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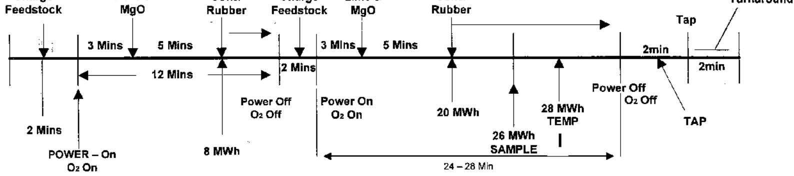
(54) Title: PRODUCTION OF FERRO-ALLOYS



(57) Abstract: A method for producing a ferro-alloy, such as steel, in an electric arc furnace or other suitable metallurgical furnace is disclosed. The method comprises supplying a mixture of (a) a carbon-containing polymer that is capable of acting as a slag foaming agent and (b) another source of carbon into the furnace during at least a part of a power-on phase of the method. A metallurgical furnace is also disclosed.

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PRODUCTION OF FERRO-ALLOYS

The present invention relates to a method and an apparatus for producing ferro-alloys (such as steel) in an electric arc furnace or other suitable metallurgical furnace.

International Publication WO 2006/024069 in the name of New South Innovations Pty Ltd, hereinafter referred to as the "International Publication" discloses a method for producing a ferro-alloy in an electric arc furnace that is characterised by supplying an unagglomerated carbon-containing polymer that functions as a slag foaming agent to the furnace.

The International Publication defines the term "unagglomerated carbon-containing polymer" as covering "both fine and coarse granulated and particulate polymers and is intended to exclude such polymers as formed together with EAF waste dust or steel dust". The International Publication describes that such agglomerated solids comprising polymers and EAF waste dust or steel dust do not function as a slag foaming agent.

The International Publication describes that, typically, the unagglomerated carbon-containing polymer is charged into an electric arc furnace such that it at least partially combusts and produces a carbonaceous residue. The International Publication also describes that the carbonaceous residue then oxidises to cause slag foaming and may additionally function as a reducing agent or a recarburiser.

The International Publication describes that, typically, the carbon-containing polymer comprises the atoms C, H and optionally O only and that, whilst other elements may be present in the polymer (e.g. N, S, P, Si, halogens etc.) these other elements may interfere with ferro-alloy production and/or produce contaminants, pollutants, noxious gases etc. The International Publication describes that, by judiciously selecting the carbon-containing polymer, the formation of noxious gases and other detrimental or harmful products can be avoided. The International Publication describes that one suitable carbon-containing polymer is polyethylene but other plastics such as polypropelyene, polystyrene, polybutadiene styrene, APS etc. may also be used.

The above description of the disclosure in the International Publication is not to be taken as an admission that the International Publication is part of the common general knowledge in Australia or elsewhere.

The disclosure in the International publication is incorporated herein by cross-reference.

The applicant has carried out trials on the method of producing ferro-alloys in the form of steel at the electric arc furnace facilities of the applicant in Melbourne and Sydney.

As a consequence, the applicant has identified parameters that are important to the successful use of unagglomerated carbon-containing polymers in the production of steel.

In addition, as a consequence of the trials, the applicant has developed a particular method of producing steel (and other ferro-alloys). The method includes the use of unagglomerated and agglomerated carbon-containing polymers.

Furthermore, as a consequence of the trials, the applicant has developed technology for successfully supplying unagglomerated and agglomerated carbon-containing polymers to an electric arc furnace, or other suitable metallurgical furnace, to carry out the above-mentioned method of producing steel in the furnace.

In particular, the technology developed by the applicant focuses on areas such as, but not limited to, (a) mixing of unagglomerated and agglomerated carbon-containing polymers and other materials, (b) supplying the mixture to a furnace including flowrate of material into the furnace, (c) materials handling of the mixture upstream of the furnace, and (d) temperature pick-up and overall heat control in the furnace.

According to the present invention there is provided a method for producing a ferro-alloy, such as steel, in an electric arc furnace or other suitable metallurgical furnace that comprises supplying a mixture of (a) a carbon-containing polymer that is capable of acting as a slag foaming agent and (b) another source of carbon into the furnace during at least a part of a power-on phase of the method.

