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DESCRIPTION

Field of invention

[0001] The object of this patent application relates to the methods and apparatus for combined heat and power systems waste heat recovery (i.e. cogeneration power plants) wherein incorporated water source high temperature heat pump utilizes at least one waste heat source of cogeneration unit.

Background of the Invention

[0002] Heat pumps that have been used in prior art to enhance the heating power of combined heat and power systems by utilizing the waste heat recovery have been deployed in a number of designs. According to US2006037349 a waste heat is used to improve the heating performance of a heat pump type air conditioner or to prevent an outdoor heat exchanger of the heat pump type air conditioner from being frosted. Yet another solution as disclosed in EP 2299098 A2, which discloses the preamble portion of the independent claims 1 and 8, incorporates an air source type heat pump for utilizing the waste heat source of cogeneration unit, wherein similarly to the one stated before, the main disadvantage of represented approach is relatively low thermal coefficient of performance compared to the water source heat pump potential.

Summary of the Invention

[0003] This invention relates to the combined heat and power systems, wherein at least one incorporated water source high temperature heat pump is used to upgrade a low temperature heat from at least one waste heat source to the higher temperature heat output, which can be afterwards used by at least one heat consumer for space or process heating, preferably in the scope of district heating. It is important to notice, that the heat pump according to the invention is used to heat up and rise the temperature of a heat transfer medium in a return line of a heat distribution network, wherein a design (i.e. operational) temperature of the heat transfer medium in a forward line of the heat distribution network is substantially higher than 60°C, when operating at normal operating conditions. It can be understood, that operating conditions of the heat distribution network are provided after commissioning and warm-up process where at least basic design temperature of the heat distribution network is successfully achieved and maintained (i.e. established) over at least a short period of time, hence at least one internal combustion engine is turned on and operating by firing the fuel in the combustion process in continuous operation and at least one heat pump is turned on and operating for liquid-vapor phase change thermodynamic cycle process (i.e. heat pump principle) and waste heat source utilization. In accordance, at least one internal combustion engine and at least one heat pump

are used to provide a first and second heat source respectively in the scope of heat distribution network where individual unit shall substantially operate in the range between its minimum and maximum rated (i.e. full load) operating power, preferably at normal rated power for highest power developed in continuous operation.

[0004] Exemplary embodiment of the present invention will now be described with reference to the accompanying drawing, i.e. schematics of a cogeneration power plant with incorporated water source high temperature heat pump in a heat distribution network (i.e. preferably at least one closed loop circuit heating system).

Brief description of the drawing

[0005] Figure 1 shows a schematic representation of combined heat and power plant preferential embodiment with incorporated water source high temperature heat pump (HP) having a condenser and evaporator unit for heat pump principle utilization, where following items are shown and marked: cogeneration unit (CHP) with prime mover, preferably internal combustion engine (ICE) with adapted electrical generator (G), heat distribution circuit comprising a network of pipes (P1 - P19), valves (V1 - V3) and pumps (PU1 - PU4) which interconnects the heat consumer (HC) with heat sources, heat exchangers (HE1 - HE3), hatches (H1 - H4), fan (F1), external cooling system (CT1), ambient (O) and control temperature sensors (T1-T13).

[0006] Referring to the preferential embodiment of the cogeneration unit (CHP) with incorporated water source high temperature heat pump (HP), the system comprises an internal combustion engine (ICE), preferably a water cooled gas engine, which runs on a gas fuel, such as natural gas, liquefied petroleum gas, landfill gas, wood gas or biogas for example. While internal combustion engine (ICE) and generator (G) are used for electricity and heat generation when powered, a significant amount of heat is released from the cylinders within the combustion process and other subcomponents (i.e. lubrication oil, charging air and exhaust gas, hereinafter addressed as flue gas), wherein the heat is either used by heat consumer (HC) rather than dissipated to the ambient (O) through the external cooling system (CT1). It is important to notice, that the main heat source for heat consumer (HC) is preferably represented by internal combustion engine (ICE) cooling system (i.e. a jacket type heat exchanger, having an inlet and outlet aperture, herein addressed as inflow and outflow aperture) whereby plurality of waste heat sources arise in the scope of the cogeneration unit (CHP) and incorporated heat pump (HP) when the internal combustion engine (ICE) and heat pump (HP) are turned on and powered, preferably at optimum efficiency or full load regime.

[0007] Effective recovery of waste heat is critical to provide a good total utilization of fuel energy, thus, first and most important waste heat source is represented by flue gas in exhaust system, which is a product of the combustion process within the internal combustion engine (ICE). Secondly, there are at least two additional waste heat sources represented by lubrication oil cooling systems, the first one represented by internal combustion engine (ICE) lubrication oil

cooling system and a second one represented by the heat pump (HP) lubrication oil cooling system (i.e. incorporated compressors lubrication oil cooling system). Furthermore, there are few minor waste heat sources, as internal combustion engine (ICE) charging air cooling system for example, which are under certain circumstances still important for good total waste heat source utilization.

[0008] According to the depicted preferential embodiment as represented on figure 1, the internal combustion engine (ICE) cooling system inflow and outflow apertures are operably coupled to the heat distribution circuit comprising a network of pipes (P1 - P19) that operably interconnects the heat consumer (HC) with heat sources in the scope of cogeneration plant with incorporated water source high temperature heat pump (HP). The heat distribution circuit further comprises a primary heat transfer medium and automated regulation means comprising the control unit (i.e. control electronics), valves (V1 - V3) and pumps (PU1 - PU4) for primary heat transfer medium flow regulation, wherein the heat of heat sources is preferably transferred to the heat consumer (HC) by principle of primary heat transfer medium circulation in a closed loop heat distribution circuit.

[0009] As partially known from prior art, the waste heat of flue gas is utilized by incorporated heat exchanger (HE1) which collects the high temperature waste heat of flue gas in exhaust system, wherein the exhaust heat exchanger (HE1) is capable to collect the waste heat due to the significant temperature difference between the flue gas in exhaust system and primary heat transfer medium in incorporated heat exchanger (HE1). Furthermore, exhaust system according to the invention preferably comprises at least one additional condensing heat exchanger (HE2), which is incorporated to collect at least the residual low temperature waste heat of flue gas, being used afterwards by water source high temperature heat pump (HP) to enhance the heating power of the cogeneration unit (CHP). More precisely, the depicted embodiment comprises two heat exchangers (HE1, HE2) incorporated into the internal combustion engine (ICE) exhaust system with aim to collect the waste heat of combustion process, wherein it is important to notice, that the first heat exchanger (HE1) is operably coupled to the forward line of heat distribution circuit, wherein the flow of primary heat transfer medium through the heat exchanger (HE1) cools down the temperature of flue gas to approximately 120°C; and furthermore, the second (i.e. preferably condensing) heat exchanger (HE2) is operably coupled with a high temperature heat pump (HP) evaporator unit, preferably in a closed loop piping system with secondary heat transfer medium involved, hence the temperature of the flue gas in exhaust system is additionally reduced to the temperature close to the ambient (O), preferably bellow 25°C. While the temperature of flue gas in exhaust system is rapidly reduced, the exhaust system may further comprise a suction fan (F1) for removal of flue gas from exhaust system, if necessary.

[0010] If appropriate, the heating power of represented cogeneration unit (CHP) can be furthermore enhanced if the first heat exchanger (HE1) is partially or completely bypassed by means of flue gas stream manipulation (i.e. regulation) means comprising motorized valves, preferably hatches (H1-H4), regulated by said control unit. Even more, if appropriate, the heat exchanger (HE2) and heat pump (HP) shall be implemented in a multistage approach or

cascade principle comprising a plurality of heat pumps (HP) and/or heat exchangers (HE2) in parallel and/or serial connection, to reach the simplified and cost effective solution for exhaust system as well. As follows, similarly as described for flue gas waste heat utilization, the waste heat of internal combustion engine charging air or lubrication oil cooling system can be collected as well by at least one additional heat exchanger (HE3), which is operably coupled to the heat pump (HP) evaporator unit in serial or parallel connection with above described heat exchanger (HE2) in exhaust system, wherein the lubrication oil cooling system of heat pump (HP) compressor is preferably incorporated into the water source high temperature heat pump (HP) enclosure.

[0011] While there are several options for waste heat source utilization it is essential to notice, that preferential embodiment of water source high temperature heat pump (HP) utilization uses at least one low temperature waste heat source for vaporization of working medium of incorporated heat pump (HP), wherein the condenser unit outlet is preferably fed to the heat distribution circuit return line, more precisely to the inflow of the internal combustion engine (ICE) cooling system, where the aim of proposed inventive approach is to reach and maintain the maximum allowed temperature of the primary heat transfer medium at the inlet of the engine cooling system. According to depicted embodiment on figure 1 the heat distribution circuit comprises a cooling system bypass connection, hence the cooling system is at least partially bypassed when the maximum allowed temperature of primary heat transfer medium at inflow aperture of the internal combustion engine (ICE) cooling system is reached and successfully maintained at defined set point with hysteresis, wherein the valve (V1) is reconfigured by automated regulation means to a position, which at least partially redirects the primary heat transfer medium stream from condenser unit outlet to the forward line of heat distribution circuit. In addition, the heat distribution circuit further comprises a heat pump (HP) condenser unit bypass connection, wherein the condenser unit is at least partially bypassed according to the heat demand situation in heat distribution circuit.

[0012] Furthermore, the invention relates to a method of the heat pump (HP) integration process, to a method for utilization of low grade temperature waste heat sources of cogeneration unit (CHP) by water source high temperature heat pump (HP) and to a method of using the apparatus according to the invention.

[0013] The following steps represent the key features of a heat pump (HP) integration and novel method for cogeneration unit (CHP) waste heat source utilization:

1. 1. Integration of the water source high temperature heat pump (HP) having a condenser and evaporator unit with working medium for liquid-vapor phase change thermodynamic cycle utilization and at least one heat exchanger (HE2, HE3), wherein:
    1. A) the high temperature heat pump (HP) condenser unit is operably coupled to the heat distribution circuit pipeline system; and
    2. B) the high temperature heat pump (HP) evaporator unit is operably coupled with at least one heat exchanger (HE2, HE3) in a closed loop piping system with secondary heat transfer medium involved.

2. 2. Collecting the heat by incorporated heat exchanger (HE2, HE3) from at least one waste heat source, wherein the heat source is:
    1. A) Flue gas stream in exhaust system; and/or
    2. B) Lubrication oil cooling system; and/or
    3. C) Intercooler charging air.
3. 3. Transfer of the heat from at least one heat source to the high temperature heat pump (HP) evaporator unit, preferably by circulation of secondary heat transfer medium in the closed loop piping system.
4. 4. Transfer of the heat from secondary heat transfer medium to the working medium in evaporator unit of the high temperature heat pump (HP), wherein the low temperature heat from at least one waste heat source is upgraded by working medium liquid-vapor phase change thermodynamic cycle, hence the temperature of the working medium in condenser unit is substantially higher than the temperature of the working medium in evaporator unit.
5. 5. Transfer of the heat from working medium in the high temperature heat pump (HP) to the primary heat transfer medium in the heat distribution circuit, wherein the temperature of the primary heat transfer medium at condenser unit outlet is substantially higher than temperature of the primary heat transfer medium at condenser unit inlet, hence the high temperature output of condenser unit is fed to the:
    1. A) Internal combustion engine (ICE) cooling system inflow (i.e. return line), wherein the inflow temperature is maintained by automated regulation means (preferably by valves (V1 - V3) and pumps (PU1 - PU4)) in a range between the 60°C and 90°C, preferably at set point with 70°C; and/or
    2. B) Forward line of the heat distribution circuit with at least one heat consumer (HC) involved.
6. 6. Usage of high temperature primary heat transfer medium by:
    1. A) Internal combustion engine (ICE) cooling system with aim to maintain the maximum allowed predefined set point of inlet temperature; and/or
    2. B) Heat consumer (HC) in the scope of the district heating, industrial or technological process.

[0014] The following steps represent the key features of a method of using the apparatus according to the invention:

1. 1. A fuel combustion process, where an engine cooling system of at least one internal combustion engine (ICE) is used to provide a first heat releasing unit for heating at least one heat transfer medium in said heat distribution network, wherein at least one waste heat source arise when the internal combustion engine (ICE) is turned on and operating by firing the fuel in the combustion process. Accordingly, plurality of internal combustion engine (ICE) units with engine cooling systems in parallel or serial connection shall be used to provide an advanced edition of the first heat releasing unit.
2. 2. A waste heat recovery process comprises a process of collecting the waste heat, wherein at least one waste heat recovery unit is used to collect at least a portion of the

heat of at least one waste heat source from group of waste heat sources comprising a flue gas in exhaust system, charging air in charging air cooling system or lubrication oil in lubrication oil cooling system. Accordingly, plurality of waste heat recovery units in parallel or serial connection shall be used to provide an advanced apparatus for waste heat recovery process utilization.

3. 3. A liquid-vapor phase change thermodynamic cycle utilization process, wherein at least one water source high temperature heat pump (HP) shall be used to provide a second heat releasing unit for heating at least one heat transfer medium in said heat distribution network, at least when said heat pump (HP) is turned on and operating. Accordingly, plurality of heat pumps (HP) units in parallel or serial connection is used to provide an advanced edition of the second heat releasing unit.
4. 4. Usage of collected heat for liquid-vapor phase change utilization, wherein at least a portion of collected heat is used for the liquid-vapor phase change cycle utilization and wherein at least a portion of the heat generated by at least one heat pump (HP) in the scope of the second heat releasing unit is used for heating the engine cooling system of at least one internal combustion engine (ICE) in the scope of the first heat releasing unit.
5. 5. Distribution of the heat in at least one closed loop circuit of said heat distribution network by circulation of at least one heat transfer medium, wherein the lowest temperature of the heat distribution medium in the engine cooling system of at least one internal combustion engine (ICE) in the scope of the first heat releasing unit is substantially higher than the lowest temperature of the heat distribution medium in at least one heat consumer (HC). Hence, at least one heat transfer medium in at least one return line of said heat distribution network is reheated by the heat pump (HP) principle utilization, wherein the temperature of the heat transfer medium in said engine cooling system of at least one internal combustion engine (ICE) is substantially higher than 60°C, at least when a design temperature of the heat distribution network is reached and said internal combustion engine (ICE) and heat pump (HP) are operating at full load.

[0015] In addition to represented method of using the apparatus according to the invention, few explanations and definitions are required, wherein combustion process is substantially a continuous process, while said internal combustion engine (ICE) normally operates in the range between its minimum and maximum rated operating power, preferably at normal rated power in continuous operation. Similarly the liquid-vapor phase change thermodynamic cycle utilization process is substantially a continuous process, wherein said heat pump (HP) operates in the range between its minimum and maximum rated operating power, preferably at normal rated power in continuous operation. If appropriate, the fuel combustion process in complex (i.e. advanced) heat and power generation plant shall be provided by plurality of internal combustion engine (ICE) units, wherein the heat in the scope of the first heat releasing unit is transferred in serial and/or in parallel connection with aim to transfer the heat between individual engine cooling systems and similarly, the liquid-vapor phase change thermodynamic cycle utilization process shall be utilized by plurality of heat pump (HP) units to provide a second heat releasing unit of the advanced heat and power generation plant.

[0016] While one of the key features of method and apparatus according to the invention is establishment of predetermined set point value for internal combustion engine coolant temperature, the thermal energy balance adjustment is executed by adapting the power of said heat pump (HP) and/or by adapting the power of said internal combustion engine (ICE) and/or by adapting the mass flow of the primary heat transfer medium through the engine cooling system of said internal combustion engine and/or by adapting the mass flow of the primary heat transfer medium through the heat pump (HP) and/or by adapting the mass flow of the secondary heat transfer medium in at least one of said closed loop circuit for waste heat source utilization. Accordingly the mass flow of the primary heat transfer medium in said heat distribution circuit is adapted by changing the flow velocity in said heat distribution circuit and/or the mass flow of the secondary heat transfer medium in said closed loop circuit is adapted by changing the flow velocity in said closed loop circuit, wherein the velocity of heat transfer medium in heat distribution network is adapted by switching (i.e. on/off regulation) and/or by adjusting the power of at least one circulation pump for mass flow adjustment. In addition, the mass flow of the primary heat transfer medium in said heat distribution circuit is alternatively adapted by stream flow regulation, wherein at least a portion of the primary heat transfer medium stream in the return line of said heat distribution circuit is redirected to the return line of said heat distribution circuit to provide a heat pump (HP) bypass connection, and/or wherein at least a portion of the primary heat transfer medium stream from said heat pump (HP) is redirected to a forward line of the heat distribution circuit to provide an engine cooling system bypass connection. Similarly the mass flow of the secondary heat transfer medium in said closed loop circuit for waste heat source utilization is adapted by stream flow regulation, wherein at least a portion of the secondary heat transfer medium stream is redirected in said closed loop circuit to provide a bypass connection for at least one waste heat recovery unit. Accordingly, the mass flow regulation of the primary heat transfer medium and/or the mass flow regulation of the secondary heat transfer medium for thermal energy balance adjustment is determined, controlled and executed by at least one control unit (i.e. electronic controller), wherein the position and/or the state (i.e. open/closed or on/off regulation) of the automated regulation means is adjusted in respect to the heat demand in said heat distribution network.

[0017] The apparatus according to the invention may further comprise at least one control unit, wherein such a controller shall be autonomous device for thermal management regulation or alternatively, at least basic functions of the thermal management controller for determination process, comparison process and execution process could be incorporated and implemented to the internal combustion engine (ICE) controller or in to the heat pump (HP) controller as well. In the determination process the environment and thermal conditions of heat distribution network is determined by the group of thermal, pressure or other sensors, wherein at least one input from at least one sensor of heat distribution network or internal combustion engine (ICE) is used for comparison process, where at least one value of at least one input parameter (i.e. preferably a temperature of the primary heat transfer medium in engine cooling system) is analyzed and compared to the limiting values, preferably being pre-defined and stored in the control unit. Accordingly the execution process comprises a process of executing instructions stored in control unit to generate appropriate output signal, where at least one parameter for thermal energy balance adjustment is generated, executed and performed by control

electronics in cooperation with automated regulation means in order to reach and maintain the threshold set-point value, wherein said threshold value is defined between the maximum value and the minimum value for set point equal value with aim to provide a hysteresis for thermal energy balance adjustment.

[0018] It can be understood that control unit (i.e. electronic module) may communicate with various output devices where the temperature of the heat transfer medium in the heat transfer network is determined, controlled and regulated by a group of automated regulation means comprising motorized valves, pumps and sensors, wherein regulation means are preferably adapted to be manipulated by at least one control unit. And furthermore, the heat distribution process in heat distribution network is provided by at least one heat transfer medium, preferably by plurality of heat distribution mediums. Accordingly the heat in said heat transfer network is transferred from first heat releasing unit to the heat consumer (HC) by circulation of the primary heat transfer medium in at least one closed loop circuit, and similarly the heat from waste heat recovery unit is transferred to the heat pump (HP) by circulation of the secondary heat transfer medium in at least one closed loop circuit, wherein the heat upgraded by at least one heat pump (HP) is furthermore transferred from heat pump (HP) condenser unit to the engine cooling system of at least one internal combustion engine (ICE) by said primary heat transfer medium.

[0019] Summarizing, the cooling circuits of cogeneration unit (CHP), herein represented as low temperature waste heat sources, are used for utilization of water source high temperature heat pump (HP), wherein its hot water output is preferably used for establishing and maintaining the highest possible or maximum allowed temperature of primary heat transfer medium for internal combustion engine (ICE) cooling system inflow (i.e. cooling jacket inlet). It can be understood, that all vital components of heat distribution circuit are preferably operably coupled for heat transfer medium circulation, wherein the compressor of the incorporated heat pump (HP) shall be driven by electric machine, powered by electricity from grid or generator (G), or alternatively if appropriate, a high temperature heat pumps (HP) compressor shall be mechanically coupled to and driven by internal combustion engine (ICE) as well. Furthermore, as can be clearly read out from previous description, the primary heat transfer medium in preferential embodiment is water and similarly, the secondary heat transfer medium in preferential embodiment is mix of water and glycol.

REFERENCES CITED IN THE DESCRIPTION

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Patentkrav

1. Fremgangsmåde til anvendelse af en varme- og kraftgenereringsanordning til opvarmning for mindst én varmeforbruger (HC) i et varmefordelingsnetværk ved valg af princippet med en højtemperaturvarmepumpe (HP) med vandkilde til udnyttelse af spildvarmekilde, hvilken fremgangsmåde omfatter:

en brændstofforbrændingsproces, hvor et motorkølesystem til mindst én indre forbrændingsmotor (ICE) anvendes til at tilvejebringe en første varmefrigivende enhed til opvarmning af mindst ét varmeoverføringsmedium i varmefordelingsnetværket, og hvor mindst én spildvarmekilde opstår, når den indre forbrændingsmotor (ICE) tændes og fungerer ved fyring med brændstoffet i forbrændingsprocessen;

en spildvarmegenvindingsproces, hvor mindst én spildvarmegenvindingsenhed anvendes til at opsamle mindst en del af varmen fra mindst én spildvarmekilde fra gruppen af spildvarmekilder, der omfatter en røggas i udstødningssystem, ladeluft i ladeluftkølesystem eller smøreolie i smøreoliekølesystem;

en proces til udnyttelse af en termodynamisk cyklus med ændring af væske-dampfase, hvor mindst én højtemperaturvarmepumpe (HP) med vandkilde anvendes til at tilvejebringe en anden varmefrigivende enhed til opvarmning af mindst ét varmeoverføringsmedium i varmefordelingsnetværket, når varmepumpen (HP) er tændt og fungerer, varmen krævet til udnyttelse af væske-dampfaseændringscyklussen opnås helt eller delvist ved hjælp af spildvarmegenvindingsprocessen, hvor mindst en del af varmen opsamlet i spildvarmegenvindingsprocessen anvendes til en proces til udnyttelse af en termodynamisk cyklus med ændring af væske-dampfase, og hvor mindst en del af varmen genereret af mindst én varmepumpe (HP) i den anden varmefrigivende enhed anvendes til opvarmning af motorkølesystemet til mindst én indre forbrændingsmotor (ICE) i den første varmefrigivende enhed;

varmen i mindst én lukket sløjfekreds af varmefordelingsnetværket fortrinsvis fordeles ved cirkulation af mindst ét varmeoverføringsmedium, hvor den laveste temperatur på varmefordelingsmediet i motorkølesystemet til mindst én indre forbrændingsmotor (ICE) i den første varmefrigivende enhed i alt væsentligt er højere end den laveste temperatur på varmefordelingsmediet i mindst én varmeforbruger (HC) i varmefordelingsnetværket, **kendetegnet ved, at** mindst ét varmeoverføringsmedium i mindst én returledning af varmefordelingsnetværket genopvarmes ved udnyttelse af varmepumpe- (HP) princippet, og hvor temperaturen på varmeoverføringsmediet i motorkølesystemet til mindst én indre forbrændingsmotor (ICE) i alt væsentligt er højere end 60 °C, mindst når en

konstruktionstemperatur for varmefordelingsnetværket er nået og den indre forbrændingsmotor (ICE) og varmepumpe (HP) fungerer ved fuld belastning.

