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(71) Applicant: **Sandvik SRP AB**
233 81 Svedala (SE)

(72) Inventors:
- **JOHANSSON, Jan A**
  23381 Svedala (SE)
- **LARSSON, Per-Ola**
  23381 Svedala (SE)
- **SJÖBERG, Patrik**
  23381 Svedala (SE)

(74) Representative: **Sandvik**
Sandvik Intellectual Property AB
811 81 Sandviken (SE)

(54) REDUCED CRUSHING FORCE VARIATION IN CRUSHERS

(57) In one aspect there is provided a crusher system (1) comprising a first crushing surface (6) and a second crushing surface (14), the two crushing surfaces (6, 14) being operative for crushing material between them, the crusher system further comprising a hydraulic system (16) which is operative for adjusting a gap (12) between the first crushing surface (6) and the second crushing surface (14) by adjusting the position of the first crushing surface (6) by means of a hydraulic cylinder (10) connected to said first crushing surface (6), wherein said hydraulic system (16) further comprises at least one accumulator (26) connected to the hydraulic cylinder (10) by means of a hydraulic fluid conduit (42), wherein the relation between the length (L) of the conduit (42) and the cross-sectional inner area (A) of the conduit (42) fulfills the condition: L/A < 425.

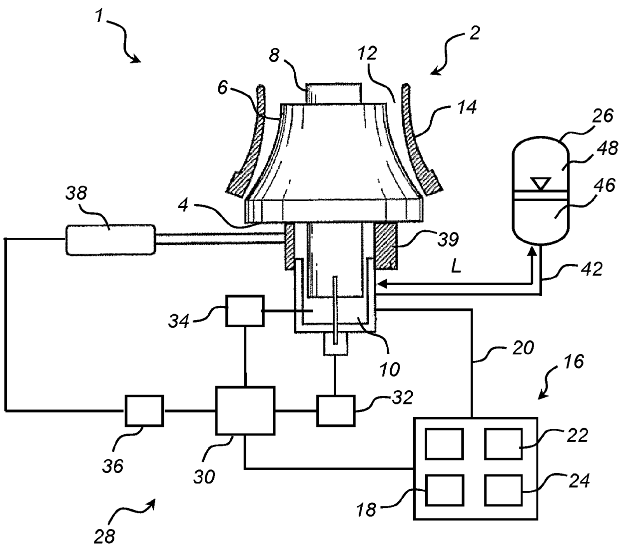

FIG.1

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a crusher system comprising a first crushing surface and a second crushing surface, the two crushing surfaces being operative for crushing material between them, the crusher system further comprising a hydraulic system which is operative for adjusting a gap between the first crushing surface and the second crushing surface by adjusting the position of the first crushing surface by means of a hydraulic cylinder connected to said first crushing surface. The present invention further relates to a method of crushing material between a first crushing surface and a second crushing surface.

BACKGROUND

[0002] Crushers are utilized in many applications for crushing hard material, such as rock, ore etc. One type of crusher is the gyratory crusher, which has a crushing head which is forced to gyrate inside a fixed crushing shell. A crushing chamber, into which pieces of rock are to be fed, is formed between a crushing mantle, which is supported by the crushing head, and the crushing shell. The width of the crushing chamber, often referred to as the gap or the setting of the crusher, may be adjusted by means of a hydraulic arrangement, also referred to as a hydroset mechanism. During the crushing of rock, ore etc. the crusher is subjected to large load variations. Such load variations cause wear, including metal fatigue, in the crusher, and may decrease the life of the crusher. GB 1 517 963 discloses a gyratory crusher having a hydraulic cylinder or an air cylinder for preventing overload situations. A pressure buffer is operative for accommodating sudden heavy load changes in the hydraulic system. The pressure buffer is connected to the hydraulic system and by a point of constriction provided between the cylinder and the pressure buffer. Document EP2271427 B1 discloses a crusher system comprising an accumulator for attenuating variations occurring in the hydraulic pressure of the hydraulic cylinder.

[0003] Although the prior art may as such present functioning systems, there is a need for a crusher system having improved longevity and reduced crushing force variations.

SUMMARY

[0004] Accordingly, objects of the present invention include to provide an improved crusher system having the advantages of the prior art systems whilst improving on drawbacks.

[0005] It has been found that these and other objects have been achieved by the configuration set forth in the appended claim 1. Further preferred embodiments are set forth in the dependent claims, the appended items section and in the description from which yet further advantages will become apparent. Embodiments disclosed herein may, unless otherwise is explicitly stated, be combined to yield still further embodiments without departing from the scope of the invention.

[0006] In one aspect there is provided a crusher system comprising a first crushing surface and a second crushing surface, the two crushing surfaces being operative for crushing material between them, the crusher system further comprising a hydraulic system which is operative for adjusting a gap between the first crushing surface and the second crushing surface by adjusting the position of the first crushing surface by means of a hydraulic cylinder connected to said first crushing surface, wherein said hydraulic system further comprises at least one accumulator connected to the hydraulic cylinder by means of at least one hydraulic fluid conduit for attenuating variations occurring in the hydraulic pressure of the hydraulic cylinder during operation of the crusher system.

[0007] In one embodiment the relation between the length L of the at least one hydraulic fluid conduit and the cross-sectional inner area A of the at least one conduit fulfills the condition:

$$\frac{L}{A} < 425$$

[0008] By the above configuration there is provided a crusher system wherein variations in crushing force are minimized and longevity is improved.

[0009] The hydraulic fluid conduit may have an oversized diameter, in particular an oversized inner diameter. In any embodiment, the inner diameter of the hydraulic fluid conduit may be greater than 2 inches.

[0010] The cross sectional shape of the hydraulic fluid conduit may preferably have a circular shape, however other shapes are conceivable, such as elliptical, rectangular, square, pentagonal, hexagonal etc.

[0011] In any embodiment, the crusher system comprises a plurality of accumulators connected to the hydraulic cylinder by means of a plurality of said hydraulic fluid conduits, wherein the cross sectional inner area A is calculated based on a single pipe equivalent diameter De of the plurality of hydraulic fluid conduits.

