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**Rheinlander**

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[54] **METHOD OF OPERATING A BLAST FURNACE**


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[52] **U.S. Cl.** ..... **75/42**
[51] **Int. Cl.** ..... **C21b 5/02**
[58] **Field of Search** ..... 75/41, 42; 266/41; 110/182.5



[56] **References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 1,393,749 | 10/1921 | Carstens | 75/42 |
| 1,934,082 | 11/1933 | Moll et al. | 75/42 |
| 3,400,921 | 9/1968 | Hemker | 266/41 X |
| 3,558,119 | 1/1971 | Demalander | 75/42 |
| 3,596,894 | 8/1971 | Duthion et al. | 75/42 |



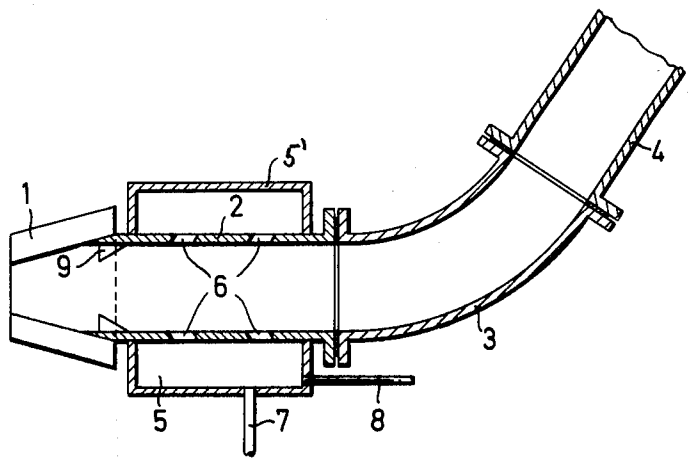
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[57] **ABSTRACT**

A method of operating a blast furnace with coke as the principal fuel and with a carbon- or hydrocarbon-containing auxiliary fuel is disclosed. The coke is charged in conventional manner through the top of the furnace while the auxiliary fuel is heated and broken down in a reaction space located outside the hearth of the furnace. The decomposition products of the auxiliary fuel thus obtained are introduced into the hearth through the tuyeres. In accordance with the invention the decomposition products of the auxiliary fuel, after exiting from the reaction space, are directly introduced into the tuyeres or their adjacent blow pipes which carry the hot blast.


