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European Patent Office
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(11) **EP 0 855 448 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
29.07.1998 Bulletin 1998/31

(51) Int. Cl.^{6}: **C22B 19/08**

(21) Application number: **97309939.3**

(22) Date of filing: **10.12.1997**

(84) Designated Contracting States:
AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **27.01.1997 GB 9701615**

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(54) Operation of lead/zinc blast furnaces

(57) A method of operating a lead/zinc blast furnace and a new lead/zinc blast furnace are disclosed. The invention provides a method of operating a lead/zinc blast furnace (2) of the type in which air or oxygen-enriched air is introduced through tuyeres (6) into a bed of coke (4) in the furnace, and feed materials comprising mixed sinter containing oxides of lead and zinc are intermittently charged into the furnace (2), the said oxides being reduced to form lead and zinc in the liquid and gaseous phases, respectively, the method being characterised by introducing a particulate char formed of partially oxidised particulate coal into the furnace.

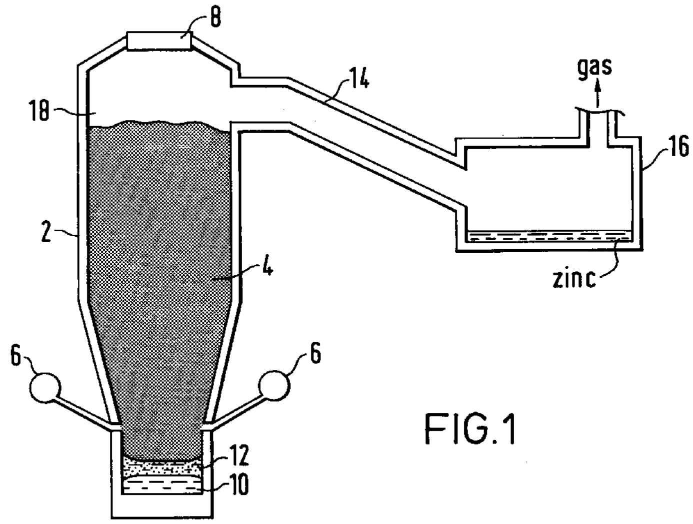

FIG.1

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Description

This invention relates to a method of operating a lead/zinc blast furnace.

Lead/zinc blast furnaces (also called Imperial Smelting Furnaces) operate by reducing oxides of lead and zinc to produce molten lead and gaseous zinc. A bed of coke is maintained in the furnace and a blast of air or oxygen-enriched air is blown through tuyeres into the lower part of the coke bed. Charges of mixed sinter, containing compounds of lead and zinc (oxides, sulphides and sulphates), and hot coke are introduced into the furnace above the coke bed. The blast of air, which is usually pre-heated, burns the coke to produce a reducing atmosphere of carbon monoxide which facilitates the reduction of the oxidised compounds, the heat liberated by the combustion of the coke being sufficient to melt the lead produced and to vaporise the zinc produced. The lead bullion (which is mainly liquid lead and copper), together with slag, is removed from the bottom of the furnace, and the gaseous zinc, together with other gaseous products such as carbon monoxide, carbon dioxide, hydrogen and steam, is passed through a lead splash condenser in which the zinc gas is condensed/absorbed and from which liquid zinc can subsequently be separated. The remaining product gases are passed through a treatment system for cleansing, separation and/or re-use.

A significant problem in the operation of such furnaces is re-oxidation of the gaseous zinc evolved. This re-oxidised zinc typically amounts to between about 8% and about 12% of the zinc evolved; it not only represents a significant loss but also tends to condense and solidify in the ductwork leading from the top of the furnace to the lead splash condenser to the extent that this ductwork becomes blocked. Removal of this re-oxidised zinc is extremely difficult, and requires the furnace operation to be interrupted, which is clearly undesirable.

The blast air is commonly enriched with oxygen in order to increase furnace throughput, however any increase in furnace throughput creates an increase in the amount of zinc re-oxidation (all other factors being maintained constant) which will increase the speed at which the ductwork becomes blocked and, consequently, the frequency at which the furnace must be closed down for the re-oxidation zinc to be cleaned away. increasing the partial pressure of the zinc also undesirably increases the rate of zinc re-oxidation.