[0012] The term "conduit" may henceforth denote a hydraulic fluid conduit.

[0013] In the preceding embodiment, the said plurality of conduits may connect to the hydraulic cylinder at respective positions that are evenly distributed around the hydraulic cylinder, such as around a circumference of the hydraulic cylinder.

[0014] A respective accumulator of the plurality of accumulators may be connected to the hydraulic cylinder by means of a respective conduit of the plurality of conduits.

[0015] In any embodiment, a respective inner diameter of a conduit of the at least one conduit may be in the range of 2 to 4 inches, such as 3 Inches.

[0016] In any embodiment, a respective length L of a conduit of the at least one conduit may be equal to or less than 2.5 meters.

[0017] The accumulator may be one of a bladder accumulator, a diaphragm accumulator and a piston accumulator, the accumulator comprising a gas compartment and a hydraulic fluid compartment separated by a separator.

[0018] The accumulator may comprise an accumulator body and a mechanical protection mechanism for damping or preventing or damping and preventing impact between the separator and the accumulator body.

[0019] In any embodiment, the mechanical protection mechanism may be configured to restrict fluid communication between the hydraulic fluid compartment and the hydraulic conduit in response to the separator approaching close proximity of an outlet portion of the accumulator body, for preventing impact between the separator and the accumulator body.

[0020] The accumulator may be a piston accumulator and the separator is a piston, wherein the mechanical protection mechanism comprises a protruding damping nose provided on the piston and a (corresponding) recess provided in the outlet portion.

[0021] In any embodiment, the hydraulic system may further comprises a dump valve, such as an electric dump valve, configured to drain hydraulic fluid/fluid, such as oil, out of the hydraulic fluid compartment to an oil tank of the hydraulic system.

[0022] The crusher system may further comprise a control system configured to, during unloading of the crusher, maintain the dump valve in an open position during a set amount of time or until a certain minimum gap between crushing surfaces (CSS) is reached.

[0023] The accumulator may have a preloading pressure, being the pressure of the gas compartment when the hydraulic fluid compartment is empty, which is at least 0.3 MPa lower than the mean operating pressure of the hydraulic cylinder 10.

[0024] In a second aspect, the disclosure pertains to a crusher station a crusher station comprising a crusher system according to any one of the embodiments of the first aspect, at least one screening device, and one or more conveyors.

[0025] In a third aspect the disclosure pertains to a method for operating a crusher system, such as a crusher system according to any embodiment of the aspects of the disclosure, the method comprising:

during loading operations, allowing the first crushing surface to be displaced downwards by means of crushing forces to cause filling of the hydraulic fluid compartment with hydraulic fluid and to increase the pressure in the hydraulic fluid compartment.

[0026] In any embodiment, the said displacement downwards of the first crushing surface may be facilitated by setting the gap to be smaller than a desired gap for the current crushing operation.

[0027] In one embodiment, the hydraulic system may further comprise a dump valve configured to drain oil out of the hydraulic fluid compartment, and the method may further comprise: during unloading operations, maintaining the dump valve in an open configuration during a set amount of time or until a certain gap is reached. The crusher may be considered to be unloading when the gap is less than 3 mm.

[0028] These and other aspects of the disclosure will be apparent from and elucidated with reference to the claims and the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] So that the manner is which the above recited features of the present disclosure can be understood in detail, a more particular description of the disclosure, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical or contemplated embodiments of this disclosure and are therefore not to be considered limiting of its scope, for the disclosure may admit to other equally effective embodiments.

FIG.1 is a schematic side view and illustrates a crusher system.

FIG.2 is a schematic view of details of a crusher system and illustrates an accumulator connected to a hydraulic cylinder according to an embodiment of the disclosure.

FIG.3 is a schematic view of details of a crusher system and illustrates a plurality of accumulators separately connected to a hydraulic cylinder, according to an embodiment of the disclosure.

FIG.4 is a schematic view of details of a crusher system according to an embodiment of the disclosure.

FIG.5 is a schematic side view of details of a crusher system and illustrates a plurality of accumulators connected to a hydraulic cylinder by means of a common conduit, according to an embodiment of the disclosure.

FIG.6 is a cross-sectional view of a piston accumulator comprising a mechanical protection mechanism, in accordance with an embodiment of the disclosure.

FIG.7 is a schematic illustration of a crusher station according to an embodiment of the disclosure.

FIG.8 is a diagrammatic illustration of a method of operating a crusher system according to an embodiment of the disclosure.

DETAILED DESCRIPTION

[0030] A crusher system and a method of operating a crusher system will now be described with reference to the drawings. In the drawings, like members are denoted by like reference numerals. Constituent features denoted by the same reference numerals in different drawings are to be understood as to have the same functions.

[0031] FIG.1 illustrates a crusher system 1 according to an exemplary embodiment of the disclosure. The crusher system 1 comprises a gyratory crusher 2, which is per se known in the prior art, see for example GB 1 517 963. The gyratory crusher 2 comprises a crushing head 4, which supports a first crushing surface formed on a crushing mantle 6 and which is fixed to a vertical shaft 8. The crushing head 4, being fixed to the vertical shaft 8, is movable in the vertical direction by means of a hydroset mechanism comprising a hydraulic cylinder 10 in shape of a hydraulic cylinder connected to the lower part of the shaft 8. The hydraulic cylinder 10 makes it possible to adjust the width of a gap 12 formed between the crushing mantle 6 and a second crushing surface formed on a stationary crushing shell 14, which surrounds the crushing mantle 6.

[0032] The crusher system 1 further comprises a hydraulic system 16. The hydraulic system 16 comprises a pump 18, which is operative for pumping hydraulic fluid to or from the hydraulic cylinder 10 via a pipe 20. A dump valve 22 is operative for rapidly dumping hydraulic fluid from the hydraulic cylinder 10, in particular in the event of overload of the gyratory crusher 2. The dump valve 22 is operative for dumping the hydraulic fluid into a tank 24, which may also serve as a pump sump for the pump 18. The dump valve 22 may be opened by means of a solenoid valve.