**17 Claims, 5 Drawing Figures**



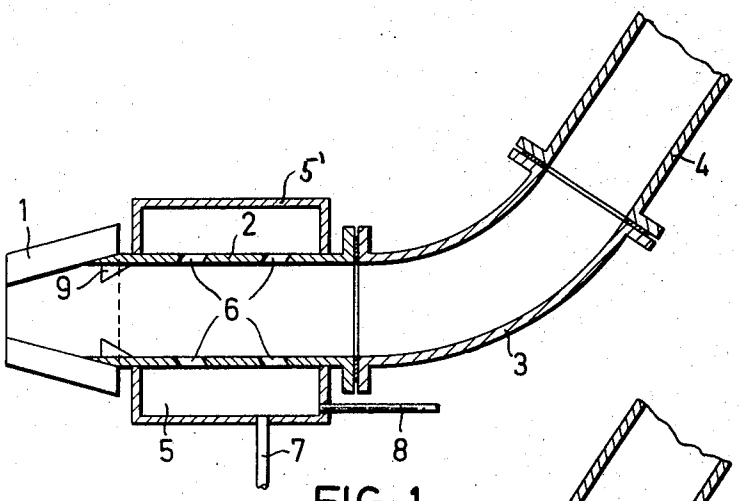



FIG. 1

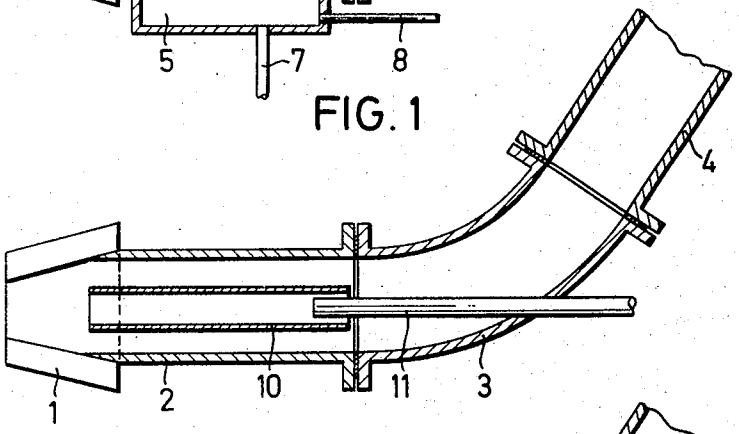



FIG. 2

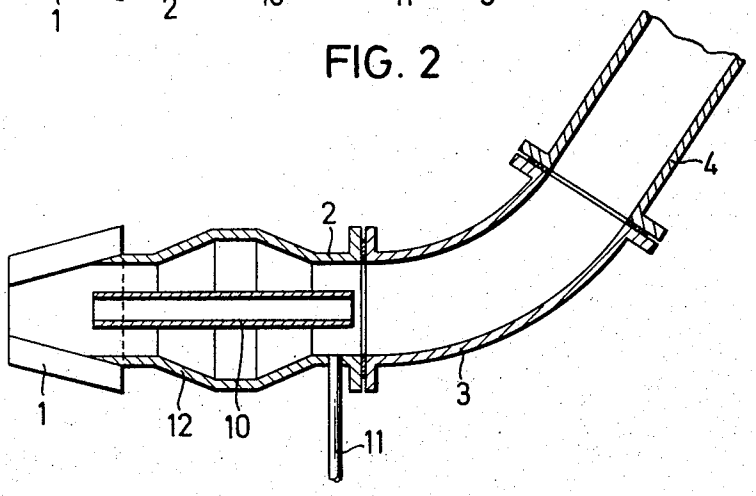



FIG. 3

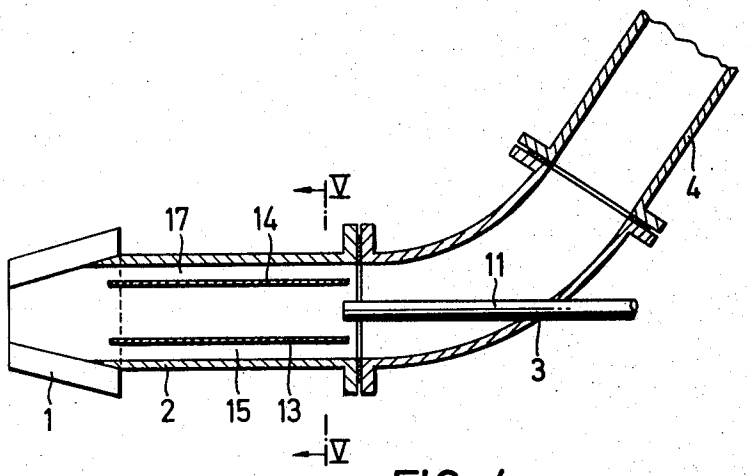



FIG. 4

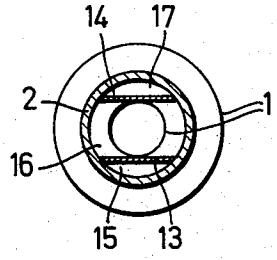



FIG. 5

# METHOD OF OPERATING A BLAST FURNACE

## FIELD OF INVENTION

The present invention is directed to a procedure for operating a blast furnace with coke as principal fuel and with a carbon- or hydrocarbon-containing auxiliary fuel. Suitable auxiliary fuels for the purposes of this invention are, for example, petroleum, petroleum products, natural gas, coke oven gas or coal dust.

## BACKGROUND INFORMATION

In the production of pig iron in blast furnaces, several attempts have been made by blast furnace operators to replace a portion of the relatively expensive coke, which is customarily used as principal fuel, by less expensive auxiliary or additional fuels (hereinafter auxiliary fuel). However, these attempts have not been fully successful. There are several reasons for this. Thus, for example, it is well known that in the prior art blast furnace processes, the upper limit for the addition of oil as auxiliary fuel per ton of pig iron, should not exceed about 100 kg. The reason for this is that the oil, prior to its introduction into the furnace through the tuyeres, passes during ordinary blast furnace operations, rapidly through the reaction space ahead or in front of the tuyeres, to wit, the reaction space which contains oxygen, carbon dioxide or steam of the hot blast with which the oil can react. In practice the dwell time of the oil in the space ahead of the tuyeres is only about 1/200 of a second. This time period, however, is much too short for effectively cracking the oil and for oxidation of the hydrocarbons in the oil. Furthermore, the subsequent cracking and heating of the thus formed decomposition products in the hearth of the furnace consumes heat. The furnace is thus deprived of heat in a zone at which it is most needed. Moreover, the entry point of the oil in the tuyeres cannot be moved back, to wit, in a direction away from the furnace within the tuyere structure because if this would be done, the oil, due to contact with the oxygen contained in the hot blast, would burn up to form carbon dioxide and water vapor. The high temperature which would be the result of such an operation, would in turn endanger the tuyere structure. On the other hand, the hearth, during the reduction of the carbon dioxide and the water vapor to carbon oxide and hydrogen, is strongly cooled by the red hot coke.

