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(54) USE OF FLUIDIC PUMPS

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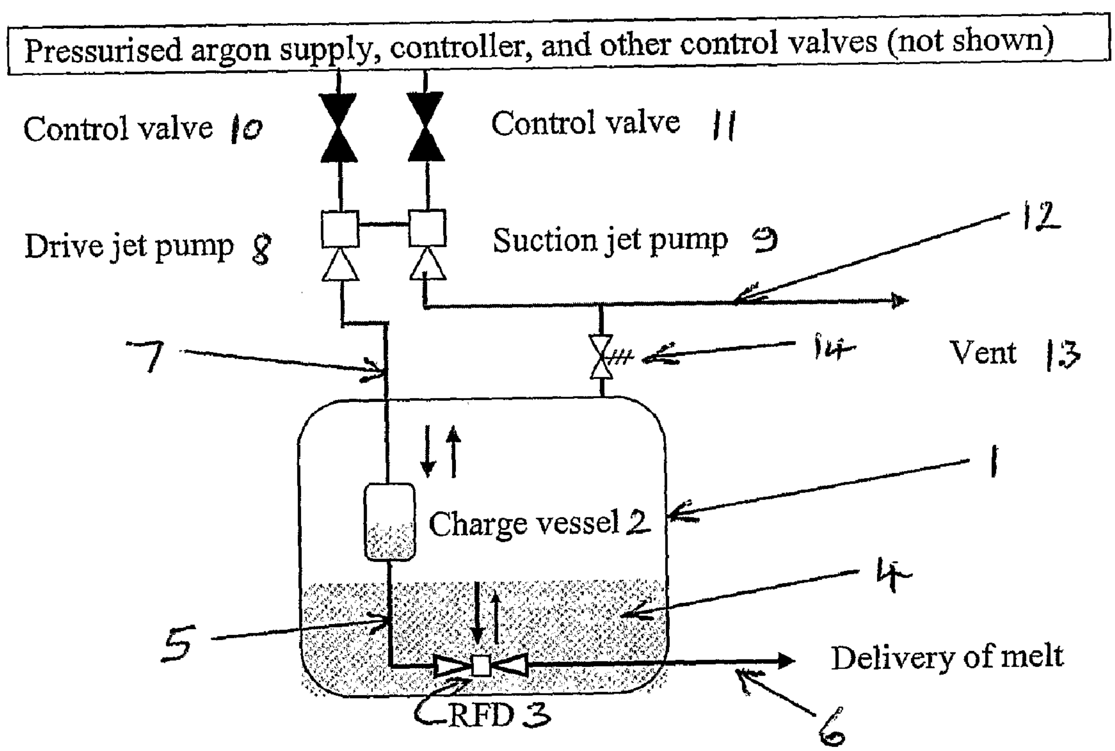
(57) ABSTRACT

The invention provides a method for the transportation of at least one material in a molten state from a first location to a second location, the method comprising the use of transfer means comprising a fluidic pump to effect the transportation of said at least one material. The preferred type of fluidic pump is the Reverse Flow Diverter (RFD) Pump. Preferably, the at least one material in a molten state comprises at least one molten inorganic salt or molten metal, preferably alkali metal halides such as potassium chloride or lithium chloride, or eutectic mixtures thereof. The materials are in a molten state, at a temperature which is usually in excess of 200° C. A preferred gas for use according to the method of the invention is dry argon. In a particularly preferred embodiment, the method of the present invention is applied to the transportation of molten salts in dry conditions in various applications in the nuclear industry.