[0033] The hydraulic system 16 also comprises at least one accumulator 26, that may be connected to the hydraulic cylinder 10 as shown in the exemplary embodiment of FIG.1. Embodiments of the accumulator 26 will be described in more detail hereinafter.

[0034] The dump valve 22 may be an electric dump valve, configured to drain hydraulic fluid/fluid, such as oil, out of the hydraulic fluid compartment 46 to an oil tank 24 of the hydraulic system 16.

[0035] The crusher system 1 further comprises a control system 28. The control system 28 comprises a control device 30 which is operative for receiving various signals indicating the operation of the gyratory crusher 2. Thus, the control device 30 is operative for receiving a signal from a position sensor 32 which indicates the present vertical position of the vertical shaft 8. From this signal the width of the gap 12 can be calculated.

[0036] The control system 30 is configured to, during unloading of the crusher 2, maintain the dump valve 22 in an open position during a set amount of time or until a certain minimum gap 12 between crushing surfaces is reached.

[0037] Furthermore, the control device 30 is operative for receiving a signal from a pressure sensor 34, indicating the hydraulic pressure in the hydraulic cylinder 10. Based on the signal from the pressure sensor 34 the control device 30 can calculate the actual mean operating pressure and the peak pressure of the gyratory crusher 2.

[0038] The control device 30 may also receive a signal from a power sensor 36, which is operative for measuring the power supplied to the gyratory crusher 2 from a motor 38, which is operative for making the vertical shaft 8 gyrate in a per se known manner.

[0039] The gyratory movement of the vertical shaft 8 is accomplished by the motor 38 driving an eccentric 39, which is arranged around the vertical shaft 8 in a per se known manner, and which is schematically illustrated in FIG.1. The power sensor 36 may also send a signal to the control device 30 indicating the number of rounds per second (in the unit 1/s or Hz), fr, of the eccentric 39.

[0040] The control device 30 is operative for controlling the operation of the pump 18, for example in an on/off manner, or in a proportional manner, such that the pump 18 supplies an amount of hydraulic fluid to the hydraulic cylinder 10 that generates a desired vertical position of the vertical shaft 8, and a desired width of the gap 12.

[0041] The control device 30 is also operative for controlling the opening of the dump valve 22. High pressure peaks, such as peaks caused by tramp entering the gap 12, are handled by the control device 30 sending a signal to the dump valve 22 to the extent that immediate opening is required.

[0042] Thus, in the crusher system 1 long term variations in the hydraulic pressure, e.g., variations that occur over time spans of 1 second and more, are handled by the control device 30 controlling the pump 18. High, and sudden, pressure peaks, caused by, e.g., tramp, are handled by the control device 30 controlling the dump valve 22.

[0043] Generally, a pressure curve of the hydraulic fluid pressure measured by the sensor 34, when operating the gyratory crusher may comprise various pressure components. In particular, a first component reflecting the mean operating pressure, a second component denoted the synchronous or sinusoidal component caused by the gyratory movement of the vertical shaft, and a third component representing a high frequency component caused by the nature of the crushing process itself.

[0044] Aptly, the accumulator 26 is designed to at least to some extent attenuate the second and third component, whereby the mean operating pressure can be maximized such that the gyratory crusher operates in an efficient manner.

[0045] FIG.2 illustrates details of the crusher system 1 including the accumulator 26 connected to the hydraulic cylinder 10 as has been explained hereinbefore. The accumulator 26 comprises an accumulator body 40 which is connected to the conduit 42. The conduit 42 may be one of a hydraulic pipe and a hydraulic hose or any means or element suitable for providing an equivalent function, wherein the term "hydraulic" denotes that it is suitable for use in a hydraulic system.

[0046] The accumulator body 40 has a movable separator 44 which separates a hydraulic fluid compartment 46 from a pressurized gas compartment 48. The conduit 20 is connected to the hydraulic cylinder 10 illustrated hereinbefore with reference to FIG.1. Thus, the pressure changes occurring in the hydraulic cylinder 10 as a result of the crushing of material in the gyratory crusher 2 will propagate through the conduit 42 and will influence the hydraulic fluid compartment 46 of the accumulator body 40.

[0047] Aptly, attenuation of the second and third component may be facilitated by configuring the accumulator with a preloading pressure, being the pressure of the gas compartment 48 of the accumulator 26 when the hydraulic fluid compartment 46 of the accumulator 26 is empty, which is at least 0.3 Mpa lower than the mean operating pressure of the hydraulic cylinder 10, such that the accumulator 26 is active and variations occurring in the hydraulic pressure of the hydraulic cylinder 10 during operation of the crusher 1 are attenuated.

[0048] Preferably, the preloading pressure of the accumulator is 0.3 to 1 MPa lower than the mean operating pressure of the hydraulic cylinder 10. The control device 30 may be operative for controlling the preloading pressure of the accumulator in view of an actual mean operating pressure of the hydraulic cylinder 10.

[0049] The prospect of obtaining a suitable operation of the accumulator 26 it is also facilitated if the accumulator 26 demonstrates a rapid response to pressure variations, as will be explained hereinafter. By this is meant that variations in the volume of hydraulic fluid in the accumulator 26 occur as soon as possible after a pressure variation has occurred in the hydraulic cylinder 10, which has been described hereinbefore with reference to FIG.1.

[0050] During each revolution of the vertical shaft 8, the hydraulic cylinder 10 may typically experience a minimum and a maximum pressure whereby ideally the flow between the hydraulic cylinder 10 and the accumulator 26 needs to reverse twice during the event of the revolution in order to facilitate a constant crushing pressure. Thus, the hydraulic system 16 needs to enable rapid flow reversals between the hydraulic cylinder 10 and the accumulator 26.

[0051] The crusher system 1 needs to quickly adapt to various types of material being fed into the crusher chamber. The material may be an aggregate of materials or pieces of material that differ in size, hardness etc., hence is more or less difficult to crush. By way of example, in the event that a relatively soft material or small pieces of material is located in the gap 12, the hydraulic cylinder 10 may typically experience a drop in pressure due to lower resistance of the material or the smaller size, and the position of the mantle 6 needs to be adjusted upwards in order to apply constant crushing force.

