US 20150276284A1

(19) United States
(12) Patent Application Publication
WAIBEL et al.
(10) Pub. No.: US 2015/0276284 A1
(43) Pub. Date: Oct. 1, 2015

(54) **COOLING DEVICE FOR A CONDENSER OF A SYSTEM FOR A THERMODYNAMIC CYCLE, SYSTEM FOR A THERMODYNAMIC CYCLE, ARRANGEMENT WITH AN INTERNAL COMBUSTION ENGINE AND A SYSTEM, VEHICLE, AND A METHOD FOR CARRYING OUT A THERMODYNAMIC CYCLE**

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(21) Appl. No.: **14/673,349**

(22) Filed: **Mar. 30, 2015**

(30) **Foreign Application Priority Data**

Mar. 31, 2014 (DE) 10 2014 206 026.5

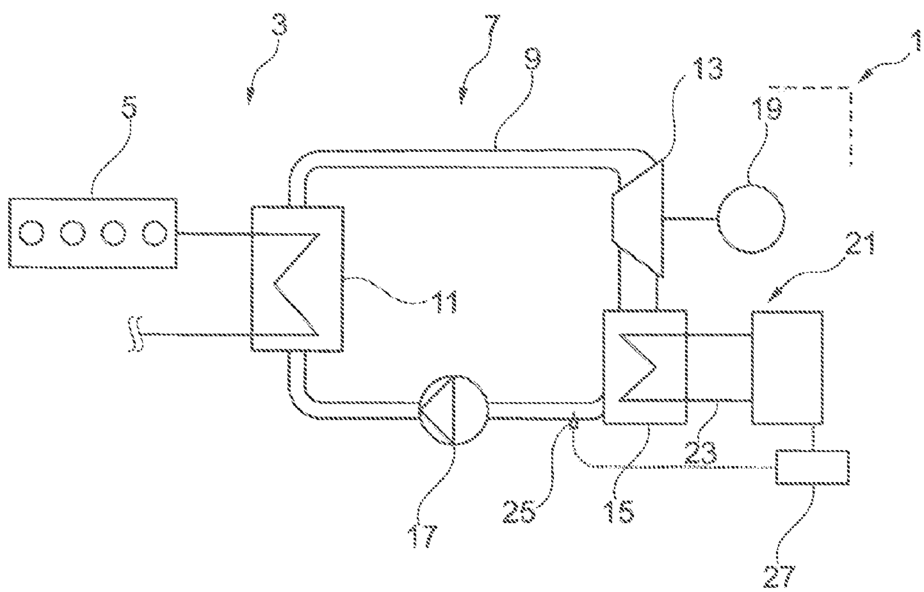
Publication Classification

(51) **Int. Cl.**
F25B 39/04 (2006.01)

(52) **U.S. Cl.**
CPC *F25B 39/04* (2013.01)

(57) **ABSTRACT**

A cooling device for a condenser of a system for a thermodynamic cycle, with a coolant circuit, wherein a conveying device for conveying a coolant through the coolant circuit is provided, and wherein the coolant circuit includes a cold branch downstream from a cooling point for the coolant and a hot branch upstream of the cooling point. The conveying device has a variable output, and/or the coolant circuit has a connecting line between the hot branch and the cold branch. A mixing device is provided, by way of which a variable portion of coolant can be supplied from the hot branch to the cold branch via the connecting line, bypassing the cooling point.



