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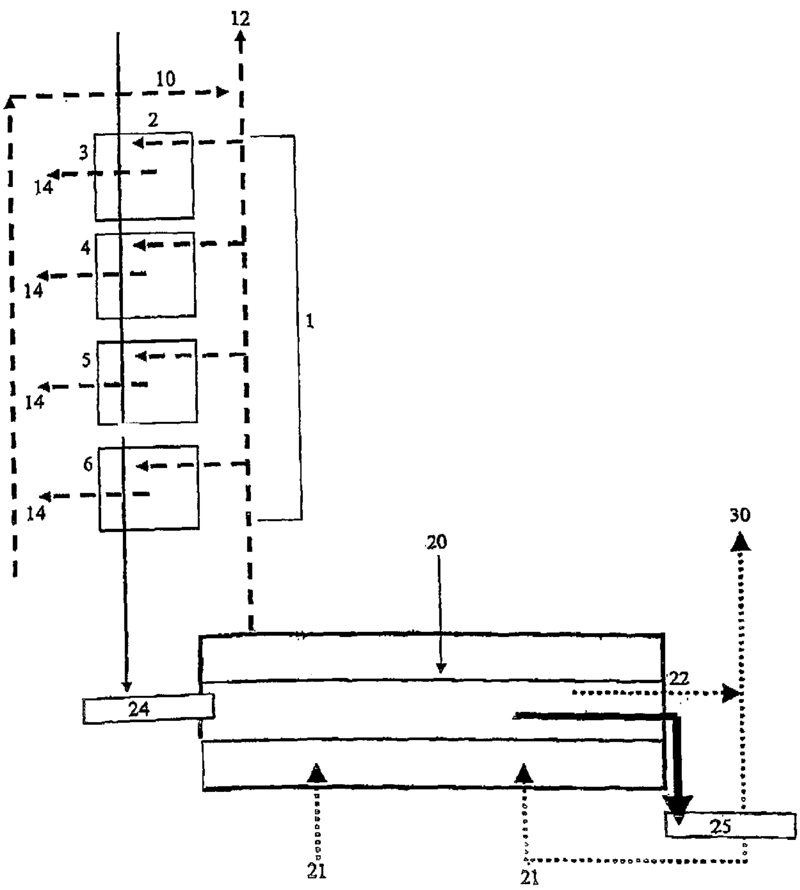
(54) Title: COAL DRYING AND CHARRING PROCESS



(57) Abstract: A process for the treatment of coal feed stream including the steps of a) removing moisture from the coal feed stream by heating to a first predetermined temperature and subsequently b) converting the volatile matter within the coal feed stream to a gas stream product by heating the coal feed stream to a second predetermined temperature c) collecting a gas product stream and d) recovering a substantially moisture free coal char product With volatile matter controlled and pre-determined by the process operator.

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COAL DRYING AND CHARRING PROCESS

FIELD OF THE INVENTION

The present invention relates to a process for coal drying and charring. The present invention particularly relates to the production of a coal char and recovery of volatile components of coal.

BACKGROUND OF THE INVENTION

One of the major problems with most existing commercial char technologies is the cost-effective upgrading of coal by drying and charring of a coal feed stream. Upgrading of coal is undertaken to remove both the moisture content and the volatile matter content, and subsequently yielding a char product of a nominated specification, and an off gas.

Most existing processes are designed to either (predominantly) dry the coal only (e.g. multiple effect evaporation or Evans-Siemon Thermal Dewatering) and/or char the coal whereby both moisture and volatile matter are driven off together (e.g. Circulating Fluid Bed or Multiple Hearth technologies). Processes that employ the drying and removal of the volatile matter together typically produce gas of reduced quality due to the elevated moisture content. Further the coal char product may have some undesirable properties due to the process employed. Specifically the char product may be particularly friable and consequently prone to break into smaller pieces during transport.

Many attempts to solve the problem have been tried. Two of the more commercially successful solutions are Circulating Fluid Bed (CFB) and Multiple Hearth Furnaces (MHF).

The CFB process has major application in power generation and mineral processing (e.g. aluminia calcination, etc.).

The CFB process can also be used to dry coal and / or produce a char product from coal feedstock. The drying of coal and the production of a char product can be done within one CFB, or the processes can be separated and carried-out in multiple CFB units. Either option results in a relatively expensive process (from a capital and operating cost perspective). The CFB process is carried out in an atmosphere where some air or oxygen is present. This results in some of the coal burning during the charring process.

The CFB requires a top size of less than 6 – 10 mm (depending upon the design configuration). The nature of the CFB fluidization process creates a significant shear / impact effect upon the fluidized particles, thereby resulting in a large breakdown in particle size, with a large quantity of fine material being produced.

The other major commercially available technology is the multiple hearth furnaces (MHF). This technology is available from a number of companies.

This process can also be used to dry coal and / or produce a char product from coal feedstock. The drying of coal and the production of a char product can be done within one MHF, or the processes can be separated and carried-out in multiple MHF units. As with the CFB units, either option results in a relatively expensive process (from a capital and operating cost perspective).

If the coal drying and charring is carried out within one MHF unit, it must be done either in an inert or an oxygen reduced atmosphere to (minimize) combustion of the char product. The process atmosphere can be achieved by operating fuel combustion burners in the lower hearths at a low fire condition (once the MHF has achieved operating temperature(s)), and a slight positive pressure (to minimise the ingress of air/oxygen). The moisture and volatile matter are removed together and the resultant off gas quality is relatively low in terms of the energy content.