[0052] Conversely, in the event that a relatively hard material is located in the gap 12, the hydraulic cylinder may experience an increase in pressure and the position of the mantle 6 needs to be adjusted downwards accordingly in order to apply constant crushing force.

[0053] A short response time to the variations in pressure in the hydraulic cylinder 10 may be facilitated by adjusting the distance L as seen in FIG.1 such that the accumulator 26 is arranged close to the hydraulic cylinder 10 in accordance with the condition of Equation 2.1:

$$L \leq \frac{v}{20 \times f_r} \qquad \text{[Eq. 2.1]}$$

[0054] The following parameters are included in this equation: v = velocity of sound in hydraulic fluid, unit: [m/s]. fr = number of rounds per second of the eccentric, see FIG.1, unit: [Hz]. L is the distance, as seen along the hydraulic fluid path between the hydraulic cylinder 10, such as the bore side, and the accumulator 26, in particular the hydraulic fluid compartment 46. Hence, the conduit 42 has a length corresponding to distance L. Accordingly, in any embodiment the distance L may be configured to fulfill the condition of Eq.2.1.

[0055] According to aspects of the disclosure, consideration additional parameters other than the distance L translates to improvements in the actual rate of mechanical adjustment of the mantle 6.

[0056] In particular, aspects of the disclosure proposes that by facilitating changes in flow rate (i.e. acceleration) of hydraulic fluid in the hydraulic system 16 this advantageously improves response time of the hydraulic system.

[0057] Consideration of the said acceleration of hydraulic fluid has been made in particular between the hydraulic fluid compartment 46 of the accumulator 26 and the hydraulic cylinder 10.

[0058] Aptly, the rate of change in flow rate is an active design parameter and may hence constitute a parameter that at least to some extent dictates the choice and/or dimensioning of certain components, such as the conduit(s) 42. For example, the dimensioning of the conduit 42 may be purposefully selected or chosen based on a value relating to one or more of a desired acceleration of fluid therein and a desired actual rate of mechanical adjustment of the mantle 6. This methodology contrasts to prior art systems that do not consider such acceleration.

[0059] A sufficiently high acceleration of the hydraulic fluid advantageously enables a rapid influx of hydraulic fluid into the hydraulic cylinder 10 and vice versa a rapid outflux of hydraulic fluid from the hydraulic cylinder 10, such that a rapid mechanical adjustment of the mantle 6, and hence the first crushing surface, may be achieved.

[0060] The rapid adjustment of the mantle 6 advantageously enables the crusher system 1 to operate with a more constant crushing force.

[0061] Generally, relating to hydraulic systems, the term hydraulic inductance Lh describes the pressure difference required for a change in flow rate (acceleration) and based on the mass inertia as expressed in Equation 2.2:

$$Lh = \frac{\ell \cdot \rho}{A} \qquad [Eq.2.2]$$

where ℓ = length and *A* = cross section of the column of hydraulic fluid.

[0062] In view of the above, the required pressure difference to accelerate the hydraulic fluid may be reduced by increasing the cross-sectional area A. Accordingly, increasing the area at a given pressure results in greater change in flow rate, hence greater acceleration.

[0063] According to aspects of the present disclosure the connecting conduit 42 is dimensioned considering both the distance L and the cross-sectional area A of conduit 42 since a greater cross-sectional area A facilitates a greater force F to accelerate the hydraulic fluid according to Equation 2.3:

$$F = P \times A \qquad [Eq.2.3]$$

where A is calculated based on an inner diameter D of the conduit 42 by means of Equation 2.4:

$$A = \frac{\pi D^2}{4} \qquad [Eq.2.4]$$

[0064] Aptly, in any embodiment the distance L may be equal to or less than 2.5 meters.

[0065] In any embodiment, wherein the hydraulic system 16 comprises two or more accumulators 26, a respective hydraulic distance L between each of the accumulators and the hydraulic cylinder 10 may be essentially equal, or equal.

[0066] Aptly, in any embodiment the inner diameter D of the conduit 42 may be greater than 2 inches.

[0067] Aptly, in any embodiment the inner diameter D of the conduit 42 may be equal to or less than 4 inches.

[0068] In any embodiment, the inner diameter D may be in the range of 2 to 4 inches, such as 3 inches.

[0069] It should be appreciated that the inner diameter D referred to herein may be a single pipe equivalent diameter De. It should further be appreciated that the distance L referred to herein may be a single pipe equivalent length Le. These concepts are known to the skilled person and it lies within his skills to determine such single pipe equivalent diameter and single pipe equivalent length.

[0070] More in particular, it has been found that the at least one conduit 42 connecting the at least one accumulator 26 should preferably be dimensioned to fulfill the condition Equation 2.5:

$$\frac{L}{A} < 425 \qquad [Eq.2.5]$$

where again, A is the cross-sectional area A of conduit 42, e.g. derived from Eq.2.4 based on the inner diameter D of the conduit 42 or, where applicable, a single pipe equivalent diameter De of a plurality of conduits 42, and L is the distance, as seen along the hydraulic fluid path between the hydraulic cylinder 10, such as the bore side, and the accumulator 26, in particular the hydraulic fluid compartment 46.

[0071] Referring to FIG.3, there is shown an exemplary embodiment comprising a plurality of accumulators 26, in particular two accumulators respectively, i.e. individually connected to the hydraulic cylinder 10 by means of a respective connecting conduit 42. It should be appreciated that it is within the capacity of the person skilled in the art of hydraulics to calculate the equivalent (single pipe) diameter of the pipes suitable for use in Eq.2.5

[0072] In an exemplary implementation of the crusher system according to the disclosure, the crusher 2 is a Sandvik CH430 cone crusher and the crusher system comprises three accumulators of piston type, each having a capacity of 10 Liters. Three hydraulic fluid conduits 42 are respectively provided in the form of a hydraulic hoses of equal length, in particular each being 1.2 meters in length and 3 inches in diameter. The three accumulators are connected individually to the hydraulic cylinder 10 of the hydroset mechanism of the cone crusher by a respective hydraulic hose of the three hydraulic hoses. This configuration is schematically illustrated in FIG.4.