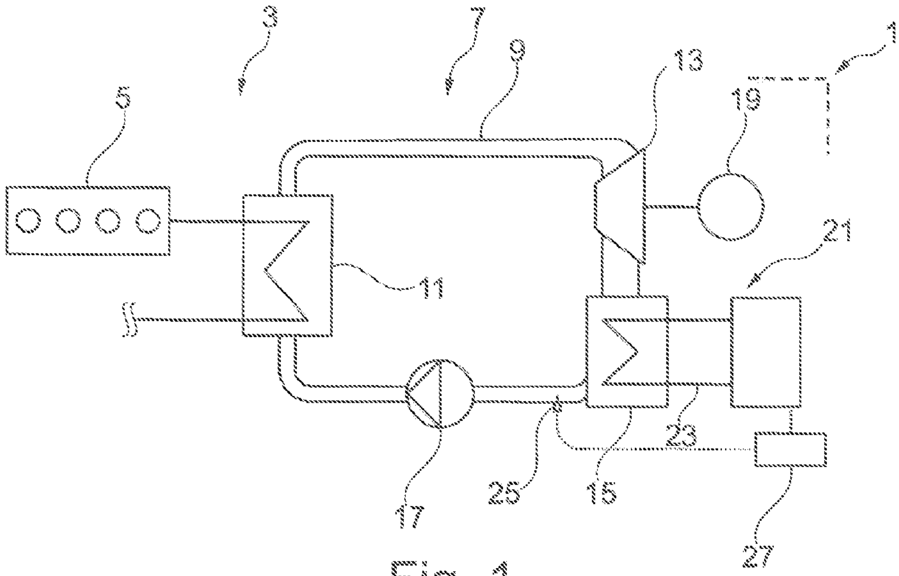

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Fig. 1

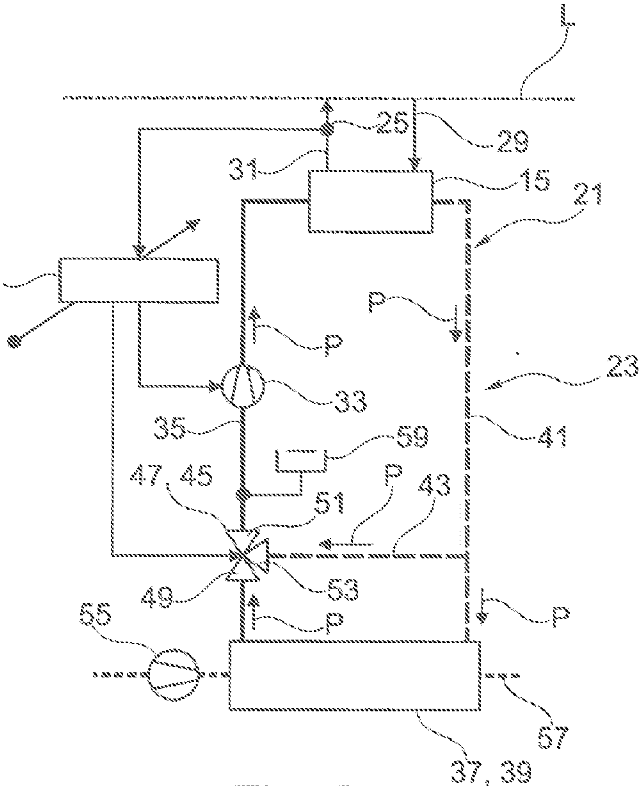
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Fig. 2

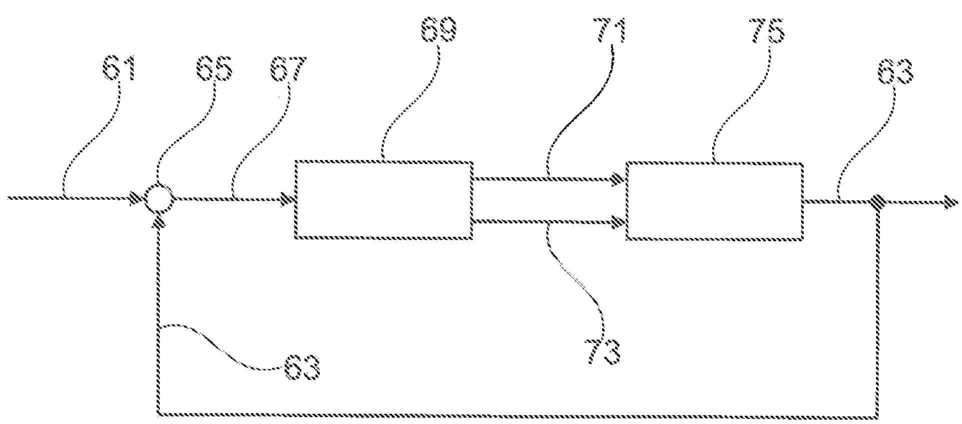

Fig. 3

COOLING DEVICE FOR A CONDENSER OF A SYSTEM FOR A THERMODYNAMIC CYCLE, SYSTEM FOR A THERMODYNAMIC CYCLE, ARRANGEMENT WITH AN INTERNAL COMBUSTION ENGINE AND A SYSTEM, VEHICLE, AND A METHOD FOR CARRYING OUT A THERMODYNAMIC CYCLE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority of DE 10 2014 206 026.5, filed Mar. 31, 2014, the priority of this application is hereby claimed and this application is incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] The invention pertains to a cooling device for a condenser of a system for a thermo-dynamic cycle, to a system for a thermodynamic cycle, to an arrangement consisting of an internal combustion engine and such a system, to a motor-driven vehicle with a corresponding arrangement, and to a method for carrying out a thermodynamic cycle.

[0003] Thermodynamic cycles of the type in question here are known as such. A working medium is heated, in particular vaporized, in a vaporizer, and then expanded in an expansion device, wherein heat of the working medium taken up in the vaporizer is converted to mechanical energy. The working medium is then cooled, in particular condensed, in a condenser, and sent back to the vaporizer again. The organic Rankine cycle, for example, corresponds essentially to the Clausius-Rankine cycle, except that it is adapted to lower working temperatures. It is therefore especially adapted to the use of waste heat of industrial processes, for example, or to that of internal combustion engines. To cool, in particular to condense, the working medium in the condenser, a cooling device is provided. This can be configured as an air cooler, for example, wherein the cooling capacity of the cooling device is set in this case by the automatic control of a blower. The disadvantage of this is that the blower has a very high energy demand. It is also possible for the cooling device to provide a direct connection between the condenser and an external heat reservoir in the form of tap water, river water, or sea water, for example. In this case, the cooling capacity available for the condenser is determined, so that the condenser is limited to operation on a certain temperature level and thus at a certain condensation pressure. This necessarily leads to a performance yield lower than maximum possible yield at many operating points of a system for operating thermodynamic cycles. If, furthermore, the temperature of the working medium at the outlet from the condenser varies with the operating point of the system as a result of the fixed cooling capacity, it is possible that, at certain operating points and especially in high load ranges of the system, it is impossible to ensure sufficient supercooling of the working medium below its condensation point in the condenser, as a result of which there is the danger that cavitations will occur in the conveying device of the system set up to convey the working medium through the circuit.