It is also desirable to reduce the consumption of coke in such furnaces, and it has been suggested that cheaper substitute materials such as coal, oil and natural gas be used, but these lead to both a decrease in zinc production and an increase in zinc re-oxidation. For a given production rate, these substitute materials lead to an undesirable increase in coke consumption because of their higher hydrogen content.

The present invention provides a method of operating a lead/zinc blast furnace of the type in which air or oxygen-enriched air is introduced through tuyeres into a bed of coke in the furnace, and feed materials comprising mixed sinter containing compounds of lead and zinc are charged into the furnace, the said compounds being reduced to form lead and zinc in the liquid and gaseous phases, respectively, the method being characterised by introducing a particulate char formed of partially oxidised particulate coal into the furnace.

Such a process reduces the consumption of coke whilst maintaining furnace productive capacity. Surprisingly, it also reduces re-oxidation of zinc relative to coal, oil, natural gas or any other coke substitute.

The char is preferably introduced into the furnace either through the tuyeres or in their immediate vicinity. In order further to reduce coke consumption the char may be introduced at an elevated temperature preferably of at least 500°C, and is suitably introduced continuously.

There are no special requirements for coal grinding machinery in order to prepare a particulate coal for oxidation to provide a particulate char for use in the method of the invention. Typically, the average particle size of the particulate coal and of the particulate char produced therefrom is between about 1mm and 3mm. Such an average particle size can readily be obtained from conventional coal grinding machinery.

Advantageously, heated nitrogen gas may be introduced into the furnace above the coke bed. This assists in conveying the gaseous furnace products to the lead splash condenser and is effective further to prevent re-oxidation of the zinc gas evolved from the furnace.

The particulate char for use in the method in accordance with the invention may be produced by partially oxidising particulate coal in a secondary reactor separate from the furnace to form particulate char at an elevated temperature and a calorific gas. The gas may be separated from the char, which is then conveyed at an elevated temperature for introduction into the furnace, whilst the gas may be continuously fed for use in another process on the same site as the furnace and the secondary reactor (eg the sinter strand).

In general, the higher the elevated temperature at which the char is produced and introduced into the furnace the greater the reduction in coke consumption. This temperature is therefore preferably at least 500°C, and more preferably between 700 and 950C. By conducting the partial oxidation reaction at a temperature of between 700°C and 800°C it is possible to attain a suitably high char temperature as it is introduced into the furnace, thus providing a satisfactory reduction in coke consumption, whilst not requiring any special materials in the construction of the secondary reactor in which the partial oxidation reaction takes place.

The invention will now be described by way of example and with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram of a lead/zinc blast furnace for use with the method in accordance with the invention;

Figures 2a and 2b are graphs showing the effect on furnace performance of enriching the blast air introduced through the tuyeres of a lead/zinc blast furnace with oxygen, and

Figures 3a and 3b are graphs showing the effect on furnace performance of injecting various materials as coke substitutes into a lead/zinc blast furnace.

The typical lead/zinc blast furnace, or Imperial smelting furnace, shown schematically in Figure 1 comprises a vertical shaft furnace 2 containing a coke bed 4 into the base region of which air or oxygen-enriched air ("blast air"), which is usually pre-heated, is introduced through tuyeres 6. In operation, charges of mixed sinter, containing oxides, sulphides and sulphates of lead and zinc, fluxing ingredients and coke are intermittently introduced into the top of the furnace 2 through a gas-tight charging system 8. Typically these charges contain, by weight, about 20% lead, 40% zinc and 10% copper. These charges are usually pre-heated, to an aggregate temperature of about 500°C (the coke typically being introduced at a temperature of about 700°C and the sinter at about 150°C). Coke is consumed by combustion with the oxygen introduced through the tuyeres and through reaction with the compounds of lead and zinc to produce lead and zinc, as is known in the art.

The furnace operating temperature and pressure is such that lead is produced in the liquid phase and falls down through the coke bed to be removed from the bottom thereof in the molten state 10, normally as "bullion", comprising liquid lead and copper. Molten slag products 12 are also removed from the bottom of the furnace.

The furnace operating temperature is sufficiently high as to evolve zinc in the gaseous phase, together with other gases including carbon monoxide, carbon dioxide, hydrogen and steam. These gases are produced at a temperature of about 800°C to 1000°C and conveyed from the top of the furnace and through ductwork 14 to a lead splash condenser 16 in which, as is known in the art, the zinc gas is condensed/adsorbed and from which molten zinc is subsequently removed. The remaining hot gas products passing through the condenser are then washed and separated for re-introduction with the furnace blast air as is conventional.