[0073] Referring to FIG.5, there is shown a further exemplary embodiment comprising a plurality of accumulators, in particular embodiment two accumulators connected to the hydraulic cylinder 10 via two parallel conduits 42' and single conduit 42". In particular, the conduit 42 thus comprises the two parallel conduits 42' and the single conduit 42" where a respective accumulator is connected to the single conduit 42" by means of a respective of the parallel conduits 42'. This configuration may be advantageous for providing contingency of the system, should for example one accumulator fail.

[0074] Typically, when the accumulator(s) operate around the preloading pressure, the separator of the accumulator may impact a bottom portion, such as an outlet portion, of the accumulator in response to a pressure drop in the hydraulic cylinder causing the gas compartment to expand rapidly. Repeated such impact may be detrimental to the accumulator and thus the longevity of the attenuating function of the system. For example, certain known systems employ accumulators having a separator in the form of a flexible membrane which may rupture when impacting the bottom of the accumulator body when the crusher operates around the preloading pressure. It is known to employ a shut-off valve in the hydraulic connection such that the accumulator may be taken offline when the pressure in the hydraulic system is equal or lower than the preloading pressure. As such, this configuration is associated with drawbacks.

[0075] FIG.6 shows an accumulator according to an embodiment of the present disclosure. The accumulator is of piston type having a separator 44 in the shape of a piston 50. The accumulator comprises an accumulator body 47 having an outlet portion 60 fluidly connected to the hydraulic fluid compartment 48.

[0076] The accumulator comprises a mechanical protection mechanism 55 for damping or preventing or damping and preventing impact between the separator 44 and the accumulator body 47, such as an outlet portion 60 of the accumulator body 47. The damping effect may be achieved by facilitating that there is hydraulic fluid inside the accumulator body when the pressure in the hydraulic cylinder drops below the preloading pressure of the accumulator.

[0077] Thus, the mechanical protection may be configured for ensuring that there is hydraulic fluid inside the accumulator body when the pressure in the hydraulic cylinder drops below the preloading pressure of the accumulator.

[0078] The configuration of a mechanical protection mechanism provides for a design that is more robust against pressure variations around the preloading pressure during loading and unloading. Thereby, there is no need to disconnect the accumulator from the hydraulic cylinder during these phases.

[0079] The mechanical protection mechanism 55 is configured to restrict fluid communication between the hydraulic fluid compartment 46 and the hydraulic conduit 42 in response to the separator 44, 50 approaching close proximity of an outlet portion 60 of the accumulator body 47 for preventing impact between the separator and the outlet portion.

[0080] The mechanical protection mechanism in the particular embodiment of FIG.6 comprises a protruding damping nose 51 provided on the piston and a corresponding recess 61 provided in the outlet portion 60. As derivable from FIG.6, the damping nose 51 protrudes from the piston 50 towards the outlet portion 60.

[0081] It should be appreciated that the appended figures are schematical and that the conduits 42 may be equal in length, although not necessarily illustrated as such.

FIG.7 shows a crushing station 100 according to an embodiment of the disclosure.

The crushing station 100 comprising a crusher system 1 according to any aspect of the present disclosure. The crushing station 100 may further comprise at least one screening device (not shown) and one or more conveyors (not shown).

FIG.8 shows a method 200 of operating a crusher system, such as the crusher system 1 according to any embodiment of the first aspect.

[0082] The method comprising a step 201 of, during loading operations, allowing the first crushing surface 6 to be displaced downwards by means of crushing forces to cause filling of the hydraulic fluid compartment 46 with hydraulic fluid and to increase the pressure in the hydraulic fluid compartment 46.

[0083] The displacement downwards of the first crushing surface 6 may be facilitated by a step 202 of setting the gap 12 to be smaller than a desired gap for a present crushing operation.

[0084] The hydraulic system 16 may further comprises a dump valve 22 configured to drain oil out of the hydraulic fluid compartment 46. The method may further comprise a step 203 of, during unloading operations, maintaining the dump valve 22 in an open configuration during a set amount of time or until a certain gap 12 is reached.

[0085] It is understood that hydraulic symbols used in the appended drawings, such as accumulator symbols, are not intended to limit the scope of the disclosure but to serve as examples for the purpose of conveying the invention.

ITEMS

[0086] Item 1. A crusher system 1 comprising a first crushing surface 6 and a second crushing surface 14, the two crushing surfaces 6, 14 being operative for crushing material between them, the crusher system further comprising a hydraulic system 16 which is operative for adjusting a gap 12 between the first crushing surface 6 and the second crushing surface 14 by adjusting the position of the first crushing surface 6 by means of a hydraulic cylinder 10 connected to said first crushing surface 6,

wherein said hydraulic system 16 further comprises at least one accumulator 26 connected to the hydraulic cylinder 10 by means of at least one hydraulic fluid conduit 42 for attenuating variations occurring in the hydraulic pressure of the hydraulic cylinder (10) during operation of the crusher system (1).

[0087] Item 2. The crusher system 1 according to any preceding or subsequent item, wherein the relation between the length L of the at least one conduit 42 and the cross-sectional inner area A of the at least one conduit 42 fulfills the condition: $L/A < 425$.

[0088] Item 3. The crusher system 1 according to any preceding or subsequent item, comprising a plurality of accumulators 26 connected to the hydraulic cylinder 10 by means of a plurality of conduits 42, wherein the inner area A is calculated based on a single pipe equivalent diameter De of the plurality of conduits 42.

[0089] Item 4. The crusher system 1 according to any preceding or subsequent item, wherein a respective accumulator 26 of the plurality of accumulators is connected to the hydraulic cylinder 10 by means of a respective conduit 42 of the plurality of conduits.

[0090] Item 5. The crusher system 1 according to any preceding or subsequent item, wherein the inner diameter D of a respective conduit of the at least one conduit 42 is in the range of 2 to 4 inches, such as 3 Inches.