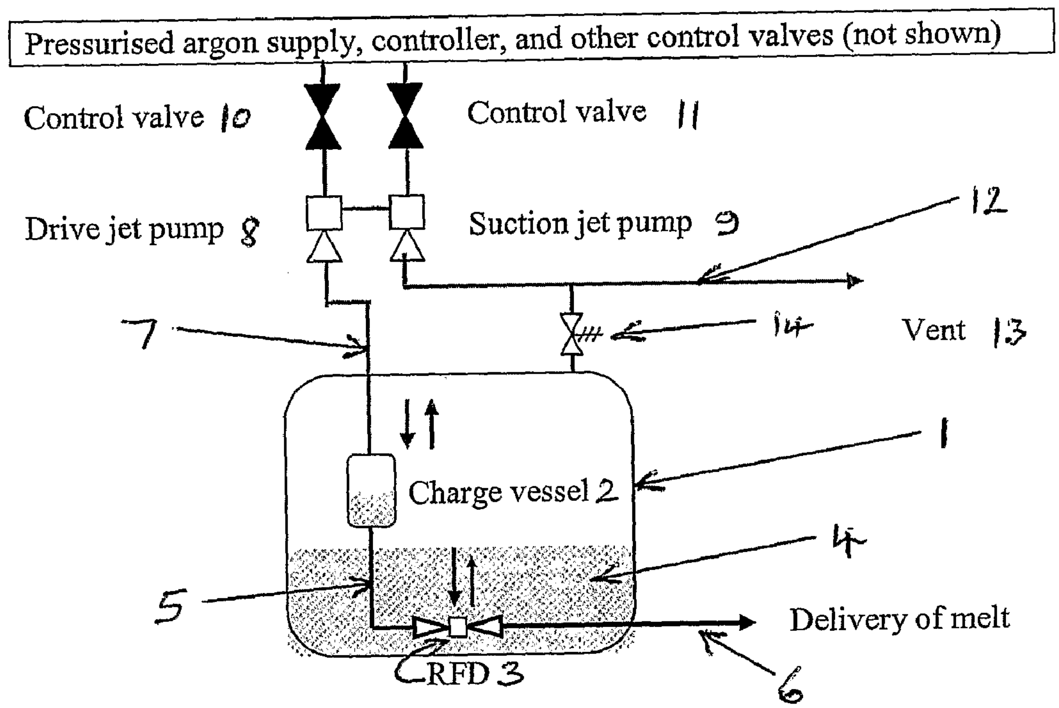
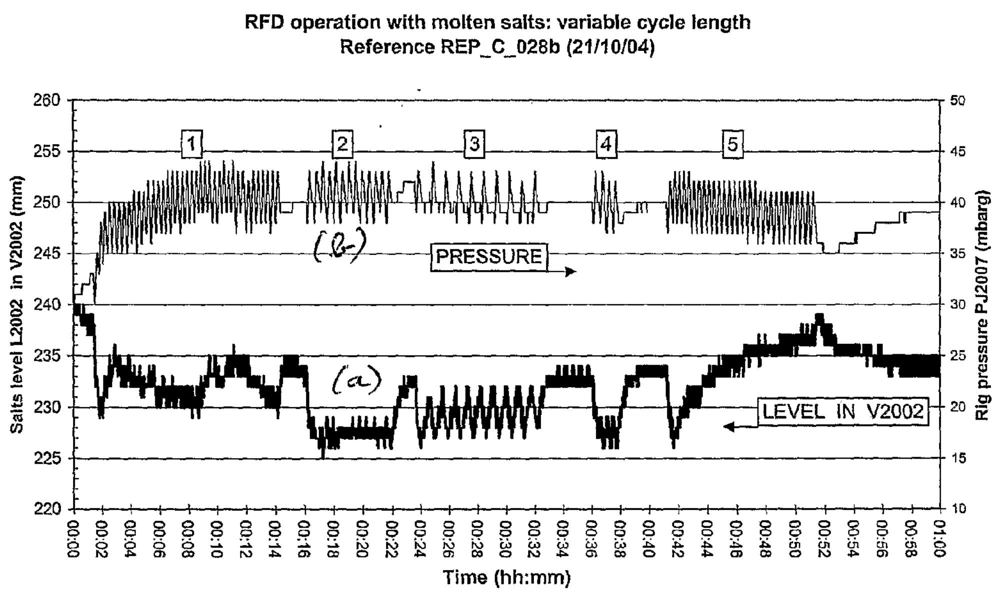

Pressurised argon supply, controller, and other control valves (not shown)
Control valve 10
Control valve 11
Drive jet pump 8
Suction jet pump 9
12
7
14
Vent 13
1
Charge vessel 2
4
5
Delivery of melt
RFD 3
6

