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ANALYSIS OF GEOMETRICAL ASPECTS OF BOF CONVERTERS AND CORRELATIONS WITH PROCESS PARAMETERS

Abstract

The continuous increase of the production steel in the last decades, caused the adjusted in steel plants in adapt in the new demand the acquiring manufactured steel. This study aimed to analyze the reactors ranging 6-350 tons of steel cast correlated their dimensional parameters and with the help of the tool data extrapolation, to propose the furnace of 800 tons. Ultimately, were checked the correlation between the important aspects as, height of boom, e slenderness ratio relation and charge/volume relation. The results show the large dimensional variation between the reactors. In some cases even with similar capabilities, the reactors are different due different manufacturers. In specific cases, the reactors have a tendency to get ideality (specific volume equal 1) or overcome with it the dimensionless level tends to decrease. The proposer reactor presented the good dimensioning and having a sharp increase in global steel demand, could be studied and implemented in the future.

Keywords:

BOF; 800 tons converter; Correlation dimensional parameters; Specific Volume.

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1. Introduction

Analyzing information obtained by world refining steelmakers (steel plant oxygen), it was possible to identify (between the companies analyzed) the capacity variation of yours reactors, in specific 6 until 330 tons of cast steel. The variations of capacity are directly related with the annual steel production of the steelmakers, in other words, lower capacity the reactor, smaller capacity production and so on.

Thus, this work aims to study the geometric behavior of the converters to oxygen analyzing and correlating them. Then, by the method of extrapolation of data propose the dimensioning of a converter that does not exist in the industry. The research was elaborated so that the answer of questions such as: what characteristics can be observed in the converters? What resistances make difficult the elaboration of the project? What is the feasibility and advantages for the sector's industries to adopt the model in question?

The methodology adopted was obtained by obtaining and quantitative evaluation of real data of the steel industry. The data were obtained by means of reports sent to the companies, under previous communication, which contained unfilled tables, requesting technical information on operating parameters, as well as dimensional parameters of the reactors practiced by the company consulted. These tables are called the Data Reference. The companies completed the tables and returned them duly filled with the information requested. Once the necessary information was obtained, the qualitative analysis of these parameters was started, and the correlation and data crossing were performed.

2. Methods and Materials

The methodology used was based on sending an Excel form named as Data Reference. This form consists of 2 tabs, where the first requests the dimensional data of the converters, as well as process data. The figure 1 and 2 below represents the first tab of the form. The second tab requests dimensional and process data from the oxygen nozzles. Figure 3 and 4 below represents the second tab of the form.

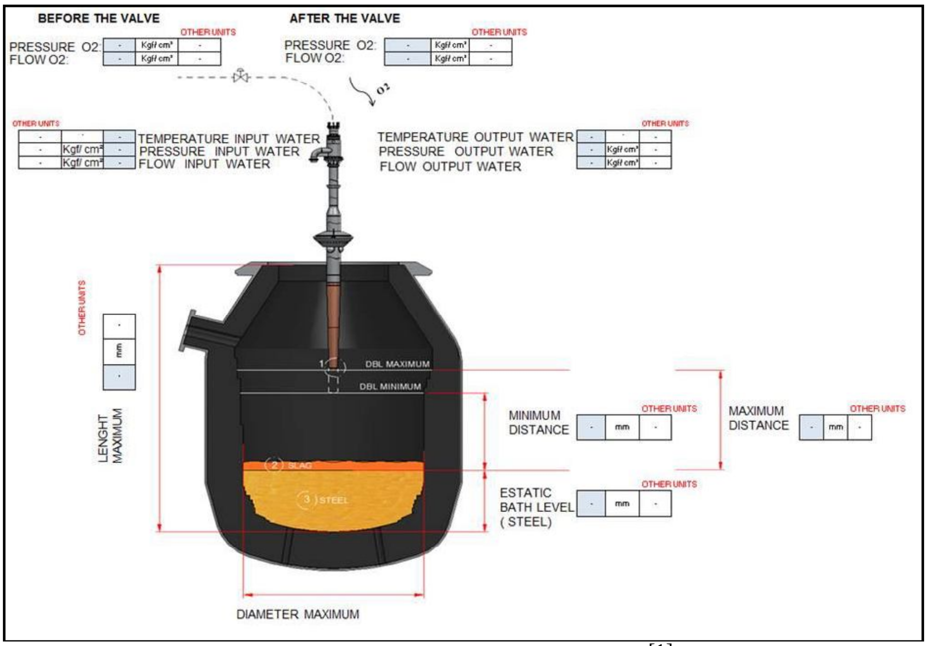

Figure 1 Data Reference Tab I [1]