The configuration of both the CFB and MHF processes is such that the off gas flowrates are usually substantial, requiring elaborate ductwork configurations. The high entrained dust loadings in the off gases require significant clean-up in cyclones, electrostatic precipitators and / or bag-houses.

A further disadvantage of the commercial process solutions described is that the elements of the process streams are combined. For example, in the CFB and MHF units the heating fuel (e.g. natural gas or LPG) combustion gases used to dry and / or char the coal feedstock are in direct contact. This also contributes to the degradation of the off gas quality. Further, the product char must be separated from the fuel combustion gases.

Many of the above processes remove the water from the coal by subjecting the coal directly to high temperature. This direct application of excessive heat to the coal can cause the formation of steam or the gasification of volatile matter to form in the middle of coal particles causing the coal to fracture and the generation of combustion leading to oxidation of the char.

In another process the drying and destructive pyrolysis is conducted at above atmospheric pressure. This has the disadvantage of high capital and running costs as well as the complication and operation of such a plant. Particularly operating a plant at elevated pressures on a continuous basis.

SUMMARY OF THE INVENTION

With the above problems in view it is therefore an object of the present invention to provide an improved, controllable process of upgrading coal by the removal of moisture and volatile matter in such a manner to produce an improved quality char product with less fines and negligible oxidation, and have a gas product with minimal entrained moisture.

With the above object in view there is provided a continuous process for the treatment of a coal feed including the steps of:

a) removing moisture from the coal feed stream by heating the said feed to a predetermined temperature;

b) converting the volatile matter within the said feed to a gas stream product by indirectly heating the said feed to a second predetermined temperature;

c) collecting a gas product stream and;

d) recovering a char being substantially moisture free and having volatile matter at a pre-determined level.

In a preferred embodiment the process may further include the step of collection or venting of the removed moisture.

An important feature of the present invention is the collection of the gas product stream separate from the moisture vapour stream. This allows for the collection of a gas product of higher energy value than that of gas products produced in other processes. The higher energy value is considered a result of the reduced moisture content in the gas product stream (as well as the separation of combustion gases from the heating/fuel medium) from the gas product stream.

Another preferred feature of the present invention is the production of a gas product stream with minimal entrained particulate matter. This is preferably achieved by the application of heat to the dryer and/or the combustion chamber being delivered to the coal in an indirect manner. By this it is meant that the heat is supplied by combustion of a fuel but the combustion does not occur in the same zone as the coal feed. This has the effect of minimising the fracturing of the coal during the process. As the fracturing of the coal feed is minimised during the process, the production of fines may be also minimized.

The reduction in the production of fine particulate matter may be particularly useful to the gas product stream quality. Minimising the particulate material in the gas product stream may be advantageous to the process in terms of product quality and process economies. If the entrained particulate matter in the gas product stream can be minimised, less downstream processing (eg. cyclones, electro-static precipitators, etc.) may be required to clean the product prior to the gas product stream being fed to other downstream uses. If the particulate matter can be reduced to an acceptable level, the gas product stream may be fed directly into a gas turbine without the deleterious effects of particles that occur in similar gas turbine configurations with other processes.

Further advantages of indirectly heating the coal may include the reduced need to separate the combustion products resulting from the combustion of the heating fuel from the gas product stream, and a reduction of the risk of the coal product stream catching fire during processing. The heating process employed for heating the coal feed stream in the combustion chamber may result in a non-reactive atmosphere in the combustion chamber and thus combustion of the coal feed stream may be minimised. Further, the waste heat from the hot gas feed used to heat the coal feed stream may have reducing chemistry to further minimise the possibility of a fire in the drying or charring apparatus.

It is preferred that the moisture may be at least partially removed at a temperature of between 40°C and 750°C preferably between 50°C and 150°C measured as the outlet gas temperature from the dryer. In a preferred embodiment, the waste heat from the hot gas feed that is fed into the dryer may have a temperature in the range of 200°C - 450°C, with a total dryer retention time of between 30 and 120 minutes (depending upon the drying requirements of the feed material) but may vary beyond these times depending on the sizing of the coal feed stream.

It is preferred that the volatile components may be at least partially removed at a temperature of between 550°C and 815°C with a combustion furnace retention time of between 10 minutes and 40 minutes thus leading to a coal char product of desired moisture and volatile content but may be longer depending on the sizing of the coal feed stream particulates.

In a preferable configuration of the process, the gas product stream may be used to provide a heat source for the process. In the process it is envisaged that the quantity of gas product stream recovered may be in excess of that required to run the process.

In a preferred embodiment the moisture removing step may be a multi step process where the coal feed stream may be moved from one chamber to subsequent chambers each at a higher temperature relative to the preceding chamber. The multi step drying process may remove moisture from the surface of the coal feed and promote the diffusion of water from the centre of the coal feed particulates.

In some applications it may be desirable to have many steps in the drying process. In an example nine steps may be used with temperatures of the drying stages shown in Table 1.

TABLE 1

Stage	Temperature
Top stage	35°C
	45°C
	65°C
	80°C
	90°C
	105°C
	110°C
	115°C
Bottom stage	120°C

The multi step process minimises the production of moisture vapour and/or volatile gas from the inner core of the particle. Such a heating process resulting in less fracturing of the coal product leading to the advantages of material of desired particle size and minimisation of fines and entrained matter in the gas product.

The final product of the process may have an analysis with the following ranges:

Carbon	44 – 98%
Ash	2 – 20%
Volatile matter	0 – 20%
Moisture	0 – 25%

In order to refine the quality of the coal char product it may be desirable to adjust the atmosphere in the dryer and/or the combustion chamber. This may be particularly desirable if the coal feed stream is mixed with other feed materials. The atmosphere of the dryer and combustion chamber may be modified by adjustment of the hot gas feed to the chambers. Thus it is possible to modify the reactive conditions of the dryer and/or combustion chamber.