For this reason it has previously been suggested first to gasify the oil or other auxiliary fuels outside the blast furnace structure proper and then to blow the gases thus formed into the upper portion of the blast furnace, thereby to improve the indirect reduction. With a view to improving the distribution of the added gas, it has also been proposed to introduce the gas into the tuyeres of the blast furnace, although this gas cannot serve the purpose of increasing the temperature in the hearth. On the contrary, by proceeding in this manner, the hearth area is deprived of heat, because the added gas has first to be heated to the temperature of the hearth. A compensation for this loss of temperature can be attained by increasing the temperature of the hot blast or by adding oxygen.

For this reason, it has also been suggested to use oil or other auxiliary fuel which is not gasified outside the blast furnace proper, but wherein the oil is split or broken down in an oxygen deficient atmosphere, sometimes in the presence of water vapor and/or carbon dioxide. In this manner a relatively large portion of the carbon contained in the oil is introduced into the hearth in the form of soot, which soot then burns in the hearth to form carbon oxide and which replaces coke-carbon.



However, all these prior art procedures require considerable expenditure in equipment for the purpose of gasifying or splitting the auxiliary fuel outside the blast furnace. A uniform distribution of the decomposition products to the individual tuyeres is extremely difficult. Furthermore, a portion of the heat value of the auxiliary fuels is lost by radiation or other unavidable procedural losses. Finally, the extremely high investment costs for such gasification and decomposition plants reduce the savings which are achieved by the replacement of coke by the auxiliary fuel. In many instances no saving in fact results, thus defeating the very purpose for using the auxiliary fuel.

## SUMMARY OF THE INVENTION

The primary purpose of the present invention is to overcome the difficulties and drawbacks of the prior art procedures and to propose a procedure which enables a significant increase of the amount of auxiliary fuel to be added to coke operated blast furnaces without requiring any complicated or expensive apparatus.

It is also an object of this invention to provide a procedure which enables the introduction of considerable quantities of auxiliary fuel into a coke operated blast furnace by means of a simple readily operated and serviced apparatus.

Generally, it is an object of this invention to improve on the art of blast furnace operations and their economics.

Briefly, and in accordance with this invention, the auxiliary fuel is broken down or split into decomposition products outside the hearth of the furnace and in a reaction space and the decomposition products thus obtained and after exiting from the reaction space are directly introduced into the individual tuyeres or their associated blow pipes and then into the hearth of the blast furnace. The coke, in conventional manner, is charged through the top of the blast furnace while the auxiliary fuel is a carbon- or hydrocarbon containing material, such as, for example, petroleum, petroleum products, natural gas, coke oven gas or coal dust or the like. Instead of introducing the decomposition products directly into the tuyeres, they may be introduced into the blow pipes adjacent the tuyeres which blow pipes, in conventional manner, carry and convey the hot blast. Thus, in the inventive procedure, the decomposition products formed from the auxiliary fuel and after their exit from the reaction space referred to, are directly introduced into the blow pipes, which carry the hot blast, or into the tuyeres and thus into the hearth portion of the furnace.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there are illustrated and described the preferred embodiments of this invention.

IN THE DRAWINGS

FIG. 1 is a longitudinal section through a first embodiment of an arrangement suitable for carrying out the inventive procedure;

FIG. 2 is a second embodiment;

FIG. 3 is a third embodiment;

FIG. 4 is a fourth embodiment; and

FIG. 5 is a section along line V—V of FIG. 4.

The inventive procedure can be carried out in several variations which are being explained in detail in conjunction with the Figures of the drawings referred to. Referring first to FIG. 1 of the drawings, reference numeral 1 indicates a conventional cooled tuyere 1 which discharges into the blast furnace space, the blast furnace proper not having been shown. In respect to blast furnace structures, attention is directed to "The Making, Shaping and Treating of Steel," Eighth Edition, published by United States Steel Corporation, pages 384 – 435, and in particular page 394, which discusses tuyeres and related structures.