CONVERTER INFORMATIONS	VALUE	UNIT	OTHER UNITS
NUMBERS CONVERTERS	-	QUANT.	-
ANNUAL NOMINAL CAPACITY	-	t	-
ANNUAL ACTUAL CAPACITY	-	t	-
	-	-	-

REQUIRED DRAWINGS			
LANCE TIP	-	-	-
CONVERTER (SIDE VIEW AND TOP VIEW OF	-	-	-
ANNUAL ACTUAL CAPACITY	-	-	-
	-	-	-

HOT METAL INFORMATIONS	VALUE	UNIT	OTHER UNITS
WEIGHT:	-	t	-
Si	-	%	-
C	-	%	-
Mn	-	%	-
P	-	%	-

2 - SLAG INFORMATIONS	VALUE	UNIT	OTHER UNITS
CaO	-	%	-
SiO2	-	%	-
FeO	-	%	-
TOTAL SLAG AMOUNT AVERAGE	-	%	-
BINARY BASICITY AVERAGE	-	%	-

3 - STEEL INFORMATIONS	VALUE	UNIT	OTHER UNITS
CaO	-	%	-
SiO2	-	%	-
FeO	-	%	-
TOTAL SLAG AMOUNT AVERAGE	-	%	-
BINARY BASICITY AVERAGE	-	%	-

4 - TUYERES INFORMATIONS	VALUE	UNIT	OTHER UNITS
NUMBER:	-	QUANT.	-
FLOW PER EACH:	-	Nm³/ min	-
PRESSURE PER EACH	-	Kgf/ cm²	-
-	-	-	-
-	-	-	-

Figure 2 Data Reference Tab I [1]

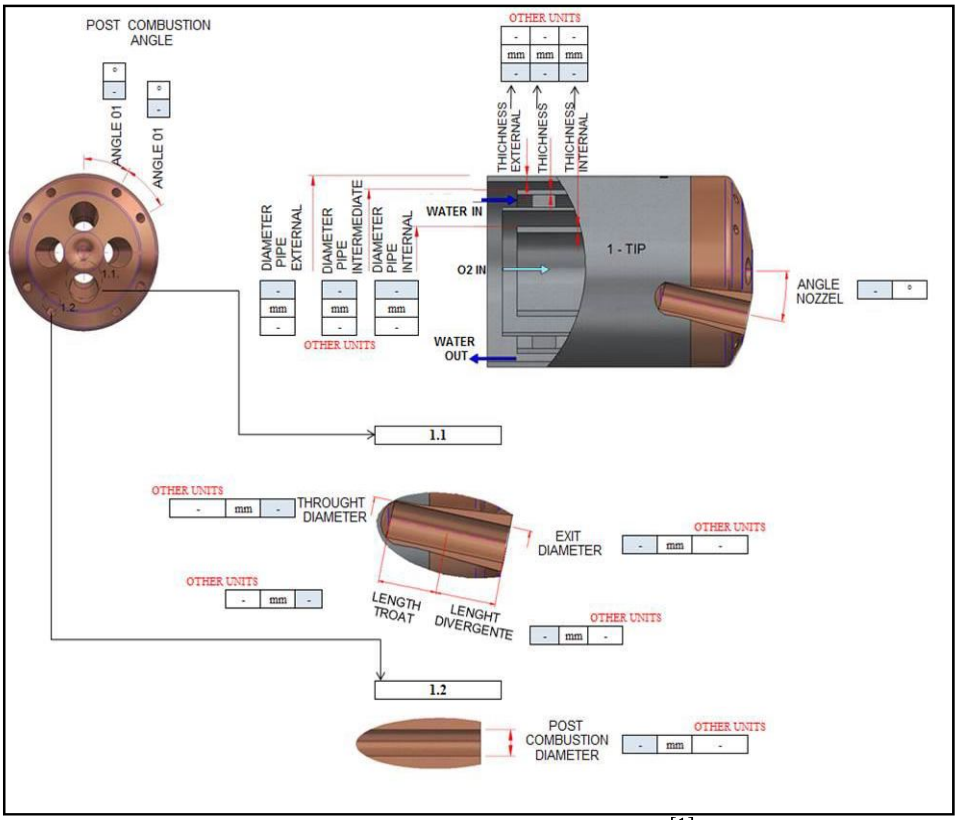

Figure 3 Data Reference Tab II [1]