In a further preferred embodiment of the present invention the coal feed stream may be mixed with other materials either prior to or during having the moisture removed or prior to the coal feed stream being charred. The other materials could be mineral sands or iron ore. If operating with other materials in the coal feed stream the drying / charring process may also act as a pre-heating and/or pre reduction step for the processing of the other materials added to the coal feed stream.

BRIEF DESCRIPTION OF THE DRAWINGS

It will be convenient to further describe the present invention with respect to the accompanying figures and examples that illustrate possible arrangements of the invention. Other arrangements of the invention are possible, and consequently the particularity of the accompanying drawings is not to be understood as superseding the generality of the preceding description of the invention.

It would be understood by a person skilled in the art that retention times and temperatures used in this process will vary depending on the desired product specifications and the coal feed used.

The process of the invention may be better understood from the following description of the preferred embodiments thereof with reference to the accompanying drawings in which:

Figure 1 is a schematic flow sheet of the process according to the present invention.

Figure 2 Graph of % volatile matter vs kiln temperature

Figure 3 Graph of char composition of carbon, ash and volatile matter vs temperature.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The process may be applied to the upgrading of sub-bituminous coal or lignite type coals. The example of sub bituminous coal will be used in the following detailed description. Any coal feed can be used where the object of the processing is to remove moisture and volatile matter to produce a coal char product and a gas product stream of coal-derived volatile matter. The quality of the coal is not important except where the product quality has specific requirements.

It would however be clear to a person skilled in the art that the process is not limited to coal only and that the process could operate effectively with other material present in the feed stream such as mineral sands or iron ore.

Referring now to Figure 1 of the drawings there is shown a flow diagram of the process of the invention.

Sized coal feed 10 having a nominal (as-received) composition of:

Carbon	44%
Ash	6%
Volatile matter	25%
Water	25%

and a nominal particle size distribution of:

TYPICAL SIZINGS	
Size fraction	Raw coal cumulative mass %
+20 mm	0.0
-20 + 16.0 mm	0.9
-16.0 + 8.0 mm	51.5
-8.0 + 4.00 mm	91.1
-4.0 + 2.0 mm	96.9
-2.0 + 1.0 mm	98.7
-1.0 + 0.5 mm	99.4
-0.50 mm	100.0

is fed into the multistage dryer 1 at inlet 2. As the coal feed 10 passes through the dryer 1 the moisture is driven off the coal feed thus at least reducing moisture content of the coal feed 10. The drying of the coal feed 10 can take place in a multistage drying process where the temperature in the first stage 3 is greater than in subsequent stages 4, or less than in subsequent stages 4. Alternatively, the drying can occur in a single stage (not shown). The multistage dryer 1 operates by the application of hot gas feed 12 over the coal stream 10, the hot gas feed 12 being substantially non-reactive to the coal feed 10.

While not wishing to be bound by any particular theory, it is believed that the heating of the coal feed 10 through the multistage dryer 1 drives the moisture off the surface of the coal feed 10 and thus by diffusion the moisture in the centre of the coal feed particle (not shown) is drawn to the surface of the coal feed particle. The heating is such that the centre of the coal feed particle is not heated sufficiently to cause the moisture or volatile matter to crack off, thus limiting the fracturing of the coal feed particles through the process by evolution of moisture or volatile matter in a gas form from the centre of the coal feed stream particulates. The moisture may be collected from the multistage dryer as vapour stream 11.

Once the coal has passed through the multistage dryer 1, it is fed into the combustion chamber 20 where the coal feed 10 is subjected to destructive pyrolysis. The combustion chamber 20 is heated externally and indirectly to the coal feed 10, through burners 21, so that the volatile matter, being a component of the coal feed 10, is at least partially driven off and recovered at gas outlet 22 in the form of gas product stream 30, and coal char product 25 is produced at the desired quality.

The heat from the burners 21, having been directed onto the combustion chamber 20 in the form of a hot gas feed 12, does not come into direct contact with the coal feed 10, but may be used as process heat for the multistage dryer 1 of the process, with the volatile matter as a gas product stream 30 collected from the combustion chamber gas outlet 22.

In a typical process, coal feed 10 with the size distribution previously described is fed into the multistage dryer 1 at the first stage 3. A hot air feed 12 is provided to assist in removing moisture from the coal feed 10. Typically this hot air feed 12 is between 200°C and 400°C at the inlet of the first stage 3. With an exhaust gas stream 14 temperature of between 20°C and 40°C, the subsequent stages 4 have an exhaust gas stream 14 temperature of between 35°C and 120°C producing a dried coal feed product 24 having the desired moisture content. At the end of the multistage dryer 1, the moisture content of the coal stream 10 may typically be reduced from approximately 25% to approximately 5 – 15% prior to the coal feed 10 being fed into the combustion chamber 20.

When in the combustion chamber 20, the coal feed 10 is charred by the application of heat from burners 21. The temperature of the heat supplied by the burners 21 is in the range of 450°C and 815°C but typically is 725°C. The coal feed 10 has a residence time in the combustion chamber 20 of between 10 and 30 minutes. Typically, the reaction time in the combustion chamber is 20 minutes to produce a coal char product 25 having a moisture content of less than 1% and a volatile matter of less than 10%. In the preferred embodiment, the combustion chamber 20 is in the form of a rotary heat tube (not shown). With the use of a rotary heat tube the combination chamber 20, will typically have a rotation speed of 0.5 – 4 rpm. However, the speed of rotation of the heat tube will vary depending on the size of the coal feed 10, the size of the heat tube and the residence time required of the coal feed stream 10 to produce the char product 25 of desired properties.

