Fluid blasting apparatus

Field of the Invention

The present invention relates to a fluid blasting apparatus having numerous applications. One application concerns the removal of refractory lining material. In particular the apparatus can be used for the removal of coke-impregnated refractory lining from riser pipes in oil refineries. While the invention is described in relation to this application, the process can equally be used in the removal of lining materials in many other similar applications.

Background of the Invention

Oil refineries process and refine crude oil into numerous petroleum products such as liquid petroleum gas (LPG), petrol (gasoline), kerosene, diesel oil, fuel oil, asphalt base, lubricating oil and paraffin wax. The crude oil is heated in a furnace and the various petroleum products are separated by fractional distillation based on the differing boiling points of the petroleum products. The longer-chain hydrocarbon molecule products, such as fuel oil, have lower boiling points than the shorter-chain hydrocarbon molecule products, such as LPG.

Fluid catalytic cracking is a process used to crack low-value, long-chain hydrocarbon molecules into high-value, short-chain hydrocarbon molecules that are used in petrol and LPG production. The process typically uses a hot zeolite-based catalyst (at around 700°C) which is mixed with a pre-heated oil feed in the base of a riser. The hot catalyst vaporises the oil and catalyses the cracking reactions that break down the long-chain hydrocarbon molecules as the mixture flows up the riser. During the cracking reactions that occur in the riser, coke (a carbonaceous material) is deposited on the surface of the catalyst molecules, reducing the activity of the catalyst.

The catalyst is then separated from the cracked hydrocarbons via a cyclonic reactor and the cracked hydrocarbons are removed for further separation by fractional distillation. The catalyst is regenerated by blowing air across the catalyst molecules to burn off the coke and restore catalyst activity. This process also heats the catalyst to around 700°C before being re-introduced into the base of the riser to catalyse further cracking reaction. In this way, the

catalyst operates in a closed loop, continually circulating around the fluid catalytic cracking unit.

Carbon steel is typically used in the construction of refinery equipment. However, many refinery processes, including fluid catalytic cracking, operate at temperatures above the operating temperatures of normal carbon steel. The carbon steel has a maximum design temperature of around 340°C. Above around 540°C, it's mechanical strength decreases dramatically and carbon steel components lose the ability to withstand significant internal pressure.

Accordingly, in order to withstand the higher operating temperatures of around 700°C in the fluid catalytic cracking process, the risers and other components are constructed from carbon steel and lined with refractory material. The thickness of the refractory wall lining varies depending on whether the lining is a hot wall or cold wall refractory lining. Hot wall linings have a thickness of around 19mm to 25mm and are retained by hex mesh or similar retention systems. Cold wall linings have a thickness of around 100mm to 125mm, are retained with Y anchors and contain around 2%-4% stainless steel fibre. As the catalyst is circulating at high temperature and velocity and is very erosive/corrosive, the refractory lining must be resistant to corrosion and provide sufficient insulation to protect the carbon steel outer shell.

The coke that is produced during the cracking reactions and is deposited on the surface of the catalyst molecules is also deposited on the refractory lining, resulting over time in a coke-impregnation of the refractory lining. The layer of coke may eventually have a thickness of anywhere from 5mm to 300mm on the surface of the refractory lining. This is particularly problematic in the refractory lining of the riser but also occurs in the refractory lining of other components. Build up of the coke layer on the refractory lining affects the flow conditions in the riser and other components and also compromises the insulating performance of the refractory lining. This compromised performance results in the refractory linings typically having to be removed and replaced about once every 4 to 8 years.

The refractory materials are porous and typically have a porosity range between 10% and 20% depending on the refractory material used. The coke is initially deposited within the pores of the refractory material, resulting in dissimilar expansion rates occurring between the

deposited coke and the refractory material. This results in spalling of the refractory lining as well as an increase in strength of the refractory lining material.