1 - TIP INFORMATIONS	VALUE	UNIT
NUMBER NOZZLES	-	QUANT.
POST COMBUSTION (YES OR NO) ?	-	-
NUMBER POST COMBUSTION	-	QUANT.
CENTER HOLE (YES OR NO) ?	-	-
DIAMETER CENTER HOLE	-	mm
	-	-
	-	-

WATER OUT		
FLOW	-	m³/h
PRESSURE	-	Kgf/cm²
TEMPERATURE	-	°C
	-	-
	-	-
	-	-
	-	-
	-	-

WATER IN		
FLOW	-	m³/h
PRESSURE	-	Kgf/cm²
TEMPERATURE	-	°C
	-	-
	-	-
	-	-

O2 IN		
FLOW	-	m³/h
PRESSURE	-	Kgf/cm²
	-	-
	-	-
	-	-
	-	-

Figura 4 Data Reference Tab II [1]

After receiving the completed form from the companies, the collected data was stored in a database named BOF tabulated data.

The parameters of operation of the converters, parameters of operation of the oxygen boom, process parameters of 34 companies scattered around the world were collected, but for this work in specific only the operating parameters of the converters were analyzed, which can be visualized In Table 1 and 2 below.

Company	Capacity (t)	Lance height rest level (mm)	DBL Minimum (mm)	DBL Maximum (mm)	Static Bath height (Lo) (mm)	Lance height rest sole (mm)	L for DBL Maximum (mm)	L para BBL Minimum (mm)	Furnace Diameter (Do) (mm)
COMPANY 1	6	150	150	250	600	2400	155	203	850
COMPANY 2	22	0	700	2100	1035	2025	0	0	2370
COMPANY 3	30	0	800	1200	890	0	450	0	2700
COMPANY 4	30	0	800	1200	890	0	450	0	2700
COMPANY 5	30	0	650	1500	950	6300	0	0	2400
COMPANY 6	35	0	800	1200	1100	0	0	0	2772
COMPANY 7	50	0	750	1333	1031	0	0	0	3372
COMPANY 8	70	0	1100	2500	1146	0	0	0	3934
COMPANY 9	75	0	1673	1964	1384	0	0	0	3732
COMPANY 10	80	0	1900	0	1779	0	0	0	4168
COMPANY 11	130	0	1400	2600	1400	0	0	0	4770
COMPANY 12	150	0	1000	1300	1372	0	0	0	5570
COMPANY 13	150	0	1500	3000	1285	0	0	0	5570
COMPANY 14	160	0	1800	2300	1286	0	0	0	5060
COMPANY 15	160	0	1800	2300	1286	0	0	0	5060
COMPANY 16	160	0	1800	2400	1286	0	0	0	5060
COMPANY 17	170	0	1500	2000	1518	0	0	0	5560
COMPANY 18	175	0	1400	2070	1200	0	711	0	4791
COMPANY 19	175	0	1220	2000	1758	0	0	0	6920
COMPANY 20	180	20925	1600	2300	1915	22840	524	0	5570
COMPANY 21	180	0	2000	2600	1726	0	636	0	5172
COMPANY 22	200	17707	1600	2800	1718	19425	0	0	5716
COMPANY 23	200	17707	1600	2800	1718	19425	0	0	7440
COMPANY 24	210	0	1651	1981	1984	0	634	0	4876,8
COMPANY 25	210	19000	0	2290	1800	15240	650	0	6150
COMPANY 26	220	0	1500	2800	1500	0	971	0	5962
COMPANY 27	265	0	1750	3111	1822	0	696	0	5638
COMPANY 28	265	0	1750	3111	1822	0	0	0	5638
COMPANY 29	265	0	1750	3111	1822	0	0	0	5638
COMPANY 30	300	19000	1600	2290	1800	15240	650	0	6150
COMPANY 31	320	9000	2000	3600	2200	11000	0	0	6065
COMPANY 32	320	9000	2000	3600	2200	11000	0	0	6065
COMPANY 33	330	0	2700	3500	1855	0	0	0	7156
COMPANY 34	330	0	1500	2900	1855	0	0	0	6380

Table 1 Operating Parameters Furnace [1]