FIGURE 1


RFD operation with molten salts: variable cycle length
Reference REP_C_028b (21/10/04)
Salts level L2002 in V2002 (mm)
Rig pressure PJ2007 (mbarg)
Time (hh:mm)
PRESSURE
LEVEL IN V2002
(b)
(a)
1
2
3
4
5
260
255
250
245
240
235
230
225
220
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45
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00:38
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00:44
00:46
00:48
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01:00

FIGURE 2

USE OF FLUIDIC PUMPS

FIELD OF THE INVENTION

[0001] The present invention relates to the transportation of materials, more particularly the transportation of molten materials. Most specifically, the invention is concerned with the transportation of materials in the molten state, and provides a simple, dependable method for this purpose.

BACKGROUND TO THE INVENTION

[0002] There is a frequent requirement in industry for the use of molten materials, both as solvents and as reaction media. Naturally, there are occasions when the use of such materials requires the use of a plurality of vessels and, therefore, necessitates the transportation of the materials between locations. Technically, this can cause problems, since it is generally the case that elevated temperatures have to be maintained throughout the operations which are being performed, in order that the molten materials remain in a molten state. Thus, it is necessary that methods of transportation which are employed should not at any point give rise to a fall in temperature which might lead to solidification of the material.

[0003] Furthermore, it is often the case that chemical reactions are required to be carried out in an inert atmosphere from which air—more specifically, the moisture associated with the atmosphere—are excluded, in order that unwanted side reactions and hydrolysis may be avoided which, in extreme circumstances, may completely prevent a desired reaction from being achieved. In addition, moisture-sensitive components have to be protected from contact with the atmosphere at all times in order that problems associated with hydrolysis and/or degradation may be avoided.

[0004] Such difficulties are frequently encountered on a laboratory scale, but may be fairly easily overcome in such circumstances by the provision of an inert blanket of, typically, nitrogen gas using standard laboratory procedures. When moisture-sensitive materials require to be handled on a commercial scale, however, the potential difficulties are exacerbated, and carefully devised procedures have to be implemented in order that serious problems do not occur. This is particularly true when such materials have to be transported though industrial scale apparatus and plant machinery, where damage to the apparatus could occur, as well as loss of the material.

[0005] In this context, the present inventors have specifically addressed the difficulties which are associated with the handling of so-called molten salts on a plant scale. These materials find widespread use, for example, in the reprocessing/waste conditioning of irradiated nuclear fuel by means of the Argonne National Laboratory electrometallurgical treatment process (ANL—EMT) and the Dimitrovgrad SSC—RIAR process, which both use molten salts at high temperatures (773 and 1000 K, respectively). Molten salts have also been proposed for use in the reprocessing of irradiated fuels from Light Water Reactors (LWRs). A further major interest in molten salts has centred on their potential use in molten salt reactors, which would produce electricity, as well as burning actinides and long-lived fission products.

[0006] These molten salts are typically mixtures of salts which are liquid only at high temperatures. Traditionally molten salts melt above 150° C., and more frequently at much higher temperatures than this, and such salts are usually composed of inorganic cations. Thus, it can be seen from a consideration of the prior art that the use of molten salts in industrial applications is widespread, and there is frequently a requirement for the handling and transportation of such materials on an industrial scale.

[0007] Specific examples of the requirement for the handling of molten salts include the transfer of molten salts with a pump, most particularly a centrifugal pump, at solar power stations, wherein a mixture comprising sodium and potassium hydroxides and nitrites, melting at 146° C., is typically employed, and wherein there is a requirement for the molten salt to be handled at temperatures of up to 500° C. Alternatively, simple mixtures of sodium and potassium hydroxides, melting at 225° C. and showing increased stability at higher temperatures, may be utilised.

[0008] It will be apparent, therefore, that there are certain key requirements for the satisfactory handling of molten salts in industrial applications. Primarily, of course, it is necessary that there should be provided a heating system capable of heating and melting salts above the melting point of the salts, and desirably at a suitably higher temperature, preferably in the range of 500° to 550° C., so to make the melt less viscous. Furthermore, the apparatus should incorporate suitable insulation around vessels and pipes, to reduce heat losses and to ensure that no cold spot develops, which could result in freezing of the salts.