Adjacent the tuyere 1 is situated the so-called nozzle tube or blow pipe 2 (hereinafter referred to as blow pipe) which discharges into the tuyere. The blow pipe, through the elbow or pipe bent 3, is connected with the supply line 4, the latter leading to an annular conduit (not shown) and usually referred to in the art as the bustle pipe. The bustle pipe is a large refractory lined pipe that encircles the furnace and distributes the heated blast from the hot blast main to the respective tuyere connections, such as the connection 4,3,2 in FIG. 1. In accordance with the invention, a reaction space 5 is provided for the decomposition or splitting of additional fuel. This reaction space 5 in the embodiment of FIG. 1 is formed by the annular hollow tube member 5' which is closed on its sides and which surrounds the blow pipe 2. The reaction space or chamber 5 of the member 5' communicates with the blow pipe space through openings 6. Supply lines 7 and 8 for the space 5 are provided for the charging of the reaction media such as auxiliary fuel, the conduits or lines 7 and 8 thus discharging into the reaction space 5. The decomposition products which are formed in the reaction space 5 exit through the openings 6 into the space of the blow pipe 2 where they intermingle with the hot blast stream which flows through the blow pipe 2 towards the tuyere 1. The reaction space 5 may be charged through lines 7 and 8 either with oxygen alone or with oxygen in mixture with carbon dioxide, water vapor and nitrogen, as well as the auxiliary fuel. In a preferred embodiment of the invention, it is recommended to arrange and shape the openings 6 which establish the communication between the reaction space 5 and the blow pipe space 2 so as to be slanted in the flow direction of the hot blast as shown in FIG. 1. In other words, the openings 6 are inclined towards the tuyere 1. Under certain circumstances it may also be advisable to provide a constriction 9 in the region where the blow pipe 2 enters the tuyere 1, as shown in FIG. 1.

In another preferred embodiment of the inventive procedure, the hot blast stream is divided into two part streams in the connecting line between the annular line or bustle pipe and the tuyere, the first partial stream (main stream) flowing through the tuyere into the hearth of the furnace while the second partial stream (secondary stream), after its separation from the main stream, is brought into contact with the auxiliary fuel, resulting in decomposition of the latter. The decomposition products formed in this manner are reunited with the main stream just prior to entry into the hearth of the blast furnace.

The secondary stream of the hot blast may then be conveyed together with the auxiliary fuel through a pipe which extends coaxially within the blow pipe so that this pipe actually serves as reaction space in the meaning of this invention and the decomposition products thus formed meet again with the oxygen of the main stream at that end of the pipe which is closest to the tuyere, to wit, just prior to entry into the hearth.

The inventive procedure operates most efficiently if the auxiliary fuel is completely split or decomposed in the reaction space. However, if the reaction space-pipe dimensions required for this purpose are of a size which cannot be accommodated within the blow pipe, partial decomposition or splitting may be sufficient to improve the operations of the blast furnace. Thus, even partial decomposition results in an improvement, if compared with the presently used methods for the introduction of the auxiliary fuel.

Dependent on the quantity ratio of oxygen to auxiliary fuel, either the entire amount of carbon contained in the auxiliary fuel or only a portion of this carbon may be burnt to carbon oxide. In the latter case, soot is formed, which subsequently is burned in the hearth, whereby the temperature in the hearth is raised to the same extent as obtained when coke-carbon is burnt. As is known from the decomposition of such auxiliary fuels, water vapor (steam), carbon dioxide or other gases and vapors may be introduced together with the auxiliary fuel into the pipe which serves as the reaction space. Further, the combustion in the reaction space may be conducted with oxygen or oxygen enriched hot air. The supply of oxygen is particularly recommended if, for the purpose of extending the reaction period, the volume of the decomposition products is to be kept small and their flow speed in the reaction space is to be kept low. In doing so, the temperature in the reaction space may be optionally adjusted. For example, the temperature in the reaction space may have substantially the same value as the hot blast temperature of the main stream; or it is possible to set a temperature in the reaction space which is higher than the temperature of the main stream of the hot blast. In the latter case, radiation losses of the reaction space inure to the benefit of the temperature of the hot blast stream which flows past on the outside of the reaction space walls. The required staying time of the auxiliary fuels in the reaction space, of course, is largely dependent on the kind of auxiliary fuel. The dimensions of the reaction space should be as large as possible if the auxiliary fuel is in the form of an oil which is broken down with difficulty only. If the reaction space is in the form of a pipe extending coaxially within the blow pipe, then this pipe should be as long as possible and, if necessary, should extend between the tuyere and the supply conduit as close as possible towards the annular supply line. In most instances it will, however, be sufficient if the horizontally extending portion of the pipe is merely used as reaction space. Further, the reaction space may be widened or enlarged by initially enlarging the diameter of the pipe in the flow direction of the reaction media, then maintaining this enlarged diameter constant for a certain length or path and finally again decreasing the

diameter to its original value. Further, by building in structures, such as, for example, spiral shaped form pieces, the path of the reaction media in the pipe which serves as reaction space may be enlarged. Finally, the auxiliary fuel, also in admixture with, for example, steam of high pressure and high temperature, may be introduced into the reaction space-pipe either vertically or opposite to the flow direction of the hot blast, so that a flame of horse-shoe shape is formed. The reaction spacepipe may be correspondingly short if the auxiliary fuel is a readily decomposable hydrocarbon, such as, for example, gasoline. A short pipe prevents on the one hand that the hydrocarbons of the auxiliary fuel come prematurely into contact with the oxygen of the main stream of the hot blast and thus burn to carbon dioxide and steam. On the other hand, such a short pipe is sufficient in order to cause at least partial splitting of the auxiliary fuel, so that a mixture of soot, carbon oxide and steam is formed, the soot, as previously stated, being burnt in the hearth and the thus forming gases improving the indirect reduction in the upper portion of the furnace above the hearth.

