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(54) **AUTOMATIC-PRESSURE-MATCHING ENERGY UTILIZATION SYSTEM**

(57) A pressure self-matching energy utilization system includes a synchronous motor (1), a control valve (2), a working pump (3), an energy accumulator (4) and a pressure actuation element (5) and corresponding oil pipe connection. A main outlet (OUT) of the synchronous motor is connected to a load keeping cavity of the pressure actuation element. A first inlet (IN1) of the synchronous motor is connected to an oil port of the energy accumulator via a first switch valve (K1) of the control valve. A second inlet (IN2) of the synchronous motor is connected to an output port of the working pump via a second switch valve (K2) of the control valve. The system can automatically match the output pressure of the working pump and the output pressure of the energy accumulator based on the magnitude of external load, to achieve the purpose of fully using the pressure energy recycled in the energy accumulator.

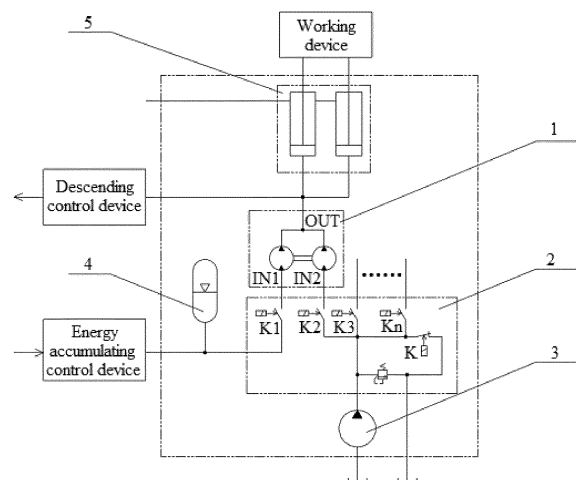


Figure 1

Description

[0001] The present application claims the priority to Chinese Patent Application No. 201710343343.1, titled "PRESSURE SELF-MATCHING ENERGY UTILIZATION SYSTEM", filed on May 16, 2017 with the Chinese Patent Office, which is incorporated herein by reference in its entirety.

FIELD

[0002] The present disclosure relates to a hydraulic utilization system for recycling energy of a construction machinery working device, and in particular to a pressure self-matching energy utilization system.

BACKGROUND

[0003] For environmental protection and energy saving, machine manufacturers in the construction machinery industry perform research work of energy recycling and utilization of a mechanical equipment, and put forward a lot of methods and principles for energy recycling and utilization, such as an oil-electric hybrid power mode, and an oil-liquid hybrid power mode. Because high price and low reliability of a motor battery which is a key component in the oil-electric hybrid power mode and a general energy saving effect of a product using this mode, the oil-electric hybrid power mode is abandoned in the industry. At present, the focus of industry research is on the technology of the oil-liquid hybrid power mode. A difficulty of this technology is how to make the recycled energy be utilized efficiently and be well matched with a load. There are two common ways in the industry. A first way is to use recycled energy to drive a pressure cylinder to pressurize oil drawn from a tank and then store the pressurized oil into an energy accumulator. An initial pressure of the oil when stored into the energy accumulator is higher than the maximum working pressure that may occur in a working device, otherwise the oil in the energy accumulator is not completely released and used because a pressure of the oil is lower than a driving pressure required by the working device. A second way is to use the recycled energy to drive a secondary element to pressurize the oil drawn from the tank and then store the pressurized oil into the energy accumulator. When the oil is used, the pressure oil in the energy accumulator is used to drive the secondary element to draw oil from the tank, to drive the working device. It can be seen from these two ways that the first way has a poor pressure matching. Because the initial pressure of the oil in the energy accumulator is higher than the maximum working pressure that may occur in the working device, energy of the pressure oil in the energy accumulator corresponding to a pressure higher than the maximum working pressure will be lost in a form of heat when the oil is released. The second way has a good pressure matching. However the second way has a low transmission efficiency. The secondary element is not well developed. There are twice conversions both in a process of storing the recycled energy into the energy accumulator and in a process of releasing the recycled energy in the energy accumulator for usage, thus a total efficiency is not more than 45%.

SUMMARY

[0004] In order to avoid the disadvantages in the conventional art, a pressure self-matching energy utilization system is provided according to the disclosure. The pressure self-matching energy utilization system has a simple structure, few transmission links and a high transmission efficiency, to economically and efficiently recycle energy.