[0009] In the event that some freezing of the molten salt does occur, however, it is essential that the apparatus should be able to withstand a subsequent re-melting operation without suffering damage, and it is important that the design of the apparatus should take such considerations into account.

[0010] It is also generally found that the volume of salts increases by 20% when changing from the solid to the molten state, so that a zoned heating system is essential to prevent bursting of pipes or vessel deformation during melting of the salts. As an alternative to the zoned-heating of vessels to avoid deformation, it is possible to provide vessels having modified designs, such as conical vessels, although this is inevitably a more expensive option.

[0011] In view of the hygroscopic nature of molten salts, it is also vital to ensure that a dry environment exists in order to prevent the salts from absorbing moisture, since this would lead to the release of hydrogen chloride gas and, as a consequence, would promote very rapid corrosion of the rig, especially at high temperatures. Thus, it is essential that an inert atmosphere is provided within the apparatus and, hence, an inerting system, preferably using an inert gas or a mixture of inert gases, is incorporated in the apparatus. Typically, said inert gas comprises argon, especially in nuclear applications where uranium metal is being handled, since nitrogen has the potential to react with uranium metal to form uranium nitride.

[0012] Desirably, a system for the handling of molten salts should also be adapted to incorporate various other additional features which would facilitate the safe and efficient handling of the said materials. Included among these features would be the following:

[0013] pressure and vacuum relief system;

[0014] gas analyser to detect concentrations of O_2 and H_2O in the ppm range, in order to monitor the quality of the inerting system;

[0015] corrosion-resistant and heat resistant metallic parts;

[0016] heat-resistant gaskets, for example graphite-containing gaskets;

[0017] design which accounts for the dilation of pipe with temperature, for example by the insertion of sections of bent pipes in order to minimise stresses on pipes and prevent damage or rupture; and

[0018] supervisory control and data acquisition system (SCADA) to provide interlocks, thereby preventing maloperation and ensuring sequenced heating—thus, for example, preventing a user from activating any pump if the salts temperatures in various places in the rig are not above a given threshold value, i.e. above the melting point temperature, or ensuring that the correct heating sequence is adhered to by eliminating the possibility that, for example, a bottom wrap might be heated as the first step.

[0019] In the light of the above requirements, the present inventors have sought to provide an apparatus and method which may be used for the safe and efficient handling and transportation of molten salts and which may find more general application in the industrial handling and transportation of molten materials.

[0020] The use of fluidic pumps is known in a large number of industrial applications for the transfer of various liquids. Specifically, in the nuclear industry, such pumps have found application in the transfer of fluidic radioactive materials at ambient temperatures and has, for example, facilitated complete containment of the fluids during maintenance procedures, due to the fact that such pumps have no moving parts in contact with the fluids and the said procedures are, consequently, all carried out on external parts of the pumps. This is a vital consideration in the case of radioactive fluids due to the highly toxic nature of the materials concerned. Examples of such applications are disclosed in GB-A-2070699, GB-A-2122262, GB-A-2220709 and GB-A-2283065.

[0021] Several types of fluidic pump are available, particular examples being Diode Pumps and Reverse Flow Diverter Pumps. The common feature of all these pumps is that they use a compressed gas, such as air or nitrogen, as the power source, and are driven by means of a cyclic gas pressure pulse. However, the use of such pumps for the transportation of fluids at very high temperatures has not been reported and, most particularly, their application to the transportation of molten materials under such conditions is not documented.

[0022] Thus, the present inventors have sought to provide a new method for the transportation of molten materials. More particularly, the present invention seeks to provide a method for the transportation of molten salts, which are generally hygroscopic inorganic salts with melting points in excess of 150° C., and more commonly above 200° C., with particular emphasis being given to the transportation of molten salts utilised in the nuclear reprocessing industry.

STATEMENTS OF INVENTION

[0023] Thus, according to the present invention, there is provided a method for the transportation of at least one material in a molten state from a first location to a second location, said method comprising the use of transfer means comprising a fluidic pump to effect the transportation of said at least one material.