The final coal char product having the following typical analysis:

Moisture	0 – 0.5
Ash	7 – 12%
Volatile matter	0 – 20%
Carbon	70 – 90%

and a typical particle size distribution of:

TYPICAL SIZINGS	
Size fraction	**Product char cumulative passing %**
+20 mm	1.7
-20 + 16.0 mm	9.9
-16.0 + 8.0 mm	49.1
-8.0 + 4.00 mm	79.8
-4.0 + 2.0 mm	89.7
-2.0 + 1.0 mm	95.1
-1.0 + 0.5 mm	97.6
-0.50 mm	100.0

Size distribution and coal char quality is inter-related with the raw coal feed to the process.

During the operation of the multistage dryer 1 and the combustion chamber 20, the gas pressure in the multistage dryer 1 and the combustion chamber 20 is approximately atmospheric. The composition of the atmosphere in the multistage dryer 1 and the combustion chamber 20 is nominally reducing.

The skilled addressee would understand that the composition of the atmosphere could be adjusted by modifying the fuel/air feed to the burners 21. Thus the atmosphere of the multistage dryer 1 can be altered to refine the process. This is particularly important when the coal feed stream 10 is mixed with other materials such as mineral sands or iron oxides with the process of the current invention acting as a pre-reduction step in a larger process.

Examples

Using a test apparatus a number of trials were run, the test apparatus consisting of:

a) Four stage multistage dryer,

b) Screw feed conveyor for transporting the coal feed from the multistage drier to the combustion chamber.

c) Rotating heat tube enclosed within an insulating box, (combustion chamber).

d) Gas fired burners for heating the combustion chamber.

In the following examples the coal feed was normal run of mine screened coal having a partial a particle size of size of -30 + 5mm.

The coal was fed into the four stage drier at the rate of approximately 75 kg/hour. The feed screw used to transport the partially dried coal to the combustion chamber in this case transported approximately 75 kg/hour at 18 Hz.

As a result of the gas burners used to heat the combustion chamber (discussed later) a large quantity of waste heat is produced in the form of hot combustion gasses. This waste heat was collected and fed into the 4 stage drier in a counter current flow.

The coal passed through the four stage drier passing from one stage to a progressively hotter stage removing some of the moisture in the coal using the waste heat produced when heating the combustion chamber. The four stage drier had a set point per stage starting from 30°C in the inlet of the multistage drier to 120°C at the outlet of the multistage drier measured as the exhaust gas temperature.

Once the coal had passed through the four stage drier the coal had a reduced moisture level, having been reduced from the raw state of 25% to 18.1%. The temperature of the coal exiting the four stage drier was measured at between 99°C and102°C.

After the coal was partially dried it was conveyed into the combustion chamber where it was subjected to indirect heating. This was done by having a chamber wall that was heated on the outside while the coal was conveyed to the inside of the chamber. The chamber was heated by gas burners with a set point of between 600°C and 815°C measured as the temperature of the furnace chamber wall. Once in the combustion chamber the coal had a residence time of approximately 30 minutes.

While in the combustion chamber the coal was conveyed from one end to the other by a rotating drum arrangement. The speed of rotation of the combustion chamber and the feed rate of coal into and out of the combustion chamber can be altered to change the residence time and the bed thickness of the coal in the combustion chamber.

During the process of being heated the coal volatile components are driven off in the form of a gas product stream and the coal is converted into a coal char. As the coal is indirectly heated, the volatile matter driven off is in a separate circuit from the combustion gasses from the gas burners. In this way the gas product stream may be collected separately from the combustion gasses and later analysed for calorific value. In a production environment the gas product stream could be used as a secondary energy source. For example the combustion chamber could be heated by burning the gas product stream produced in the combustion chamber.

The charred coal exiting the combustion chamber had a temperature of between 200°C and 600°C and is cooled and stock piled for later use. In this example samples were collected for analysis of the chemical and physical properties. The results of the chemical and physical analysis are shown in below in the specific examples.

Due to test plant configuration limitations only a small percentage of water was removed in the drying stage. Earlier test work has shown that a staged drying process was optimum. By removing between 10 - 50% of the moisture prior to the coal entering the combustion chamber, the resulting product is less friable and has better mechanical properties for subsequent handling.

Using the apparatus and procedure outlined above a number of tests were conducted to measure the effect of the operating variables of the coal char quality. Due to the limitations in the drying circuit identified above the drying circuit was not optimized and experiments were undertaken with a variation of the combustion chamber set point temperatures of between 600°C and 850°C.

The analysis of the sample is on an air dried basis with minimal atmospheric exposure of the final coal char product. It would be appreciated that the moisture of the sample can vary after exposure to the atmosphere.