[0091] Item 6. The crusher system 1 according to any preceding or subsequent item, wherein the respective length L of a conduit of the at least one conduit (42) is equal to or less than 2.5 meters.

[0092] Item 7. The crusher system 1 according to any preceding or subsequent item, wherein the accumulator 26 is one of a bladder accumulator, a diaphragm accumulator and a piston accumulator, the accumulator 26 comprising a gas compartment 48 and a hydraulic fluid compartment 46 separated by a separator 44.

[0093] Item 8. The crusher system 1 according to any preceding or subsequent item, wherein the accumulator comprises an accumulator body 47 and a mechanical protection mechanism 55 for damping or preventing or damping and preventing impact between the separator 44 and the accumulator body 47.

[0094] Item 9. The crusher system 1 according to any preceding or subsequent item, wherein the mechanical protection mechanism is configured to restrict fluid communication between the hydraulic fluid compartment 46 and the hydraulic conduit 42 in response to the separator 44, 50 approaching close proximity of an outlet portion 60 of the accumulator body 47, for preventing impact between the separator and the accumulator body.

[0095] Item 10. The crusher system according to any preceding or subsequent item, wherein the accumulator is a piston accumulator and the separator 44 is a piston 50, wherein the mechanical protection mechanism comprises a protruding damping nose 51 provided on the piston and a (corresponding) recess 61 provided in the outlet portion 60.

[0096] Item 11. The crusher system according to any preceding or subsequent item, wherein the hydraulic system 16 further comprises a dump valve 22, such as an electric dump valve, configured to drain hydraulic fluid/fluid, such as oil, out of the hydraulic fluid compartment 46 to an oil tank 24 of the hydraulic system 16.

[0097] Item 12. The crusher system according to any preceding or subsequent item, further comprising a control system 30 configured to, during unloading of the crusher 2, maintain the dump valve 22 in an open position during a set amount of time or until a certain minimum gap 12 between crushing surfaces (CSS) is reached.

[0098] Item 13. The crusher system according to any preceding or subsequent item, wherein the accumulator 26 has a preloading pressure, being the pressure of the gas compartment 48 when the hydraulic fluid compartment 46 is empty, which is at least 0.3 MPa lower than the mean operating pressure of the hydraulic cylinder 10.

[0099] Item 14. A crushing station 100 comprising a crusher system 1 according to any one of the preceding items, at least one screening device and one or more conveyors.

[0100] Item 15. Method for operating a crusher system, such as a crusher system according to any one of the preceding items, the method comprising a step 201 of, during loading operations, allowing the first crushing surface 6 to be displaced downwards by means of crushing forces to cause filling of the hydraulic fluid compartment 46 with hydraulic fluid and to increase the pressure in the hydraulic fluid compartment 46.

[0101] Item 16. The method according to the preceding item 15 or any subsequent item, wherein said displacement downwards of the first crushing surface 6 is facilitated by a step 202 of setting the gap 12 to be smaller than a desired gap for a present crushing operation.

[0102] Item 17. The method according to any one of the preceding items 15 to 16, wherein the hydraulic system 16 further comprises a dump valve 22 configured to drain oil out of the hydraulic fluid compartment 46, the method further comprising a step 203 of, during unloading operations, maintaining the dump valve 22 in an open configuration during a set amount of time or until a certain gap 12 is reached.

Claims

1. A crusher system (1) comprising a first crushing surface (6) and a second crushing surface (14), the two crushing surfaces (6, 14) being operative for crushing material between them, the crusher system further comprising a hydraulic system (16) which is operative for adjusting a gap (12) between the first crushing surface (6) and the second crushing surface (14) by adjusting the position of the first crushing surface (6) by means of a hydraulic cylinder (10) connected to said first crushing surface (6), wherein said hydraulic system (16) further comprises at least one accumulator (26) connected to the hydraulic cylinder (10) by means of at least one hydraulic fluid conduit (42), **characterized in that** the relation between the length (L) of the at least one conduit (42) and the cross-sectional inner area (A) of the at least one conduit (42) fulfills the condition:

$$\frac{L}{A} < 425$$

2. The crusher system (1) according to claim 1, comprising a plurality of accumulators (26) connected to the hydraulic cylinder (10) by means of a plurality of said conduits (42), wherein the inner area (A) is calculated based on a single pipe equivalent diameter (De) of the plurality of conduits (42).

3. The crusher system (1) according to claim 2, wherein a respective accumulator (26) of the plurality of accumulators is connected to the hydraulic cylinder (10) by means of a respective conduit (42) of the plurality of conduits.

4. The crusher system (1) according to any preceding claim, wherein the inner diameter (D) of a respective conduit of the at least one conduit (42) is in the range of 2 to 4 inches, such as 3 Inches.

5. The crusher system (1) according to any preceding claim, wherein the length (L) of a respective conduit of the at least one conduit (42) is equal to or less than 2.5 meters.

6. The crusher system (1) according to any one of the preceding claims, wherein the accumulator (26) is one of a bladder accumulator, a diaphragm accumulator and a piston accumulator, the accumulator (26) comprising a gas compartment (48) and a hydraulic fluid compartment (46) separated by a separator (44).

7. The crusher system (1) according to any one of the preceding claims, wherein the accumulator comprises an accumulator body (47) and a mechanical protection mechanism (55) for damping or preventing or for damping and preventing impact between the separator (44) and the accumulator body (47).

8. The crusher system (1) according to the preceding claim, wherein the mechanical protection mechanism is configured to restrict fluid communication between the hydraulic fluid compartment (46) and the hydraulic conduit (42) in response to the separator (44, 50) approaching close proximity of an outlet portion (60) of the accumulator body (47), for said damping or preventing impact between the separator and the accumulator body.

9. The crusher according to any one of the preceding claims, wherein the accumulator is a piston accumulator and the separator (44) is a piston (50), wherein the mechanical protection mechanism comprises a protruding damping nose (51) provided on the piston and a (corresponding) recess (61) provided in the outlet portion (60).

