We, DEUTSCHE VOEST-ALPINE INDUSTRIEANLAGENBAU GmbH (formerly Korf Engineering GmbH)
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hereby apply for the grant of a standard patent for an invention entitled:

PROCESS FOR MELTING METAL SCRAP AND
APPARATUS FOR PERFORMING THE PROCESS

which is described in the accompanying complete specification

Details of basic application(s):

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<th>Number of basic application</th>
<th>Name of Convention country in which basic application was filed</th>
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My/our address for service is care of GRIFFITH HACK & CO., Patent Attorneys, 601 St. Kilda Road, Melbourne 3004, Victoria, Australia.

DATED this 12th day of October 1988

DEUTSCHE VOEST-ALPINE INDUSTRIEANLAGENBAU GmbH

GRIFFITH HACK & CO.

TO: The Commissioner of Patents.
As the longitudinal section through an inventive scrap melting furnace according to fig. 1 shows, the latter essentially comprises the furnace shaft 1, the furnace hearth 2, the hearth area 3 and the intermediate water-cooled grate 4. Both shaft and hearth or hearth area are lined with refractory material 5. There can also be an external cooling by spray water via a ring main 6. The furnace shaft is charged with scrap by means of a bucket 7, which can be opened by means of a bottom flap 8. For the gas tight closure of the furnace, the furnace shaft is provided with a hinged cover 9 on which the scrap is initially held back. When the full bucket 7 has been placed on the filling shaft 10, cover 9 is opened and the scrap drops onto the packed ceramic bed 11 located above grate 4. Burners 12 produce in the hearth area 3 hot combustion gases, whose temperature is well above the melting point of the scrap. These gases flow through the grate 4 and the packed ceramic bed 11 and melt the scrap. The gas then flows through the scrap bed and leaves the furnace via the waste gas line 13. The molten metal formed drips through the packed ceramic bed, where superheating
takes place before the drips drop onto the hearth 2. The molten metal collecting on the hearth is superheated by the gas radiation in the hearth area 3 and by the radiation of the hearth area walls and to a limited extent by convection.

The molten metal is removed through the tap holes 14 and the molten slag via the opening 15 from the furnace.

In the case of premature wear, the furnace hearth can be lowered by means of a hydraulic device 16 and replaced by a relined hearth.

The hot waste gas is after-burned in a secondary combustion chamber according to fig. 2 and mixed with cooling air at the appropriate temperature (recuperator intake). The combustion air is preheated in a following heat exchanger with the sensible heat of the waste gas. The dust produced is subsequently discharged in a filter.

1. Process for melting high melting metal scrap, particularly steel scrap, in a shaft furnace operated in cokeless manner by means of fluid fuels and whose furnace shaft is separated from the furnace hearth connected to the bottom thereof by means of a cooled grate arrangement, in which the burners issue into the furnace substantially at right angles to the longitudinal axis of the shaft and the combustion heat is recuperatively preheated by means of the shaft furnace waste gases, characterized in that the amount of heat introduced into the melting unit by means of the burners is subdivided in clearly defined dosable manner into a component drawn off from the furnace shaft and a component remaining in the furnace hearth, that

a) the radiating surface of the refractory wall lining in the furnace hearth is between 1.8 and 3.5 m²/tonne of molten metal produced,

b) the radiation-active, average layer thickness of the gas in the furnace hearth is between 1.5 and 3.5 m and

c) the temperature at which the waste gas enters the recuperator is controlled as a function of the height of the charge material bed in the furnace shaft, said height being dependent on the scrap type used.
3. Process according to claims 1 or 2, characterized in that the height of the bed is set in such a way that the entry temperature into the recuperator is adjusted so as to minimize the oxidizing on of the charge material in the furnace shaft, in conjunction with said minimization of the bed height and as a function of an air inlet temperature for the burners into the furnace hearth between 800 and 900°C.

4. Process according to claims 1 to 3, characterized in that the heat transfer to the bath of the molten phase takes place 80 to 90% and preferably 85% by radiation and 10 to 20%, preferably 15% by convection and, based on the hearth area, the radiation percentage is formed from approximately 25% gas radiation and 50 to 80%, preferably 75% wall radiation.

5. Process according to at least one of the claims 1 to 4, characterized in that the temperature in the furnace shaft is adjusted at least to the level of the vaporization temperature of zinc, a possibly present zinc component in the shaft vaporizers and is completely oxidized in the secondary combustion chamber, so that it can be subsequently separated from the dust phase obtained.