SUMMARY OF THE INVENTION

[0004] The invention is based on the goal of creating a cooling device by means of which the disadvantages cited above can be avoided. The invention is also based on the goal of creating a corresponding system, an arrangement consisting of an internal combustion engine and a system, a motor-driven vehicle, and a method for operating a thermodynamic cycle, wherein the cited disadvantages do not occur.

[0005] The goal is achieved in that a cooling device is set up to cool a condenser of a system for operating a thermodynamic cycle, highly preferably an organic Rankine cycle, known by the abbreviation "ORC", wherein the cooling device comprises a coolant circuit. A conveying device for conveying a coolant through the coolant circuit is provided. The coolant circuit comprises a cold branch upstream of a cooling point for the coolant and a hot branch downstream from the cooling point. According to a first exemplary embodiment, the cooling device is characterized in that the conveying device comprises a variable output. As a result, the cooling capacity of the cooling device can always be adapted to the current operating point of the system for the thermodynamic cycle by variation of the output of the conveying device, so that the temperature level and thus the condensation pressure in the condenser can always be set precisely. Alternatively, according to a second exemplary embodiment, it is provided that the coolant circuit comprises a connecting line between the hot branch and the cold branch, wherein a mixing device is provided, by means of which a variable portion of the coolant can be sent from the hot branch to the cold branch via the connecting line, thus bypassing the cooling point. As a result, a temperature level of the coolant upstream of the condenser is adjustable, as a result of which in turn the cooling capacity of the cooling device can be adjusted. This device can therefore always be adapted in this way as well, exactly and precisely, to an operating point of the system.

[0006] The cooling point refers to an area of the coolant circuit in which the coolant is cooled, in particular recooled, wherein the heat taken up by the coolant in the condenser is carried away here. The cold branch of the coolant circuit connects the cooling point to the condenser, so that cooled coolant can be supplied to it, wherein the hot branch connects the condenser to the cooling point, so that coolant heated in the condenser can be sent to the cooling point for cooling. The cooling device is to this extent not configured as an open system with direct connection of the condenser to the environment or to an external heat reservoir, but rather as a recooled primary coolant circuit, which is itself cooled in the area of the cooling point.

[0007] In an exemplary embodiment of the cooling device, the conveying device is configured as a pump, wherein the output of the pump is variable, in that it has a variable rotational speed.

[0008] A portion of coolant taken from the hot branch and variable in the mixing device can be adjusted in particular to achieve a desired ratio of a volume flow rate of the coolant flowing via the connecting line to a volume flow rate flowing via the cooling point. It is obvious that cold coolant thus arriving in the mixing device from the cooling point can be mixed with hot coolant arriving from the condenser and branched off upstream of the cooling point, so that ultimately in this way the temperature of the coolant supplied to the condenser for cooling is adjustable.

[0009] In a third exemplary embodiment of the cooling device, both the conveying device comprises a variable output and the coolant circuit comprises a connecting line between the hot branch and the cold branch, wherein a mixing device is provided, by means of which a variable portion of coolant from the hot branch can be supplied to the cold branch via the connecting line, thus bypassing the cooling point. In this way, there are two degrees of freedom available for automatically controlling the cooling capacity, so that this capacity can be set very precisely and independently of the temperature level of the cooling point. Thus the condensation pressure in the condenser is precisely adjustable and adaptable to any operating point of the system which may occur. An optimal power yield can therefore be ensured at all operating points, and the cooling of the condenser is not limited by a fixed cooling capacity to a certain temperature level and thus to a certain condensation pressure. The conveying device, especially when it is configured as a variable-speed pump, consumes in particular much less power than the blower of an air-cooled condenser. In addition, the cooling capacity of the cooling device proposed here can be set more precisely than is possible with air cooling with ambient air by means of a blower.

[0010] An exemplary embodiment of the cooling device is characterized in that the conveying device is configured as an automatically controllable conveying device. As a result, the flow rate of the coolant through the coolant circuit, in particular the volume flow rate of coolant through the condenser, can be set especially accurately. It is possible for a conveying line of the conveying device to be automatically controlled to set the volume flow rate through the condenser. It is especially preferable for the conveying device to be configured as an automatically controllable pump. The rotational speed of the pump is preferably controllable, which represents an especially simple embodiment of an automatically controllable conveying device.