10. The crusher according to any one of the preceding claims, wherein the hydraulic system (16) further comprises a dump valve (22), such as an electric dump valve, configured to drain hydraulic fluid/fluid, such as oil, out of the hydraulic fluid compartment (46) to an oil tank (24) of the hydraulic system (16).

11. The crusher according to any one of the preceding claims, further comprising a control system (30) configured to, during unloading of the crusher (2), maintain the dump valve (22) in an open position during a set amount of time or until a certain minimum gap (12) between crushing surfaces (CSS) is reached.

12. The crusher according to any one of the preceding claims, wherein the accumulator (26) has a preloading pressure, being the pressure of the gas compartment (48) when the hydraulic fluid compartment (46) is empty, which is at least 0.3 MPa lower than the mean operating pressure of the hydraulic cylinder (10).

13. Method for operating a crusher system, such as a crusher system according to any one of the preceding claims 1 to 12, the method comprising:
during loading operations, a step (201) of allowing the first crushing surface (6) to be displaced downwards by means of crushing forces to cause filling of the hydraulic fluid compartment (46) with hydraulic fluid and to increase the pressure in the hydraulic fluid compartment (46).

14. The method according to the preceding claim 13, wherein said displacement downwards of the first crushing surface (6) is facilitated by a step (202) of setting the gap (12) to be smaller than a desired gap for a present crushing operation.

15. The method according to any one of the preceding claims 13 to 14, wherein the hydraulic system (16) further comprises a dump valve (22) configured to drain oil out of the hydraulic fluid compartment (46), the method further comprising:
during unloading operations, a step (203) of maintaining the dump valve (22) in an open configuration during a set amount of time or until a certain gap (12) is reached.

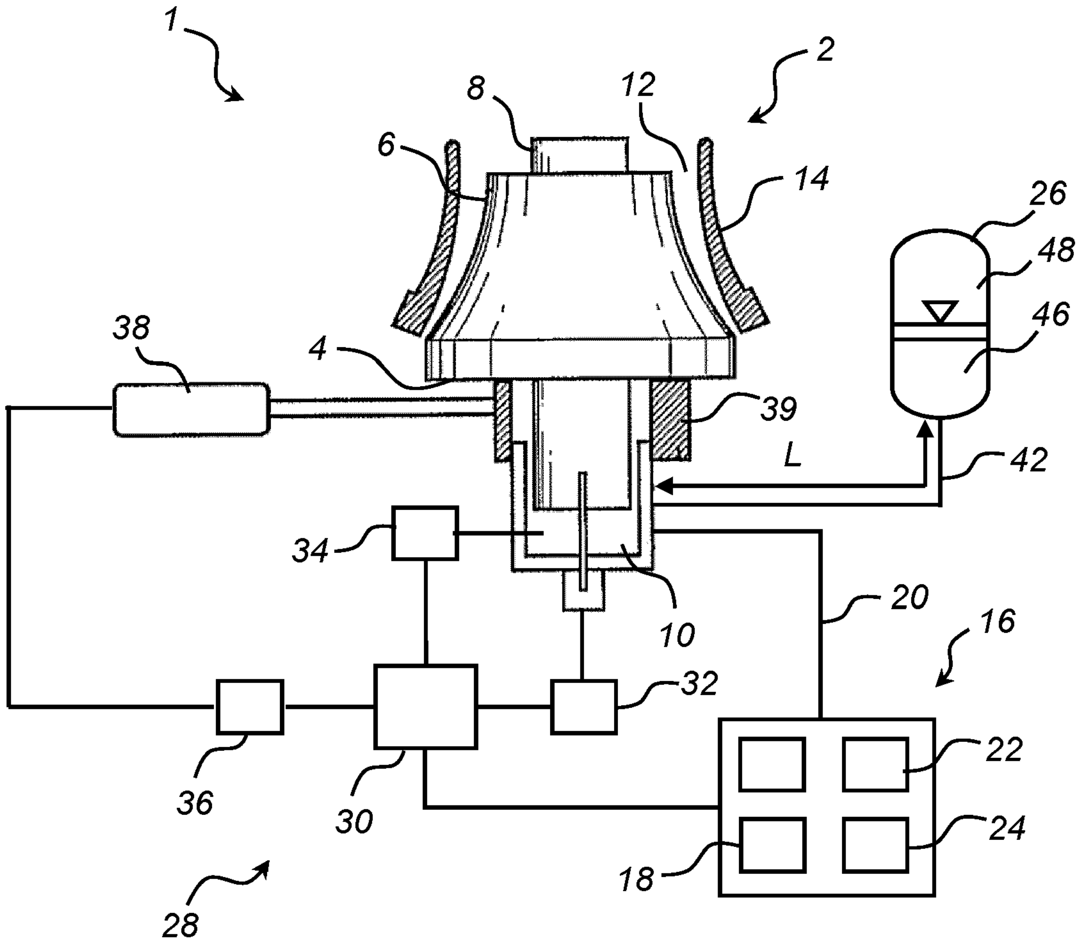

FIG.1

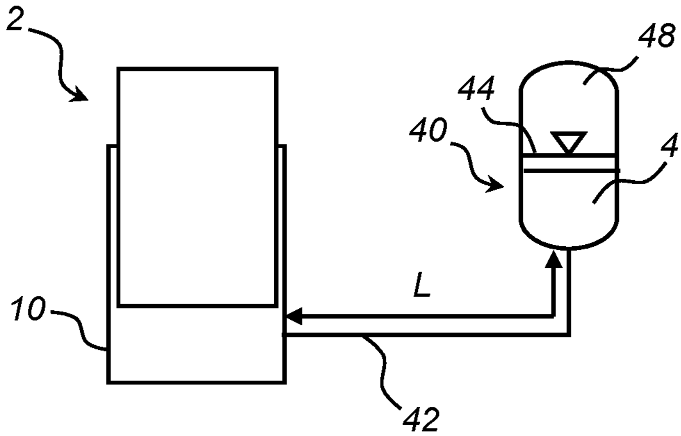

FIG.2

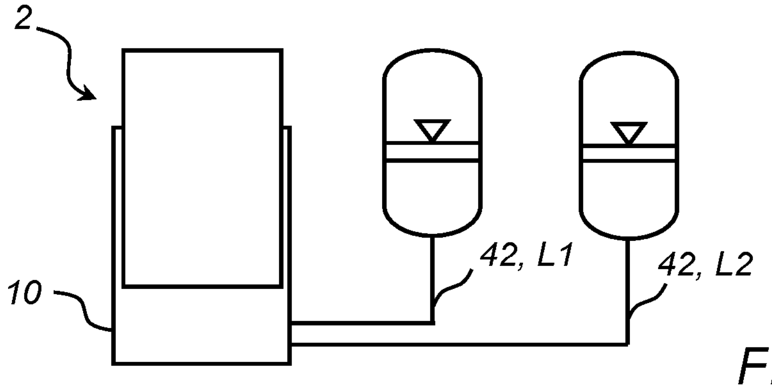

FIG.3

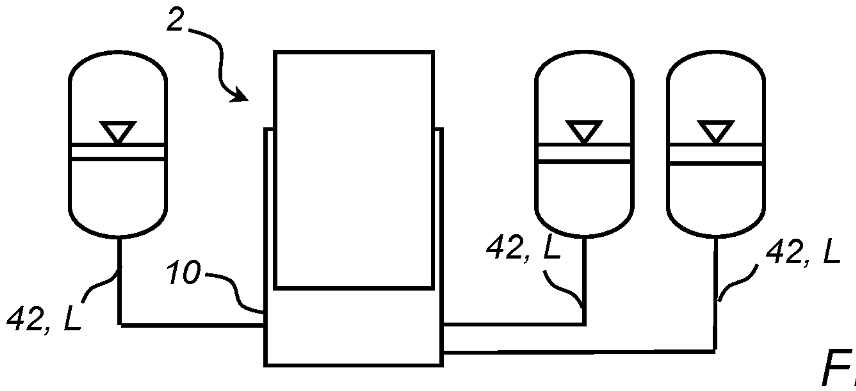

FIG.4

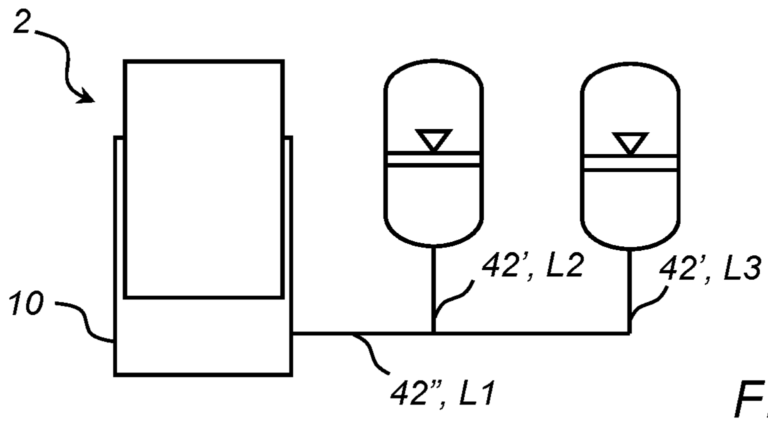

FIG.5

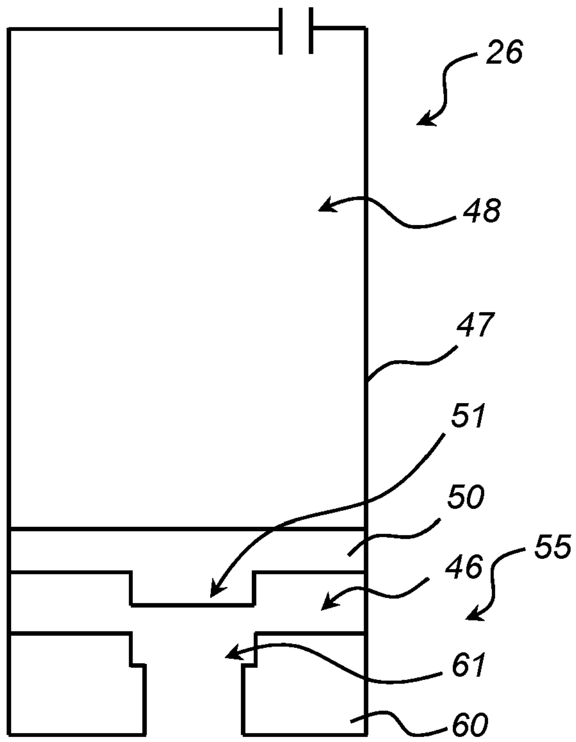

FIG.6

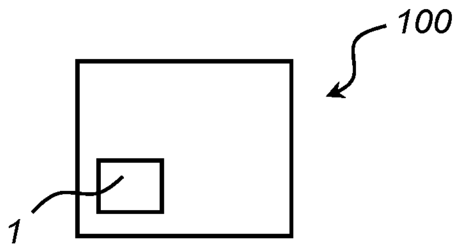

FIG.7

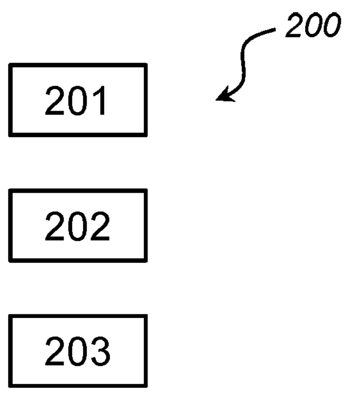

FIG.8

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EUROPEAN SEARCH REPORT

Application Number
EP 23 17 8604

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A,D	EP 2 271 427 B1 (SANDVIK INTELLECTUAL PROPERTY [SE]) 24 July 2019 (2019-07-24) * paragraphs [0006] - [0017], [0022], [0030] - [0032], [0038] - [0048]; figures 1,3,6 * -----	1-15	INV. B02C1/02 B02C2/04 B02C4/32 B02C25/00
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TECHNICAL FIELDS SEARCHED (IPC)

B02C

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	1 December 2023	Iuliano, Emanuela

CATEGORY OF CITED DOCUMENTS

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01-12-2023

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