[0005] A pressure self-matching energy utilization system includes a synchronous motor, a control valve, a working pump, an energy accumulator and a pressure actuation element and corresponding oil pipe connection. A main outlet OUT of the synchronous motor is connected to a load keeping cavity of the pressure actuation element. A first inlet IN1 of the synchronous motor is connected to an oil port of the energy accumulator via a first switch valve K1 of the control valve. A second inlet IN2 of the synchronous motor is connected to an output port of the working pump via a second switch valve K2 of the control valve.

[0006] Furthermore, the synchronous motor has no low pressure drain port, an accumulating pressure of the energy accumulator is represented as P_x , a working pressure of the working pump is represented as P_b , a demand pressure of the actuation element is represented as P_n , $P_x + P_b \geq 2P_n$ and $P_x < 2P_n$. In this way, the working pressure of the working pump continuously raises from a no-load pressure until the output pressure $P_b \geq 2P_n - P_x$. At this time, the synchronous motor starts to rotate, outputs pressure oil from both the first inlet IN1 and the second inlet IN2 to the pressure actuation element, and the pressure actuation element lifts a working device. The synchronous motor functions as a pressure distributor, which reduces the high pressure and increases the low pressure. The synchronous motor compensates a pressure $P_n - P_x$, by which the working pump is higher than a load, to the energy accumulator to drive the load by the working pump and the energy accumulator. A lift speed of the load depends on an output flow of the working pump. Since the synchronous motor has no drain port, all working ports has a high pressure, a volumetric efficiency of the synchronous motor 1 is close to 100%. Thus a total transmission efficiency is more than 90%, and an energy utilization

rate is high. These way and parameters are the preferred embodiments for implement this disclosure.

[0007] The pressure actuation element may be one or more oil cylinders and/or one or more hydraulic motors. The load keeping cavity of the pressure actuation element is further connected to a descending control device, the descending control device is configured to control the pressure actuation element to control descending of a working device. The oil port of the energy accumulator is further connected to an energy accumulating control device, the energy accumulating control device is configured to charge energy to be recycled into the energy accumulator.

[0008] The working pump may be a fixed displacement pump or a variable displacement pump.

[0009] A switch valve control signal of the control valve is a hydraulic signal and/or an electrical signal.

[0010] The beneficial effects of the disclosure are described as follows. In the present disclosure, a torque pressure transformation principle of the synchronous motor and a characteristic of the working pump that the working pressure depends on the load are used. When the pressure of the energy accumulator cannot drive the pressure actuation element, the working pressure of the working pump is continuously raised from a low pressure. The synchronous motor performs pressure distribution, and compensates the pressure of the working pump higher than that of the load to the energy accumulator to drive the load by the working pump and the energy accumulator. By the pressure self-matching, purposes of utilizing the energy accumulator for recycling energy to replace an oil pump to do work to outside and reducing an input power of a prime motor and reducing fuel consumption are achieved. The system according to this disclosure has a simple structure, few transmission links and a high transmission efficiency, and the system use common elements which is developed well and which is reliable. The system according to this disclosure is suitable for lifting and rotating of construction machinery and agricultural equipment working devices, especially for lifting of swing arms of excavator type devices.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Figure 1 is a schematic principle view of a system according to the disclosure.

1 synchronous motor	IN1 first inlet	IN2 second inlet
OUT main outlet	2 control valve	3 working pump
4 energy accumulator	5 pressure actuation element	

DETAILED DESCRIPTION OF EMBODIMENTS

[0012] The present disclosure is described below in detail in conjunction with the drawings and embodiments.

[0013] An energy utilization process of an energy accumulator is described as follows. As illustrated in Figure 1, when an actuation element 5 lifts a working device, a first switch valve K1 and a second switch valve K2 of a control valve 2 are switched on, a switch valve K is switched off. Pressure oil in the energy accumulator 4 is transmitted to a first inlet IN1 of a synchronous motor 1, oil in the working pump 3 is transmitted to a second inlet IN2 of the synchronous motor 1. In this case, the synchronous motor 1 performs automatic matching based on an accumulating pressure (which is represented as P_x) of the energy accumulator 4, a working pressure (which is represented as P_b) of the working pump 3 and a demand pressure (which is represented as P_n) of the actuation element 5, to make $P_x + P_b \geq 2P_n$. A specific working process is described as follows.