6. Furnace for performing the process according to at least one of the claims 1 to 5, containing a vertical furnace shaft and a furnace hearth separated from one another by a cooled grate, characterized in that the furnace hearth directly connected to the cooled grate arrangement of the furnace shaft widens downwards initially concentrically in cross-section with a parabolic or bevelled radiating surface and subsequently, at least in the burning area, passes into a vertical, cylindrical portion of correspondingly increased diameter.

7. Furnace according to claim 6, characterized in that the angular inclination of the parabolic radiating surfaces is selected in such a way that the irradiation direction thereof is directed roughly onto the central region of the liquidus phase on the hearth bottom.
8. Furnace according to claim 7, characterized in that the flame cross-sections of the burner or burners are minimized at right angles to the radiating surface of the furnace walls.

9. Furnace according to claim 8, characterized in that the burners are arranged tangentially horizontally and preferably inclined by up to max. 10% against the roof.

11. Furnace according to at least one of the claims 6 to 10, characterized in that behind the furnace shaft is arranged a secondary combustion chamber for burning impurities present in the oxidizing atmosphere.

13. Furnace according to at least one of the claims 6 to 12, characterized in that by means of underbath nozzles and/or per se known lance means carbon-containing components can be introduced into the metal bath within the furnace.
TO BE COMPLETED BY APPLICANT

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Complete Specification for the invention entitled:
PROCESS FOR MELTING METAL SCRAP AND
APPARATUS FOR PERFORMING THE PROCESS

The following statement is a full description of this invention
including the best method of performing it known to me:-
Process for melting metal scrap and apparatus for performing the process

The invention relates to a process for melting metal scrap according to the preamble of claim 1, and to an apparatus for performing the process.

In the foundry practice field processes for melting iron for pig iron production using cupola furnaces operated in cokeless manner are known. Thus, e.g. German Patent 22 04 042 describes a process for melting iron in a vertical shaft furnace without using coke and using a fuel/air mixture, which is burnt outside the furnace in burners, which are positioned close to the lower part of the furnace, iron scrap and cast iron being charged into the upper end of the furnace and melted, in that superheated material drips through a bed of loose refractory materials arranged within the shaft and said refractory materials are heated by the combustion products of the burners, before the upwardly travelling combustion products melt the metal moving towards them and molten metal can be tapped from the bottom of the furnace. The combustion products are introduced from all sides into the free area of the furnace from several burners, which are entirely located below the refractory material bed, the temperature of the gases in the vicinity of the bed being kept at max. 1600°C. The actual furnace hearth is formed by a lower cylindrical extension of the cylindrical furnace shaft with the same diameter. Shaft and hearth are separated from one another by a water-cooled grate with the bed material arranged thereon. At the bottom of the furnace collects the molten metal which has dripped through the grate and can be tapped off there continuously or intermittently by means of a tap hole, which also applies with regards to the slag floating on the molten metal.

The furnace arrangement in said known Hayes or Taft furnace is such that the combustion gases from the combustion chambers meet in a central lower zone of the shaft in the so-called hearth area below the grate and flowing upwards from there heat the refractory bed and then in counterflow heat the charge material.
An appropriate further development of this cokeless cupola furnace for foundry practice is formed by the known Duker furnace, which also functions with a cylindrical shaft arrangement, whose lower part with constant cross-section located below the water-cooled grate forms the furnace hearth, into which the oil burners issue roughly radially through the furnace wall. The molten pig iron collecting in the bottom region can be tapped off by means of a skimmer arrangement and supplied to a super heater.

A fuel oil or gas-heated shaft furnace for melting and superheating metal, specifically cast iron and copper is described in German Patent 38 43 678, which operates with an addition of coke per charge and has several outer burner chambers, which are connected via water-cooled nozzles to the furnace interior, the burner chambers and the nozzles being located in the through-drip zone formed by the coke per charge. In said known shaft furnace theoretically no slag protection is required for the dripping iron, because this is ensured by the reducing combustion of fuel oil and natural gas.

In connection with scrap melt-down processes, reference is also made to the shaft furnace described in German Patent 23 27 073, whose melt-down vessel increases in cross-section to a limited, continuous extent in the downwards direction and in which the radial burner systems are located in the immediate bottom area of the melt-down vessel, where the liquidus phase collects. The molten pig iron is continuously tapped off by means of a drain in the bottom. An only adequate separation between the solid charge material, such as e.g. iron scrap or the like and the liquidus phase is achieved due to the total omission of a separating grate arrangement by means of a central base in the bottom area, by means of which the heat transfer between the molten material and the charge material column is reduced, or is at least kept as small as possible.