Company	Life converter (run)	Life tuyeres (run)	Bubbling flow (Nm³/h)	Converter height (Coated brick) (mm)	Converter volume (m³)	Slenderness Relation (H/D)	Specific Volume
COMPANY 1	0	0	0	2200	1,3	2,6	0,2
COMPANY 2	76	0	50	4850	18,26	2,0	0,8
COMPANY 3	5526	0	0	4332	22	1,6	0,7
COMPANY 4	5200	0	0	4332	22	1,6	0,7
COMPANY 5	1000	0	0	4870	22,5	2,0	0,8
COMPANY 6	0	0	0	5628	27,39	2,0	0,8
COMPANY 7	23047	0	0	6236	48	1,8	1,0
COMPANY 8	0	0	0	6107	58,89	1,6	0,8
COMPANY 9	0	0	0	6456	57,9	1,7	0,8
COMPANY 10	150	150	170	6339	67,05	1,5	0,8
COMPANY 11	4000	0	0	7260	103,9	1,5	0,8
COMPANY 12	1674	0	0	8166	158	1,5	1,1
COMPANY 13	4500	0	0	7912	158	1,4	1,1
COMPANY 14	5500	4500	450	7615	120	1,5	0,8
COMPANY 15	5500	4500	450	7615	120	1,5	0,8
COMPANY 16	5300	300	440	7615	130	1,5	0,8
COMPANY 17	4000	0	0	8171	152,6	1,5	0,9
COMPANY 18	4500	2650	120	7639	141,8	1,6	0,8
COMPANY 19	3000	2000	480	8480	141,8	1,2	0,8
COMPANY 20	0	0	720	8750	178	1,6	1,0
COMPANY 21	0	0	700	7870	133,5	1,5	0,7
COMPANY 22	6000	0	0	9240	176,17	1,6	0,9
COMPANY 23	4357	2800	1140	9755	185,8	1,3	0,9
COMPANY 24	0	0	0	10706	130	2,2	0,6
COMPANY 25	25000	0	0	10706	217	1,7	1,0
COMPANY 26	0	0	0	5608	185,8	0,9	0,8
COMPANY 27	30000	0	0	9202	185	1,6	0,7
COMPANY 28	15166	0	0	9202	185	1,6	0,7
COMPANY 29	16942	0	0	9202	185	1,6	0,7
COMPANY 30	7000	0	0	10706	260	1,7	0,9
COMPANY 31	6000	0	0	9621	220	1,6	0,7
COMPANY 32	6000	3000	100	9621	220	1,6	0,7
COMPANY 33	1200	0	0	10086	334,24	1,4	1,0
COMPANY 34	3500	4000	2400	9770	275,5	1,5	0,8

Table 2 Operating Parameters Furnace [1]

Where

- Lo - represents the height of liquid metal, steel, after the melting and refining process and without any movement, also called Static Bath Level [mm];
- L - represents the cavity formed by the impact of the jet of oxygen on the surface of the bath. This measurement constantly changes during the blow due to the instability of the liquid surface and the turbulence of the reactions [mm];
- Do - Represents the internal diameter of the furnace which will also be used to determine the slenderness ratio of the studied converters [mm];
- D - Represents the diameter of the open cavity with the impact of the oxygen jet on the surface of the metallic bath [mm];
- H - Internal height of the refractory [mm];
- DBL- Distance from the oxygen boom to the liquid bath [mm].

These dimensions are shown in Figure 5 below.