[0024] Typically, said at least one material in a molten state comprises at least one molten inorganic salt or molten metal. Preferred molten inorganic salts comprise inorganic halides, most preferably alkali metal halides such as potassium chloride or lithium chloride, or eutectic mixtures thereof. Said materials are in a molten state, at a temperature which is generally in excess of 150° C., and more usually in excess of 200° C. Optionally, said at least one material in a molten state may additionally comprise sludge, fines, or other suspended material.

[0025] Said method comprises the provision of a fluidic pump in the apparatus in which said at least one molten material is contained in order to move, lift, transport, transfer or pump said material from said first location to said second location.

[0026] It is frequently the case that the at least one material which is to be transported is sensitive to moisture and/or oxygen. This is certainly true in the case of hygroscopic materials such as molten salts and, in such cases, it is necessary to maintain dry conditions and a dry atmosphere throughout processing. Thus, a preferred embodiment of the invention envisages a non-aqueous system, wherein there is provided a method according to the invention for the transportation of at least one material in a molten state from a first location to a second location in dry conditions, free from aqueous contamination or any aqueous materials.

[0027] In the case of oxygen sensitive materials it is, of course, a requirement that an inert atmosphere should be provided. As previously noted, the common feature of these fluidic pumps is that they use a compressed gas, such as air or nitrogen, as the power source, and are driven by means of a cyclic gas pressure pulse. In necessary instances, therefore, the pressurised gas may comprise a dry or an inert gas, or a gas which is both dry and inert. Said gas may comprise a mixture of gases and, in cases where oxygen sensitivity does not have to be considered, compressed air, preferably dry compressed air, provides a suitable gas. A preferred inert gas is argon; dry argon is suitable for virtually all applications.

[0028] Optionally, the gas may be heated to substantially the same temperature as the melt prior to use in order to avoid the possibility that some solidification of the molten material may occur on contact with the gas, or during transportation. The pathway through which the gas is introduced into the apparatus containing the molten material may also be heated, in order to ensure that the gas remains at elevated temperature prior to contact with the molten material. However, in many applications it is not found to be necessary for either the gas or the pathway to be heated, since no solidification of the molten material occurs in the absence of such heating.

DESCRIPTION OF THE INVENTION

[0029] The simplest type of pump is the Reverse Flow Diverter (RFD) Pump and this is particularly suited to the present application. The RFD pump comprises a gas controller, a charge vessel, a reverse flow diverter and discharge pipework. The operation of the pump relies on the repeated supply of compressed gas to the charge vessel in two phases, the drive phase and the refill phase.

[0030] During the drive phase compressed gas is passed through the gas controller to the charge vessel and this forces the molten material through the RFD, where an increase in flow velocity occurs in a region of reduced cross-section, leading to a fall in pressure in that region which causes more molten material to be sucked from a connected supply tank and, thereby, on to delivery through the discharge pipework. This phase continues until the charge vessel is empty, whereupon the pump enters the refill phase when molten material passes from the supply tank, through the RFD, to refill the charge vessel. When necessary, a partial vacuum may optionally be applied to the charge vessel, via the gas controller, to augment the filling rate. Once the charge vessel is full, the pump re-enters the drive phase and the phases are repeated in this way in order to produce a cyclic pumping action.

[0031] An RFD pump may be installed either externally to the supply tank, with penetration into the lower part of the supply tank or, where space and lid penetrations allow, the pump may be located inside the tank. An alternative form of RFD pump comprises the Immersion RFD, which utilises an RFD mounted within a gas piston, and thereby minimises the maximum lid penetration required; such form of pump is of particular use when space or tank lower penetrations are limited, since it is possible to insert the pump into a supply tank via an inspection port.

[0032] Suitable materials for construction of fluidic pumps are determined largely by the nature of the products with which they are to come in contact. Clearly, it is essential that the materials should be resistant to attack by these products. In the case of molten salts, for example, it has been found that carbon steel is generally satisfactory, although with some molten salts at particularly high temperatures or pressures, the increased fluid flow experienced in the region of reduced cross-section within the RFD can result in some corrosion occurring under certain conditions. In such cases, the situation may be remedied by employing a more resistant material in the manufacture of the RFD, suitable examples including a Hastelloy or a silicon carbide ceramic.