More specifically, the present invention provides a method for producing a ferro-alloy, such as steel, in an electric arc furnace or other suitable metallurgical furnace that comprises supplying a mixture of (a) a carbon-containing polymer that is capable of acting as a slag foaming agent and (b) another source of carbon into the furnace during at least a part of a first power-on phase of the method and supplying a further mixture of the carbon-containing polymer and another source of carbon into the electric arc furnace during a second power-on phase of the method.

More specifically, the present invention provides a method of producing a ferro-alloy in an electric arc furnace or other suitable metallurgical furnace which comprises:

(a) supplying an initial charge of a feedstock for the ferro-alloy to the furnace;

(b) operating in a first power-on phase and establishing an arc between an electrode or electrodes of the furnace and the solid feedstock charge and generating heat in the furnace and melting the solid feedstock charge;

(c) after a first period of time into the first power-on phase, commencing supply of a mixture of (i) a carbon-containing polymer that is capable of acting as a slag foaming agent and (ii) an another source of carbon into the furnace;

(d) at the end of the first power-on phase, supplying a further charge of the ferro-alloy feedstock to the furnace;

(e) operating in a second power-on phase by re-establishing the arc;

(f) after a first period of time into the second power-on phase, commencing injection of a mixture of (i) a carbon-containing polymer that is capable of acting as a slag foaming agent and (ii) an another source of carbon into the furnace; and

(g) at the end of the second power-on phase, tapping molten ferro-alloy from the furnace.

The method may include injecting the mixture of the carbon-containing polymer and the other source of carbon during non-power-on phases of the method.

The carbon-containing polymer may be an unagglomerated polymer described herein.

Typically, the unagglomerated carbon-containing polymer is as described in the International Publication.

The unagglomerated carbon-containing polymer may comprise any one or more of rubber (synthetic or natural) and other polymers such as polypropylene, polystyrene, polybutadiene styrene, and APS. Typically, the polymer has a secondary function as an energy source.

The carbon-containing polymer may be an agglomerated carbon-containing polymer. Examples of such agglomerates include agglomerates of carbon-containing polymers and any one or more of fluxes, iron oxides (such as mill scale), and bag house solids.

Typically, the further carbon source is as described in the International Publication and, by way of example, may act as a fuel and, in addition, may contribute to slag foaming, and act as a reducing agent or recarburizer.

The other source of carbon may comprise any one or more of coke, carbon char, charcoal and graphite.

A furnace operator may use any suitable parameter to assess the time to commence supply of the mixture of the carbon-containing polymer and the other carbon source during the power-on phase or phases.

By way of example, the operator may time the commencement of such supply based on any one or more of the power consumption of the furnace, the composition of the melt in the furnace, and the melt temperature.

The power-on time during the power-on phase or phases may also be used as an indicator of the times to commence supply of the carbon-containing source and the other carbon source.

The preferred ratio of the carbon-containing source and the other carbon source in the above-mentioned mixture of these materials may vary with particular furnaces.

The ratio of the carbon-containing source and the other carbon source in the above-mentioned mixture of these materials may be varied during the time period or periods of supply of the mixture to the furnace.

The flowrate of the mixture of the carbon-containing source and the other carbon source may be constant or may be varied during the time period or periods of supply of the mixture to the furnace.

There may be continuous or periodic supply of the mixture of the carbon-containing source and the other carbon source during the power-on phase or phases.

The carbon-containing polymer may comprise 20-60 wt.% of the total weight of the mixture.

More typically, the carbon-containing polymer comprises 20-50 wt.% of the total weight of the mixture.

Typically, the carbon-containing polymer comprises 20-40 wt.% of the total weight of the mixture.

Preferably the carbon-containing polymer comprises 25-35 wt.% of the total weight of the mixture.

The mixture of the carbon-containing source and the other carbon source supplied to the furnace during the first power-on phase may be the same as the mixture supplied during the second power-on phase.

Alternatively, the mixtures may be different in terms of the materials and/or the ratios of the materials.