The furnace zinc yield is strongly related to the kinetics of re-oxidation of the evolved zinc by the other gaseous products. In a typical conventionally operated lead/zinc gas furnace, between 8% and 12% of the evolved zinc is lost to re-oxidation. Not only is this loss undesirable per se, but also the re-oxidised zinc tends to form a solid residue in the ductwork 14. This residue increases a blockage in the ductwork 14 and is very difficult to remove. Moreover, in order to increase furnace throughput it is common to enrich the blast air with oxygen. Whilst this does increase furnace production it does nothing to prevent zinc re-oxidation. Furthermore, increasing the oxygen enrichment not only increases furnace output (see Figure 2a) but also increases coke consumption, as is clearly shown in Figure 2b, which illustrates predicted carbon consumption according to two theoretical models - our own, labeled "BOC", and that of Professor H.K. Kellogg, labelled "Kellogg", as published by The Metals Society in the Lead/Zinc 1990 Conference Proceedings, Chapter 34, pages 549-570.

To reduce the consumption of coke in a lead/zinc blast furnace, attempts have been made to substitute oil, coal and/or natural gas for at least some of the coke. These cheaper substitute materials have generally been injected into the coke bed and, as can be seen from Figure 3a, this does lead to a reduction in coke consumption. Unfortunately, as can be seen from Figure 3b, the introduction of coal and oil into a lead/zinc blast furnace also lends to a reduction in the zinc yield. The zinc lost appears as re-oxidised zinc; the increase in zinc re-oxidation hastens blocking of the ductwork 14 with the attendant difficulties discussed above.

We have now posited that a major factor causing the re-oxidation of zinc in these furnaces is the presence of hydrogen in the materials with which the furnace is charged, which is evolved as a gaseous product and which encourages the zinc re-oxidation reaction. It is believed that the hydrogen content of the charge materials explains the curves of Figures 3a and 3b. Coal contains more hydrogen than does oil, which in turn contains more hydrogen than does natural gas (although not shown in Figure 3a, the curves for natural gas would be expected to fall beneath those shown for oil in Figure 3a). Therefore, introducing a carboniferous material containing little hydrogen (in the form of hydrocarbons, for example) will significantly improve the reduction in coke consumption whilst maintaining zinc yield. Of course this carboniferous material could be coke, however we propose introducing particulate char formed by partially oxidising particulate coal into the furnace, and the predicted saving in coke consumption through the injection of char can clearly be seen in Figure 3b. If introduced at an elevated temperature, this char will reduce coke consumption whilst at least maintaining, and possibly even slightly improving, zinc yield. More importantly, however, the introduction of particulate char will lead to a significant reduction in zinc re-oxidation as compared to a process in which coal is introduced. This is illustrated in Table 1 below.

Table 1 shows the effects on the operation of a lead/zinc smelting furnace of injecting either coal or particulate char, at various rates of oxygen enrichment, as predicted by our model. As can be seen, at a zinc production rate of about

250 tonnes per day the introduction of char leads to significant savings, of about 25% Oxygen and about 9% in coke consumption, as compared to the introduction of coal.

Our modelling has also shown that the zinc condensing efficiency of the furnace, for operation with char, coal and oil injection, is 89.1%, 87.8% and 86.4% respectively. Thus, when introducing char into a lead/zinc smelting furnace, 10.9% of the zinc is lost to re-oxidation; when introducing coal or oil, 12.2% or 14.6%, respectively, of the zinc is lost. The introduction of particulate char can therefore lead to a significant reduction in zinc re-oxidation as compared to a process in which oil is introduced, of as much as about 35%.

TABLE 1

Effects On Pb/Zn Furnace Operation Of Coal/Char Injection

% Oxygen Enrichment	COAL INJECTION		CHAR INJECTION	
	Coke Consumption tonnes per day (tpd)	Zinc Production tpd	Coke Consumption tpd	Zinc Production tpd
0%	155	212	151	220
2%	180	232	176	241
3%	-	-	189	251
4%	206	252	-	-

Advantageously, a proportion of the lead and zinc compounds may be injected into the furnace in the form of fine powder, through the tuyeres or in the vicinity thereof. This proportion, the absolute limit of which is a matter of the design and operating parameters of the furnace, serves to reduce the overall energy consumption of the furnace; since this proportion can be introduced as dust, it reduces the amount of material which has to undergo sintering prior to its introduction into the top of the furnace.