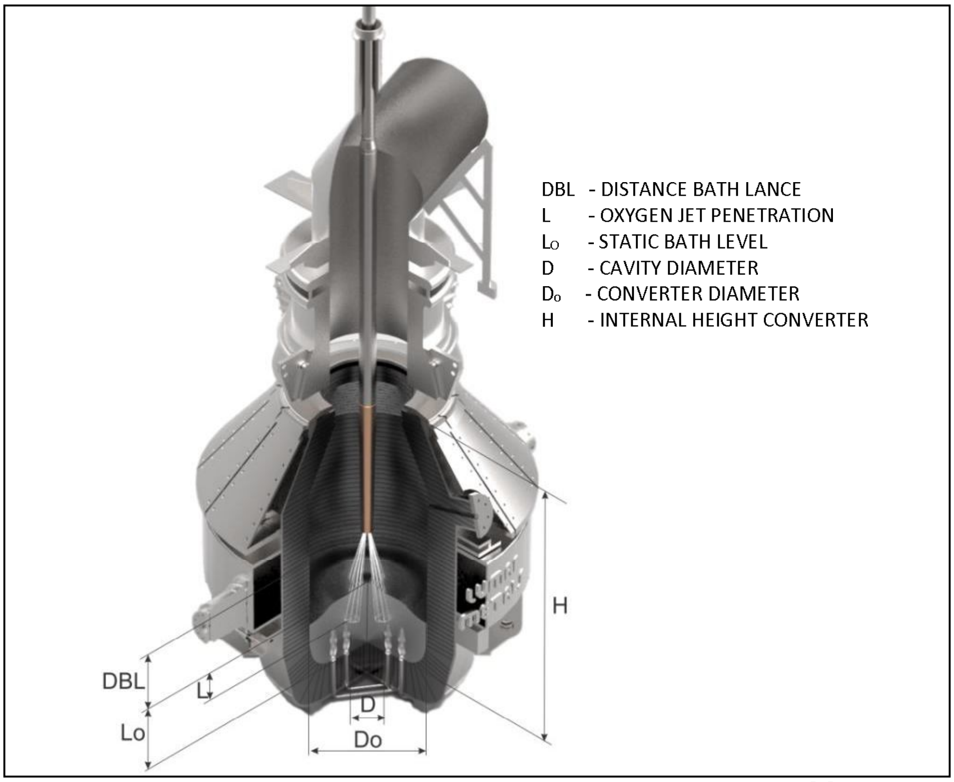

Figure 5 Schematic representation D, D_o, L, L_o, DBL [1]

3. Results and Discussion

After being received and tabulated in the media informed in the previous topic, the data were analyzed and the correlations were performed in which they will be presented next. For this study, only the graphs that have as index of correlation and behavior an index of more than 65% were considered.

Figure 6 shows the variation of the capacities of the converters in which the data were collected.

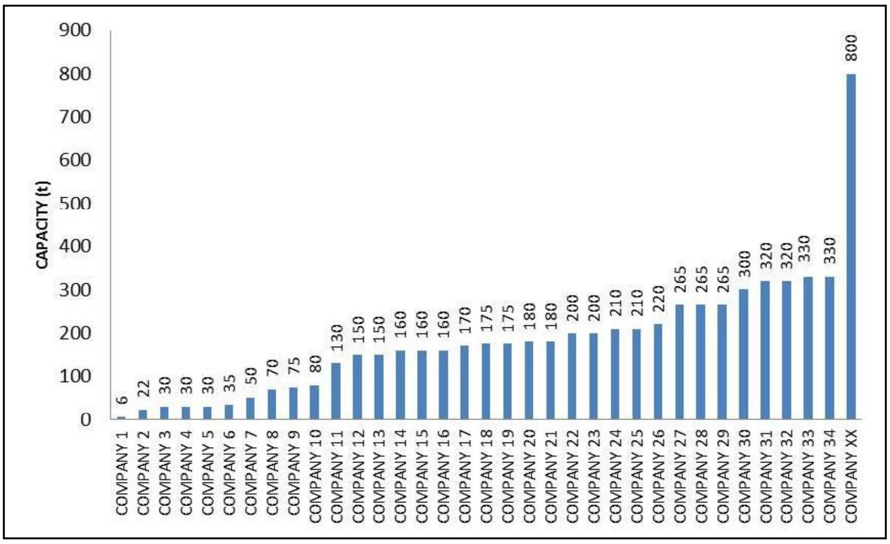

Figure 6 Variation Converters

Figure 6 shows the variation of the converters that were the collected data. It also presents the proposed extrapolation of data for a converter that does not exist in the industry. The 800 tons' converter is represented by company XX and was the object extrapolated from the real information obtained.

The abscissa axis shows the companies and the axis of the ordinates shows the tons' capacity of the converters. The increase of the converters is directly related to the need of the steel companies to attend to each time the need to produce steel. The proposal for extrapolation to 800 tons follows the current trend of concentrating production in order to optimize operations and reduce teams to perform support functions, concentrating on the scale production and steel of the world market.

Then, in Figure 7, the correlations between the capacity of the converters x diameter (DO) and height (H) are presented.