Typically, the sizes and the densities of each of the components of the mixture of the carbon-containing source and the other carbon source are selected having regard to the materials handling requirements for mixing and transporting the mixture to the furnace. Components may be pre-mixed remotely from the furnace and stored as a mixture proximate the furnace and supplied via a pipeline to the furnace as required during the operation of the method. Alternatively, the components may be stored separately proximate the furnace and mixed as required and transported to the furnace. The materials handling considerations including forming the mixture as a homogeneous mixture, i.e. a mixture that has a substantially uniform density with minimum segregation of the components, and being able to transport the mixture to the furnace efficiently, i.e. by avoiding blockages in pipes.

Typically, the size of the carbon-containing source is selected to be less than 6 mm and preferably less than 4 mm.

Typically, the method comprises injecting an oxygen-containing gas, such as oxygen, into the furnace during the power-on phase or phases.

The method may include monitoring the slag profile, as described herein, during the course of the method and controlling injection of the mixture of the carbon-containing polymer and the other source of carbon having regard to the monitored slag profile.

The term "slag profile" is understood herein to mean characteristics, such as iron oxide levels, of the slag that provide an indication (directly or indirectly) of the operation of the method.

The slag profile may be monitored continuously or periodically.

The initial and the further charge of the feedstock may be solid charges. One or both charge may include at least some molten metal.

According to the present invention, there is also provided a metallurgical furnace such as an electric arc furnace that comprises a materials handling system for supplying a mixture of (i) a carbon-containing polymer that is capable of acting as a slag foaming agent and (ii) another source of carbon to the furnace during a method of producing a ferro-alloy in the furnace.

Typically, the materials handling system comprises separate hoppers for storing the carbon-containing polymer and the other carbon source, a pipeline for transporting the carbon-containing polymer and the other carbon source to the furnace, and control valves for controlling the flow of each of the carbon-containing polymer and the other carbon source into the supply line so that the mixture of these materials forms in the pipeline and is transported to and supplied to the furnace.

Typically, the materials handling system comprises a blower for entraining the mixture and transporting the mixture along the pipeline.

Typically, the materials handling system is arranged to supply the carbon-containing polymer to the pipeline upstream of the introduction point or points for the other carbon source.

The mixture of the carbon-containing polymer and the other carbon source may be supplied to the furnace by any suitable apparatus.

For example, the mixture may be injected into the furnace via a lance or lances extending into the furnace through an opening in a side or the roof of the furnace.

Other injection options include an intergrated burner/injector or intergrated burners/injectors extending through the side wall and/or the roof and consumable lances extending into the furnace.

The present invention is described further by way of example with reference to the accompanying drawing which is a timeline for one embodiment of a method of producing steel in an electric arc furnace in accordance with the present invention.

The following description of the timeline shown in the figure was developed during the course of trials at the Sydney electric arc facilities of the applicant.

In general terms, the technology developed by the applicant as a consequence of the trials, including the flowsheet, focuses on areas such as, but not limited to, mixing of unagglomerated carbon-containing polymers, as described herein, and other materials, supplying the mixture to a furnace, materials handling of the mixture upstream of the furnace, and temperature pick-up and overall heat control in the furnace.

It can readily be appreciated that appropriate timelines for producing steel in other electric arc furnaces could readily be developed on a case-by-case basis.

With reference to the figure, a first solid feedstock for producing steel in the form of a scrap charge is supplied to the electric arc furnace in a two minute period of time.

After charging the furnace, power is supplied to the furnace electrodes and oxygen (or other suitable oxygen-containing gas) is injected into the furnace. Arcs are established between the electrodes and the solid feedstock, thereby generating heat that progressively melts the solid charge.

After approximately 3MWh of power had been supplied to the furnace, which is typically a period of time of three minutes into this first power-on phase, injection of fluxes in the form of lime and magnesia into the furnace commences. These materials are supplied to form a slag on molten material forming in the furnace. The figure of 3MWh equates to the power required for the electrodes to "bore down" through the scrap and to be arcing on the heavy melt in the bottom of the furnace.