Example 1

Operating Parameters	
Combustion chamber coal input temperature	83°C
Combustion chamber set point	630°C
Combustion chamber char discharge temperature	377°C
Feed screw Hz	18
Combustion chamber rotation Hz	50

Char Chemical

Chemical Analysis	
Coal Char	
Air dried moisture	1%
Ash	8.5%
Volatile matter	12.85%
Free carbon	76.0%
Gross calorific value MJ/kg	-
Flu Gas	
Gas	10 MJ/M^3
Condensate	30.0 MJ/kg

Example 2

Operating Parameters	
Combustion chamber coal input temperature	100°C
Combustion chamber set point	700°C
Combustion chamber char discharge temperature	550°C
Feed screw Hz	18
Combustion chamber rotation Hz	50

Char Chemical and Physical Analysis

Particle Size Analysis	
Size fraction (mm)	**Fractional Mass %**
+16.00 mm	24.9
-16.00 +8.00mm	45.3
-8.00 +4.00mm	16.9
-4.00 +2.00mm	4.8
-2.00 +1.00mm	4.0
-1.00 +0.50mm	1.8
-0.05mm	2.3
Mechanical Properties	
Hardgrove Grindability Index	51
Chemical Analysis	
Coal Char	
Air dried moisture	3.1%
Ash	9.7%
Volatile matter	9.7%
Free carbon	77.5%
Gross calorific value MJ/kg	29.24
Flu Gas	
Gas	10 MJ/M^3
Condensate	30.0 MJ/kg

Example 3

Operating Parameters	
Combustion chamber coal input temperature	100°C
Combustion chamber set point	745°C
Combustion chamber char discharge temperature	528°C
Feed screw Hz	14
Combustion Chamber Rotation Hz	50

Char Chemical and Physical Analysis

Particle Size Analysis	
Size fraction (mm)	**Fractional Mass %**
+16.00 mm	13.3
-16.00 +8.00mm	38.5
-8.00 +4.00mm	29.1
-4.00 +2.00mm	9.5
-2.00 +1.00mm	4.7
-1.00 +0.50mm	2.3
-0.05mm	2.3
Mechanical Properties	
Hardgrove Grindability Index	53
Chemical Analysis	
Coal Char	
Air dried moisture	0.1%
Ash	9.3%
Volatile matter	8.6%
Free carbon	82.0%
Gross calorific value MJ/kg	30.27
Flu Gas	
Gas	10 MJ/M^3
Condensate	30.0 MJ/kg

Example 4

Operating Parameters	
Combustion chamber coal input temperature	100°C
Combustion chamber set point	756°C
Combustion chamber char discharge temperature	585°C
Feed screw Hz	18
Combustion chamber rotation Hz	50

Char Chemical and Physical Analysis

Particle Size Analysis	
Size fraction (mm)	**Fractional Mass %**
+16.00 mm	11.3
-16.00 +8.00mm	39.7
-8.00 +4.00mm	26.2
-4.00 +2.00mm	11.9
-2.00 +1.00mm	5.8
-1.00 +0.50mm	2.7
-0.05mm	2.3
Mechanical Properties	
Hardgrove Grindability Index	48
Chemical Analysis	
Coal Char	
Air dried moisture	0.8%
Ash	9.2%
Volatile Matter	4.6%
Free Carbon	85.4%
Gross Calorific Value MJ/kg	30.53
Flu Gas	
Gas	10 MJ/M^3
Condensate	30.0 MJ/kg

Example 5

Operating Parameters	
Combustion chamber coal input temperature	100°C
Combustion chamber set point	785°C
Combustion chamber char discharge temperature	578°C
Feed screw Hz	12
Combustion Chamber Rotation Hz	60

Char Chemical and Physical Analysis

Particle Size Analysis	
Size fraction (mm)	**Fractional Mass %**
+16.00 mm	6.4
-16.00 +8.00mm	38.8
-8.00 +4.00mm	32.2
-4.00 +2.00mm	13.0
-2.00 +1.00mm	5.5
-1.00 +0.50mm	1.7
-0.05mm	2.4
Mechanical Properties	
Hardgrove Grindability Index	51
Chemical Analysis	
Coal Char	
Air dried moisture	0.6%
Ash	8.7%
Volatile matter	2.6%
Free carbon	88.1%
Gross calorific value MJ/kg	30.89
Flu Gas	
Gas	10 MJ/M^3
Condensate	30.0 MJ/kg

Example 6

Operating Parameters	
Combustion chamber coal input temperature	100°C
Combustion chamber set point	815°C
Combustion chamber char discharge temperature	600°C
Feed screw Hz	10
Combustion Chamber Rotation Hz	62

Char Chemical and Physical Analysis

Particle Size Analysis	
Size fraction (mm)	**Fractional Mass %**
+16.00 mm	10.2
-16.00 +8.00mm	35.8
-8.00 +4.00mm	35.5
-4.00 +2.00mm	9.1
-2.00 +1.00mm	5.0
-1.00 +0.50mm	2.3
-0.05mm	2.1
Mechanical Properties	
Hardgrove Grindability Index	46
Chemical Analysis	
Coal Char	
Air dried moisture	>0.1%
Ash	9.2%
Volatile matter	1.6%
Free carbon	89.1
Gross calorific value MJ/kg	30.71
Flu Gas	
Gas	10 MJ/M^3
Condensate	30.0 MJ/kg

The results of the variation in combustion chamber set point are shown graphically in Figure 2. Figure 2 shows the relationship between percentage volatile matter and combustion chamber temperature, with a residence time in the kiln of 30 minutes. It can be seen that the retained volatile matter is a function of temperature. As the temperature of the combustion chamber is raised, the percentage volatile matter in the coal is reduced.

Figure 3 shows the coal char composition after passing through the combustion chamber with a residence time of approximately 30 minutes. The graph shows that as the temperature is increased, the percentage volatile matter decreases and the percentage of free carbon is increased.

The char produced in the process described unexpectedly results in a char product which displays uniquely uniform product quality through the particles of char. Volatile matter is noticeably more uniform through the particles and the surface of the coal char is not oxidised as is normal with a number of the commercial processes available.