[0033] When handling the transfer of molten salts, fluidic pumps have the advantage that there are no moving parts in direct contact with the salts, thereby minimising the wear and corrosion problems so frequently encountered with conventional pumps.

[0034] In operation, the design and choice of a suitable RFD pump for a given melt density is essential to achieve flow when the suction drive cycle is applied repeatedly. Furthermore, suitable heating of the charge vessel and RFD device is essential in order to maintain the material in a molten state. Operation of the RFD device is dependent on the provision of at least two jet pumps, comprising at least one drive jet pump and at least one suction jet pump, or the availability of vacuum and pressurised gas.

[0035] Preferably, the fluidic pump comprises a controller, adapted to time the drive and suction phases so as to achieve a satisfactory flow, and to avoid overblow or aspiration, and the creation of a spray of molten material at the delivery end of the pipe. Clearly, as pressurised gas is supplied to an apparatus, the pressure in the apparatus will increase and, therefore, adjusting the controller so as to set the drive and suction times in accordance with these requirements is an operation most satisfactorily carried out by a skilled person, since it is important that undesirable pressure fluctuations should be avoided whilst performing the method of the invention.

[0036] Another preferred feature of a fluidic pump for use according to the method of the invention envisages the provision of a gas leg, between the charge vessel and each of said at least two jet pumps, in order to avoid the possibility that the melt could reach the jet pump, in the event that the melt was over-aspired. Preferably, each of said gas legs has a height of at least 8 m.

[0037] It is also preferred that, during operation, a pressure relief adjustment should be carried out to ensure that the pressure is 40 mbarg or less, so that overfilling of the charge vessel may be avoided. Self-filling of the charge vessel occurs due to the positive pressure in the main vessel. It is also desirable that a facility should be available to allow for a decrease in the suction time, so as to accommodate the self-filling of the charge vessel.

[0038] The method of the invention is applicable to the transportation of a range of molten materials. Particular mention may be made of molten salts or combination of molten salts, having melting points in the range of 200° to 1200° C. However, the molten material may also comprise at least one of the following:

[0039] a metal in a molten state, typically sodium, zirconium, aluminium, titanium, cadmium, uranium or other actinide;

[0040] a molten alloy, for example as generally used in the foundry or steel-making industry;

[0041] a chemical compound or mixture having a melting point in the range 200° to 1200° C., for example LiCl/KCl eutectic, or NaOH/sodium carbonate eutectic, the latter having m.p. 284° C. and finding use in pyrochemistry and for the treatment or destruction of wastes;

[0042] a polymer having a melting point in excess of 200° C.

[0043] Successful application of the method of the invention requires that the material to be transported should be sufficiently mobile in its molten state to allow it to flow through a given apparatus from a first location to a second location. Consequently, it is necessary that the viscosity of the material should not exceed certain limits. In general it is found that optimum results are achieved when the viscosity does not exceed 20 cp, and preferably, it will not exceed 15 cp. In such circumstances, transportation of a range of molten materials may be achieved at rates in the range between 0.1 to 10 l/s, with the exact rate frequently being dependent on parameters such as the diameter of pipes and the efficiency of the fluidic pump which can, of course, place limitations on the upper end of this range.

[0044] It will be understood from the foregoing that it is often preferred that the gas which is supplied should be dry and/or inert, in order that the gas will not react with, or be absorbed by, the molten material. However, circumstances may be envisaged wherein it might be acceptable, or even desirable, that the gas should react with, or be absorbed by, the said materials. Thus, the invention is not limited to the use of non-reacting gases, since it may be required to react or saturate a molten material with a particular gas.

[0045] The method of the invention provides a simple, reliable and repeatable means for the transportation of molten materials, and does not require the provision of additional moving parts. In operation, no further heating of the molten material occurs, as is the case with the increasing temperature observed as a consequence of the mechanical energy delivered by a centrifugal pump, for example.