The preferred embodiment of the inventive procedure as described hereinabove may, of course, also be carried out in such a manner that the main stream of the hot blast is conveyed through the pipe which coaxially extends within the interior of the blow pipe, while the reaction space, in which the secondary stream of the hot wind is reacted with the auxiliary fuel, is passed through the annular space which extends between the inner wall of the blow pipe and the outer wall of the pipe, the latter extending coaxially in the interior of the blow pipe.

Apparative arrangements in which the two variations of the procedure as described above can be successfully performed are illustrated in FIGS. **2** and **3** in longitudinal section.

FIG. **2**, in the same manner as in FIG. **1**, shows a cooled tuyere **1**, the blow pipe **2** terminating in the tuyere **1**. The blow pipe **2** communicates with the supply line **4** through the elbow or bent pipe section **3**. The supply line **4** leads to the annular line or bustle pipe not shown. A pipe **10** is coaxially arranged within the space of the blow pipe **2**. The pipe **10** serves in this embodiment as reaction space for the auxiliary fuel. A supply conduit **11** for the auxiliary fuel terminates within the pipe **10**. Not only auxiliary fuel but also steam, oxygen or other gases and vapor may be charged through conduit **11**.

The auxiliary fuel reacts in pipe **10** with the secondary hot blast stream which flows through the pipe **10** along its entire length, the main stream of the hot blast flowing through the annular space between pipe **10** and blow pipe wall **2**. If the auxiliary fuel is in the form of a hydrocarbon which is readily decomposed or split, the end of conduit **11** may be moved frontwardly and the pipe **10** may be shortened to such an extent that only a very short pipe cylinder is placed on the end of the conduit **11**. The decisive factor is solely that the auxiliary fuel, when it exits from the supply conduit **11** into the reaction space of the pipe **10**, comes into contact with a small quantity of oxygen only, while the main amount of the oxygen comes into reactive contact with the decomposition products exiting from pipe **10** just prior to entry of the decomposition products into the hearth, this main portion of the oxygen emanating from the main stream of the hot blast. The exit of the auxiliary fuel from the supply conduit **11** into the reaction space-pipe **10** may be accomplished, for example, by providing suitable bores or openings in the supply conduit **11**. The distance between the end of the pipe **10** adjacent the furnace and the end of the tuyere which projects into the blast furnace space should be dimensioned such that the soot which is formed during the splitting of the auxiliary fuel, is ignited just ahead of the tuyere.

In FIG. **3**, the same reference numerals refer to corresponding parts as shown in FIGS. **1** and **2**. In the embodiment of FIG. **3**, the procedure is, however, such that the main stream of the hot blast flows through the pipe **10**, while the secondary stream contacts the auxiliary fuel in the annular space which extends between the outer wall of the pipe **10** and the inner wall of the blow pipe **2**. This annular space is thus the reaction space. It will be noted that the blow pipe **2** is partially formed by a portion **12** which first gradually flares outwardly to form a larger diameter space, then, with this larger diameter extends cylindrically for a certain length and thereafter again tapers inwardly to the original diameter of the blow pipe **2**. The annular reaction space is thus correspondingly enlarged so that the reaction media flow correspondingly slower there through. The division ratio of the hot blast into main and secondary streams is determined in the arrangements of FIGS. **2** and **3** by the ratio of the free inlet cross-section of the pipe **10** and the annular space which is formed between the pipe **10** and the blow pipe **2**. In FIG. **3**, the supply conduit **11** for the auxiliary fuel extends perpendicular to the flow direction of the hot blast. The supply of the auxiliary fuel, however, can also be effected radially or tangentially. It is also within the scope of this invention to introduce the auxiliary fuel at different points or areas into the reaction space. The same applies to the arrangements of FIGS. **1** and **2**.