This uniformity of product results in a highly reactive and useful coal char. Coal char is used as an input for other processes. In the mineral processing industry the consistency of coal char is important as a constant product allows for fine control of the subsequent processes leading to greater plant efficiency. Inconsistent feed into pyro metallurgical process results in unstable or difficult to predict processes and a reduction in output and product quality.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A continuous process for the treatment of a coal feed including the steps of:

a) removing moisture from the coal feed stream by heating the said feed to a predetermined temperature;

b) converting the volatile matter within the said feed to a gas stream product by indirectly heating the said feed to a second predetermined temperature;

c) collecting a gas product stream and;

d) recovering a char being substantially moisture free and having volatile matter at a pre-determined level.

2. The process of claim 1, wherein the moisture is removed from the coal in a series of steps prior to being heated to the second predetermined temperature.

3. The process of claim 1, wherein the first predetermined temperature is between 50°C and 150°C

4. The process of claim 1, wherein the first predetermined temperature is between 95°C and 105°C

5. The process of any one of the preceding claims, wherein the atmosphere of the dryer is reducing.

6. The process of any one of the preceding claims, wherein the second predetermined temperature is between 450°C and 850°C.

7. The process of any one of the preceding claims, wherein the second predetermined temperature is between 600°C and 850°C.

8. The process of any one of the preceding claims, wherein the second predetermined temperature is between 700°C and 815°C.

9. The process of any one of the preceding claims, wherein the process is run at substantially atmospheric pressure.

10. The process of any one of the preceding claims, wherein the coal char product has:

Moisture	0 – 0.5%
Ash	6 – 12%
Volatile matter	0 – 20%
Carbon	Balance

11. The process of any one of the preceding claims, wherein the coal char product has:

Moisture	0.1 – 3.1%
Ash	8.7 – 9.7%
Volatile matter	1.6 – 9.7%
Carbon	Balance

12. The process of any one of the preceding claims, wherein the moisture from the drying stage is collected.

13. A process of any one of the preceding claims where the volatile matter is collected separate from the moisture of the drying stage.

14. The process of any one of the preceding claims, wherein the gas product stream has sufficiently low particulate matter so as to allow the gas product stream to be feed to a gas turbine.

15. The process of producing coal char as herein before described with reference to the accompanying description and example.