The particulate char, which may be produced at an elevated temperature in a secondary reactor adjacent the blast furnace (thus also producing a calorific gas which can be removed for use elsewhere on the site, in another process, for example in the sinter strand) and fed into the furnace 2. Alternatively, the particulate char can be obtained from commercial suppliers. In either case, the char is introduced into the furnace 2 via the tuyeres 6, or in the immediate vicinity thereof, at a temperature of at least 500°C.

In order to convey the evolved gas products from the top of the furnace 2 through the ductwork 14 to the lead splash condenser 16, it is common to inject heated air through jets 18 above the coke bed. Whilst it must be recognised that this increases the overall oxygen potential in the top gases, it is believed that the widespread understanding that this practice is beneficial with respect to zinc re-oxidation is in fact not well-founded. This practice increases the temperature range through which the gases must be cooled and in which zinc re-oxidation can occur, and it is our belief that air injection in fact contributes to zinc re-oxidation. Accordingly, the substitution of a heated inert gas such as nitrogen in place of the air injected through jets 18 will tend to reduce zinc re-oxidation and hence further improve zinc yield.

Claims

1. A method of operating a lead/zinc blast furnace of the type in which air or oxygen-enriched air is introduced through tuyeres into a bed of coke in the furnace, and feed materials comprising mixed sinter containing compounds of lead and zinc are charged into the furnace, the said compounds being reduced to form lead and zinc in the liquid and gaseous phases, respectively, the method being characterised by introducing a particulate char formed of partially oxidised particulate coal into the furnace.

2. A method as claimed in Claim 1 wherein the char is introduced into the furnace through, or in the immediate vicinity of, the tuyeres.

3. A method as claimed in Claim 1 or Claim 2 wherein the char is introduced into the furnace at an elevated temperature of at least 500°C.

4. A method as claimed in any one of Claims 1 to 3 wherein the char is introduced continuously into the furnace.

5. A method as claimed in any preceding Claim wherein the average size of the particulate char is between 1mm and 3mm.

6. A method as claimed in any preceding Claim wherein a proportion of the compounds of lead and zinc are introduced into the furnace in fine particulate form, through or in the immediate vicinity of the tuyeres.

7. A method as claimed in any preceding Claim comprising injecting heated nitrogen into the furnace above the coke bed.

8. A method as claimed in any preceding Claim comprising partially oxidising particulate coal in a secondary reactor separate from the furnace to form particulate char at an elevated temperature and a calorific gas, separating said gas from said char, and conveying said char at an elevated temperature for introduction into the furnace.

9. A method as claimed in Claim 8 wherein the partial oxidation is performed at a temperature above 500°C.

9. A method as claimed in Claim 8 wherein the temperature is between 700°C and 800°C.

10. A method as claimed in any one of Claims 7 to 9 comprising continuously feeding at least part of the calorific gas to another process on the same site as the furnace and the secondary reactor.

11. A method substantially as hereinbefore described.

12. A lead/zinc blast furnace comprising a coke bed and tuyeres for introducing air or oxygen-enriched air thereinto characterised by means adapted for introducing particulate char into the coke bed through, or in the immediate vicinity of, the tuyeres.