[0014] In a case of $P_x < 2P_n$, at the beginning moment, the pressure of the energy accumulator 4 is unable to drive the pressure actuation element 5, at this time the synchronous motor 1 cannot be rotated. Oil at the first inlet IN1 and the second inlet IN2 of the synchronous motor cannot flow into the main outlet OUT of the synchronous motor. It can be known from a hydraulic transmission principle that the working pressure of the working pump 3 depends on a load. In this way, the working pressure of the working pump 3 continuously raises from a no-load pressure until the output pressure $P_b \geq 2P_n - P_x$. At this time, the synchronous motor 1 starts to rotate, outputs pressure oil from both the first inlet IN1 and the second inlet IN2 to the pressure actuation element 5, and the pressure actuation element lifts a working device. The synchronous motor 1 functions as a pressure distributor, which reduces the high pressure and increases the low pressure. The synchronous motor compensates a pressure $P_n - P_x$, by which the working pump 3 is higher than a load, to the energy accumulator 4 to drive the load by the working pump and the energy accumulator. A lift speed of the load depends on an output flow of the working pump 3. Since the synchronous motor 1 has no drain port, all working ports has a high pressure, a volumetric efficiency of the synchronous motor 1 is close to 100%. Thus a total transmission efficiency is more than 90%, and an energy utilization rate is high. These way and parameters are the preferred embodiments for implement this disclosure.

[0015] In a case of $P_x > 2P_n$, the pressure of the energy accumulator 4 may drive the pressure actuation element 5. The synchronous motor 1 is rotated in a high speed under a function of the pressure oil from the first inlet IN1, and the second inlet IN2 has a very low pressure, even a negative pressure. The load of the working pump 3 is zero in this case,

and there is no power outputted by the working pump 3. If oil drainage of the energy accumulator 4 is performed with throttle control, energy of the pressure oil corresponding to a $2P_n - P_x$ overpressure will be lost in a form of heat. If the oil drainage of the energy accumulator 4 is not performed with throttle control, the pressure oil released by the energy accumulator 4 makes the lifting of the working device be continuously accelerated and results in an uncontrollable lifting speed, and the synchronous motor 1 is possible to draw no oil and generate abnormal sound and damage components. In addition, in case of a certain recycled energy, a too high recycle pressure results in a too small volume of the recycled oil. In this case, each lift cycle of the working device cannot be completed during releasing of the recycled oil, pump oil supply is constantly switched, which results in a poor machine operability. Therefore, this situation should be avoided.

[0016] The embodiments disclosed above are only preferred embodiments of the present disclosure, and the present disclosure is not limited thereto. For those skilled in the art, any modifications and changes may be made to the disclosure. Modifications, equivalent replacements and improvements made without departing from the spirit and principle of the present disclosure should fall into the protection scope of the present disclosure.

Claims

1. A pressure self-matching energy utilization system, comprising: a synchronous motor (1), a control valve (2), a working pump (3), an energy accumulator (4) and a pressure actuation element (5); wherein a main outlet (OUT) of the synchronous motor (1) is connected to a load keeping cavity of the pressure actuation element (5), a first inlet (IN1) of the synchronous motor (1) is connected to an oil port of the energy accumulator (4) via a first switch valve (K1) of the control valve (2), and a second inlet (IN2) of the synchronous motor (1) is connected to an output port of the working pump (3) via a second switch valve (K2) of the control valve (2).
2. The pressure self-matching energy utilization system according to claim 1, wherein, the synchronous motor (1) has no low pressure drain port, an accumulating pressure of the energy accumulator (4) is represented as P_x , a working pressure of the working pump (3) is represented as P_b , a demand pressure of the actuation element (5) is represented as P_n , $P_x + P_b \geq 2P_n$ and $P_x < 2P_n$.
3. The pressure self-matching energy utilization system according to claim 2, wherein, the pressure actuation element (5) comprises at least one oil cylinder and/or at least one hydraulic motor.
4. The pressure self-matching energy utilization system according to claim 3, wherein, the load keeping cavity of the pressure actuation element (5) is further connected to a descending control device, the descending control device is configured to control the pressure actuation element (5) to control descending of a working device.
5. The pressure self-matching energy utilization system according to any one of claims 1 to 4, wherein, the oil port of the energy accumulator (4) is further connected to an energy accumulating control device, the energy accumulating control device is configured to charge energy to be recycled into the energy accumulator (4).
6. The pressure self-matching energy utilization system according to claim 5, wherein, the working pump (3) is a fixed displacement pump or a variable displacement pump.
7. The pressure self-matching energy utilization system according to claim 6, wherein, a switch valve control signal of the control valve (2) is a hydraulic signal and/or an electrical signal.