After approximately 8MWh of power has been supplied to the furnace, which is typically a period of eight minutes into the first power-on phase, a mixture of an unagglomerated carbon-containing polymer in the form of rubber and another carbon source in the form of coke are injected into the furnace. The figure of 8MWh equates to when a flat bath of molten material and a liquid slag begin to form. The injection of the mixture continues at a constant flow rate for a period of four minutes to the end of the first power-on (and oxygen injection) phase. The mixture is injected via a lance extending into the furnace. The rubber/coke mixture acts as a fuel, with combustion of rubber/coke generating heat. The rubber/coke, including the combustion products, also act as a slag foaming agent, as described in the International Publication.

A second charge of the feedstock for producing steel in the form of a scrap charge is supplied to the furnace during a two minute period following the end of the first power-on phase.

After charging the second feedstock charge, power to the furnace and oxygen (or other suitable oxygen-containing gas) injection are re-established and the furnace commences operating a second power-on phase.

After approximately 3MWh of power has been supplied to the furnace following the second feedstock charge, which is typically three minutes of the second power-on phase, fluxes in the form of lime and magnesia are supplied to the furnace to contribute to maintaining a required level of slag in the furnace.

After approximately 20 MWh of power has been supplied to the furnace since the first feedstock charge, which is typically a further five minute period of time in the second power-on phase, the mixture of rubber and coke is again injected into the furnace via the lance and injection of the mixture continues at a constant flow rate until the end of the second power-on (and oxygen injection) phase. Typically, the second power-on (and oxygen injection) phase runs for 24-28 minutes.

After the second power-on phase ends, the furnace is tapped to discharge molten steel and slag from the furnace during a two minute period.

At the end of tapping, there is a two minute turnaround time before the method is repeated with a new charge of scrap is supplied to the furnace.

Based on the trials at the Sydney and the Melbourne electric arc furnace facilities of the applicant, results achieved to date indicate that the invention has the potential to:

(a) speed up the slag-foaming process;

(b) achieves a reduction in electricity consumption, meaning a fall in greenhouse gas emissions if produced by coal-fired power stations;

(c) reduces total cost of production by reducing the quantity of injectant material required;

(d) improve furnace productivity by a reduction in "tap-to-tap" time - a measure of the time taken to produce one batch of molten steel.

In addition, the use of unagglomerated carbon-containing polymers has significant potential can potentially be diverted away from land fills.

The above findings are significant outcomes.

Many modifications may be made to the embodiment of the method of the present invention described above without departing from the spirit and scope of the invention.

By way of example, whilst the embodiment is described in the context of producing steel, the present invention is not so limited and extends to the production of ferro-alloys generally.

Furthermore, whilst the embodiment is described in the context of producing steel in an electric arc furnace, the present invention is not so limited and extends to the production of steel and ferro-alloys generally in any suitable matallurgical vessel.

In addition, whilst the embodiment includes the use of an unagglomerated carbon-containing polymer, the present invention is not so limited and extends to the use of agglomerated carbon-containing polymers.

In addition, whilst the embodiment includes the supply of the mixture of the unagglomerated carbon-containing polymer and the other carbon source by injecting the mixture through one of more than one lance extending into the furnace, the present invention is not so limited and extends to supplying the mixture in to the furnace using any suitable apparatus.

In addition, whilst the embodiment includes particular time periods for charging the furnace, and supplying other materials to the furnace, the present invention is not limited to these time periods and extends to any suitable time periods. In addition, the present invention extends to situations in which there is continuous charging of materials to the furnace.

In addition, whilst the embodiment includes continuous injection of the mixture of the unagglomerated carbon-containing polymer and the other carbon source at constant flow rates during part of power-on phases, the present invention is not so limited and extends to periodic injection and/or variable flow rates of injection during power-on phases and, if required, other non-power-on phases of the method.

In addition, whilst the embodiment includes the use of lime and magnesia as slag-forming agents, the present invention is not so limited and extends to the use of any suitable materials.

In addition, whilst the embodiment includes supplying lime and magnesia during the first and second power-on phases, the present invention is not so limited and extends to adding these and other fluxes with the scrap, during power-on and after power on.

In addition, whilst the embodiment includes operating the method with two power-on phases, the present invention is not so limited and extends to operating with one or any other suitable number of power-on phases.