Typically, manually operated jack hammers are used to chip the refractory material away from the steel shell. However, this process requires workers to enter the confined spaces inside the riser and other components of the fluid catalytic cracking unit. This work is extremely labour intensive and dangerous and requires a full shut down of the fluid catalytic cracking unit for a considerable period of time. There is a risk of injuries and health complications for workers operating jack hammers in the confined and toxic environment inside the fluid catalytic cracking unit.

Further, with shutdowns potentially costing the refinery millions of dollars per day, it is imperative to minimise the duration of any shutdown. Jack hammering the refractory lining from the steel shell is a slow and hence costly process. The jack hammering operation also often results in damage to the steel shell from the jack hammer.

The coke-impregnated refractory lining also becomes exceptionally hard (in the order of 150MPa), making it extremely difficult to remove. In some instances, the coke-impregnated refractory lining is too hard to remove effectively by jack hammering and consequently, entire sections of the fluid catalytic cracking unit must be cut away and replaced. This process is prohibitively expensive and also involves long shutdown periods.

Object of the Invention

It is an object of the present invention to substantially overcome or at least ameliorate one or more of the above disadvantages, or at least to provide a useful alternative.

Summary of the Invention

In a first aspect, the present invention provides a fluid blasting apparatus comprising:

a frame;

a head assembly supported by said frame;

a drive mechanism mounted to said head assembly and adapted to drive a nozzle drive shaft about a rotation axis; and

a rotatable nozzle comprising a stem having a longitudinal axis, a proximal end in fluid

communication with a high pressure fluid source and a distal end having a nozzle tip, wherein the stem is mounted to the head assembly at the proximal end by a rear stem bearing and between the proximal and distal ends by a front stem bearing;

wherein the front stem bearing is supported on the nozzle drive shaft and located eccentric relative to the rotation axis, such that said front stem bearing rotates around a circular path during rotation of the nozzle drive shaft and wherein the longitudinal axis is oblique to the rotation axis and the path of the nozzle tip generally describes a circle.

In a preferred embodiment, the rear stem bearing is mounted to an external surface of said head assembly at or adjacent to said rotation axis.

Preferably, the drive mechanism includes a belt or chain extending between a drive sprocket and a driven sprocket secured to the nozzle drive shaft. Further preferably, the drive sprocket has a smaller diameter than the driven sprocket.

A preferred embodiment of the apparatus further includes a cylinder having a proximal end secured to said frame and a distal end secured to said head assembly, whereby expansion of said cylinder results in translational movement of the head assembly relative to said frame.

Preferably, the cylinder is a double acting hydraulic cylinder.

In a preferred embodiment, the drive sprocket is driven by a hydraulic motor.

Preferably, the path of the stem about the rotation axis generally describes a conical surface.

In a second aspect, the present invention provides a method of removing coke or a coke-impregnated refractory material lining from a generally cylindrical interior surface comprising:

providing a rotatable nozzle comprising a stem having a longitudinal axis, a proximal end in fluid communication with a high pressure fluid source and a distal end having a nozzle tip, wherein the stem is mounted at the proximal end by a rear stem bearing and between the proximal and distal ends by a front stem bearing supported on a nozzle drive shaft and located eccentric relative to a rotation axis of the nozzle drive shaft;

blasting the coke-impregnated refractory material lining with a high-pressure fluid jet

from the nozzle tip; and

rotating the nozzle drive shaft about the rotation axis such that the front stem bearing and the nozzle tip describe a generally circular path.

Preferably, the method includes the step of moving the rotating nozzle in a direction extending generally parallel to said surface. Further preferably, the method includes the step of rotating the nozzle about a central axis of the cylindrical surface.

In a preferred embodiment, the fluid jet is a water jet. Further preferably, the water pressure is between 250 MPa and 350 MPa.

Brief Description of the Drawings

A preferred embodiment of the invention will now be described by way of specific example with reference to the accompanying drawings, in which:

Fig. 1 is a front view of a fluid blasting apparatus;

Fig. 2 is a top view of the fluid blasting apparatus of Fig. 1;

Fig. 3 is a side view of a head assembly of the fluid blasting apparatus of Fig. 1;

Fig. 4 is a sectional side view of the head assembly, taken through plane AA; and

Fig. 5 is a sectional side view of the head assembly, taken through plane BB.

