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(54) **Liquid ring pump**

Flüssigkeitsringpumpe

Pompe à anneau liquide

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EP 0 554 937 B1

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Description

This invention relates to a new multi-phase pumping device which, by compressing the gas and simultaneously pumping the liquid by means of separate operations, enables any multi-phase fluid with any gas content to be effectively pumped in a simple, automatic and reliable manner with high efficiency.

The known purpose of a multi-phase pumping device is to increase the pressure of a multi-phase fluid to enable it to overcome considerable level differences and/or to travel through long distances in pipelines, as is currently required for example in the petroleum sector where the depletion of the available reserves in the major reservoirs has resulted in attention being turned towards reservoirs which are smaller and/or further from already existing process installations and/or located under deep water, in which the pressure is generally insufficient to effectively convey the two-phase fluid at an acceptable throughput through pipelines of reasonable dimensions for a production period of reasonable length.

Devices and systems are already known in the state of the art for increasing the pressure of a multi-phase fluid, for example in the working of hydrocarbon reservoirs situated under the sea and/or deep water, but all these known devices and systems have drawbacks and limitations in use.

In this respect, in a first known system a determined gas flow is conveyed within the pipeline connecting the reservoir to the well head and mixes with the reservoir fluid to reduce its average density, so facilitating the outflow of said fluid from the wells.

This method has however a series of drawbacks in that it requires the presence of a compression unit, a pipeline dedicated to the transport of the gas and finally the equipping of existing wells with gas injection devices. Again, the addition of gas to the reservoir fluid can result in the deleterious formation of gas bubbles and liquid pockets along the transport pipeline and in the possible riser used to connect the transport pipeline to a process installation, platform or the like.

A second known system consists of installing a specific liquid pumping device at the bottom of the well, utilizing the fact that at this point the reservoir fluid has a mainly liquid composition as a consequence of the high reservoir pressure. This latter system is thermodynamically efficient but unfortunately requires energy to be continuously fed to a most difficult position for powering the pump located at the bottom of the well. Again, in addition to the difficulties involved in installing the pumping unit, such a system, being very sensitive to the presence of gas and sand or solid particulate matter in general, is of limited operational life and requires frequent maintenance and/or repair, as has been found in practice.

Another known system uses a two-phase gas-liquid separator installed in the vicinity of a well head plus a pumping unit for operating on the liquid flow leaving the separator, whereas the gas leaving the separator, being

a fluid of low density and viscosity and therefore undergoing only low pressure drop during transport, can be fed directly into a separate pipeline to the side of the liquid pipeline if the distance to be transported is not too great. However if the distance is great, the gas leaving the separator must also be compressed by a suitable compressor unit, in which case it can be re-mixed with the previously pumped liquid and the resultant fluid fed through a single pipeline.

This latter system also suffers from installation and cost drawbacks as it requires the use of a separator, a pumping unit for the liquid and a compression unit for the gas, or alternatively a separate pipeline through which to feed the gas.

Finally in a further known system, a multi-phase pumping device is used able to generate the necessary pressure increase, which can be considerable, for the required fluid flow. For such a device it is of fundamental importance to know the volumetric gas fraction contained in the fluid, in that for volumetric fractions of between 30 and 80% the device has to be based on the principle of operation of liquid pumps, whereas for fractions exceeding 95% it has to be based on the principle of operation of wet gas compressors. From this, it is apparent that there are currently no devices able to operate with any gas content and hence able to operate under particular flow conditions, such as when the fluid stream conveys long gas bubbles alternating with pockets of liquid. In this respect, the pumping devices currently known in the art or under study represent adaptations of known machine types such as multi-stage centrifugal compressors or screw pumps which when operating with a two-phase fluid have an efficiency of the order of 30-40%, hence involving the delivery and the continuous consumption of considerable quantities of energy.

Again, the complex configuration of these machines means that there is considerable uncertainty regarding the period for which they can operate without requiring maintenance or the repair of faults.

"CH-A-228732 discloses a liquid ring pump for simultaneously pumping a gaseous and a liquid fluid by mixing them in adjustable proportion and then pumping the resulting mixture in a sole liquid ring pump giving separate streams of liquid and gaseous phase alone".

The object of the present invention is to obviate the aforesaid drawbacks by providing a multi-phase pumping device which allows effective pumping of any multi-phase fluid of any gas content in a simple and reliable manner without the need for additional equipment, and with high efficiency and hence low energy consumption.

This is substantially attained in that the pumping of the liquid by the device of the invention is effected simultaneously with but separately from the compression of the gas contained in the multi-phase fluid to be pumped.

More specifically, besides being centrifuged by an eccentric bladed impeller and hence undergoing pres-

sure increase by the conversion of its kinetic energy into pressure energy within a tube with its cross-section orientated approximately perpendicular to the direction of circulation of said liquid part, ie substantially a Pitot tube positioned at the periphery of the peripherally toroidal disc casing of said multi-phase pumping device, the liquid part of the fluid to be pumped forms, concentric with the axis of said casing, a liquid ring which by rotating rigidly with said blades forms a peripheral seal for the gas of said fluid contained in the spaces between said blades, the volume of these spaces decreasing progressively from the intake pipe to the gas delivery pipe, so that the gas undergoes compression.