[0011] An exemplary embodiment of the cooling device is characterized in that the connecting line branches off from the hot branch upstream of a recooling device, wherein the recooling device is set up to cool the coolant in the coolant circuit. The connecting line leads to the cold branch downstream from the recooling device. The cooling point of the cooling device in this exemplary embodiment is realized by the recooling device, wherein preferably the primary cooling circuit realized by the coolant circuit is connected for heat transfer to a secondary coolant circuit. Alternatively, it is possible for the recooling device to connect the coolant circuit to an external heat reservoir by way of a thermal connection. The recooling device is preferably configured to use outside water or air as coolant, in particular tap water, river water, sea water, or ambient air. Especially in the case of marine applications of the system, recooling by sea water is preferred. By means of the recooling device, the coolant can be cooled very effectively in the area of the cooling point, wherein its waste heat can be dissipated to the environment easily and at low cost. Because the connecting line branches off from the hot branch upstream of the recooling device, as-yet-uncooled coolant heated in the condenser can be sent through the connecting line. Because the connecting line leads to the cold branch downstream from the recooling device, it is possible at this point, at which preferably the mixing device is also provided, to mix cold coolant arriving from the recooling device especially efficiently with hot coolant arriving via the connecting line.

[0012] Another exemplary embodiment of the cooling device is characterized in that the connecting line leads to the cold branch upstream of the conveying device. Thus the mixing device is also preferably arranged upstream of the conveying device, so that it conveys coolant which has already been mixed and is thus at the specified temperature reached in the mixing device. In terms of automatic control technology, this proves to be especially favorable, and it is easier than if the connecting line were to lead to the cold branch downstream from the conveying device, which would mean that the conveying device was merely conveying cold coolant.

[0013] An exemplary embodiment of the cooling device is characterized in that the mixing device is configured as a three-way mixer, wherein the cold branch leads to a first and a second connector of the three-way mixer, wherein the connecting line leads to a third connector of the three-way mixer. The part of the cold branch arriving from the cooling point leads to a first connector of the three-way mixer, wherein the path of the coolant continues from a second connector of the three-way mixer to the condenser. The connecting line is connected to the third connector of the three-way mixer, so that coolant from the first and third connectors is mixed in the mixing device and sent to the second connector. This represents an especially simple and low-cost as well as easy-to-control embodiment of the mixing device. The mixer can comprise a first functional setting, in which the first connector is connected to the second connector, wherein the third connector is blocked. In this case, the mixing device allows only cold coolant through, so that, to this extent, a minimum temperature of the medium is realized. In a second functional setting, the third connector is connected to the second connector, wherein the first connector is blocked. In this case, the mixing device allows only hot coolant through, so that to this extent a maximum temperature of the medium is realized. Between these two extreme positions, there are preferably various functional settings, especially preferably a continuum of functional settings, that can be realized, so that the temperature of the coolant can be adjusted by the mixing device to any or to almost any temperature between the minimum temperature and the maximum temperature of the medium.

[0014] In another embodiment the cooling device is characterized by control unit, which is set up to produce a presettable absolute or relative temperature level in a condenser of a system for operating a thermodynamic cycle, highly preferably an ORC, by actuating the conveying device and/or by actuating the mixing device. The control unit is set up preferably to produce the desired temperature level by actuation of both the conveying device and the mixing device. By means of the control unit, it is possible in any case to produce an absolute or relative temperature level in the condenser in a highly exact and precise manner, preferably to control it in an open-loop or closed-loop manner.

[0015] An absolute temperature level is understood to mean an absolute, previously determined temperature to be reached for the working medium in the condenser or directly downstream from the outlet of the working medium from the condenser. A relative temperature level is understood to mean a previously determined degree of supercooling of the working medium in the condenser or directly downstream from the condenser, therefore a previously determined difference between the working medium temperature and the condensation point of the working medium in the condenser. By effectively adjusting the degree of supercooling, it can be ensured that the working medium does not cavitate in the working medium pump of the system. By way of the adjustment of the absolute or relative temperature level in the condenser or directly downstream from the condenser, furthermore, the power yield of the system can also be optimized. What is needed for this purpose in particular is the precise adjustment of the pressure in the condenser, which can be adjusted very precisely by variation of the working medium temperature and therefore by variation of the cooling capacity of the cooling device. This pressure acts as a backpressure at the expansion device and therefore, together with other operating parameters of the system, plays a primary role in determining the power yield of the system. The cooling capacity which the cooling device must have to adjust the temperature level to a presettable value varies as a function of the operating point of the system, in particular as a function of the heat input into the system, because, depending on the heat input into the vaporizer, a greater or lesser amount of heat must be carried away from the condenser. By means of the cooling device proposed here, it is to be prevented in particular that more heat is carried away than is necessary to achieve a previously determined supercooling of the working medium. Otherwise this has a negative effect on the power yield of the system.

[0016] The control unit is set up to maintain the preset volume flow rate of the coolant via automatic control of the output of the conveying device and to maintain the preset coolant temperature at the inlet into the condenser by actuating or automatically controlling the mixing device. In this way, the cooling capacity of the cooling device can be controlled very sensitively by the control unit in either open-loop or closed-loop fashion, especially by combining the variation of the output of the conveying device with the variation of the temperature setting in the mixing device.

[0017] An exemplary embodiment of the cooling device is characterized in that the control unit is set up to optimize the power yield of the system by actuation of the conveying device and/or of the mixing device. In this case, the control unit preferably comprises a feedback circuit for at least one parameter which is a characteristic of the power yield of the system, so that the power yield can be optimized directly, i.e., automatically controlled. As a result, the cooling capacity of the cooling device can always be coordinated optimally with the current operating point of the system. It is especially preferable for the control unit to be set up to optimize the power yield of the system by actuating both the conveying device and the mixing device.

