favours slag metal reaction and accelerates dephosphorisation. When the converter is tilted to an angle 45°, the surface area of the slag surface is increased and its thickness reduced, whereby the elimination of carbon is accelerated. In this position of the converter the angle of impingement is 75° from the horizontal.

Method of Basic Lining:

The converter was rammed, with pea size magnesite mixed with sodium silicate (water glass), around a wooden former so as to give 3" thick lining at the sides, with 5" thickness at the bottom.

At first the bottom was rammed to 5" thickness and then the former was put in position and the mixture rammed around it. To provide holes at the tuyeres wooden pieces $\frac{1}{2}$" round and of sufficient length were rammed in position. The nose of the converter was rammed separately. After drying and removing the former both the pieces were bolted together.

Experimental Work:

Experimental work on the basic lined side-blown converter was delayed owing to difficulties in obtaining an adequate supply of oxygen and an air compressor capable of supplying a sufficiently high air blast pressure. The only experiment undertaken up to the time of writing this paper had to be abandoned before the development of the carbon flame owing to shortage of oxygen and the inability to attain a sufficiently high air blast pressure. The results obtained on this partial blow are given in Table I.

These results demonstrate:

1. Similar results can be obtained in the basic-lined, side blown converter to those obtained in the L-D on top blown converter.

2. The relative rates of carbon and phosphorus removal can be more positively controlled by tilting the converter, thereby altering the slag thickness, thus:

(a) when blowing with 30 lbs./sq.in. oxygen pressure in the vertical position (the thickest slag covering) satisfactory dephosphorisation was achieved without loss of carbon.

(b) when blowing with the converter tilted at an angle of 45°(thinner slag covering) and part of the slag removed practically, no dephosphorisation occurred.

3. The basic-lined, side-blown converter can be employed, with suitable ferro-silicon and ferro-manganese additions, for the production of low phosphorus pig iron from normal grades of Indian pig iron.

4. The inability to develope a sufficiently high oxygen pressure prevented satisfactory elimination of carbon.

5. Satisfactory desulphurisation was obtained during the first period, whilst the silicon was also reduced during the first period, but inadequate blast pressure prevented further reduction.

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TABLE -I

RESULTS OF BASIC-LINED, SIDE-BLOWN CONVERTER TRIAL

Time	Remarks	Angle of converter inclination.	Analysis				
			C	Si	S	P	Mn
1300	3cwts. of pig iron ex-cupola) Charged sample **8 lbs.** of pea size lime)	-	3.49	1.38	0.093	0.356	0.396
	Metal blown with oxygen at 30 lbs/ sq.in. for ten minutes during which a further 10 lbs. of lime was added	Vertical					
1312	Sample ex-converter		3.50	0.644	0.073	0.182	0.176
	35 lbs. of pig iron tapped to which 5 ozs. of 80% ferro-manganese was added.						
1315	Sample	-	3.60	0.690	0.072	0.198	0.693
	50% of the slag removed and blowing continued for 15 minutes with the converter tilted at an angle of 45° until oxygen.	45°					
1330	Supply failed. Sample		3.53	0.506	0.070	0.175	0.099

Experiment abandoned owing to failure of oxygen and air supply.