The division of the hot blast stream into two partial streams may, however, also be effected by arranging one or several separating walls or spacers which extend parallel to the axis of the blow type. These separating walls then divide the cylindrical space of the blow pipe into at least two separated chambers or spaces. One of the chambers is then flown through by the first or main partial stream of the hot blast while the secondary stream flows through the second chamber where it is admixed with the auxiliary fuel, for example, by spraying finely atomized oil into the second chamber. The two streams contact each other at the end of the separating wall. Whether this separating wall should project into the tuyere structure or should terminate in the interior of the blow pipe or at the end of the blow pipe, is dependent on the reactivity of the supplied auxiliary fuel.

If a plane wall is used as separator which extends through the axis, then the cross-section is divided into two semi-circles. If this wall is moved upwardly, two cross-sections of circular segment shape are formed. The wall, however, may also be arched so as to form two cross-sections of any desired shape.

In order to attain a large contact surface between the hot air blast and the decomposition products of the auxiliary fuel, after the decomposition products have exited from the reaction space, the cylindrical space of the blow pipe may be divided into more than two spaces. For this purpose, several separating walls **13, 14** (see FIGS. **4** and **5**) are required. If these separating

walls extend parallel to each other, then disc shaped partial spaces **15, 16** and **17** are formed. By contrast, if the separating walls are radially arranged, the individual partial spaces have then the cross-section of circular segments. Of two adjacent spaces **16, 17** or **15, 16,** one of the spaces (**15, 17**) is then exclusively flown through by hot blast while the other space (**16**) is flown through by hot blast and also by auxiliary fuel, such as oil, so that a partial combustion takes place in the latter space. At the end of the separating walls, the two streams intermingle on a large surface. This is particularly important if unburnt material, such as soot, is contained in the decomposition products of the partial combustion.

The particular advantages of the inventive procedure reside in the fact that the decomposition products of the auxiliary fuel are supplied to each of the tuyeres individually without requiring an intermediate storage or transport of the soot by inert carrier gases. Since the reaction space is situated very closely adjacent ahead of the hearth, the gaseous decomposition products and the soot can be introduced into the hearth of the blast furnace at a temperature which is practically the same as the reaction temperature so that only insignificant heat losses occur by the splitting or decomposition. The ignition of the soot with the oxygen of the main stream of the hot blast is thus possible along a very short path. Particularly important is, however, that complicated or large apparatus outside the blast furnace are avoided and the operation and servicing of the inventive procedure is exceedingly simple.

The invention will now be described by a specific Example, it being understood that this Example is given by way of illustration and not by way of limitation and that many changes may be effected without affecting in any way the scope and spirit of the invention as recited in the appended claims.

## EXAMPLE

The Example refers to a blast furnace operation to be carried out in a relatively small-size blast furnace fitted with 13 tuyeres, the tuyere - blow pipe structures and their operation being of the kind illustrated in and described in connection with FIG. **3.**

The blast furnace has an output of 40 t of pig iron per hour and normally consumes 500 kg of coke and 80 kg of oil per ton of produced pig iron. In accordance with the procedure of this invention, it is the intention to lower the coke supply and to increase instead the oil supply, to wit, the auxiliary fuel. In this particular test, it is intended to raise the oil supply to 200 kg per ton of pig iron. If one adopts a replacement ratio of coke:oil = 1, a fuel consumption of 380 kg (500 – 120) of coke and 200 kg (80 + 120) of oil per ton of pig iron is then calculated. This in turn means that an hourly consumption of 15.2 t of coke and 8 t of oil must be provided for.

The 380 kg of coke per ton of pig iron may be attributed for the required purposes as follows:

40 kg - alloying coke
133 kg - reduction coke
207 kg - heating coke.

The coke contains in this Example 87 percent of carbon and 0.4 percent of hydrogen. This means that 1 kg of coke requires 3.86 $Nm^3$ of air blast. It follows that for 1 ton of pig iron $207 \times 3.86 = 800$ $Nm^3$ air blast are required. With a pig iron production of 40 t per hour, a blast requirement of 32,000 $Nm^3$ per hour is thus needed.

The oil had a carbon content of 84 percent and a hydrogen content of 12 percent. In order to gasify this oil to carbon oxide and hydrogen, 3.72 $m^3$ air blast per kilogram are required. With a supply of 200 kg of oil per ton of pig iron and with a pig iron output of 40 t per hour, the hourly blast requirements are 29,800 $Nm^3$. 5.85 $Nm^3$ of gas are then formed from each kilogram of oil. The amount of gas is 1,170 $Nm^3$ per ton of pig iron and 46,800 $Nm^3$ per hour.