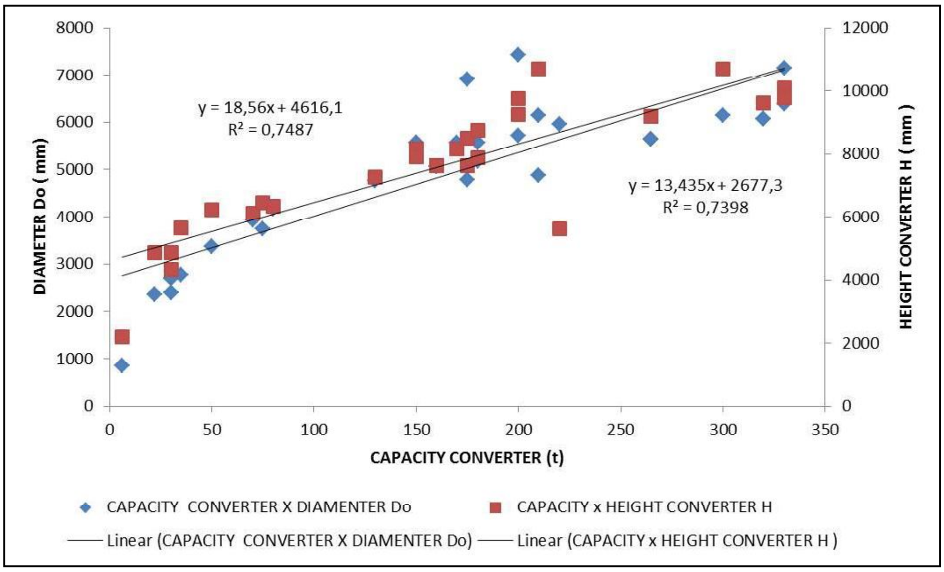

Figure 7 Capacity x Diameter x Height

Figure 7 shows the good correlation between the diameters of the converters, with their respective capacities, and their heights. It can be seen that the furnaces follow a linearity how much yours dimensional. In furnaces with smaller capacity, the heights (H) and diameter (Do) are smaller, and so on.

It can also be observed that converters with a capacity of around 200 tons' present behavior that goes beyond the linearity of the regression. One of the facts that contributes to this behavior is the greater volume of reactors in this region, and with this, different conceptions of the world-wide manufacturers of Green Field plants, such as SIEMENS VAI, SMS DEMAG, NIPPON STEEL, DANIELLI, etc. [1].

Then, Figure 8 shows the increase of the level of the gradual static bath in that the dimensional (Height H and Diameter Do) of the converter is also increased. These parameters are linked to the load variation or even increase of the load imposed with objectives of increasing productivity. These actions affect the specific volume index.

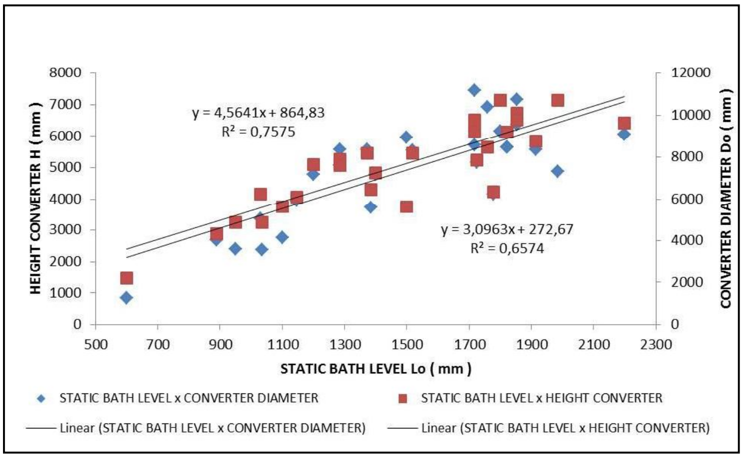

Figure 8 Static Bath Level Lo x Diameter (Do) x Height (H)

By adding the specific volume in the analyzes, it can be seen in Figure 9 that most of the converters are working with the specific volume below 1 m³ / t. Working with the specific volume with values above 1 is recommended as losses are avoided as metal-slag projections out of the converter during the run.