[0018] The goal is also achieved in that a system for operating a thermodynamic cycle, quite preferably an organic Rankine cycle, is created, which is characterized by a cooling device according to one of the previously described exemplary embodiments. The advantages already described in conjunction with the cooling device are thus realized for the system. In particular, the system can be automatically regulated by way of the cooling device to deliver an optimal power yield at all operating points.

[0019] The system comprises a working medium circuit, around which a vaporizer, an expansion device, a condenser, and preferably a working medium pump for conveying working medium through the circuit are arranged—in that order. The cooling device is functionally connected to the condenser so that the working medium can be cooled in the condenser.

[0020] The system also comprises at least one temperature sensor and/or at least one pressure sensor in the condenser or directly downstream from the condenser, i.e., downstream with respect to the direction in which the working medium flows through the circuit, this sensor being functionally connected to the control unit for the open-loop or closed-loop control of the cooling device. By the use of the temperature sensor and/or the pressure sensor, a thermodynamic state of the working medium in the condenser can be acquired, and the cooling capacity of the cooling device can be adjusted on that basis, adjusted in particular in an open-loop or closed-loop manner.

[0021] An exemplary embodiment of the system is characterized in that it is set up to use waste heat of an internal combustion engine. For this purpose in particular, an ORC is preferably carried out in the system. It is possible in this case to make use of the waste heat in an exhaust gas stream or in a coolant stream of the internal combustion engine. Alternatively, it is possible that the system could be set up to use waste heat or heat from some other heat source such as industrial waste heat and/or to use geothermal heat, preferably also by means of an ORC.

[0022] Ethanol is preferably provided as the working medium in the system. This is especially well adapted to the operating points in the system which are reached during the use of waste heat from the exhaust gas of an internal combustion engine and is also well adapted to an ORC.

[0023] The goal is also achieved in by an arrangement that comprises an internal combustion engine and a system according to one of the previously described exemplary embodiments. The system is functionally connected to the internal combustion engine for use of the waste heat of the engine. The system can be used to convert the waste heat into mechanical and/or electrical energy, which is sent back to the internal combustion engine again, such as to a crankshaft of the internal combustion engine, especially by means of an electric motor, which is functionally connected to the crankshaft. Alternatively or in addition, the energy converted in the system from the waste heat of the internal combustion engine can be sent to an external consumer or to a power supply system. It is possible that the power supply system could be an on-board power supply system of a motor-driven vehicle which comprises the arrangement. The system makes it possible to achieve a considerable increase in the efficiency of the internal combustion engine through the use of its waste heat. Instead of being uselessly dissipated into the environment, the waste heat is put to positive use.

[0024] The internal combustion engine of the arrangement is preferably configured as a reciprocating piston engine. In a preferred exemplary embodiment, the internal combustion engine serves in particular to drive heavy land vehicles such as mining vehicles and trains or water craft, wherein the internal combustion engine is used in a locomotive or motor coach or in a ship. The use of the internal combustion engine to drive a vehicle serving defensive purposes such as a tank is also possible. In another exemplary embodiment of the internal combustion engine, it is stationary and used for stationary power generation to generate emergency power or to cover continuous-load or peak-load demands, wherein the internal combustion engine in this case preferably drives a generator. The stationary use of the internal combustion engine to drive auxiliary units such as fire-fighting pumps on offshore drilling rigs is also possible. An application of the internal combustion engine in the area of the recovery of fossil materials and especially fossil fuels such as oil and/or gas is also possible. The internal combustion engine can also be used in industry or in the construction field for the production of construction vehicles such as cranes and bulldozers. The internal combustion engine is preferably configured as a diesel engine; as a gasoline engine; or as a gas engine for operation with natural gas, biogas, customized gas, or some other suitable gas. Especially when the internal combustion engine is configured as a gas engine, it is suitable for use in block-type thermal power stations for stationary power generation.

[0025] The goal is also achieved by a motor vehicle that is characterized by an arrangement according to one of the previously described exemplary embodiments. With respect to the motor-driven vehicle, the advantages already explained in conjunction with the cooling device, the system, and the arrangement are realized. The energy converted by the system from the waste heat of the internal combustion engine can be used effectively either to support the internal combustion engine or for other purposes, such as to supply an on-board power supply system of the motor-driven vehicle with electrical energy.

[0026] In an exemplary embodiment the motor-driven vehicle is configured as a water craft, especially as a ship, preferably as a ferry. Here the waste heat can be used in a variety of ways to operate various systems of the ship, especially an on-board power supply system, i.e., the ship's own power grid, or to support the internal combustion engine. It in addition, it is also possible to realize the recooling device in a water craft in an especially simple and low-cost manner by using sea water or river water for the recooling. Thus a virtually inexhaustible heat reservoir is available for recooling, so that, whatever else may happen, the precise setting of the thermodynamic state of the working medium in the condenser cannot fail because of a lack of recooling capacity.