In order to calculate the necessary cross-sectional areas in the tuyere stock (blow pipe) and in the reaction space, these quantities have to be recalculated into $Nm^3$ after distribution to the 13 tuyeres of the blast furnace. In doing so, a pressure of two absolute atmospheres (ata), a blast temperature of 1,250°C and a temperature of the gasified oil of 1,400°C is assumed. Per tuyere, the following quantities per second are then obtained: 1.92$m^3$ of blast furnace blast stream, 1.78$m^3$ of oil gasification blast stream and 3.06$m^3$ of gasified oil. If a maximum permissible flow velocity of 200m/s is set, the required cross-sectional areas are as follows:

For the blast furnace blast - 96$cm^2$
for the oil gasification blast - 89$cm^2$ and
for the gasified oil - 153$cm^2$.

As described in connection with FIG. **3,** the blast furnace blast stream flows through the pipe **10** located within the blow pipe **2,12.** At a flow speed of 200m/s, the inner diameter of the pipe **10,** to wit, its flow passage, should then be 11.08cm. The wall thickness of pipe **10** is 1 cm while the outer diameter is thus 13.08 cm. The oil gasification blast stream flows through the annular space (reaction space) formed between the blow pipe wall **2,12** and the outer diameter of the pipe **10.** The inner diameter of this annular reaction space is thus 13.08 cm, i.e., it is of course equal to the outer diameter of the pipe **10,** while the outer diameter of the annular reaction space - which is the same as the inner diameter of the blow pipe - is then 16.9 cm, so that the ratio of quantity of blast stream flowing through the pipe **10** and the quantity of blast stream flowing through the annular reaction space for oil gasification purposes is 1.92:1.78.

At the end of the blow pipe adjacent the tuyere **1,** the annular cross-section is larger since the gasified oil stream should not exceed the flow speed of 200 m/s. Consequently, the outer diameter of the annular reaction space - which is the inner diameter of the blow pipe - amounts to 19.1 cm at this location. The blast furnace blast stream flowing through the pipe **10** and the gasified oil formed in the annular reaction space, enter the tuyere **1** at a speed of 200 m/s and thence flow into the hearth portion of the blast furnace. The indirect reduction in the furnace is increased, as compared to the conventional procedure, because the reduction gas quantity and the amount of hydrogen are greater than when a lesser amount of oil is used. This increased indirect reduction results in a replacement ratio of coke:oil which is greater than 1:1, so that the quantity of coke to be charged to the furnace can be still further reduced without affecting the pig iron output.

What is claimed is:

**1.** In a method of operating a blastfurnace with coke as the principal fuel and with a carbon- or hydrocar-

bon-containing auxiliary fuel, such as petroleum, petroleum products, natural gas, coke oven gas or coal dust, wherein the coke, in conventional manner, is charged through the top of the furnace while the auxiliary fuel is heated and broken down in a reaction space located outside the hearth of the furnace and the decomposition products of the auxiliary fuel thus obtained are introduced into the hearth through tuyere means, the hot blast for the operation of the furnace being carried by blow pipe means adjacent to and communicating with said tuyere means and being introduced into the furnace through said tuyere means, the improvement which comprises that said auxiliary fuel is decomposed and incompletely burnt in said reaction space and the incompletely burnt decomposition products thus formed are directly introduced into said blow pipe means or said tuyere means as an auxiliary flow just prior to the discharge of said hot blast into the furnace through said tuyere means.

**2.** The improvement as claimed in claim **1,** wherein the quantity ratio of auxiliary fuel to oxygen in the reaction space is such that the decomposition products exiting from said reaction space contain a large proportion of soot.

**3.** The improvement as claimed in claim **1,** wherein pure oxygen is introduced into said reaction space.

**4.** The improvement of claim **1,** wherein said blow pipe means defines at least three separate flow passages, said hot blast flowing through each of said flow passages, while auxiliary fuel is charged to less than all said flow passages.

**5.** The improvement as claimed in claim **1,** wherein said hot blast is divided in said blow pipe means into first and second streams of which one stream is introduced into the hearth of the furnace through said tuyere means while the other stream, after separation from said one stream, is contacted in said reaction space with said auxiliary fuel to break down said auxiliary fuel, said other stream constituting said reaction space and said auxiliary flow, whereafter the decomposition products thus formed and said other stream are united with said one stream at a location which is closely adjacent to the entry point into the hearth of the furnace.

**6.** The improvement as claimed in claim **5,** wherein the auxiliary fuel is introduced into said other stream in a direction perpendicular or opposite to the flow direction of said other stream of the hot blast.

**7.** The improvement as claimed in claim **1,** wherein said blow pipe means defines first and second separated flow passages, said first flow passage coaxially surrounding said second flow passage, one of said flow passages defining said reaction space and said auxiliary flow, said auxiliary fuel being introduced into said one flow passage and the hot blast flowing through both of said flow passages.