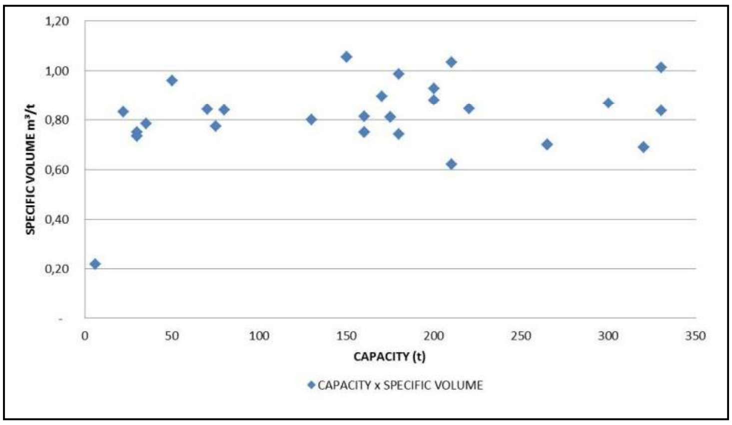

Figure 9 Capacity x Specific volume

From the information obtained in wall work, was possible through the data extrapolation method, the basic dimensions of an 800 tons' converter, as shown in Figure 10, could be proposed.

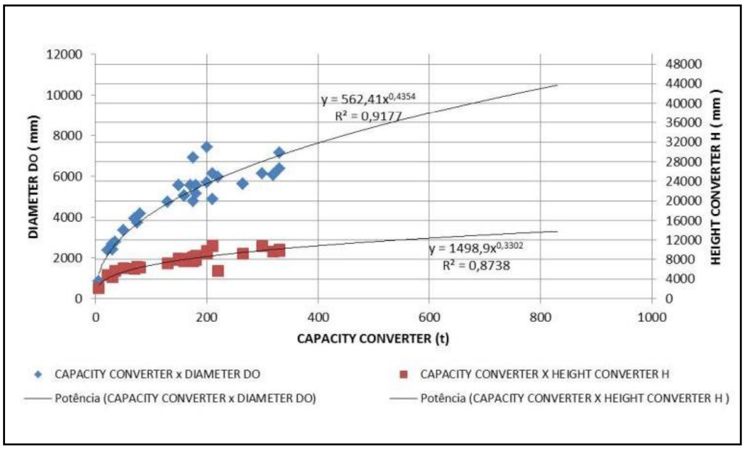

Figure 10: Extrapolation Converters

After the regression was performed, the data were extrapolated through the power equations, then the results of internal height and internal diameters (dimensions in millimeters) of the furnace were found. Figure 11 represents the approximate dimensional required to obtain an 800 ton. Was utilized the equation the power equation because showed results more accurate, approximate the real.