In addition, whilst the embodiment describes the supply of the mixture of the unagglomerated carbon-containing polymer and the other carbon source, the present invention also extends to embodiments in which there is supply of only one of the components at other times in the method.

CLAIMS

1. A method for producing a ferro-alloy, such as steel, in an electric arc furnace or other suitable metallurgical furnace that comprises supplying a mixture of (a) a carbon-containing polymer that is capable of acting as a slag foaming agent and (b) another source of carbon into the furnace during at least a part of a power-on phase of the method.

2. A method for producing a ferro-alloy, such as steel, in an electric arc furnace or other suitable metallurgical furnace that comprises supplying a mixture of (a) a carbon-containing polymer that is capable of acting as a slag foaming agent and (b) another source of carbon into the furnace during at least a part of a first power-on phase of the method and supplying a further mixture of the carbon-containing polymer and another source of carbon into the electric arc furnace during a second power-on phase of the method.

3. A method of producing a ferro-alloy in an electric arc furnace or other suitable metallurgical furnace which comprises:

(a) supplying an initial charge of a feedstock for the ferro-alloy to the furnace;

(b) operating in a first power-on phase and establishing an arc between an electrode or electrodes of the furnace and the solid feedstock charge and generating heat in the furnace and melting the solid feedstock charge;

(c) after a first period of time into the first power-on phase, commencing supply of a mixture of (i) a carbon-containing polymer that is capable of acting as a slag foaming agent and (ii) an another source of carbon into the furnace;

(d) at the end of the first power-on phase, supplying a further charge of the ferro-alloy feedstock to the furnace;

(e) operating in a second power-on phase by re-establishing the arc;

(f) after a first period of time into the second power-on phase, commencing injection of a mixture of (i) a carbon-containing polymer that is capable of acting as a slag foaming agent and (ii) an another source of carbon into the furnace; and

(g) at the end of the second power-on phase, tapping molten ferro-alloy from the furnace.

4. The method defined in any one of the preceding claims wherein the carbon-containing polymer comprises any one or more of rubber (synthetic or natural) and other polymers such as polypropylene, polystyrene, polybutadiene styrene, and APS.

5. The method defined in any one of the preceding claims wherein the other source of carbon comprises any one or more of coke, carbon char, charcoal and graphite.

6. The method defined in any one of the preceding claims comprises assessing the time to commence supply of the mixture of the carbon-containing polymer and the other carbon source during the power-on phase or phases based on any one or more of the power consumption of the furnace, the composition of the melt in the furnace, and the melt temperature.

7. The method defined in any one of the preceding claims comprises varying the ratio of the carbon-containing source and the other carbon source in the mixture of these materials during the time period or periods of supply of the mixture to the furnace.

8. The method defined in any one of the preceding claims comprises maintaining the flowrate of the mixture of the carbon-containing source and the other carbon source constant during the time period or periods of supply of the mixture to the furnace.

9. The method defined in any one of claims 1 to 7 comprises varying the flowrate of the mixture of the carbon-containing source and the other carbon source during the time period or periods of supply of the mixture to the furnace.

10. The method defined in any one of the preceding claims comprises maintaining a continuous supply of the mixture of the carbon-containing source and the other carbon source during the power-on phase or phases.

11. The method defined in any one of the preceding claims wherein the carbon-containing polymer comprises 20-60 wt.% of the total weight of the mixture.

12. The method defined in any one of the preceding claims wherein the carbon-containing polymer comprises 25-35 wt.% of the total weight of the mixture.

13. The method defined in any one of the preceding claims wherein the mixture of the carbon-containing source and the other carbon source supplied to the furnace during the first power-on phase is the same as the mixture supplied during the second power-on phase.

14. The method defined in any one of the preceding claims comprises injecting an oxygen-containing gas, such as oxygen, into the furnace during the power-on phase or phases.

15. A metallurgical furnace such as an electric arc furnace that comprises a materials handling system for supplying a mixture of (i) a carbon-containing polymer that is capable of acting as a slag foaming agent and (ii) another source of carbon to the furnace during a method of producing a ferro-alloy in the furnace.