Figure 1

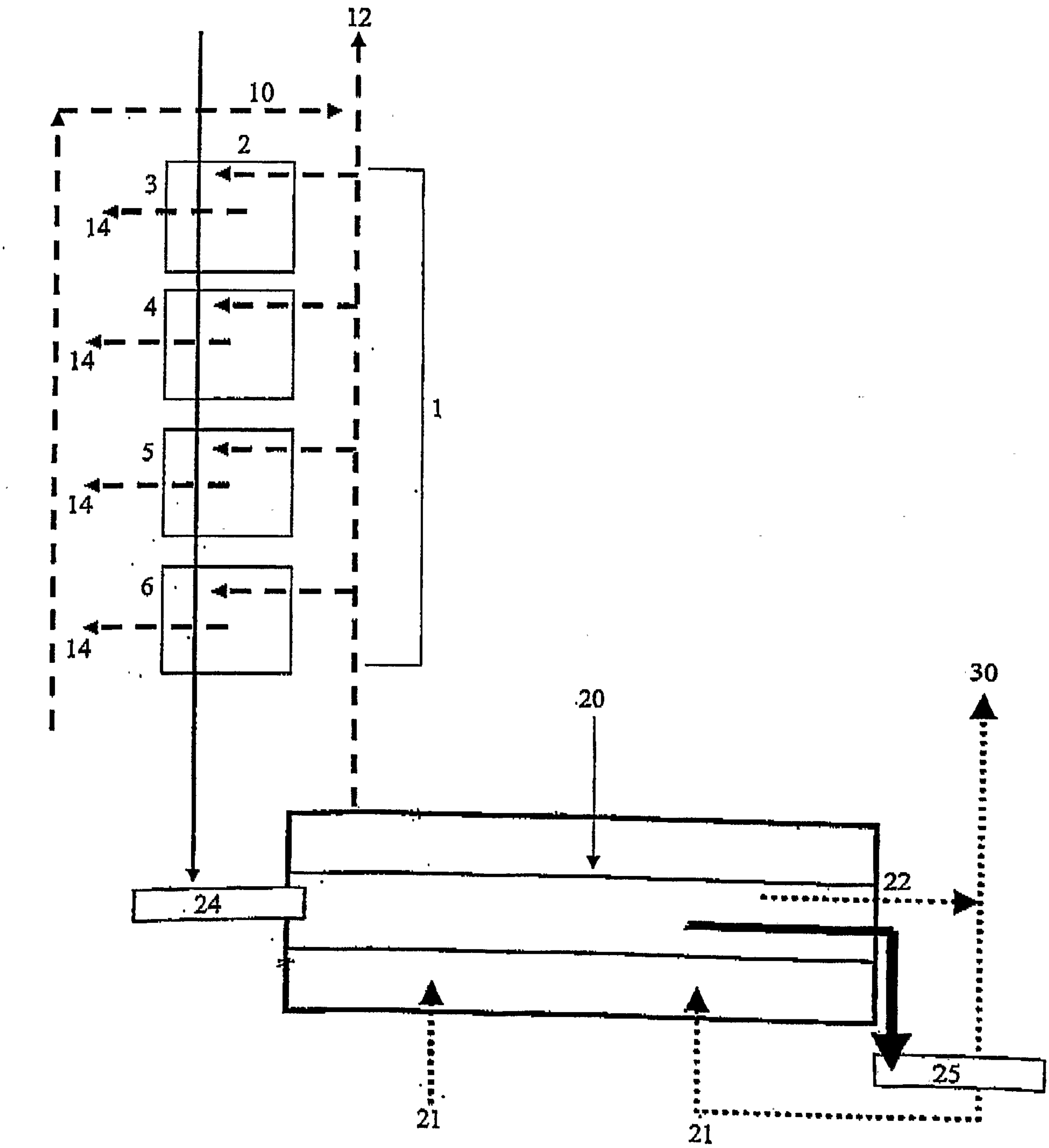


Figure 2

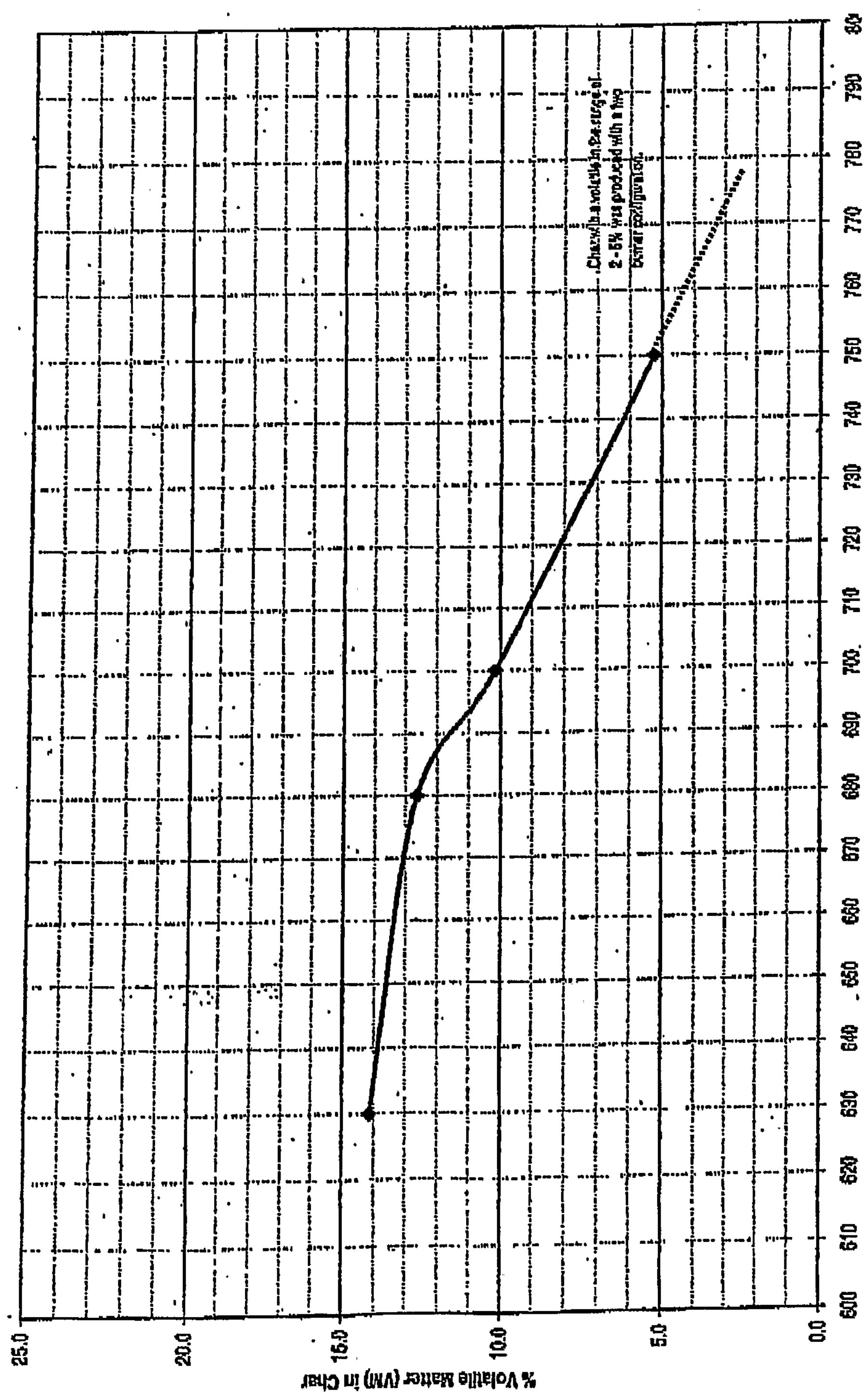
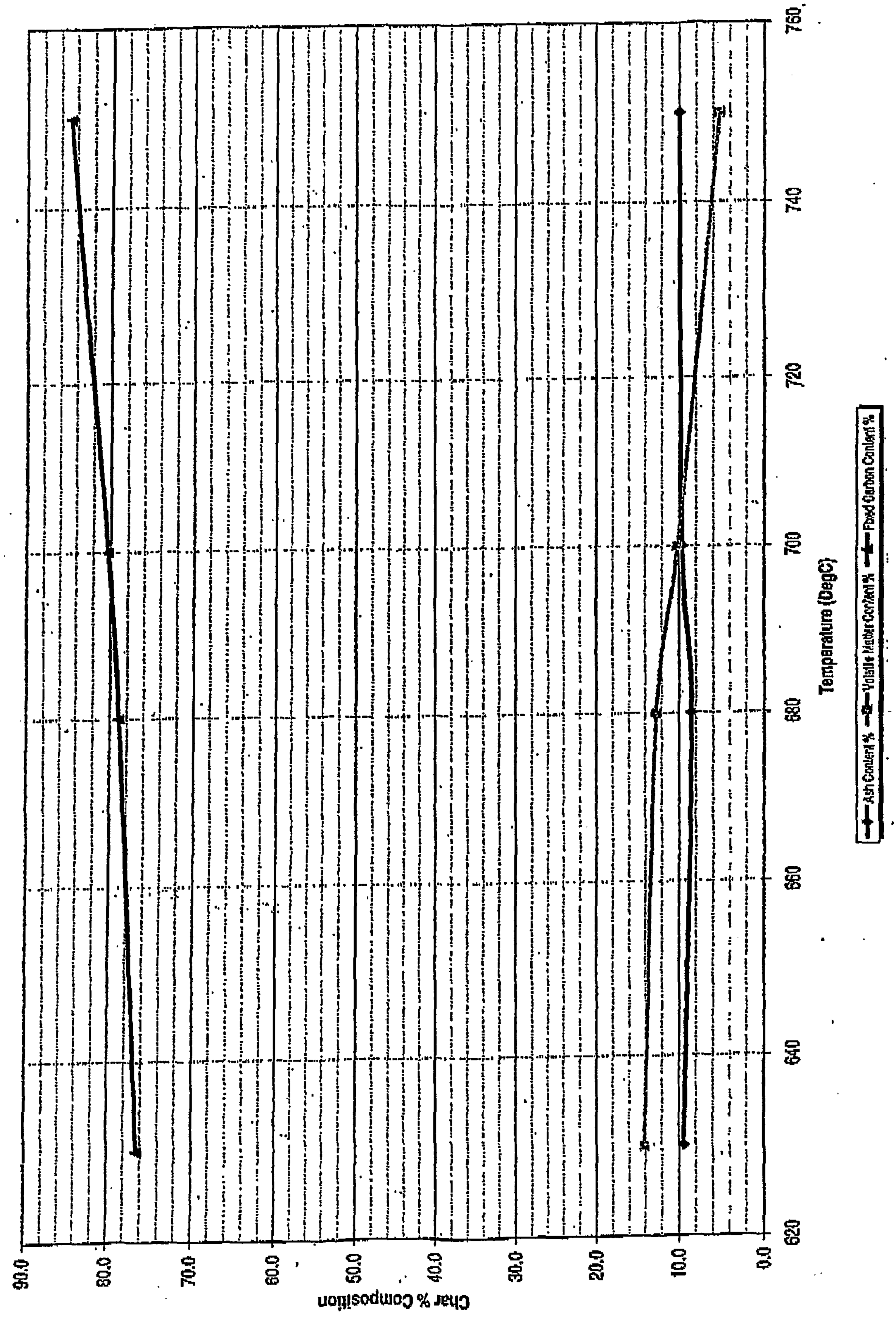