**8.** The improvement of claim **7,** wherein said auxiliary fuel is introduced into said second flow passage.

**9.** The improvement of claim **7,** wherein said flow passages are united adjacent said tuyere means.

**10.** The improvement of claim **7,** wherein the auxiliary fuel is introduced into said first flow passage.

**11.** In a method of operating a blastfurnace with coke as the principal fuel and with a carbon- or hydrocarbon-containing auxiliary fuel, such as petroleum, petroleum products, natural gas, coke oven gas or coal dust, wherein the coke, in conventional manner, is charged through the top of the furnace while the auxiliary fuel is heated and broken down in a reaction space located outside the hearth of the furnace and the decomposition products of the auxiliary fuel thus obtained are introduced into the hearth through tuyere means, the hot blast for the operation of the furnace being carried by blow pipe means adjacent to and communicating with said tuyere means and being introduced into the furnace through said tuyere means, the improvement which comprises that said reaction space surrounds and communicates with said blow pipe means, said decomposition products of the auxiliary fuel after formation in said reaction space and after exiting from said reaction space, being directly introduced into said blow pipe means where the decomposition products intermingle with the hot blast flowing through said blow pipe means, said hot blast and decomposition products thereafter flowing into the hearth through said tuyere means.

**12.** The improvement of claim **11,** wherein said decomposition products enter said blow pipe means in a direction which is inclined relative to the flow direction of hot blast through said blow pipe means.

**13.** The improvement of claim **11,** wherein said hot blast and said decomposition products flow towards said tuyere means through a zone having a cross-section which is narrower than the cross-section of the flow space defined by said blow pipe means.

**14.** In a method of operating a blast-furnace with coke as the principal fuel and with a carbon- or hydro-carbon-containing auxiliary fuel, such as petroleum, petroleum products, natural gas, coke oven gas or coal dust, wherein the coke, in conventional manner, is charged through the top of the furnace while the auxiliary fuel is heated and broken down outside the hearth of the furnace and the decomposition products of the auxiliary fuel thus obtained are introduced into the hearth through tuyere means, the hot blast for the operation of the furnace being carried by blow pipe means adjacent to and communicating with said tuyere means and being introduced into the furnace through said tuyere means, the improvement which comprises at least partially breaking down said auxiliary fuel in a reaction zone closely adjacent said tuyere means and conveying the decomposition products thus obtained into the flow passage of said blow pipe means for contact with the hot blast flowing therethrough, said reaction zone surrounding and communicating with said flow passage.

**15.** In a method of operating a blast-furnace with coke as the principal fuel and with a carbon- or hydrocarbon-containing auxiliary fuel, such as petroleum, petroleum products, natural gas, coke oven gas or coal dust, wherein the coke, in conventional manner, is charged through the top of the furnace while the auxiliary fuel is heated and broken down in a reaction space located outside the hearth of the furnace and the decomposition products of the auxiliary fuel thus obtained are introduced into the hearth through tuyere means, the hot blast for the operation of the furnace being carried by blow pipe means adjacent to and communicating with said tuyere means and being introduced into the furnace through said tuyere means, the improvement which comprises that said decomposition products of the auxiliary fuel, after exiting from said reaction space, are directly introduced into said blow pipe means or said tuyere means, said blow pipe means

defining first and second separated flow passages, said first flow passage coaxially surrounding said second flow passage, one of said flow passages defining said reaction space, said auxiliary fuel being introduced into said first flow passage and the hot blast flowing through both of said flow passages.

**16.** In a method of operating a blast-furnace with coke as the principal fuel and with a carbon- or hydrocarbon-containing auxiliary fuel, such as petroleum, petroleum products, natural gas, coke oven gas or coal dust, wherein the coke, in conventional manner, is charged through the top of the furnace while the auxiliary fuel is heated and broken down outside the hearth of the furnace and the decomposition products of the auxiliary fuel thus obtained are introduced into the hearth through tuyere means, the hot blast for the operation of the furnace being carried by blow pipe means adjacent to and communicating with said tuyere means and being introduced into the furnace through said tuyere means, the improvement which comprises at least partially breaking down and incompletely burning said auxiliary fuel in a reaction zone closely adjacent said tuyere means and conveying the decomposition products thus obtained into the flow passage of said blow pipe means in the form of an auxiliary flow for contact with the hot blast flowing therethrough, said auxiliary flow intermingling with said hot blast just prior to the discharge of the hot blast into the furnace through said tuyere means.

**17.** The improvement of claim **16,** wherein said flow passage defines first and second passage-ways, one of said passage-ways constituting said reaction zone and auxiliary flow, said auxiliary fuel being introduced into said one passage-way while said hot blast is introduced into both of said passage-ways.

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