16. The furnace defined in claim 15 wherein the materials handling system comprises separate hoppers for storing the carbon-containing polymer and the other carbon source, a pipeline for transporting the carbon-containing polymer and the other carbon source to the furnace, and control valves for controlling the flow of each of the carbon-containing polymer and the other carbon source into the supply line so that the mixture of these materials forms in the pipeline and is transported to and supplied to the furnace.

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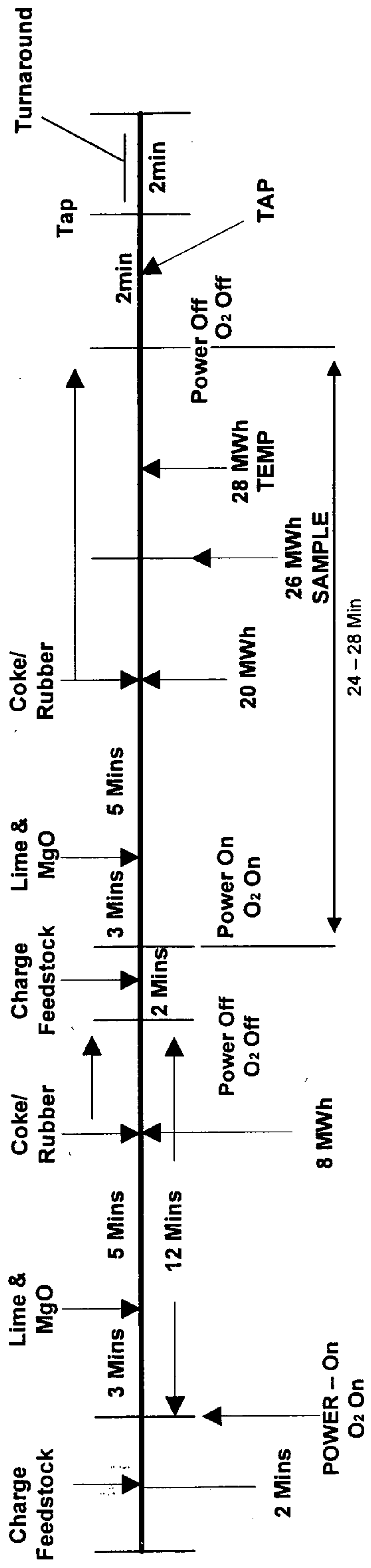
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2min
TAP
Power Off
O2 Off
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TEMP
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SAMPLE
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20 MWh
5 Mins
Lime &
MgO
Power On
O2 On
3 Mins
Charge
Feedstock
2 Mins
Power Off
O2 Off
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2009/001126

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

C22C 33/00 (2006.01)	*C21C 5/00* (2006.01)	*C22C 38/00* (2006.01)
C21B 3/00 (2006.01)	*C21C 7/00* (2006.01)	*F27B 1/00* (2006.01)
C21B 11/00 (2006.01)	*C22B 4/06* (2006.01)	*F27B 3/00* (2006.01)
C21B 13/00 (2006.01)	*C22C 35/00* (2006.01)	*F27D 11/00* (2006.01)
C21C 1/00 (2006.01)	*C22C 37/00* (2006.01)	

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPI and EPODOC with IPC marks (C22C33/IC, C22C37/IC, C22C38/IC, C22C35/IC, C21B3/IC, C21B11/IC, C21B13/IC, C21C1/IC, C21C5/IC, C21C7/IC, C22B4/06/IC, F27B1/IC, F27B3/IC, F27D11/IC) and keywords (POLYMER+, RUBBER+, CARBON, CHAR+, CHARCOAL, SLAG, FOAM+)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2006/024069 A1 (UNISEARCH LIMITED) 9 March 2006 Page 2 lines 15 – 30; page 3 lines 31 – 36; page 4 lines 1 – 23; page 5 lines 19 – 27; Examples 4, 6, 10, 11; Figure 5	1 – 5, 7, 10 – 12, 14
Y	Page 2 lines 15 – 30; page 3 lines 31 – 36; page 4 lines 1 – 23; page 5 lines 19 – 27; Examples 4, 6, 10, 11; Figure 5	15, 16
X	US 2002/0112567 A1 (KAWAKAMI ET AL.) 22 August 2002 Paragraphs [0356], [0388]; Figures 22, 23; Examples 1 – 4, 9; Table 19 in page 33	1, 4, 5, 7, 11, 12, 14
Y	US 5322544 A (STEBBING) 21 June 1994 Figures 1, 2; column 2 line 36 – column 4 line 50	15, 16