[0046] In a particularly preferred embodiment, the method of the present invention may be successfully applied to the transportation of molten salts at high temperatures, and particularly to the transportation of molten inorganic halides, such as lithium chloride, potassium chloride and eutectic mixtures thereof. The method is of particular value in the transportation of such molten salts in various applications in the nuclear industry, especially in nuclear fuel reprocessing, when the molten salts may be contaminated with numerous species showing radioactivity, including, for example, various lanthanide and actinide metals and their compounds, or assorted fission products, and provides a safe and convenient means for the transportation of the said materials.

DESCRIPTION OF THE DRAWINGS

[0047] The method of the present invention will now be further illustrated, though without in any way limiting its scope, by reference to the accompanying figures, wherein

[0048] FIG. **1** shows a schematic diagram of a Reverse Flow Diverter Fluidic Pump in an internally mounted arrangement for use in the transportation of molten salts according to the method of the invention; and

[0049] FIG. **2** shows a graphical representation of the results achieved by the application of the method of the invention to the transportation of molten salts.

[0050] Looking firstly at FIG. **1**, there is shown a simplified schematic diagram of a Reverse Flow Diverter Pump in an internally mounted arrangement, suitable for use in a molten salts dynamic rig. The apparatus comprises a feed vessel (**1**), inside which are located a charge vessel (**2**) and a Reverse Flow Diverter (**3**). The feed vessel and charge vessel contain molten salt (**4**). The Reverse Flow Diverter (**3**) is connected to the charge vessel (**2**) by means of a pipeline (**5**), and a further pipeline (**6**) exits the feed vessel (**1**) from the Reverse Flow Diverter (**3**). Pipeline (**7**) connects the charge vessel (**2**) to drive jet pump (**8**), which, in turn, is linked to suction jet pump (**9**) and first control valve (**10**). The suction jet pump (**9**) is connected to a second control valve (**11**) and, via pipeline (**12**), to vent (**13**). Pipeline (**12**) is also linked to the feed vessel (**1**) by means of pressure relief valve (**14**). Valve (**14**) serves to protect feed vessel (**1**) from overpressure; a vacuum relief valve (not shown) is also fitted to feed vessel (**1**) as an additional means of protection against overpressure. The apparatus of FIG. **1** also includes an argon supply, a suitable control unit, and other control valves which are not specifically illustrated.

[0051] In operation, argon, supplied under pressure, is passed through first control valve (**10**) and drive jet pump (**8**) to the charge vessel (**2**), thereby forcing the fluid through the pipeline (**5**) to the Reverse Flow Diverter (**3**) and causing more fluid to be sucked from the feed vessel (**1**). The fluid is then delivered through the pipeline (**6**) and transported to a different location. This part of the cycle comprises the drive phase and continues until the charge vessel is empty, which typically is for a period of around 15 seconds.

[0052] Thereafter, in the refill phase, fluid passes from the feed vessel (**1**) through the Reverse Flow Diverter (**3**) to refill the charge vessel (**2**). Preferably, a partial vacuum is applied to the charge vessel (**2**) by means of the suction jet pump (**9**), via pipeline (**12**), in order to augment the rate of filling. This part of the cycle is generally complete in around 45 seconds, so that the full cycle takes in the order of 1 minute to complete, and is then repeated as many times as necessary to complete the transfer of molten material.

[0053] Turning now to FIG. **2**, there is illustrated the results of extended trials of a Reverse Flow Diverter with molten salts, showing plots of (a) salt level and (b) rig pressure against time. The labels **1** to **5** on the plot correspond to various rest times between each drive-suction cycle. By comparison of the observed change in salt level with the rig pressure at the same time in the operation, it may be deduced that the molten material was pumped by the RFD.

[0054] Thus, for example, at the end of the series indicated by labels **3** and **4**, once the RFD pump is stopped, the level in the pumping tank (V**2002**) increases as the holdup of melt decreases in the receipt vessel and pipes, that is as the melt drains back into the pumping tank. Conversely, at the start of the series indicated by label **2**, once the RFD pump is started, the level in the main tank decreases whilst the holdup of melt increases in pipes, i.e. the main tank is partially emptied. More generally, in a closed loop system between two vessels, the melt level in the pumping tank will vary primarily as a function of the flow rate of the melt. However, these variations are frequently more complex than the shutdown and startup examples explained herein, as will be apparent to the skilled person from a detailed analysis of FIG. **2**.