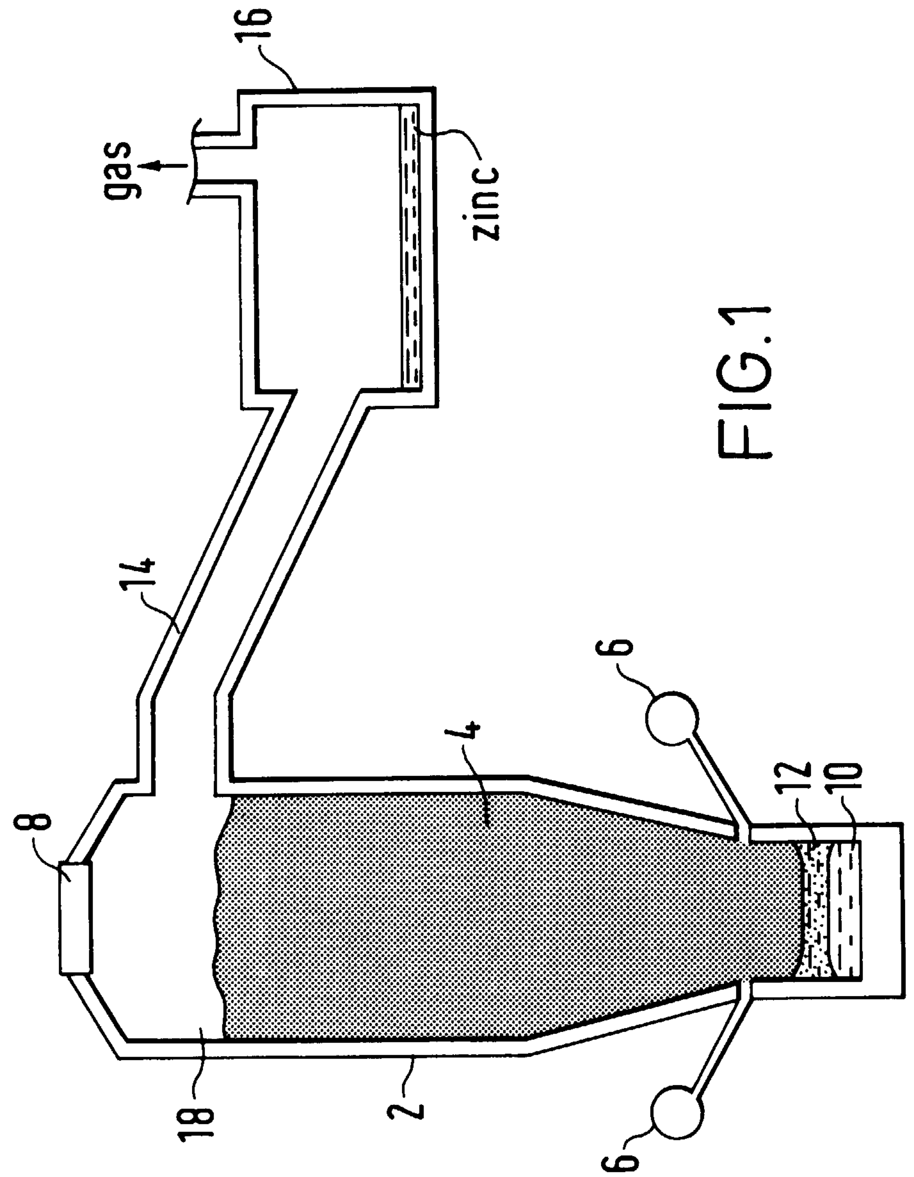


FIG.1

FIG. 2a : EFFECT OF OXYGEN ENRICHMENT ON ZINC PRODUCTION (100% COKE OPERATION)