Detailed Description of the Preferred Embodiments

A fluid blasting apparatus 10 is depicted in the drawings. The apparatus 10 is used to support, control and direct a high pressure liquid jet for removing a coke layer from the surface of a refractory material.

The apparatus 10 includes a frame 12. The frame 12 is fabricated as a rigid metal structure or truss, capable of withstanding considerable forces. The frame 12 may be mounted to a heavy vehicle or crane, or alternatively secured to a larger structure, such as a concrete slab or wall.

The frame 12 includes a head assembly 14, which is supported by and slidable relative to the frame 12. The apparatus 10 also includes a cylinder 16 having a proximal end 18 which is secured to the frame 12 and a distal end 20 which is secured to the head assembly 14. The

cylinder 16 is a double acting hydraulic cylinder 16. Expansion of the cylinder 16 results in translational movement of the head assembly 14 relative to the support frame 12. Upper and lower guide bars 22, 24 of the support frame 12 assist with guiding the head assembly 14 during operation of the hydraulic cylinder 16.

The apparatus 10 includes a nozzle 30 mounted to the head assembly 14. The nozzle 30 is best depicted in Fig. 3. The nozzle 30 has a stem or lance 32 extending along a longitudinal axis XX, and the nozzle has a nozzle tip 34, capable of ejecting water or other fluids at high pressure.

The head assembly 14 includes a continuous drive means 40, in the form of a chain or belt drive 42. The continuous drive means 40 is adapted to rotate the stem 32 around the rotation axis ZZ, which is oblique to the longitudinal axis XX, such that during a revolution of the stem 32, the path of the nozzle tip 34 generally describes a circle and the path of the stem 32 generally describes a conical surface.

The belt or chain 42 engages a drive sprocket 44 and a driven sprocket 46. The drive sprocket 44 has a smaller diameter than the driven sprocket 46, resulting in a reduction of angular velocity, and an increase in the torque. The drive sprocket 44 is powered by a hydraulic drive motor 50, best seen in Fig. 5.

The driven sprocket 46 is secured to a nozzle drive shaft 60, and the nozzle drive shaft 60 rotates about the rotation axis ZZ during rotation of the driven sprocket 46. The nozzle drive shaft 60 is supported on a bearing 68. The nozzle drive shaft 60 supports a plate 62 having a front stem bearing 63 which is located eccentric relative to the rotation axis ZZ, such that the front stem bearing 63 rotates around a circular path during rotation of the nozzle drive shaft 60. The perpendicular distance between the rotation axis ZZ and the front stem bearing 63 is between about 5mm and 25mm.

The trailing end 64 of the stem 32 is mounted on a rear stem bearing 66 which is mounted to an external surface of the head assembly 14. The rear stem bearing 66 is a self aligning bearing. The rear stem bearing 66 is connected to a high pressure hydro blast pipe with hydraulic fittings 70, which receive high pressure water from a pump (not shown).

The operation of the fluid blasting apparatus 10 will now be described. When an accumulated layer of coke or coke-impregnated refractory material requires removal from a riser, or other component within an oil refinery, the riser is temporarily shut down. The riser tube is typically between 800mm and 1600mm in diameter, and up to 30 metres in length. During the shutdown period, the fluid blasting apparatus 10 is located within the riser, and anchored to the walls, or another fixed structure within the refinery. High pressure water is then ejected from the nozzle tip 34 at a pressure of at least 120 MPa. In practice, the optimal pressure is between 250 MPa, and 350 MPa, preferably around 300 MPa. However, the nozzle 30 may be operated at pressures as high as 600 MPa.