The liquid and gas delivery pipes are provided with suitable valves able to automatically close the pipes at certain pressures.

This makes it possible to achieve effective high-efficiency pumping of a fluid consisting only of liquids following automatic closure of the valve in the gas delivery pipe, and also effective high-efficiency compression of a fluid consisting only of gas following automatic closure of the valve in the liquid delivery pipe.

Hence, the pumping device for a multi-phase fluid, comprising a disc casing on the inner periphery of which there is provided a tube of Pitot tube type connected to a delivery pipe, an intake pipe for said multi-phase fluid being connected to said casing in correspondence with the axis of this latter, is characterised according to the present invention in that said casing, of toroidal peripheral profile, is fixed and within it there is rotated by a motor a bladed impeller mounted eccentrically to said casing axis, in a position approximately diametrically opposite said Pitot tube, a second delivery pipe being provided in that casing region opposite said intake pipe about the plane containing both the axis of said casing and the axis of said impeller and in proximity to this latter axis, the two said delivery pipes each being provided with an automatic valve.

The invention is described in detail hereinafter with reference to the accompanying drawings, which illustrate a preferred embodiment thereof by way of non-limiting example only, in that technical or constructional modifications can be made thereto but without leaving the scope of the present invention.

In said drawings:

Figure 1 is a partly sectional perspective view of a multi-phase pumping device constructed in accordance with the invention;

Figure 2 is a side sectional view of the device of Figure 1;

Figure 3 is a front sectional view on the line AA of Figure 2.

In the figures the reference numeral 1 indicates the disc casing of the multi-phase pumping device. Said casing 1 is fixed on supports 2 and 3 and has a toroidal peripheral profile 4. Within the casing 1 on its inner pe-

ripheral surface there is provided a tube orientated with its cross-section approximately perpendicular to the direction of circulation of the liquid part 22 of the multi-phase fluid to be pumped, and hence substantially a Pitot tube 5, which is connected to a delivery pipe 6 provided with an automatic valve 7, there being connected to the disc casing 1 in proximity to its axis 10 a multi-phase fluid intake pipe 8, also provided with an automatic valve 9. A bladed impeller 11 is mounted eccentrically to said axis 10 inside the casing 1, and is rotated in the direction of the arrow 19 by a motor 12 (see specifically Figure 3) which drives the impeller shaft 13. Said eccentricity of the impeller 11 is such that the casing axis 14 is in a position approximately diametrically opposite said Pitot tube 5. Finally, in proximity to said impeller axis 14 in that casing region opposite said intake pipe 8 about the plane containing both the casing axis 10 and the impeller axis 13, this plane being indicated by the dashed and dotted line 15, there opens at 16 a second delivery pipe 17, also provided with an automatic valve 18.

The method of operating the multi-phase pumping device is as follows.

The multi-phase fluid which enters the chamber 20 defined by the casing 1 via the automatic valve 9, the pipe 8 and the entry hole 21, is rotated by the blades 11 of the eccentric impeller rotating in the direction of the arrow 19 about its axis 13, with the result that its liquid part 22 is centrifuged to form a liquid ring concentric with the axis 10 of the casing 1, the inner surface 23 of which forms a peripheral seal for the gas 24 of said fluid, which remains contained within the region 25 in the spaces between said blades 11. However as the volume of said spaces decreases progressively from the intake pipe 8 to the delivery pipe 17, said gas undergoes compression and therefore flows from the pipe 17 at a pressure which is higher the greater the reduction in the volume of said spaces. That part of the centrifuged liquid which enters the Pitot tube converts its kinetic energy into pressure.

If however said multi-phase fluid is reduced to only a liquid phase, said liquid ring increases in thickness and tends to occupy the entire said chamber 20 until the insufficient pressure created in said region 25 causes the valve 18 to close, providing optimum high-efficiency pumping of the liquid.

If the multi-phase fluid is reduced to only a gaseous phase, said liquid ring decreases in thickness until the insufficient pressure at the Pitot tube causes the valve 7 to close before the seal against the impeller blades is broken, so allowing optimum high-efficiency compression of the gas.

The advantages of such a device are immediately apparent.

Firstly there are no limits on the volumetric gas content acceptable by the device. In addition the theoretical work of compression of the gas is reduced to a minimum because the heat generated during the compression consequent on the reduction in the volume between two successive blades is progressively removed by the liq-

uid ring which rotates rigidly with the blades, so enabling an almost isothermal compression to be achieved, with a reduction in the work of compression of the order of 15-20% on that of usual polytropic compression. In addition, as the gas compression and the liquid pumping are effected separately, the efficiencies of these operations are comparable with or only slightly less than the efficiencies of separately operating devices, ie liquid ring gas compressors and Pitot tube pumps for liquid pumping.