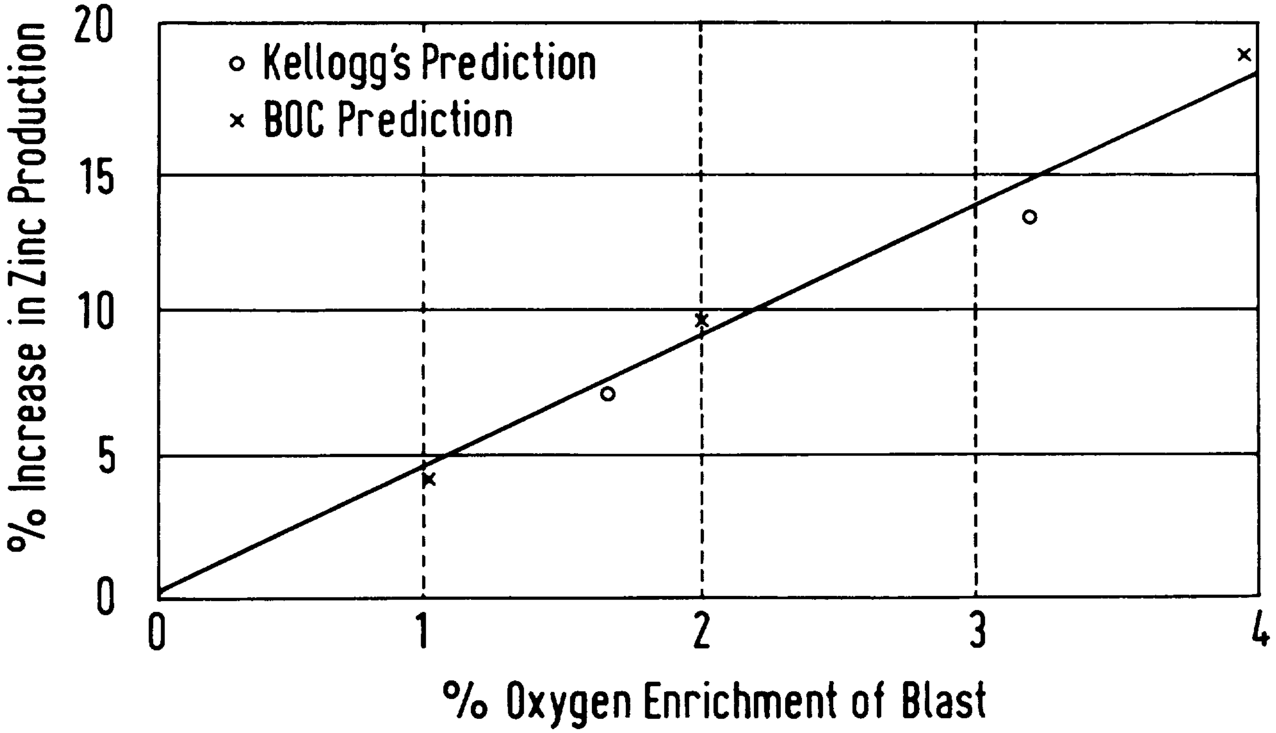


FIG. 2b: EFFECT OF OXYGEN ENRICHMENT ON CARBON CONSUMPTION (100% COKE OPERATION)