The aforementioned, cokeless-operated foundry shaft furnaces have the common feature that the furnace shaft and furnace hearth form a single,
substantially cross-sectionally cylindrical component, i.e. a simple tube shaft. The lower portion of the latter constitutes the furnace hearth with minimized surfaces for the furnace wall.

However, the melting unit arrangement of the known Flaven furnace comprises two constructional units which differ even as regards the external construction, namely a vertical, cross-sectionally cylindrical furnace shaft and a furnace hearth horizontal with respect thereto and in whose one end the furnace shaft issues by means of a water-cooled grate and whose other end receives the burner, whose flame is directed onto the tap area of the liquidus phase and whose flame gases flow horizontally over the liquid bath and in guided manner to the grate arrangement and rise again from there in counterflow within the furnace shaft. The tunnel-like hearth area gives for the iron bath a relatively large surface, over which can pass the hot fuel gas, without the main part of the refractory material of the hearth furnace being subject to the direct action of the burner flame. Thus, in the case of this known arrangement, the heat supply proportion by thermal irradiation from the hearth wall is at a minimum.

Finally a process for melting metal in a shaft furnace using a liquid or gaseous fuel with a grate located at the lower end of the furnace for supporting the not yet molten metal introduced in the furnace is known (DE-OS 36 10 498), in which the oxygen-containing gas required for burning the fuel is heated prior to combustion and in which a tunnel-like furnace hearth issues horizontally into the lower part of a vertical furnace shaft. The burners are located in the end face opposite to the furnace shaft opening, so that the flame thereof in the longitudinal direction of the furnace hearth is directed onto the inlet port in the furnace shaft, so that it supplies heat to the entire inner area and consequently the hearth walls or the refractory material thereof and the heat can then irradiate in the form of radiant heat onto the molten iron surface.

The hitherto known shaft melting furnaces of the described type are
only suitable for pig iron production in foundries, because the relatively low temperatures attainable in the furnace hearth lead to an excessive carbon proportion in the liquidus phase for steel production. Thus, foundry furnaces are only operated with a maximum of less than 40% steel scrap with respect to the charge material.

The problem of the present invention is to provide a process and an apparatus of the aforementioned type making it not only possible to use random scrap components as the charge material, but e.g. also 100% steel scrap and simultaneously, as a function of the desired further processing in the furnace hearth can, if desired, be placed molten steel, whilst also simplifying and improving the construction of the apparatus for performing the process.

From the process standpoint this problem is inventively solved by the features of the characterizing part of claim 1. Advantageous further developments thereof can be gathered from subclaims 2 to 4.

From the apparatus standpoint, the problem is in particular inventively solved by the characterizing features of claim 5. Advantageous further developments and constructions in connection with the apparatus can be gathered from the remaining subclaims.

Due to the fact that the radiating surfaces of the refractory lining in the hearth furnace, measured against the melting capacity in tonnes of charge material per hour and precisely defined relative thereto, optimum conditions exist regarding the superheating possibility of the liquidus phase. Independently of whether there is cokele\textsuperscript{1} operation or coke is used, the known cupola furnaces essentially have no radiant energy in the inventive sense for the heating of the liquid phase, because therein the hearth walls are kept to the minimum. Thus, such shaft furnaces are only suitable for cast iron production and the processing of steel is impossible due to the low temperatures present. Steel melting furnaces are operated in the foundry field with a maximum charge material proportion of 40% steel scrap, whilst taking
account of certain difficulties and higher steel proportions would appear to be impossible for processing.

However, excessively large radiating surfaces of the walls in the hearth area lead to high energy losses via the refractory material of the wall, so that an inadequate energy component passes into the furnace shaft and the temperature attainable there is no longer sufficient to melt the scrap present.

Not only the installed capacity, but the subdivision of the energy over the bath and shaft is of decisive importance, so that on the one hand there is sufficient energy in the shaft for melting the scrap and on the other hand the hearth area is dimensioned in such a way that the molten metal can be superheated to adequately high temperatures. For this purpose a particularly advantageous dependence is produced between the inlet temperature into the recuperator, whilst minimizing the risk of oxidizing on the charge material in the furnace shaft, as a function of the bed height of said material.