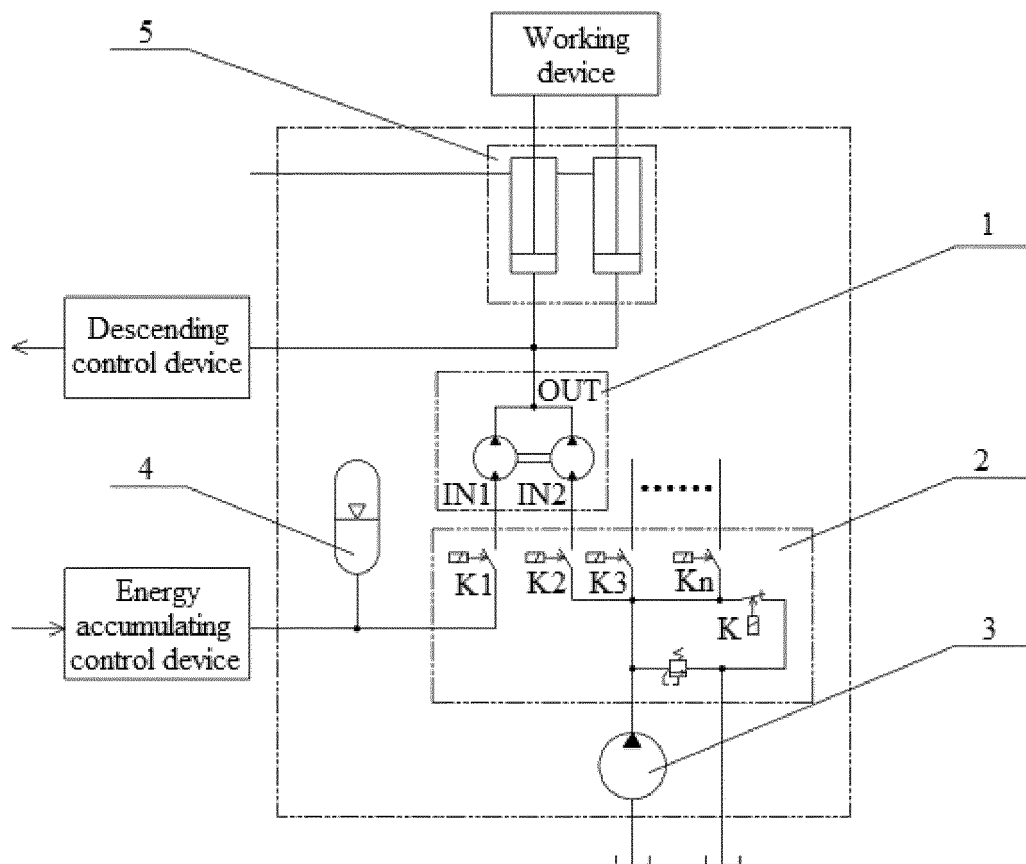


Figure 1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/083257

A. CLASSIFICATION OF SUBJECT MATTER

F15B 21/14 (2006.01) i; F15B 1/02 (2006.01) n
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F15B, E02F, E21D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS; CNTXT; SIPOABS; DWPI: 蓄能, 储能, 回收, 收集, 压力, 匹配, motor?, pump?, energy, regenerat+, recovery, storage, pressur+, match+, accumulat+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 107013535 A (SUNWARD INTELLIGENT EQUIPMENT CO., LTD.), 04 August 2017 (04.08.2017), claims 1-7	1-7
PX	CN 206830577 U (SUNWARD INTELLIGENT EQUIPMENT CO., LTD.), 02 January 2018 (02.01.2018), claims 1-7	1-7
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A	CN 101408213 A (ZHEJIANG UNIVERSITY), 15 April 2009 (15.04.2009), entire document	1-7

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search 06 July 2018	Date of mailing of the international search report 24 July 2018
Name and mailing address of the ISA State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No. (86-10) 62019451	Authorized officer WANG, Han Telephone No. 86-(10)-62085483

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/083257

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Form PCT/ISA/210 (continuation of second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2018/083257

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CN 206830577 U	02 January 2018	None	
CN 102691700 A	26 September 2012	CN 102691700 B	03 December 2014
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Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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