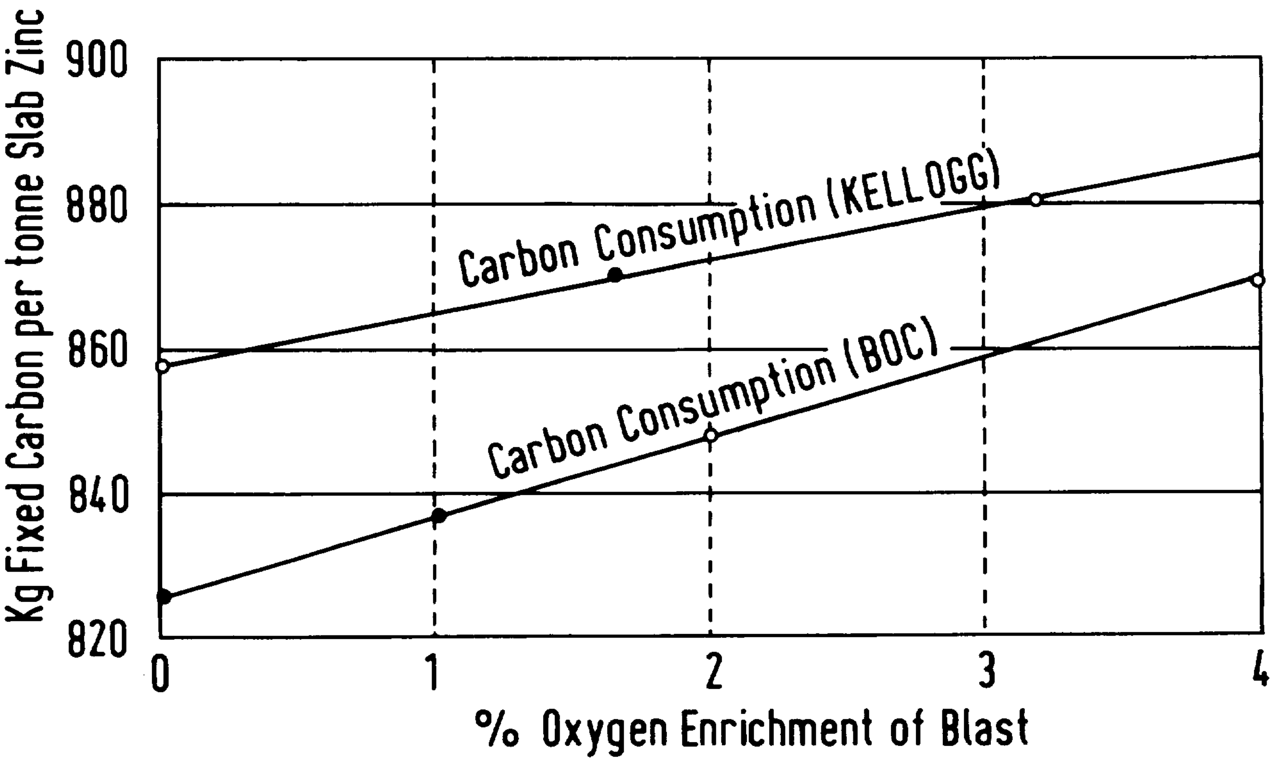


FIG. 3a: EFFECT OF TUYERE FUEL INJECTION ON COKE SAVING.