The transition between the furnace shaft and the furnace hearth is, unlike in the prior art, not of the type revealing no cross-sectional change, nor of the type in which shaft and hearth are vertically joined together as separate elements. The concentric arrangement of the furnace hearth with a large diameter with respect to the furnace shaft with a small diameter in such a way that the transition takes place via sloping surfaces defining parabolic radiating surfaces, also simplifies the refractory lining and improves the dripping behaviour of the molten metal in the melting unit in a particularly advantageous manner. The problems occurring when lining with the refractory material, e.g. in the Flaven furnace, as well as the poor dripping behaviour below the water-cooled furnace grate occurring therein, is obviated by the novel arrangement according to the invention. A vertical, circular cross-section issues into another vertical, circular cross-section via an inclined wall portion located directly below the water-cooled grate and whose dimensioning once again corresponds to the smaller
cross-section of the furnace shaft. The gas inflow conditions in the shaft over the grate are also advantageously influenced in this connection. The charge material and in particular the steel scrap bed height, unlike in the known teaching, no longer has to be maximized but, as is particularly important for the present charge material, can in fact be minimized, because the heat exchange effect via the bed column no longer has any primary influence on the process sequence and instead via heat exchangers the air mixture for the burners is so preheated that it is possible to operate with the indicated low charge heights above the grate. The waste gas inlet temperature into the recuperator is on the one hand controlled by the scrap bed height and its characteristics and on the other hand by the secondary combustion and cooling air addition. The major influence of the heat distribution of the burners on the shaft and on the lower furnace in the case of an appropriate division of said two components, is fully assisted in the present procedure, whilst bearing in mind the novel constructional features.

As a result of the high temperatures reached, it is e.g. possible to vaporize in the shaft metal components other than present in the charge material as impurities, such as zinc and such fractions can be completely oxidized in a secondary combustion chamber and subsequently become constituents of the dust ash, which can be kept in separators and then discharged. As a function of the enrichment of such contaminations with certain coarse and/or fine dust characteristics, in this connection discharge can take place in fractionally filtered or other forms.

In order to be able to set the desired carbon content in the metal bath and simultaneously suppress slag formation of the charge material on the bath surface, carbon carriers can be blown into the metal bath, using both underbath nozzles and lances insertable above or below the bath surface. Thus, it is easily possible to produce from the charge material both steel and cast iron.
By means of the attached figs. 1 and 2, which show an exemplified possibility for the process sequence or for the construction of the melting unit in diagrammatic manner, the present invention is further illustrated.

As the longitudinal section through an inventive scrap melting furnace according to fig. 1 shows, the latter essentially comprises the furnace shaft 1, the furnace hearth 2, the hearth area 3 and the intermediate water-cooled grate 4. Both shaft and hearth or hearth area are lined with refractory material 5. There can also be an external cooling by spray water via a ring main 6. The furnace shaft is charged with scrap by means of a bucket 7, which can be opened by means of a bottom flap 8. For the gas tight closure of the furnace, the furnace shaft is provided with a hinged cover 9 on which the scrap is initially held back. When the full bucket 7 has been placed on the filling shaft 10, cover 9 is opened and the scrap drops onto the packed ceramic bed 11 located above grate 4. Burners 12 produce in the hearth area 3 hot combustion gases, whose temperature is well above the melting point of the scrap. These gases flow through the grate 4 and the packed ceramic bed 11 and melt the scrap. The gas then flows through the scrap bed and leaves the furnace via the waste gas line 13. The molten metal formed drips through the packed ceramic bed, where superheating takes place before the drips drop onto the hearth 2. The molten metal collecting on the hearth is superheated by the gas radiation in the hearth area 3 and by the radiation of the hearth area walls and to a limited extent by convection.

The molten metal is removed through the tap holes 14 and the molten slag via the opening 15 from the furnace.

In the case of premature wear, the furnace hearth can be lowered by means of a hydraulic device 16 and replaced by a relined hearth.