As the water is ejected at high pressure, the hydraulic motor 50 drives the chain or belt 42, to rotate the nozzle drive shaft 60 about the rotation axis ZZ. Simultaneously, the stem 32 rotates with the nozzle drive shaft 60. However, because the front stem bearing 63 is eccentric relative to the rotation axis ZZ, and the rear stem bearing 66 is located generally on the rotation axis ZZ, the result is that the stem 32 traces out a right circular conic profile. The conic profile advantageously means that the water jet is dispensed in a circular pattern, meaning that the portion of the refractory and coke layer which is blasted constantly changes.

Simultaneous with the operation of the chain or belt 42, the expansion of the cylinder 16 results in translational movement of the head assembly 14, which moves generally up or down within the riser tube.

In one embodiment, the fluid blasting apparatus 10 can also rotate around a vertical axis, enabling the complete circumference of the internal riser wall to be blasted with water.

Advantageously, the conical motion of the stem 32 permits the water jet to hit the coke-impregnated refractory material at an angle which is oblique or non-perpendicular to the riser surface. This assists the water jet to contact and hence remove coke and coke-impregnated refractory material from a large surface area of the riser.

While the invention has been described with respect to the removal of coke and coke-impregnated refractory material from riser tubes in oil refineries, it may also be utilised for the removal of ash within steam boilers, and it will be appreciated by those skilled in the art

that the fluid blasting apparatus can be used in other material removal or cleaning applications.

Although the invention has been described with reference to specific examples, it will be appreciated by those skilled in the art that the invention may be embodied in many other forms.

CLAIMS:

1. A fluid blasting apparatus comprising:

a frame;

a head assembly supported by said frame;

a drive mechanism mounted to said head assembly and adapted to drive a nozzle drive shaft about a rotation axis; and

a rotatable nozzle comprising a stem having a longitudinal axis, a proximal end in fluid communication with a high pressure fluid source and a distal end having a nozzle tip, wherein the stem is mounted to the head assembly at the proximal end by a rear stem bearing and between the proximal and distal ends by a front stem bearing;

wherein the front stem bearing is supported on the nozzle drive shaft and located eccentric relative to the rotation axis, such that said front stem bearing rotates around a circular path during rotation of the nozzle drive shaft and wherein the longitudinal axis is oblique to the rotation axis and the path of the nozzle tip generally describes a circle.

2. The apparatus of claim 1, wherein the rear stem bearing is mounted to an external surface of said head assembly at or adjacent to said rotation axis.

3. The apparatus of claim 2, wherein the drive mechanism includes a belt or chain extending between a drive sprocket and a driven sprocket secured to the nozzle drive shaft.

4. The apparatus of claim 3, wherein the drive sprocket has a smaller diameter than the driven sprocket.

5. The apparatus of claim 1, further including a cylinder having a proximal end secured to said frame and a distal end secured to said head assembly, whereby expansion of said cylinder results in translational movement of the head assembly relative to said frame.

6. The apparatus of claim 5, wherein the cylinder is a double acting hydraulic cylinder.

7. The apparatus of claim 3, wherein the drive sprocket is driven by a hydraulic motor.

8. The apparatus of claim 1, wherein the path of the stem about the rotation axis generally describes a conical surface.

9. A method of removing coke or a coke-impregnated refractory material lining from a generally cylindrical interior surface comprising:

providing a rotatable nozzle comprising a stem having a longitudinal axis, a proximal end in fluid communication with a high pressure fluid source and a distal end having a nozzle tip, wherein the stem is mounted at the proximal end by a rear stem bearing and between the proximal and distal ends by a front stem bearing supported on a nozzle drive shaft and located eccentric relative to a rotation axis of the nozzle drive shaft;

blasting the coke-impregnated refractory material lining with a high-pressure fluid jet from the nozzle tip; and

rotating the nozzle drive shaft about the rotation axis such that the front stem bearing and the nozzle tip describe a generally circular path.

10. The method of claim 9, including the step of moving the rotating nozzle in a direction extending generally parallel to said surface.

11. The method of claim 10, further including the step of rotating the nozzle about a central axis of the cylindrical surface.

12. The method of claim 9, wherein the fluid jet is a water jet.

13. The method of claim 12, wherein the water pressure is between 250 MPa and 350 MPa.