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 23 October 2009	Date of mailing of the international search report 28 OCT 2009
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. +61 2 6283 7999	Authorized officer **MILKA WENAS** AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No : +61 2 6283 2593

Supplemental Box 1
(To be used when the space in any of Boxes I to IV is not sufficient)

Continuation of Box No: III

This **International Searching Authority** has found that there are three different inventions as follows:

1. Claims 1, 15 are directed to a method for producing a ferro-alloy, such as steel, in an electric arc furnace or other suitable metallurgical furnace, that comprises supplying a mixture of a carbon-containing polymer that is capable of acting as a slag foaming agent and another source of carbon into the furnace by using a material handling system during at least a part of a power-on phase of the method. It is considered that the above features comprise a first distinguishing feature.

2. Claim 2 is directed to a method for producing a ferro-alloy, such as steel, in an electric arc furnace or other suitable metallurgical furnace, that comprises supplying a mixture of a mixture of a carbon-containing polymer that is capable of acting as a slag foaming agent and another source of carbon into the furnace during at least a part of a first power-on phase of the method and supplying a further mixture of the carbon-containing polymer and another source of carbon into the electric arc furnace during a second power-on phase of the method. It is considered that the above features comprise a second distinguishing feature.

3. Claim 3 is directed to a method for producing a ferro-alloy in an electric arc furnace or other suitable metallurgical furnace comprises supplying an initial charge of a feedstock for the ferro-alloy to the furnace; operating in a first power-on phase and establishing an arc between an electrode or electrodes of the furnace and the solid feedstock charge and generating heat in the furnace and melting the solid feedstock charge; after a first period of time into the first power-on phase, commencing supply of a mixture of a carbon-containing polymer that is capable of acting as a slag foaming agent and another source of carbon into the furnace; at the end of the first power-on phase; at the end of the first power-on phase, supplying a further charge of the ferro-alloy feedstock to the furnace; operating in a second power-on phase by re-establishing the arc; after a first period of time into the second power-on phase, commencing injection of a mixture of a carbon-containing polymer that is capable of acting as a slag foaming agent and another source of carbon into the furnace; and at the end of the second power-on phase, tapping molten ferro-alloy from the furnace. It is considered that the above features comprise a third distinguishing feature.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

The only feature common to all of the claims is supplying a mixture of a carbon-containing polymer that is capable of acting as a slag foaming agent and another source of carbon into the furnace during at least a part of a power-on phase of the method.

However, this concept is not novel in the light of:
D1 WO 2006/024069 A1 (UNISEARCH LIMITED) 9 March 2006
D2 US 2002/0112567 A1 (KAWAKAMI ET AL.) 22 August 2002

This means that the common feature can not constitute a special technical feature within the meaning of PCT Rule 13.2, second sentence, since it makes no contribution over the prior art.

Since the common feature does not satisfy the requirement for being a special technical feature it follows that it cannot provide the necessary technical relationship between the identified inventions. Therefore the claims do not satisfy the requirement of unity of invention ***a posteriori.***

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please refer to Supplemental Box 1

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2009/001126

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2002-241830 A (DAIDO STEEL CO LTD) 28 August 2002. English abstract retrieved from EPODOC database Abstract	1 – 16

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
WO	2006024069	AU	2005279678	BR	PI0514874	CA	2578576
		CN	101035920	EP	1799875	KR	20070049222
		MX	2007002540	US	2008092692	ZA	200702731
US	2002112567	AU	16877/99	BR	9814479	CA	2315031
		CN	1283222	ID	26484	JP	11193406
		JP	11193410	JP	11193411	JP	11217614
		JP	11310811	JP	11310812	US	6837916
		WO	9934022				
US	5322544	WO	9324662				
JP	2002241830	NONE					

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX