(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 086 215 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
09.11.2022 Bulletin 2022/45

(21) Application number: **21171987.7**

(22) Date of filing: **04.05.2021**

(51) International Patent Classification (IPC):
B66C 13/40 *(2006.01)* ***B66C 23/00*** *(2006.01)*
B66C 23/68 *(2006.01)* ***B66C 13/20*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
B66C 23/54; B66C 13/20

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **Hiab AB**
164 22 Kista (SE)

(72) Inventors:
- **RÖSTH, Marcus**
  Hudiksvall (SE)
- **GUSTAFSSON, Pelle**
  Hudiksvall (SE)
- **SANTINI, Alessandro**
  Bologna (IT)

(74) Representative: **Bjerkén Hynell KB**
Tulegatan 53
113 53 Stockholm (SE)

(54) AN ENERGY EFFICIENT CRANE, AND A METHOD OF THE CRANE

(57) A crane (2) mounted on a vehicle (4) comprising a boom, hydraulic actuators arranged to apply movements to the crane boom system in response to received driving instructions (14); a sensor system (16) configured to monitor current positions of the crane components and to generate sensor signals (18). A control interface (20) is provided arranged to receive a set of operating instructions, a crane controller (24) configured to generate driving instructions (14) and configured to estimate a pressure level of a required working pressure of the hydraulic pump (12) and a required flow level of each of the hydraulic actuators for the wanted movements of boom, and to estimate a waste contribution measure for the wanted movements boom, based on the difference between the working pressure of a hydraulic pump (12) and the estimated pressure levels and further the estimated required flow level, of each of the hydraulic actuators for the wanted movements of the crane components (6), and also to compare the estimated waste contribution measure to a predetermined level. If the estimated waste contribution measure is larger than the predetermined level, the crane controller (24) is configured to determine and generate one driving instruction (14) to reduce the estimated required flow level of at least one of the hydraulic actuators for the wanted movements of the boom.

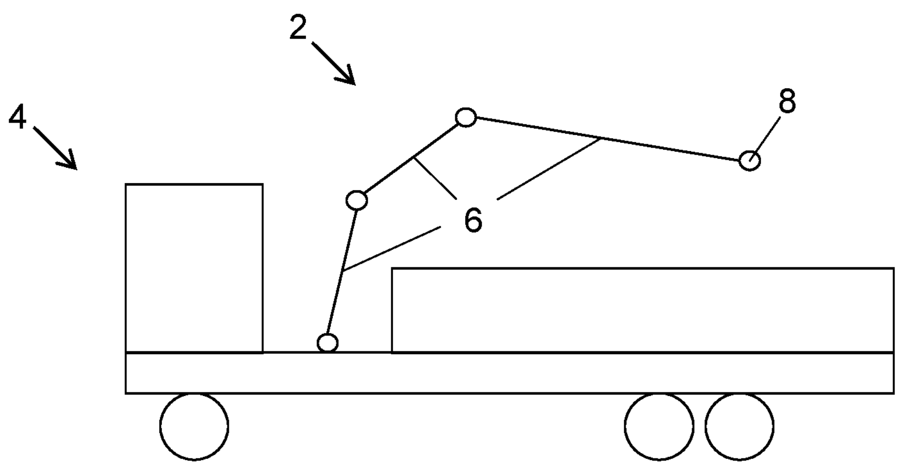

FIG. 4

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Description

Technical field

[0001] The present disclosure relates to a crane and a method of a crane, and particularly a loader crane intended to work more energy efficient than presently used cranes which is particularly advantageous if the crane is a hydraulic crane with an electric power source.

Background

[0002] Operating multiple functions of a crane at the same time is today regarded as showing skills as a crane operator. From an energy efficiency point of view this is however not necessarily preferred as it might generate a lot of waste energy. Waste energy here being defined as supplied energy to the hydraulic system that is not used for movements of crane components.

The waste energy is not only unwanted because it increases the amount of energy that is needed for the system without performing any actual movements of the crane components. It is furthermore a disadvantage in that waste energy is dissipated as heat which increases the temperature of the hydraulic fluid in the system. The temperature increase degrades the quality of the hydraulic fluid and hence affects the service frequency of the system. Thus, by reducing the waste energy, the effects of these associated problems will also be reduced.

[0003] It has been noted that a part of the consumed energy by the crane system is not actively used for the movements of the crane components but is waste energy, as an effect of operating multiple functions at the same time. This has a big impact on for example crane systems with an electric power source, as it affects the available operation time of e.g. a battery, or a fuel cell, before recharging or refilling with hydrogen. If the waste energy is reduced the operating lifetime in between charging of the battery may be improved, or smaller batteries may be used reducing the cost and weight of the system on the truck. An improved solution is hence needed addressing a way to reduce the waste of energy.

[0004] As can be seen in the examples discussed in the detailed part of the description, the waste energy may even be larger than the useful energy that is used for actually moving the crane components. This is due to the fact that if one function demands a high pressure, that high pressure will then be the system pressure for all functions. If a concurrently used crane function only requires low pressure but high flow, a large portion of waste energy will be the result.

[0005] In the following some patent documents in the technical field of controlling loading and unloading procedures of a crane will be identified and briefly discussed.

[0006] US20190308851A1 discloses a crane arrangement mounted on a vehicle. The crane arrangement comprising a first boom connected to the first column and a second boom connected to the first boom. A hydraulic system is configured to move the crane boom by a hydraulic actuator. The hydraulic flow is dumped into a reservoir if measured pressure of the hydraulic system is higher than a maximum working pressure.

US20140060030A1 discloses a crane system on a vehicle and a controller is provided configured to move a work tool in accordance with an operator instruction received via an input device. Accumulator pressure is stored which is associated with the movement of an actuator which is further compared with the current pressure measured by the sensors. An alert is generated if the measured value is not in the range of a threshold value. WO2019206774A1 discloses a truck mounted crane system wherein, the crane system comprises multiple booms connected to each other and the crane is a mobile crane. The hydraulic actuator of the crane boom system is operated by hydraulic fluid flow where the fluid is discharged from the pump using an electric motor. Further, it is disclosed that the required pressure is measured for the desired movement of the boom, and a computing device collects the data from the pressure sensor to control the pressure of hydraulic drives.

US20170268541A1 discloses a crane system with a lifting arm, and a crane maneuvering handle is provided to control the displacement of the first hydraulic power to move the arm. Further, when pressure detected by a first pressure sensor reaches a predetermined minimum working pressure then the hydraulic flow is cut-off to increase the efficiency of the crane system.

[0007] The present invention relates to cranes and evaluating the operation performance of the crane, in particular in terms of energy efficiency. The main object of the invention is to reduce waste energy and hence save energy in crane applications, and a more specific object is to achieve a more inherently energy efficient automatized operation of the crane.

Summary

[0008] The above-mentioned objects are achieved by the present invention according to the independent claims.

[0009] Preferred embodiments are set forth in the dependent claims.

[0010] The crane described herein comprises a so-called automatic eco operational mode. When this operation mode is active and it is determined in accordance with the present invention that an estimated waste contribution measure is larger than a predetermined level, an action is automatically issued by the crane controller to reduce the waste energy for the crane by limiting the flow of at least one of the hydraulic actuators controlling crane functions that require high flow of the hydraulic fluid.

By reducing the flow of at least one of the hydraulic actuators for wanted movements of the crane components, the speed in the movement generated by that actuator will also be reduced, and preferably non-proportional to a lever stroke of a maneuvering unit.

[0011] According to the invention, an estimated waste contribution measure is determined, that is the difference between the working pressure of the hydraulic pump and the estimated pressure levels multiplied by the estimated required flow level of each of the hydraulic actuators for each of the wanted movements of the crane components. The estimated waste contribution measure is hence an estimation of the hydraulic power that is wasted by the system, i.e. not utilized for active movements of the boom system.

[0012] As an alternative to being controlled by an operator using an input unit, the present invention may further also be implemented on a crane with a control interface comprising a communication interface to an autonomous system controlling the crane and optionally also the vehicle that the crane is mounted to. In that case an external monitoring service would monitor and evaluate the performance of the crane and the autonomous system in addition to, or instead of, monitoring and evaluating the operation skills of an operator.

[0013] The main advantage achieved by the crane disclosed herein, is the automatized, i.e. inherent, energy saving by reducing waste energy. This is a significant advantage especially for electrically operated cranes where less energy consumption equals longer use time for the customer between charging or a smaller and then a less costly battery with same use time.

[0014] Another advantage of the solution applied by the present invention is that it does not require any extra sensors or other hardware, as it is a pure software solution which means that it may be implemented in existing products and hardware.

[0015] The invention may further be used as a learning tool that encourages energy efficient operation of the crane. If a crane operator is trained with a crane according to the invention as defined by the claims, the energy efficient operation strategy encouraged by the learning tool may be continued to be used on other cranes.

Brief description of the drawings

[0016]

Figures 1-3 are graphs illustrating advantageous aspects of the present invention.

Figure 4 is a schematic illustration of a vehicle provided with a crane according to the present invention.

Figure 5 is a schematic block diagram illustrating the crane according to the present invention.

Figure 6 is a flow diagram illustrating the method according to the present invention.

Detailed description

[0017] The crane and method will now be described in detail with references to the appended figures. Throughout the figures the same, or similar, items have the same reference signs. Moreover, the items and the figures are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

[0018] The energy supplied by a hydraulic pump of a crane is defined as the integral of the hydraulic power over a time period of operation. The hydraulic power is calculated by the pressure multiplied by the flow supplied by the pump. The different hydraulic cylinders used for crane functions like the slewing of the crane, the first boom movement, the second boom movement and the extension/retraction of the second boom telescopic boom system, have different working requirements in terms of pressure and flow. The required pressure may further be dependent on the load and the position of the respective crane components but may be monitored using pressure sensors and further estimated for future movements based on input from the pressure sensors and/or known parameters of the planned movements. When operating multiple functions at the same time, it is the function that requires the largest pressure that determines the working pressure level of the hydraulic pump. This implies that there will be a waste component if also other crane functions requiring a lower working pressure are activated at the same time. The waste component will further be dependent on the flow requirement of the other crane functions, as the hydraulic power supplied to the system is further dependent on the flow of the hydraulic fluid. A portion of the consumed energy of the hydraulic system is hence waste, i.e. not used for moving the crane components, if operating multiple functions at the same time that are not matched in terms of working pressure and to some extent flow.

[0019] As can be seen in the examples discussed below with references to figures 1-3, the waste energy may even be larger than the useful energy that is used for actually moving the crane components. This is due to the fact that if one function demands a high pressure, that high pressure will then be the system pressure for all functions. If a concurrently used crane function only requires low pressure but high flow, a large portion of waste energy will be the result.

[0020] Figures 1-3 are graphs illustrating the energy consumption during use of an exemplary crane provided with an inner boom (IB), an outer boom (OB), and an extension (EXT). In the figures also the energy consumption during slewing (SLEW) is illustrated. The required energy for the movements is shown by dashed areas, and energy waste is shown by dotted areas. The consumed energy of the hydraulic system is the sum of the required energy for the movements and the waste energy. In the figures the Y-axis designates pressure and the X-axis designates flow.

[0021] In figure 1 an energy consumption graph is shown, where multiple crane functions are operated simultaneously. In figure 1, the inner boom (IB) requires high pressure and the extension (EXT) requires high flow but low pressure. The waste energy for the extension function is larger than the amount of energy used for the actual movements. This happens when all functions are simultaneously driven without taking waste energy into account. In this example the total input is 49.6kW, and the waste is 30.8kW, i.e. the waste energy is 164.44% of the useful energy.

[0022] By not operating the inner boom (IB) function (which is the function requiring the highest pressure) at the same time as the slewing (SLEW), outer boom (OB) and extensions (EXT), the waste energy may be decreased from 30.8 kW to 12.9kW in this specific example, see figure 2, where the inner boom (IB) is activated at another point in time and is not illustrated in figure 2. Here, the total energy input is 28.3kW, and the waste energy is 12.9kW, i.e. 83.78% of the useful energy.

[0023] The waste energy may be further decreased to 1.3 kW in another specific case, by also refraining from operating the outer boom (OB), see figure 3 (the outer boom function is hence not illustrated in figure 3 as it is activated individually at another point in time). In this case the total input energy is 14.2kW, and the waste energy is 1.3kW, i.e. 9.68% of the useful energy.

[0024] From these examples one can see that simultaneous use of a function with a high pressure demand and a function requiring a low pressure but a high flow should be avoided to reduce energy waste. For automatic crane functions where the target position of the crane tip, or the target geometry of the crane components, is known and the movements of individual crane functions are planned by a crane controller this aspect may be taken into account when planning the movement scheme to reach a target.

[0025] The simplest version of an energy efficient path planner would be moving only one crane function at a time to reach the target angle or length to reach the target position or geometry. As an example, first slew, then the first boom, then the second boom, and then finish by moving the extensions. By doing so we would not get any energy waste at all. However, the time for completing the movement would be considerably longer than compared to the normal case with simultaneous multiple functions and the crane components would likely hit either the vehicle or some obstacles in the environment.

[0026] So to solve these issues, the path planner must be smarter, the easiest method is to move the known high pressure functions first, normally the first and the second boom which pressures can be assumed high, or measured.

[0027] Example on a path:

Use available flow to move first and second booms to its goal angles for reaching the target position, move slew as fast as possible to its goal angle, and at same time drive extension, but prioritize flow to slew to reach target as fast as possible, and move extension to target position.

[0028] To reach the target position it is likely that practical issues like the bending of the boom system etc. will require a slight repositioning of the crane tip close to target to reach it exactly. This may be performed as a final adjustment, or if these factors are known from the start, they may be further taken into consideration when planning the movements.

[0029] The above-described planner is a "simple" example of the planner to illustrate the crane and method as defined by the appended claims. If this should be implemented in a product, more complex approach in the planner could further take into account effects of bending, pressures, flow needs, the distance from start to end position when planning a path which is as efficient as possible but not slowing down the crane.

[0030] With references to figures 4 and 5, the present invention will now be described in detail. Thus, the present invention relates to a crane 2 arranged to be mounted to e.g. a vehicle 4, or any other object, e.g. a boat, a building, or a wind turbine.

[0031] The crane comprises a crane boom system, comprising crane components 6 that includes a crane tip 8 arranged at a free end of an outermost crane boom.

More particularly, the crane components 6 may comprise a crane column arranged to rotate, or slew, around a vertical axis perpendicular to the plane of the vehicle, a first (inner) boom connected to the crane column, and a second (outer) telescopic boom connected to the first boom and provided with one or more extensions. Additional components, such as additional telescopic booms (also referred to as jibs) or crane tool may form part of the crane components.

[0032] Furthermore, the crane comprises a system 10 of hydraulic actuators of the crane boom system arranged to be operated by hydraulic fluid with a hydraulic flow, where the hydraulic fluid being discharged from a hydraulic pump 12 at a variable working pressure. The hydraulic actuators are further arranged to apply movements to the crane boom system such that the crane tip 8 is moved from a current position to a target position in response to received driving instructions 14.

[0033] The crane also comprises a sensor system 16 configured to monitor current positions of the crane components, and operating conditions of the system 10 of hydraulic actuators, and to generate sensor signals 18 in response to the monitored current positions and operating conditions.

Thus, the sensor system is configured to monitor current positions of the crane components, and comprises sensors arranged to measure e.g. an angle of a crane boom compared to a reference plane, or the extension length of the telescopic boom. The sensor system is also configured to monitor the operating conditions of the system of the hydraulic actuators and the hydraulic pump, and to generate sensor signals in response to measured pressures and flows at specific parts of the hydraulic system. The sensor system is hence used to monitor current positions and operating conditions of the crane.

[0034] In addition the crane comprises a control interface 20 arranged to receive an operating instruction, preferably from an input unit 22, defining wanted movements of the crane components.

[0035] The crane also comprises a crane controller 24 configured to generate driving instructions 14 to be applied to the system 10 of hydraulic actuators of the crane boom system based on the received set of operating instructions defining wanted movements of the crane components.

[0036] The input unit 22, e.g. a maneuvering unit, may be used by an operator to operate the crane, remotely or at the site of the working assignment for the crane. The control interface 20 of the crane may alternatively comprise an interface to an autonomous system controlling the crane and optionally also the vehicle that the crane is mounted to.

As an example, the crane operator may by pulling a first and a second lever at the maneuvering unit, generate operating instructions for raising the first boom of the crane and at the same time extending the second boom telescopic extensions. The operation instructions will be received over the control interface and the crane controller will generate driving instructions to be applied to the hydraulic system so that the hydraulic cylinders of the first boom and extension cylinders are supplied with hydraulic fluid accordingly.

[0037] The crane controller 24 is further configured to estimate a pressure level of a required working pressure of the hydraulic pump 12 and required flow level of each of the hydraulic actuators for the wanted movements of the crane components 6, based on the generated sensor signals 18 and/or predetermined operating conditions.

The crane controller 24 is also configured to estimate a waste contribution measure for the wanted movements of the crane components 6, based on the difference between the working pressure of the hydraulic pump 12 and the estimated pressure levels and further the estimated required flow level, of each of the hydraulic actuators for the wanted movements of the crane components 6. The waste contribution measure is a measure of the energy waste if the wanted movements of the crane components are performed in comparison to the energy required for each of the involved hydraulic actuators at specific point of time.

[0038] The crane controller 24 is configured to compare the estimated waste contribution measure to a predetermined level, and in response to determining that the estimated waste contribution measure is larger than the predetermined level, the crane controller 24 is configured to determine and generate at least one driving instruction 14 to reduce the estimated required flow level of at least one of the hydraulic actuators for the wanted movements of the crane components. The determined at least one driving instruction 14 being such that the estimated waste contribution measure is reduced to a level equal or below the predetermined level.

[0039] In order to perform the reduction of the flow level of at least one of the hydraulic actuators the crane controller 24 is preferably provided with a set of rules to be applied. The set of rule may comprise one or many of the following exemplary rules:

A rule that is applied to identify the hydraulic actuator having the highest estimated required flow level and then reducing the flow level, e.g. by a preset percentage.

A rule that is applied to identify the hydraulic actuators having the two highest estimated required flow levels and then reducing the flow levels, e.g. by a preset percentage.

A rule that is applied to identify the hydraulic actuator having the highest estimated required flow level and then decide to activate that hydraulic actuator at a later point of time.

[0040] According to one embodiment, the predetermined level is a predefined percentage of the hydraulic power required for the wanted movements of the crane components 6. The predetermined level may be in the range of 25%-50% of the hydraulic power required for the wanted movements. As an alternative, the waste contribution measure may be a constant, configurable by e.g. the operator, the fleet manager, or preset when installing the crane on e.g. the vehicle.

[0041] The energy supplied by the hydraulic pump to the crane components is defined as the integral of the hydraulic power over a time period of operation. The hydraulic power is calculated by the pressure multiplied by the flow supplied by the pump. The different hydraulic cylinders used for crane functions like the slewing of the crane, the first boom movement, the second boom movement and the extension/retraction of the second boom telescopic boom system, have different working requirements in terms of pressure and flow. The required pressure may further be dependent on the load and the position of the respective crane components but may be monitored using pressure sensors and further estimated for future movements based on input from the pressure sensors and/or known parameters of the planned movements.

[0042] In another embodiment, the crane controller 24 is further configured to identify, in response to determining that the estimated waste contribution measure is larger than the predetermined level, at least one of the hydraulic actuators as a crane function to deactivate, or to reduce energy consumption of, and to generate driving instructions 14 to deactivate, or to reduce energy consumption of, the identified at least one of the hydraulic actuators. The crane function to deactivate, or to reduce energy consumption of, is preferably identified as a crane function with a low estimated pressure level and a high estimated flow level relative to the other hydraulic actuators or as a crane function with a high pressure relative to the other hydraulic actuators.

[0043] In a further embodiment, upon reducing the flow to at least one of the hydraulic actuators for the wanted movements of the crane components 6 resulting in that the speed in the movement generated by that hydraulic actuator will also be reduced, the crane controller 24 is configured to control the effect of a lever stroke activation of a maneuvering unit 22 such that a lever stroke activation of the maneuvering unit results is a non-proportional activation of the a least one hydraulic actuator controlled by the lever.

[0044] In another embodiment, the crane further comprises a communication interface 34 for transmitting crane operation data to a crane monitoring service. The crane controller 24 is further configured to receive driving instructions from the crane monitoring service via the communication interface 34. The optional communication interface 34 is indicated in figure 5 as a dashed box. The communication may be performed using any available wireless communication protocol, e.g. via Bluetooth, or Internet.

[0045] The crane controller 24 may be implemented by one or many processing units. These processing unit may have different dedicated tasks, e.g. by so-called edge computing. Edge computing is a distributed computing method that brings computation and data storage closer to the location where it is needed, in order to improve response times and save bandwidth. As an example, one processing unit may perform the actual control of the crane, and another may perform calculations and analysis by extracting data from the crane operation procedures, that advantageously may be communicated to an external crane monitoring service.

[0046] According to another embodiment, the crane comprises at least one electric motor 26 arranged to be powered by a battery system 28 and further being arranged to drive the hydraulic pump 12. The electrical energy from the battery system to the electric motor is illustrated by a bold arrow in figure 5, which also indicates the driving power to the hydraulic pump. As an alternative, the hydraulic pump is driven by a diesel engine on the vehicle.

[0047] According to the present invention a vehicle 4 is provided, that comprises a crane 2 as described above.

[0048] The present invention also relates to a method of a crane 2 arranged to be mounted to e.g. a vehicle 4. The crane has been described in detail above and it is herein referred to that description. The method will now be described with references to the flow diagram shown in figure 6.

The method comprises:

[0049]

A - Estimating a pressure level of the required working pressure of the hydraulic pump and a required flow level of each of the hydraulic actuators for the wanted movements of the crane components, based on the generated sensor signals and/or predetermined operation conditions.

B - Estimating a waste contribution measure for the wanted movements of the crane components, based on the difference between the working pressure of the hydraulic pump and the estimated pressure levels and further the estimated required flow level, of each of the hydraulic actuators for the wanted movements of the crane components.

C - Comparing the estimated waste contribution measure to a predetermined level, and in response to determining that the estimated waste contribution measure is larger than the predetermined level, the method further comprises:

D - Determining and generating at least one driving instruction to reduce the estimated required flow level of at least one of the hydraulic actuators for the wanted movements of the crane components, and wherein the determined at least one driving instruction being such that the estimated waste contribution measure is reduced to a level equal or below the predetermined level.

[0050] In the following, some embodiments of the method are listed. These have the same technical features and advantages as for the corresponding features of the crane described above. Consequently, these technical features and advantages are not repeated or explained anew in order to avoid unnecessary repetition.

[0051] Preferably, the predetermined level is a predefined percentage of the hydraulic power required for the wanted movements of the crane components.

[0052] In still another embodiment, the method comprises identifying, in response to determining that the estimated waste contribution measure is larger than the predetermined level, at least one of the hydraulic actuators as a crane function to deactivate, or to reduce energy consumption of, the identified at least one of the hydraulic actuators.

[0053] The crane function to deactivate, or to reduce energy consumption of, is preferably identified as a crane function with a low estimated pressure level and a high estimated flow level relative to the other hydraulic actuators or as a crane function with a high pressure relative to the other hydraulic actuators.

[0054] Upon reducing the flow to at least one of the hydraulic actuators for the wanted movements of the crane components resulting in that the speed in the movement generated by that hydraulic actuator will also be reduced, the method preferably further comprises controlling the effect of a lever stroke activation of a maneuvering unit such that a lever stroke activation of the maneuvering unit results is a non-proportional activation of the a least one hydraulic actuator controlled by the lever.

[0055] In another embodiment, the method comprises transmitting crane operation data to a crane monitoring service, and receiving driving instructions from the crane monitoring service via the communication interface.

[0056] The present invention is not limited to the above-described preferred embodiments. Various alternatives, modifications and equivalents may be used. Therefore, the above embodiments should not be taken as limiting the scope of the invention, which is defined by the appending claims.

Claims

1. A crane (2) arranged to be mounted to e.g. a vehicle (4), the crane comprising:

   - a crane boom system, comprising crane components (6) that includes a crane tip (8) arranged at a free end of an outermost crane boom;
   - a system (10) of hydraulic actuators of the crane boom system arranged to be operated by hydraulic fluid with a hydraulic flow, the hydraulic fluid being discharged from a hydraulic pump (12) at a variable working pressure and wherein the hydraulic actuators are further arranged to apply movements to the crane boom system in response to received driving instructions (14);
   - a sensor system (16) configured to monitor current positions of the crane components, and, operating conditions of the system (10) of hydraulic actuators, and to generate sensor signals (18) in response to the monitored current positions and operating conditions;
   - a control interface (20) arranged to receive a set of operating instructions, defining wanted movements of the crane components, and
   - a crane controller (24) configured to generate driving instructions (14) to be applied by the system (10) of hydraulic actuators of the crane boom system based on the received set of operating instructions defining wanted movements of the crane components,

   characterized in that the crane controller (24) is further configured to estimate a pressure level of a required working pressure of the hydraulic pump (12) and a required flow level of each of the hydraulic actuators for the wanted movements of the crane components (6), based on the generated sensor signals (18) and/or predetermined operation conditions, and to estimate a waste contribution measure for the wanted movements of the crane components (6), based on the difference between the working pressure of the hydraulic pump (12) and the estimated pressure levels and further the estimated required flow level, of each of the hydraulic actuators for the wanted movements of the crane components (6), wherein the crane controller (24) is configured to compare the estimated waste contribution measure to a predetermined level, and in response to determining that the estimated waste contribution measure is larger than the predetermined level, the crane controller (24) is configured to determine and generate at least one driving instruction (14) to reduce the estimated required flow level of at least one of the hydraulic actuators for the wanted movements of the crane components, and wherein the determined at least one driving instruction (14) being such that the estimated waste contribution measure is reduced to a level equal or below the predetermined level.

2. The crane (2) according to claim 1, wherein said predetermined level is a predefined percentage of the hydraulic power required for the wanted movements of the crane components (6).

3. The crane (2) according to claim 1 or 2, wherein the crane controller (24) is further arranged to identify, in response to determining that the estimated waste contribution is larger than the predetermined level, at least one of the hydraulic actuators as a crane function to deactivate or to reduce energy consumption of, and to generate driving instructions (14) to deactivate, or to reduce energy consumption of, said identified at least one of the hydraulic actuators.

4. The crane (2) according to claim 3, wherein the crane function to deactivate or reduce energy consumption of, is identified as a crane function with a low estimated pressure level and a high estimated flow level relative to the other hydraulic actuators or as a crane function requiring a high hydraulic pressure relative to the other hydraulic actuators.

5. The crane (2) according to any of claims 3 or 4, wherein, upon reducing the flow to at least one of the hydraulic actuators for the wanted movements of the crane components (6) resulting in that the speed in the movement generated by that hydraulic actuator will also be reduced, the crane controller (24) is configured to control the effect of a lever stroke activation of a maneuvering unit (22) such that a lever stroke activation of the maneuvering unit results is a non-proportional activation of the a least one hydraulic actuator controlled by the lever.

6. The crane (2) according to any of claims 1-5, further comprising a communication interface (34) for transmitting crane operation data to a crane monitoring service, wherein the crane controller (24) is further configured to receive driving instructions from the crane monitoring service via the communication interface (34).

7. The crane according to any of claims 1-6, further comprising at least one electric motor (26) arranged to be powered by a battery system (28), or a fuel cell, and further being arranged to drive the hydraulic pump (12).

8. A method of a crane arranged to be mounted to a vehicle, the crane comprising:

   - a crane boom system, comprising crane components (6) that includes a crane tip (8) arranged at a free end of an outermost crane boom;

- a system (10) of hydraulic actuators of the crane boom system arranged to be operated by hydraulic fluid with a hydraulic flow, the hydraulic fluid being discharged from a hydraulic pump (12) at a variable working pressure and wherein the hydraulic actuators are further arranged to apply movements to the crane boom system in response to received driving instructions (14);
- a sensor system (16) configured to monitor current positions of the crane components, and, operating conditions of the system (10) of hydraulic actuators, and to generate sensor signals (18) in response to the monitored current positions and operating conditions;
- a control interface (20) arranged to receive a set of operating instructions, defining wanted movements of the crane components, and
- a crane controller (24) configured to generate driving instructions (14) to be applied by the system (10) of hydraulic actuators of the crane boom system based on the received set of operating instructions defining wanted movements of the crane components,

characterized in that the method comprises:

A - estimating a pressure level of the required working pressure of the hydraulic pump and a required flow level of each of the hydraulic actuators for the wanted movements of the crane components, based on the generated sensor signals and/or predetermined operation conditions,
B - estimating a waste contribution measure for the wanted movements of the crane components, based on the difference between the working pressure of the hydraulic pump and the estimated pressure levels and further the estimated required flow level, of each of the hydraulic actuators for the wanted movements of the crane components,
C - comparing the estimated waste contribution measure to a predetermined level, and in response to determining that the estimated waste contribution is larger than the predetermined level, the method further comprises:
D - determining and generating at least one driving instruction to reduce the estimated required flow level of at least one of the hydraulic actuators for the wanted movements of the crane components, and wherein the determined at least one driving instruction being such that the estimated waste contribution measure is reduced to a level equal or below the predetermined level.

9. The method according to claim 8, wherein said predetermined level is a predefined percentage of the hydraulic power required for the wanted movements of the crane components.

10. The method according to claim 8 or 9, comprising identifying, in response to determining that the estimated waste contribution is larger than the predetermined level, at least one of the hydraulic actuators as a crane function to deactivate or to reduce energy consumption of, and generating driving instructions to deactivate, or to reduce energy consumption of, said identified at least one of the hydraulic actuators.

11. The method according to claim 10, wherein the crane function to deactivate or reduce energy consumption of, is identified as a crane function with a low estimated pressure level and a high estimated flow level relative to the other hydraulic actuators or as a crane function requiring a high hydraulic pressure relative to the other hydraulic actuators.

12. The method according to any of claims 10 or 11, wherein, upon reducing the flow to at least one of the hydraulic actuators for the wanted movements of the crane components resulting in that the speed in the movement generated by that hydraulic actuator will also be reduced, the method further comprises controlling the effect of a lever stroke activation of a maneuvering unit such that a lever stroke activation of the maneuvering unit results is a non-proportional activation of the a least one hydraulic actuator controlled by the lever.

13. The method according to any of claims 8-12, comprising transmitting crane operation data to a crane monitoring service, and receiving driving instructions from the crane monitoring service via the communication interface..

14. A vehicle (4) comprising a crane (2) according to any of claims 1-7.

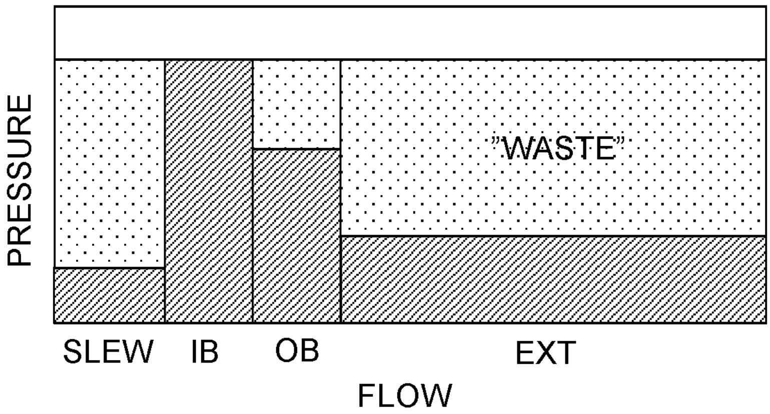

FIG. 1

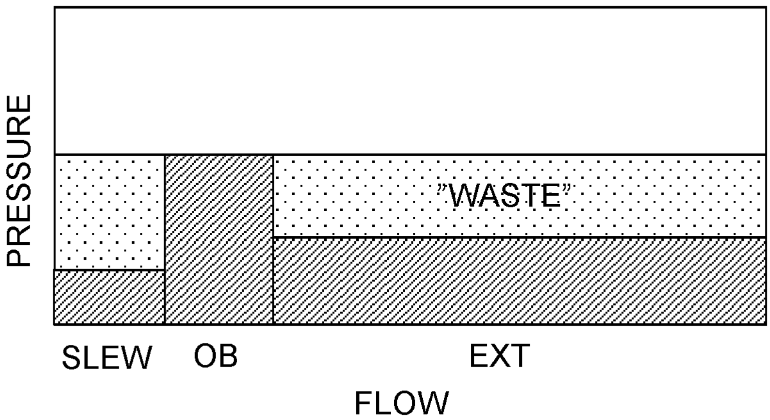

FIG. 2

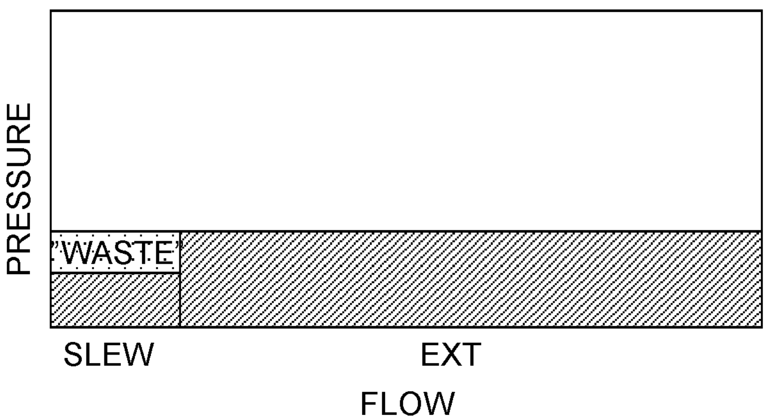

FIG. 3

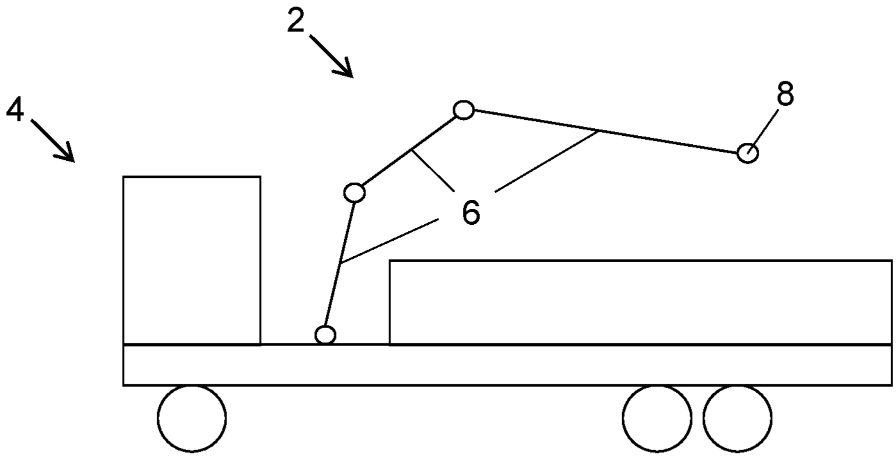

FIG. 4

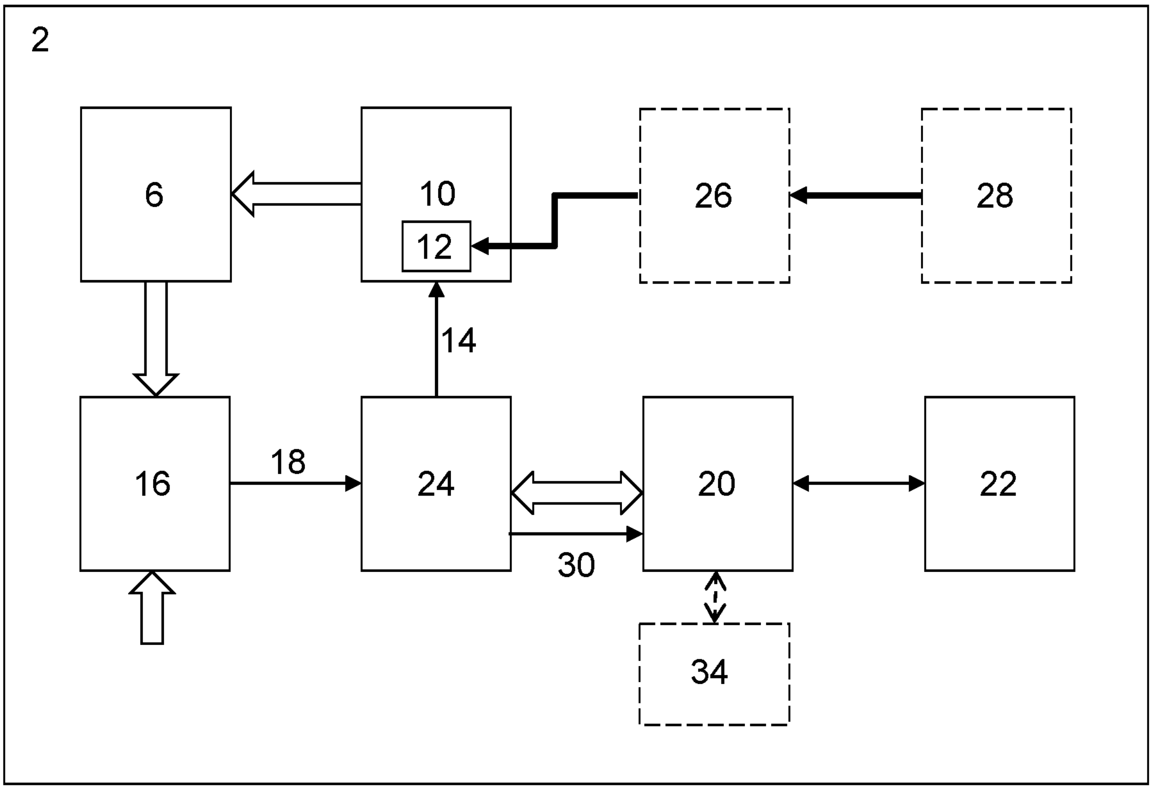

FIG. 5

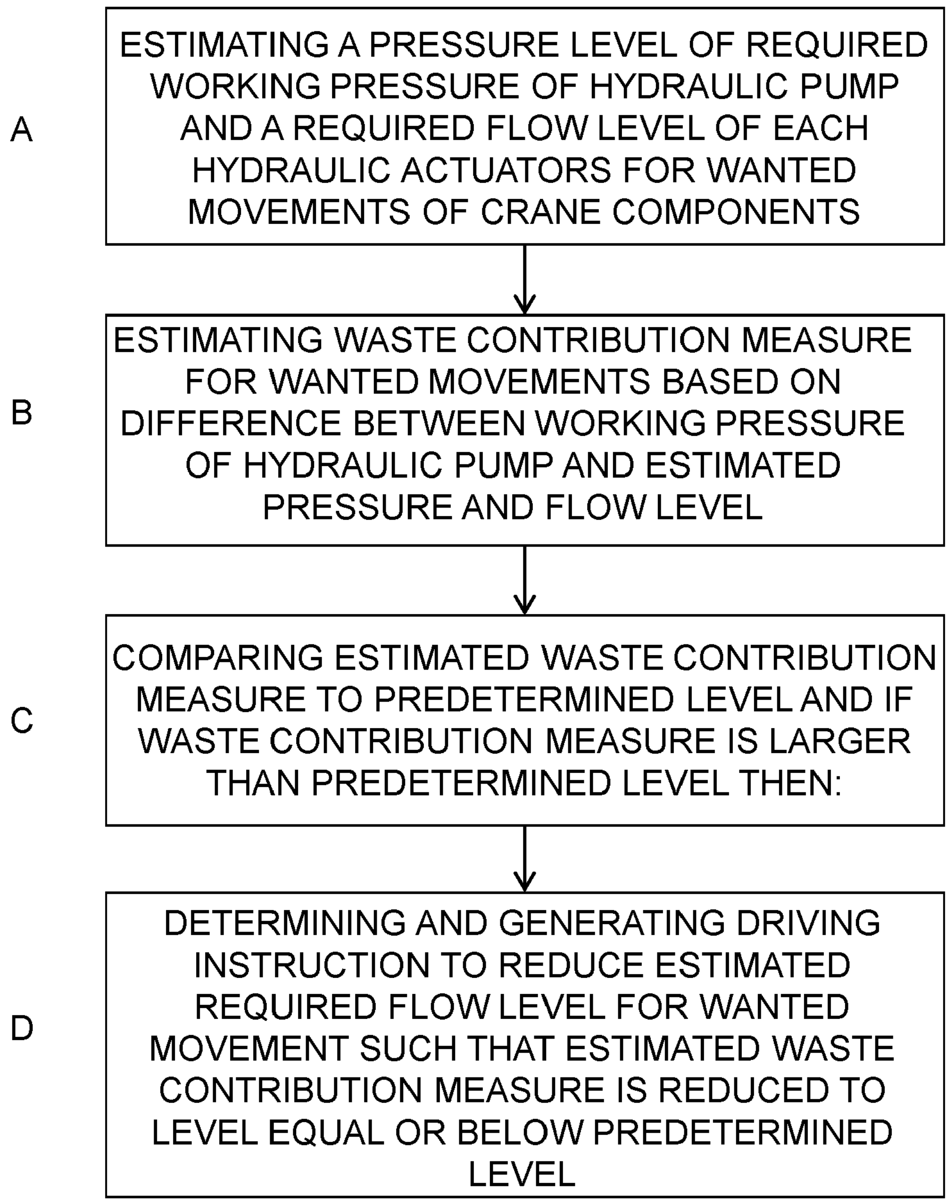
A
ESTIMATING A PRESSURE LEVEL OF REQUIRED WORKING PRESSURE OF HYDRAULIC PUMP AND A REQUIRED FLOW LEVEL OF EACH HYDRAULIC ACTUATORS FOR WANTED MOVEMENTS OF CRANE COMPONENTS
B
ESTIMATING WASTE CONTRIBUTION MEASURE FOR WANTED MOVEMENTS BASED ON DIFFERENCE BETWEEN WORKING PRESSURE OF HYDRAULIC PUMP AND ESTIMATED PRESSURE AND FLOW LEVEL
C
COMPARING ESTIMATED WASTE CONTRIBUTION MEASURE TO PREDETERMINED LEVEL AND IF WASTE CONTRIBUTION MEASURE IS LARGER THAN PREDETERMINED LEVEL THEN:
D
DETERMINING AND GENERATING DRIVING INSTRUCTION TO REDUCE ESTIMATED REQUIRED FLOW LEVEL FOR WANTED MOVEMENT SUCH THAT ESTIMATED WASTE CONTRIBUTION MEASURE IS REDUCED TO LEVEL EQUAL OR BELOW PREDETERMINED LEVEL

FIG. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 21 17 1987

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	18 October 2021	Colletti, Roberta

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