[0027] The goal is also achieved, finally, in that a method for operating a thermodynamic cycle, quite preferably an organic Rankine cycle, is created. The method is provided in particular for the operation of a system according to one of the previously described exemplary embodiments. In this case the system comprises an evaporator, an expansion device, and a condenser, arranged in that order in the direction in which the working medium flows through the circuit of the system, wherein it also comprises a cooling device, preferably a cooling device according to one of the preceding exemplary embodiments. Within the scope of the method, the desired cooling capacity of the condenser is achieved by actuation of the variable-output conveying device of the cooling device and/or by actuation of a mixing device for supplying a variable portion of coolant from a hot branch of the cooling device to a cold branch of the cooling device via a connecting line. The cooling capacity of the condenser is preferably adjusted by appropriate actuation of both the conveying device and the mixing device. Thus the advantages which have already been described in conjunction with the cooling device, the system, the arrangement, and the motor-driven vehicle are realized.

[0028] Within the scope of the method, a pump, especially a variable-speed pump, is used as the conveying device, wherein the output of the pump is adjusted by varying its rotational speed.

[0029] In an embodiment of the method the output of the conveying device and/or a functional setting of the mixing device is automatically controlled. This makes possible an especially precise setting of the cooling capacity of the cooling device and thus simultaneously of the cooling capacity of the condenser. Preferably both the output of the conveying device and the functional setting of the mixing device are automatically controlled.

[0030] Finally, in another embodiment of the method the cooling capacity of the cooling device is automatically controlled to achieve the optimal power yield of the system and/or a presettable absolute or relative temperature level of the working medium in the condenser or immediately downstream from the condenser. Thus an optimal power yield can be guaranteed at all operating points of the system in an especially suitable and exact manner.

[0031] The description of the cooling device and of the system on the one hand and of the method on the other hand are to be understood as complementary to each other. In particular, method steps which have been explained explicitly or implicitly in conjunction with the cooling device or the system are preferably steps, individually or in combination, of a preferred embodiment of the method. In the same way, features of the cooling device or of the system which have been explained explicitly or implicitly in conjunction with the method are preferably features, individually or in combination, of a preferred exemplary embodiment of the cooling device or of the system. The cooling device or the system is preferably characterized by at least one feature which is required by at least one method step of the method. The method is characterized preferably by at least one method step which is required by at least one feature of the cooling device or of the system.

[0032] The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of the disclosure. For a better understanding of the invention, its operating advantages, specific objects attained by its use, reference should be had to the drawings and descriptive matter in which there are illustrated and described preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWING

[0033] In the drawing:

[0034] FIG. **1** shows a schematic diagram of an exemplary embodiment of a motor-driven vehicle with an arrangement consisting of an internal combustion engine and a system with a cooling device;

[0035] FIG. **2** shows a schematic diagram of an exemplary embodiment of the cooling device; and

[0036] FIG. **3** shows a schematic diagram of an embodiment of the method in the form of an automatic control circuit.

DETAILED DESCRIPTION OF THE INVENTION

[0037] FIG. **1** shows a schematic diagram of an exemplary embodiment of a motor-driven vehicle **1**, which comprises an arrangement **3** consisting of an internal combustion engine **5** and a system **7** for operating a thermodynamic cycle, here in particular an organic Rankine cycle (ORC). The motor-driven vehicle **1** is preferably configured as a ship. Alternatively, however, an embodiment of the motor-driven vehicle **1** as a rail vehicle, as a mining or construction vehicle, as a defensive vehicle, as a truck, or even as a passenger vehicle is also possible.

[0038] The use of the arrangement **3** is not limited to motor-driven vehicles; instead, it can be used in other areas as well, including stationary uses of the internal combustion engine **5** to operate pumps on an offshore drilling rig, for example, where the waste heat of the engine can be put to positive use.

[0039] Finally, the system **7** is not limited to use in an arrangement with an internal combustion engine **5**. On the contrary, it can be used in other ways to use waste heat such as to use industrial waste heat or even to use other heat sources such as geothermal heat.

[0040] The system **7** comprises a working medium circuit **9**, along which an evaporator **11**, an expansion device **13**, and a condenser **15** are arranged in that order in the flow direction of the working medium. The working medium is conveyable through the working medium circuit **9** by a working medium pump **17**. The working medium used is preferably ethanol.

[0041] The expansion device **13** is preferably configured as a continuous-flow machine or as a displacement machine, especially as a turbine, as a reciprocating piston expander, as a rotary vane pump, as a Roots expander, or as a scroll expander. A configuration of the expansion device **13** as a helical screw expander, however, is especially preferred. The expansion device **13** is functionally connected to a generator **19** to convert mechanical energy recovered in the expansion device **13** into electrical energy.

[0042] The evaporator **11** is functionally connected to the internal combustion engine **5** preferably in such a way that waste heat contained in the exhaust gas and/or in the coolant circuit of the internal combustion engine **5**, in particular the waste heat contained in the exhaust gas of the engine, can be sent to the working medium of the system **7** in the evaporator **11**.