Claims

1. A pumping device for a multi-phase fluid with any gas content, especially for multi-phase fluids coming from hydrocarbon reservoirs, comprising a disc casing (1) of toroidal peripheral profile (4), a bladed impeller (11) mounted eccentrically to said casing (1), an entry hole (21) connected to the intake pipe (8) for the multi-phase fluid, two delivery ports connected to the delivery pipes (6, 17), a port (16) of the delivery pipe (17) located in proximity to the impeller axis (14) and opposite to the intake pipe (8); the internal chamber (20) of the pumping device being divided into an external liquid ring (22) and an internal region (25) between the blades (11) in which the gaseous phase is contained, characterised in that the internal region (25) contains the gaseous phase as bubbles (24) dispersed into the liquid phase, pumped multi-phase fluid being delivered from the internal region (25) by the port (16); in that the part of the centrifuged liquid is delivered by the Pitot tube (5) through the pipe (6), said delivery pipe (6) being located eccentrically and in a position diametrically opposite to the axis (14) of impeller (11), and in that the delivery pipes (6, 17) are provided with automatic valves (7, 18), of which the valve (7) is automatically closed when the multi-phase fluid is reduced to only a gaseous phase and the valve (18) is automatically closed when the multi-phase fluid is reduced to only a liquid phase, so allowing compression of the gas phase or pumping of the liquid phase respectively.

Patentansprüche

1. Pumpvorrichtung für ein Mehrphasenfluid mit einem beliebigen Gasgehalt, insbesondere für Mehrphasenfluide, die von Kohlenwasserstoff-Reservoirs kommen, mit einem Scheibengehäuse (1) mit einem ringförmigen Umfangprofil (4), einem mit Schaufeln versehenen Pumpenrad (11), das exzentrisch an dem Gehäuse (1) angebracht ist, einem Eintrittsloch (21), das mit dem Einlaßrohr (8) für das Mehrphasenfluid verbunden ist, zwei Lieferöffnungen, die mit den Lieferrohren (6, 17) verbunden

sind, einer Öffnung (16) des Lieferrohres (17), die in der Nähe der Pumpenradachse (14) und gegenüberliegend zu dem Einlaßrohr (8) angeordnet ist; wobei die innere Kammer (20) der Pumpvorrichtung in einen äußeren Flüssigkeitsring (22) und einen inneren Bereich (25) zwischen den Schaufeln (11) aufgeteilt ist, in dem die gasförmige Phase enthalten ist,

dadurch **gekennzeichnet**,

daß der innere Bereich (25) die gasförmige Phase als Blasen (24) enthält, die in die flüssige Phase dispergiert sind, wobei gepumptes Mehrphasenfluid von dem inneren Bereich (25) durch die Öffnung (16) geliefert wird; daß der Teil der zentrifugierten Flüssigkeit mittels dem Staurohr (5) durch das Rohr (6) geliefert wird, wobei das Lieferrohr (6) exzentrisch und in einer Position diametral gegenüberliegend zu der Achse (14) des Pumpenrades (11) angeordnet ist, und daß die Lieferrohre (6, 17) mit automatischen Ventilen (7, 18) versehen sind, von denen das Ventil (7) automatisch geschlossen wird, wenn das Mehrphasenfluid auf nur eine gasförmige Phase reduziert ist und das Ventil (18) automatisch geschlossen wird, wenn das Mehrphasenfluid auf nur eine flüssige Phase reduziert ist, wodurch so eine Komprimierung der Gasphase bzw. ein Pumpen der flüssigen Phase ermöglicht wird.

Revendications

1. Dispositif de pompage pour un fluide en phase multiple ayant une teneur quelconque en gaz, en particulier pour des fluides en phase multiple provenant de réservoirs d'hydrocarbures, comprenant une enveloppe en forme de disque (1) ayant un profil périphérique toroïdal (4), une roue munie de pales (11) montée excentriquement sur ladite enveloppe (1), un trou d'entrée (21) relié à la conduite d'admission (8) pour le fluide en phase multiple, deux orifices de refoulement reliés aux conduites de refoulement (6, 17), un orifice (16) de la conduite de refoulement (17) situé à proximité de l'axe (14) de la roue et opposé à la conduite d'admission (8); la chambre interne (20) du dispositif de pompage étant divisée en un anneau externe de liquide (22) et en une zone interne (25) entre les pales (11) dans laquelle la phase gazeuse est contenue, caractérisé en ce que la zone interne (25) contient la phase gazeuse sous forme de bulles (24) dispersées dans la phase liquide, le fluide en phase multiple pompé étant refoulé à partir de la zone interne (25) par l'orifice (16); en ce que la partie du liquide centrifugé est refoulée par le tube de Pitot (5) à travers la conduite (6), ladite conduite de refoulement (6) étant située excentriquement et dans une position diamétralement opposée à l'axe (14) de la roue (11), et en ce que les conduites de refoulement (6, 17) sont

munies de soupapes automatiques (7, 18), parmi lesquelles la soupape (7) est fermée automatiquement lorsque le fluide en phase multiple est réduit à seulement une phase gazeuse et la soupape (18) est fermée automatiquement lorsque le fluide en phase multiple est réduit à seulement une phase liquide, permettant ainsi la compression de la phase gazeuse ou le pompage de la phase liquide, respectivement.

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Fig.1