1. A method for the transportation of at least one material in a molten state from a first location to a second location, said method comprising the use of transfer means comprising a fluidic pump to effect the transportation of said at least one material, wherein said material has a melting point at a temperature which is in excess of 150° C.

2. A method as claimed in claim **1** wherein said fluidic pump comprises a Diode Pump or a Reverse Flow Diverter Pump.

3. (canceled)

4. A method as claimed in claim **2** wherein said Reverse Flow Diverter Pump comprises gas control means, a charge vessel, a reverse flow diverter and discharge pipework, said gas control means facilitating the repeated supply of pressurised gas to the charge vessel in two phases, said phases comprising a drive phase and a refill phase.

5. A method as claimed in claim **4** wherein, during the refill phase, a partial vacuum is applied to the charge vessel via the gas control means to augment the filling rate.

6. A method as claimed in claim **2** wherein said Reverse Flow Diverter Pump is located inside a feed vessel.

7. A method as claimed in claim **2** wherein said Reverse Flow Diverter Pump is installed externally to a feed vessel, with penetration into the lower part of the supply tank.

8. A method as claimed in claim **2** wherein said Reverse Flow Diverter Pump comprises an Immersion Reverse Flow Diverter.

9. A method as claimed in claim **2** wherein said gas control means comprises at least two jet pumps, comprising at least one drive jet pump and at least one suction jet pump, or the availability of vacuum and pressurised gas.

10. A method as claimed in claim **9** which additionally comprises the provision of a gas leg between the charge vessel and each of said at least two jet pumps.

11. (canceled)

12. A method as claimed in claim **1** wherein the material for construction of said fluidic pump comprises carbon steel, a Hastelloy, or a silicon carbide ceramic.

13. (canceled)

14. A method as claimed in claim **1** wherein said transfer means is adapted to allow for the dilation of pipework with temperature.

15. A method as claimed in claim **14** wherein said transfer means comprises sections of bent pipes.

16. A method as claimed in claim **1** wherein said temperature is in excess of 200° C.

17. A method as claimed in claim **1** wherein said transportation of said at least one material in a molten state from said first location to said second location occurs in dry conditions which are free from aqueous contamination.

18. A method as claimed in any claim **4** wherein said pressurised gas comprises a dry and/or inert gas.

19. (canceled)

20. (canceled)

21. (canceled)

22. (canceled)

23. A method as claimed in claim **4** wherein said pressurised gas comprises dry argon.

24. A method as claimed in claim **4** wherein said pressurised gas is heated to substantially the same temperature as the melt prior to use.

25. A method as claimed in claim **4** wherein the pathway through which the gas is introduced into the apparatus containing the molten material is heated to ensure that the gas remains at elevated temperature prior to contact with the molten material.

26. A method as claimed in claim **1** wherein said at least one material in a molten state comprises at least one molten inorganic salt or molten metal, a chemical compound or mixture having a melting point in the range 200° to 1200° C., or a polymer having a melting point in excess of 200° C.

27. (canceled)

28. (cancelled)

29. A method as claimed in claim **26** wherein said at least one molten inorganic salt comprises potassium chloride or lithium chloride, or eutectic mixtures thereof.

30. A method as claimed in claim **26** wherein said molten inorganic salt is contaminated with species showing radioactivity.

31. (canceled)

32. A method as claimed in claim **26** wherein said at least one molten metal comprises at least one of sodium, zirconium, aluminum, titanium, cadmium, uranium or other actinide, or a molten alloy such as generally used in the foundry or steel-making industry.

33. (canceled)

34. (canceled)

35. A method as claimed in claim **26** wherein said mixture comprises NaOH/sodium carbonate eutectic.

36. (canceled)

37. A method as claimed in claim **1** wherein the viscosity of the at least one material in a molten state does not exceed 20 cp.

38. (canceled)

39. A method as claimed in claim **1** wherein the rate of transportation of said at least one molten material is in the range between 0.1 and 10 l/s.

40. (canceled)

41. (canceled)

42. (canceled)

43. (canceled)

44. (canceled)

45. (canceled)

46. (canceled)

* * * * *