[0043] To cool the working medium in the condenser **15**, in particular to condense it, a cooling device **21** is provided with a coolant circuit **23**. A sensor device **25** for detecting a temperature and/or a pressure of the working medium in the condenser **15** is provided preferably directly downstream from the condenser **15** or even in the condenser **15**. The formulation "in the condenser" is always to be understood not only as a value detected directly inside the condenser **15** but also as a value detected immediately downstream from it, because, if these values differ at all from each other, the difference is irrelevant. The sensor device **25** is functionally connected to a control unit **27**, which for its own part is functionally connected to the cooling device **21** to adjust its cooling capacity.

[0044] It has been found that the waste heat supplied to the evaporator **11** varies as a function of an operating point of the internal combustion engine **5**. Thus an operating point of the system **7** varies at the same time, as well as the cooling capacity of the cooling device **21** required to achieve an optimal power yield of the system. The cooling capacity is adjusted precisely by means of the cooling device **21** and the control unit **27** to achieve the optimal power yield at every operating point of the system **7**.

[0045] FIG. **2** shows a schematic diagram of an exemplary embodiment of the cooling device **21**. Also shown are the condenser **15**, a working medium feed line **29** to the condenser **15**, and a working medium outlet line **31** leading from the condenser **15**. The broken line "L" marks the system boundary between the condenser **15** and the rest of the system **7**.

[0046] The cooling device **21** comprises the coolant circuit **23**, which is configured as a primary coolant circuit. A conveying device **33**, here configured as a pump, is provided to convey coolant around the coolant circuit **23**, where the conveying device **33** comprises a variable output, here a variable rotational speed for producing the desired volume flow rate of coolant in the coolant circuit **23**. The coolant circuit **23** comprises a cold branch **35** located downstream—with respect to the flow direction of the coolant—from a cooling point **37**, which is configured here as a recooling device **39**, and a hot branch **41**, upstream of the cooling point **37**. Between the hot branch **41** and the cold branch **35**, a connecting line **43** is arranged, and a mixing device **45** is provided, which is configured here as a three-way mixer **47**, by means of which a variable portion of coolant from the hot branch **41** can be sent via the connecting line **43** to the cold branch **35**. The functional setting of the mixing device **45** is variably adjustable, so that a variable mixing ratio between the hot coolant arriving through the connecting line **43** and the cold coolant arriving from the cooling point **37** can be set.

[0047] The cold branch **35** passes via a first connector **49** to a second connector **51**, wherein the connecting line **43** leads to a third connector **53** of the three-way mixer **47**.

[0048] The arrows P in FIG. **2** indicate the flow direction of the coolant in the coolant circuit **23**, wherein the coolant is conveyable by the conveying device **33** around the coolant circuit **23** in the indicated flow directions.

[0049] It is obvious here that the connecting line **43** branches off from the hot branch **41** upstream of the recooling device **39**, wherein it leads to the cold branch downstream from the recooling device **39**, wherein it leads in particular into the cold branch at a point upstream of the conveying device **33**.

[0050] The recooling device **39** is configured to recool the coolant by means of a recooling medium, which is conveyable by a recooling medium pump **55** around a recooling path **57**, which is preferably configured as a secondary coolant circuit. Sea water is preferably used here as the recooling medium, especially in the case of an embodiment of the motor-driven vehicle **1** as a ship. If the ship is configured as a river boat, however, preferably river water is used as the recooling medium.

[0051] In other applications of the system **7**, it is possible to provide, as an alternative, that air, especially ambient air, or a thermal connection with some other external heat reservoir is used as the recooling medium. Tap water, for example, is another possible example of a recooling medium.

[0052] The coolant circuit **23** also comprises a compensating reservoir **59** for the coolant.

[0053] FIG. **2** shows the control unit **27**, which is functionally connected to the sensor device **25** for detecting the thermodynamic state of the working medium in the condenser **15**, especially for detecting the temperature and/or the pressure of the working medium.

[0054] The control unit **27** is also functionally connected to the conveying device **33** for open-loop or closed-loop control of its output, especially for the open-loop or closed-loop control of the rotational speed of a conveying device **33** configured as a pump. In addition, the control unit **27** is functionally connected to the mixing device **45** for the open-loop or closed-loop control of its functional setting. By means of appropriate actuation of the mixing device **45**, a temperature of the coolant downstream from the mixing device **45** and thus in particular a coolant inlet temperature into the condenser **15** can be automatically controlled, wherein at the same time, by application actuation of the conveying device **33**, a volume flow rate of the coolant through the coolant circuit **23** and especially through the condenser **15** can be automatically controlled. Overall, therefore, the cooling capacity of the cooling device **21** is automatically controllable preferably as a function of an operating point of the system **7**. It is thus possible to adjust precisely the state of the working medium downstream from the condenser **15**. This is possible in particular because of the cooling device **21**, even though the temperature of the recooling medium in the recooling path **57** typically cannot be controlled in open-loop or closed-loop fashion and instead is determined by external circumstances. This is obvious when sea water or ambient air is used as the recooling medium.

[0055] Water is preferably used as the coolant in the cooling device **21** and especially in the coolant circuit **23**.

[0056] FIG. **3** shows a schematic diagram of an embodiment of the method in the form of an automatic control circuit. A setpoint **61** in the form of a nominal value of a thermodynamic variable of state of the working medium in the condenser **15**, preferably a nominal temperature or a nominal supercooling of the working medium is entered into the automatic control circuit. An actual value **63** of the thermodynamic state variable, which is preferably measured by the sensor device **25**, is sent back to a comparison member **65**, and a control deviation **67** between the setpoint **61** and the actual value **63** is determined.