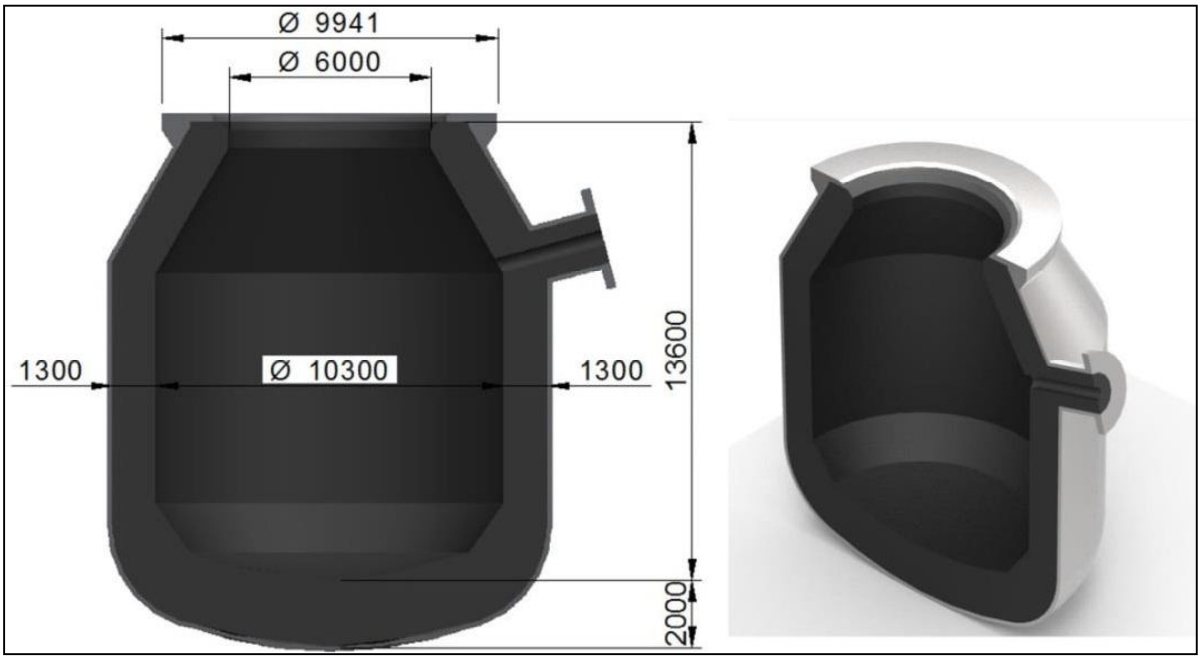

Figure 11 Converter de 800 tons extrapolated [1]

The Furnace of 800 ton, has total height of 15600 millimeters (equivalent the height of the building 4 floors approximate), internal diameter of 10300 and wall thicknesses of 1300 millimeters. Although your extrapolated dimensions are high, the furnace has the slenderness relation in 1,3. Thus, when compared with others converters, can be considered a furnace "Slim", in other words, a furnace height.

Proposal project, has specific volume of 1,14 m³/t above the ideality, that is equal 1. Furnaces that works with specific volume above ideality are considered oversized furnaces.

The specific volume calculation is obtained through the equation below.

$$V_s = \frac{V.\,useful}{Capacity} \qquad \text{(Equation 1)}$$

Where: V_s – Specific Volume (m³/t) – V_{useful} – Useful Volume (m³) – Capacity (t)

Realizing the dimensional analysis of all converters studied at one time, can be verified in Figure 12 the dimensional variation of the converters when overlapped. The lines represent the internal contours, useful volume, of the converters. It is understood as useful volume, any internal volume of the converter that can be occupied by the emulsion.

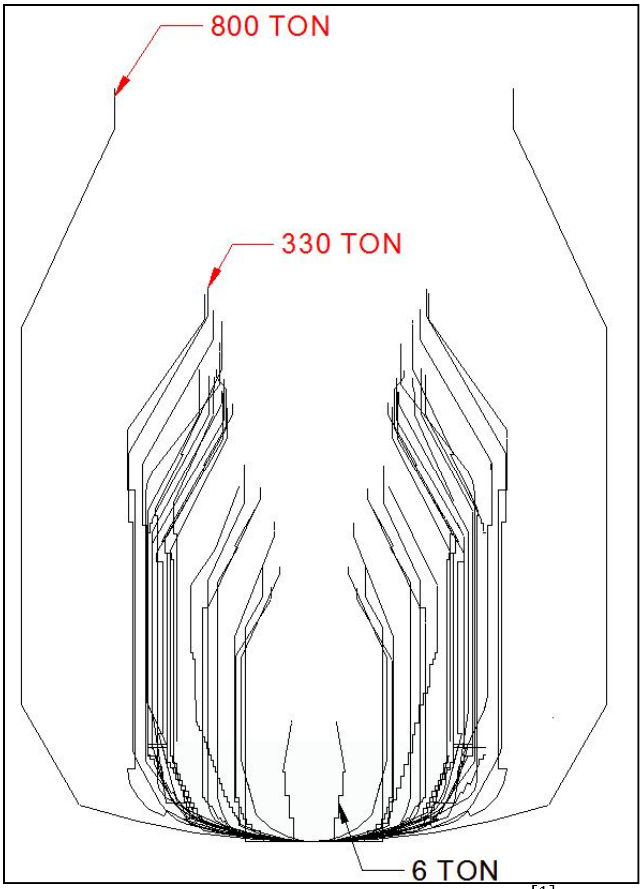

Figure 12 Overlapping Converters [1]

4. Conclusions

With the accomplishment of this work it is possible to conclude:

1. The analysis and correlation of parameters reveals that the dimensional variation of the converters is directly linked to the distinct needs of each steel mill in the steel production.
2. The 800-ton extrapolated converter has a good design; however, its manufacture would be unlikely due to its dimensions and due to the current scenario.
3. Lower capacity converters tend to have a static bath level high, while higher capacity converters have the level of static bath shallower.
4. Approximately 88% of the studied converters tend to suffer from projections of slag metal out of the furnace because they work with a specific volume below the ideality of 1 m^3 / t, while only 22% of the furnaces studied work with a specific volume above 1 m^3 / t, ovens considered to be oversized.

5. Acknowledgments

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6. References

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