% Volatile Matter (VM) in Char
25.0
20.0
15.0
10.0
5.0
0.0
Set Point Temperature (DegC)
600
610
620
630
640
650
660
670
680
690
700
710
720
730
740
750
760
770
780
790
800

Figure 3


Char % Composition
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
620
640
660
680
700
720
740
760
Temperature (DegC)
Ash Content %
Volatile Matter Content %
Fixed Carbon Content %

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU03/00857

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. 7: C10B 57/10, 47/30

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)
IPC C10B 57/10, 47/30, 47/20

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)
DWPI IPC+KEYWORDS (multi, stage, step, coal, lignite, volatile, temperature, moisture, drying)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	Derwent Abstract Accession No.52851 E/26 , Class H09, EP 54506 A (SIDMAR SA) 23 June 1982 & EP 54506 A See abstract and Figure	1-7, 9, 12-13 2
X Y	GB 2085915 A (TOSCO CORPORATION) 6 May 1982 See entire document .	1-4, 6-10, 13 2
Y	US 4445976 A (LA DELFA et al.) 1 May 1984 See column 1 lines 11-26, column 2 lines 26-57, column 5 lines 15-37 and Figure.	2

[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)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "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	Date of mailing of the international search report
15 August 2003	26 AUG 2003

Name and mailing address of the ISA/AU	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU03/00857

C (Continuation).	**DOCUMENTS CONSIDERED TO BE RELEVANT**	
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4502227 A (JANUSCH) 5 March 1985 See entire document.	
A	GB 2035366 A (VEB GASKOMBINAT SCHWARZE PUMPE) 18 June 1980 See page 3 lines 17-87.	
A	US 4176010 A (DUDEK et al.) 27 November 1979 See column 4 lines 9-17.	
A	US 3990865 A (CYBRIWSKY et al.) 9 November 1976 See column 5 lines 17-49 and Figure 1	
A	WO 99/13025 A (GENERATION TECHNOLOGY RESEARCH PTY LTD) 18 March 1999 See page 5 lines 10-26.	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU03/00857

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					
EP	54506	LU	82999				
GB	2085915	AR	226925	AU	75221/81	BR	8106788
		DE	3141407	IT	1143245	JP	57098593
		ZA	8106333				
US	4445976	AU	89261/82	BR	8205946	DE	3237791
		FR	2514478	GB	2109521	JP	58076495
US	4502227	AT	192/82	AU	10282/83	CA	1194442
		DD	209473	DE	3248372	GB	2115003
		IN	156113	JP	58171486	PL	240169
		YU	97/83				
GB	2035366	AU	51630/79	NL	7906674	AT	5577/79
		IN	152361	JP	55089393	PL	218799
		SU	1041559	YU	2501/79	DE	2935594
US	3990865	CA	1058875				
WO	9913025	AU	86175/98	EP	1027408	US	6148599
US	4176010	DE	2633789	US	4198273		

END OF ANNEX