[0057] The setpoint **61** is preferably taken from a characteristic diagram, which is based on at least one operating parameter of the system **7** for characterizing its operating states. As an alternative, it is also possible to select a constant setpoint **61** for the operation of the system **7**. In this case, the cooling capacity of the cooling device **21** is arrived at in particular as a function of the heat input into the vaporizer **11**.

[0058] The control deviation **67** is sent to the controller **69**, which, on this basis, calculates two values for the actuators, namely, a first starting value **71** for the output of the conveying device **33**, especially a rotational speed of the conveying device **33** configured as a pump, and a second starting value **73** for the actuation of the mixing device **45**. The two starting values **71**, **73** act on a controlled system **75** comprising in particular the mixing device **45** and the conveying device **33** as well as, finally, the condenser **15**. The output of the conveying device **33** and the functional setting of the mixing device **45** are preferably adjusted to match the default values **71**, **73**, which is not shown here explicitly. To this extent, what is involved is subsidiary automatic control.

[0059] In the controlled system **75**, a new actual value **63** for the thermodynamic state variable of the working medium in the condenser **15** is then reached.

[0060] Quite generally, within the scope of the method, therefore, the cooling capacity of the condenser **15** of the system **7** is adjusted by actuation of the variable-output conveying device **33**, wherein in addition the mixing device **45** is actuated to supply a variable portion of coolant from the hot branch **41** to the cold branch **35** via the connecting line **43**.

[0061] If a constant value is selected for the setpoint **61**, this value is preferably determined in such a way that the system **7** delivers the greatest possible power yield at all operating points. If the setpoint **61** is taken from a characteristic diagram, this preferably shows the values for the desired setpoint **61** at which the system **7** supplies its optimal power yield as a function of its operating point. Accordingly, the cooling capacity of the cooling device **21** is automatically controlled especially to result in the optimal power yield of the system. **7**.

[0062] Overall it has been found that, by means of the method, it is possible automatically to control the cooling capacity of the cooling device **21** in an energy-saving and yet very precise manner, so that the system **7** can operate with its optimal power yield.

[0063] While specific embodiments of the invention have been shown and described in detail to illustrate the inventive principles, it will be understood that the invention may be embodied otherwise without departing from such principles.

We claim:

1. A cooling device for a condenser of a system for a thermodynamic cycle, comprising: a coolant circuit; a conveying device for conveying a coolant through the coolant circuit, wherein the coolant circuit comprises a cold branch downstream from a cooling point for the coolant and a hot branch upstream of the cooling point, wherein the conveying device has a variable output, and/or the coolant circuit comprises a connecting line between the hot branch and the cold branch; and a mixing device provided so that a variable portion of coolant from the hot branch is sendable to the cold branch via the connecting line, bypassing the cooling point.

2. The cooling device according to claim **1**, wherein the conveying device is configured as an automatically controllable conveying device.

3. The cooling device according to claim **1**, and further comprising a recooling device set up to cool the coolant in the coolant circuit, wherein the connecting line branches off from the hot branch upstream of the recooling device, wherein the connecting line leads to the cold branch downstream from the recooling device.

4. The cooling device according to claim **1**, wherein the connecting line leads to the cold branch upstream of the conveying device.

5. The cooling device according to claim **1**, wherein the mixing device is a three-way mixer, wherein the cold branch passes through a first and a second connector of the three-way mixer, and wherein the connecting line leads to a third connector of the three-way mixer.

6. The cooling device according to claim **1**, further comprising a control unit operative to produce a presettable absolute or relative temperature level in the condenser of the system for a thermodynamic cycle by actuation of the conveying device and/or of the mixing device.

7. The cooling device according to claim **6**, wherein the control unit is operative to optimize a power yield of the system for a thermodynamic cycle by actuation of the conveying device and/or by actuation of the mixing device.

8. A system for a thermodynamic cycle, comprising a cooling device according to claim **1**.

9. The system according to claim **8**, wherein the system is configured to use waste heat of an internal combustion engine.

10. An arrangement, comprising: an internal combustion engine; and the system according to claim **8**.

11. A motor-driven vehicle comprising the arrangement according to claim **10**.

12. The motor-driven vehicle according to claim **11**, wherein the motor-driven vehicle is a water craft.

13. The motor-driven vehicle according to claim **12**, wherein the water craft is a ship.

14. A method for carrying out a thermodynamic cycle, for operating a system having an evaporator, an expansion device, a condenser, and a cooling device according to claim **1**, the method comprising the step of adjusting cooling capacity of the condenser by actuation of a variable-output conveying device of the cooling device and/or by actuation of a mixing device for supplying a variable portion of coolant from a hot branch of the cooling device to a cold branch of the cooling device via a connecting line.

15. The method according to claim **14**, including controlling an output of the conveying device and/or a functional setting of the mixing device.

16. The method according to claim **14**, including controlling cooling capacity to provide an optimal power yield of the system or to produce a presettable absolute or relative temperature level in the condenser.

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