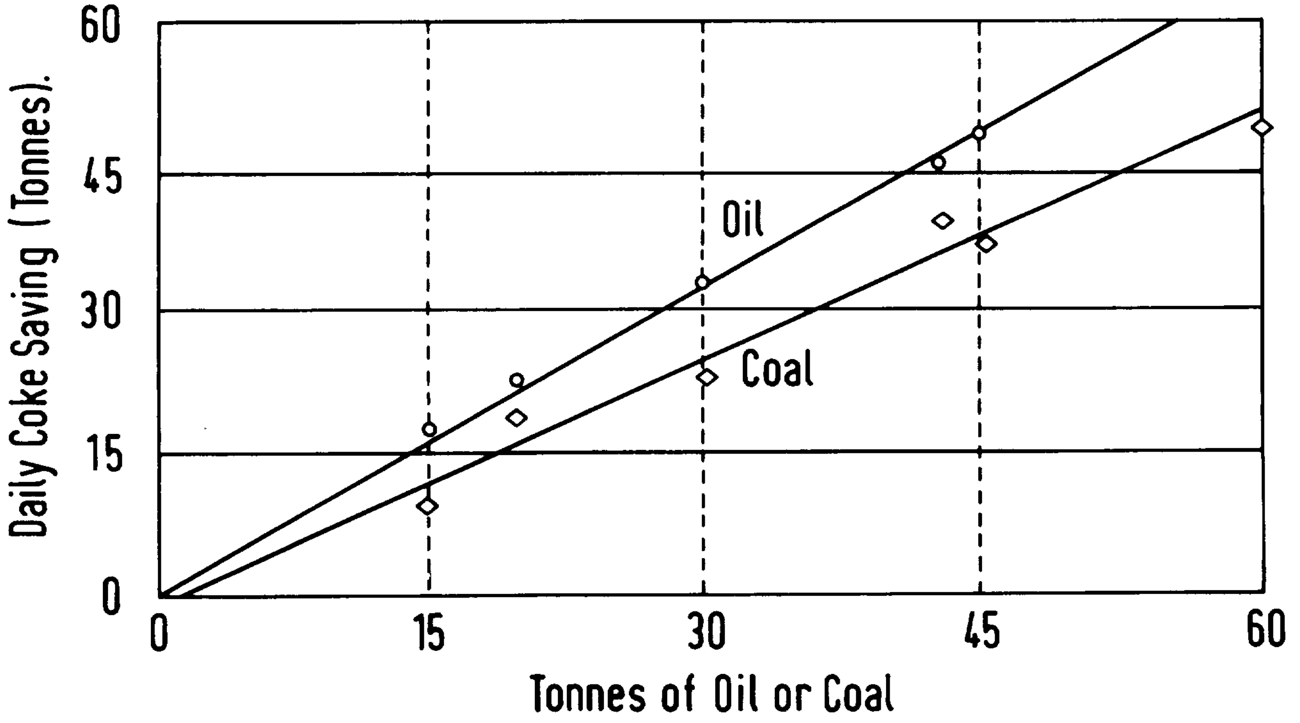
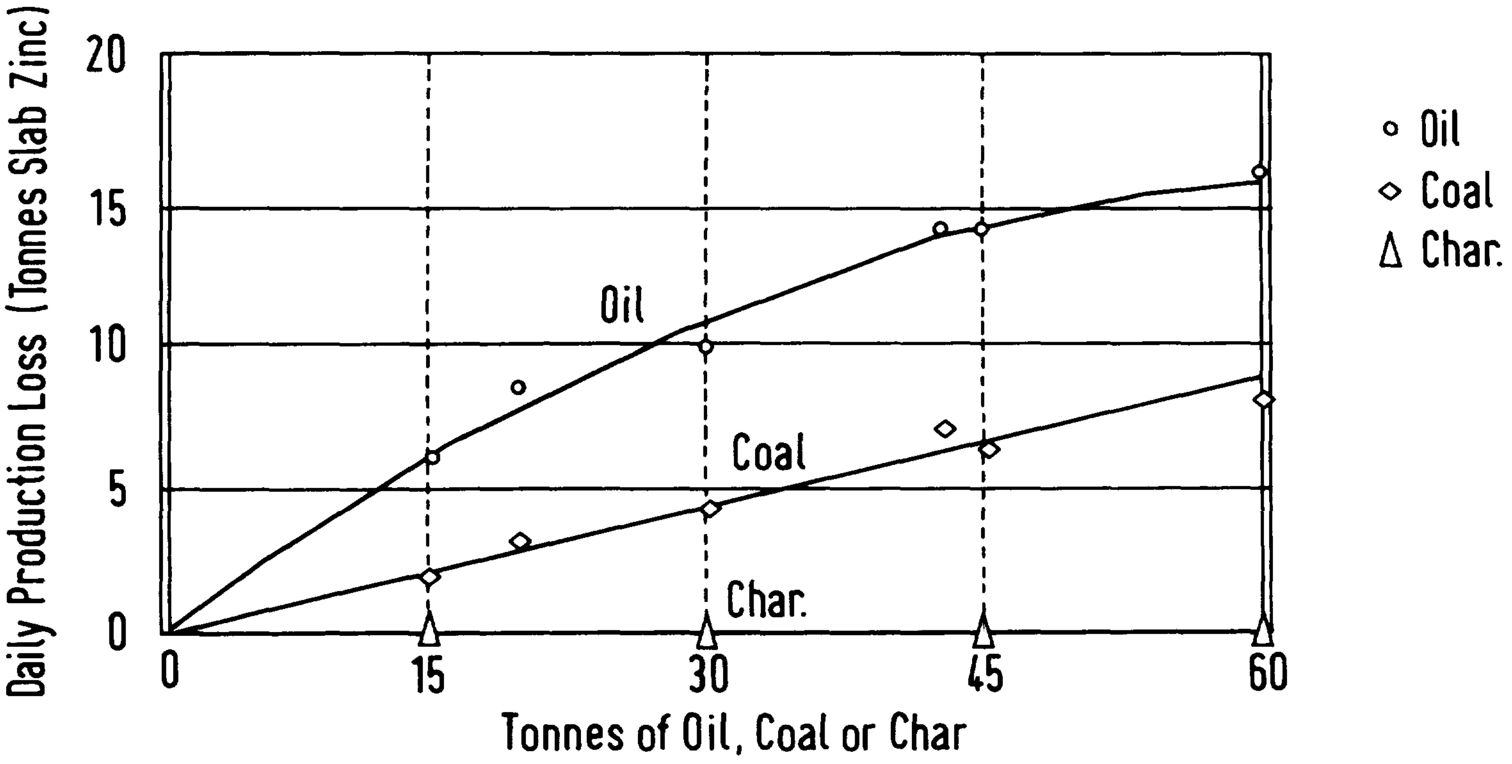


FIG. 3b: LOSS OF ZINC PRODUCTION AS A FUNCTION OF TUYERE FUEL INJECTION (NO OXYGEN ENRICHMENT)



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EUROPEAN SEARCH REPORT

Application Number
EP 97 30 9939

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	GB 2 197 343 A (IMP SMELTING PROCESSES) * claim 1 * ---	1	C22B19/08
A	PATENT ABSTRACTS OF JAPAN vol. 012, no. 365 (C-532), 29 September 1988 & JP 63 118026 A (SUMITOMO METAL MINING CO LTD), 23 May 1988, * abstract * -----	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
C22B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	23 February 1998	Kesten, W

CATEGORY OF CITED DOCUMENTS

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