The hot waste gas is after-burned in a secondary combustion chamber according to fig. 2 and mixed with cooling air at the appropriate
temperature (recuperator intake). The combustion air is preheated in a following heat exchanger with the sensible heat of the waste gas. The dust produced is subsequently discharged in a filter.
THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. Process for melting high melting metal scrap, particularly steel scrap, in a shaft furnace operated in cokeless manner by means of fluid fuels and whose furnace shaft is separated from the furnace hearth connected to the bottom thereof by means of a cooled grate arrangement, in which the burners issue into the furnace substantially at right angles to the longitudinal axis of the shaft and the combustion heat is recuperatively preheated by means of the shaft furnace waste gases, characterized in that the amount of heat introduced into the melting unit by means of the burners is subdivided in clearly defined dosable manner into a component drawn off from the furnace shaft and a component remaining in the furnace hearth, that

a) the radiating surface of the refractory wall lining in the furnace hearth is between 1.8 and 3.5 m²/tonne of molten metal produced,

b) the radiation-active, average layer thickness of the gas in the furnace hearth is between 1.5 and 3.5 m and

c) the temperature at which the waste gas enters the recuperator is controlled as a function of the height of the charge material bed in the furnace shaft, said height being dependent on the scrap type used.

2. Process according to claim 1, characterized in that the radiating surface is between 2 and 2.8 m² and the average layer thickness of the gas is between 2 and 2.5 m.

3. Process according to claims 1 or 2, characterized in that the height of the bed is set in such a way that the entry temperature into the recuperator is adjusted so as to minimize the oxidizing on of the charge material in the furnace shaft, in conjunction
with said minimization of the bed height and as a function of an air inlet temperature for the burners into the furnace hearth between 800 and 900°C.

4. Process according to claims 1 to 3, characterized in that the heat transfer to the bath of the molten phase takes place 80 to 90% and preferably 85% by radiation and 10 to 20%, preferably 15% by convection and, based on the hearth area, the radiation percentage is formed from approximately 25% gas radiation and 50 to 80%, preferably 75% wall radiation.

5. Process according to at least one of the claims 1 to 4, characterized in that the temperature in the furnace shaft is adjusted at least to the level of the vaporization temperature of zinc, a possibly present zinc component in the shaft vaporizers and is completely oxidized in the secondary combustion chamber, so that it can be subsequently separated from the dust phase obtained.

6. Furnace for performing the process according to at least one of the claims 1 to 5, containing a vertical furnace shaft and a furnace hearth separated from one another by a cooled grate, characterized in that the furnace hearth directly connected to the cooled grate arrangement of the furnace shaft widens downwards initially concentrically in cross-section with a parabolic or bevelled radiating surface and subsequently, at least in the burning area, passes into a vertical, cylindrical portion of correspondingly increased diameter.

7. Furnace according to claim 6, characterized in that the angular inclination of the parabolic radiating surfaces is selected in such a way that the irradiation direction thereof is directed roughly onto the central region of the liquidus phase on the hearth bottom.
8. Furnace according to claim 7, characterized in that the flame cross-sections of the burner or burners are minimized at right angles to the radiating surface of the furnace walls.

9. Furnace according to claim 8, characterized in that the burners are arranged tangentially horizontally and preferably inclined by up to max. 10% against the roof.

10. Furnace according to at least one of the claims 6 to 9, characterized in that the furnace shaft is a cylindrical shaft, whose circular cross-section passes via the parabolically widening upper portion in the furnace hearth and towards the lower portion of the furnace hearth continuously into the enlarged cross-section there.

11. Furnace according to at least one of the claims 6 to 10, characterized in that behind the furnace shaft is arranged a secondary combustion chamber for burning impurities present in the oxidizing atmosphere.

12. Furnace according to at least one of the claims 6 to 11, characterized in that the height of the hearth furnace is such that the average active layer thickness of the gas in the combustion chamber above the molten metal is between 1.5 and 3.5 m, preferably between 2 and 2.5 m, the average active layer thickness being understood to mean the average distance of the bevelled heat-radiating wall of refractory material in the furnace area from the bath surface.

13. Furnace according to at least one of the claims 6 to 12, characterized in that by means of underbath nozzles and/or per se known lance means carbon-containing components can be introduced into the metal bath within the furnace.

DATED THIS 12TH DAY OF OCTOBER 1988
DEUTSCHE VOEST-ALPINE INDUSTRIALAGENBAU GmbH
By its Patent Attorneys:
GRIFFITH HACK & CO.,
Fellows Institute of Patent
Attorneys of Australia
DRAWINGS
FIG. 2

Scrap coal additives

Waste gas

Secondary combustion chamber

Dust

Heat exchanger

Filter

Flue

molten metal Slog

molten metal Slog

Dust
END