2. Fremgangsmåde ifølge krav 1, **kendetegnet ved, at** brændstofforbrændingsprocessen i alt væsentligt er en kontinuerlig proces, hvor den indre forbrændingsmotor (ICE) fungerer inden for intervallet mellem dens minimale og maksimale mærkedrifteffekt, fortrinsvis ved normal mærkeeffekt i kontinuerlig drift;

processen med udnyttelse af den termodynamiske cyklus med ændring af væske-dampfase i alt væsentligt er en kontinuerlig proces, hvor varmepumpen (HP) fungerer inden for intervallet mellem dens minimale og maksimale mærkedrifteffekt, fortrinsvis ved normal mærkeeffekt i kontinuerlig drift;

spildvarmegenvindingsprocessen omfatter en proces med røggaskondensering, hvor den opsamlede varme anvendes til udnyttelse af varmepumpe- (HP) princippet, og hvor temperaturen på røggassen reduceres til under 25°C, røggassen fjernes således i udstødningssystemet ved ventilation af udstødningssystemet ved hjælp af en inkorporeret ventilator (F1);

spildvarmegenvindingsprocessen anvendes til udnyttelse af køleprincippet, hvor varmegenvindingsprocessen anvendes til afkøling af ladeluften for udnyttelse af brændstofforbrændingsprocessen;

temperaturen på varmeoverføringsmediet i varmeoverføringsnetværket bestemmes, styres og reguleres af en gruppe af automatiserede reguleringsmidler, der omfatter ventiler (V1 - V3), pumper (PU1 - PU4) og sensorer (T1 - T13), hvor reguleringsmidlerne fortrinsvis er tilpasset til at blive håndteret af mindst én styrenhed.

3. Fremgangsmåde ifølge krav 2, **kendetegnet ved, at** brændstofforbrændingsprocessen tilvejebringes af en flerhed af indre forbrændingsmotor- (ICE) enheder, hvor varmen i den første varmefrigivende enhed overføres i seriel og/eller i parallel forbindelse for overføring af varmen mellem motorkølesystemer for at tilvejebringe en første varmefrigivende enhed;

processen med udnyttelse af den termodynamiske cyklus med ændring af væske-dampfase tilvejebringes af flerhed af varmepumpe- (HP) enheder, hvor varmen i den anden varmefrigivende enhed overføres i seriel og/eller parallel forbindelse til overføring af varmen mellem varmepumpe- (HP) enheder for at tilvejebringe den anden varmefrigivende enhed;

varmefordelingsprocessen i varmefordelingsnetværk tilvejebringes af en flerhed af varmefordelingsmedier, hvor varmen i varmeoverføringsnetværket overføres fra første

varmefrigivende enhed til varmeforbrugeren (HC) ved cirkulation af primært varmeoverføringsmedium i mindst én lukket sløjfekreds, hvor varmen fra spildvarmegenvindingsenheden overføres til varmepumpen (HP) ved cirkulation af det sekundære varmeoverføringsmedium i mindst én lukket sløjfekreds, og hvor varmen opgraderet af mindst én varmepumpe (HP) endvidere overføres til motorkølesystemet til mindst én indre forbrændingsmotor (ICE) ved hjælp af det primære varmeoverføringsmedium.

4. Fremgangsmåde ifølge krav 3, **kendetegnet ved, at** temperaturen på det primære varmeoverføringsmedium i motorkølesystemet til den indre forbrændingsmotor (ICE) bevares ved en forudbestemt indstillingspunktværdi, hvor termisk energibalancejustering sker ved tilpasning af varmepumpens (HP) effekt og/eller ved tilpasning af den indre forbrændingsmotors (ICE) effekt og/eller ved tilpasning af massestrømningen af det primære varmeoverføringsmedium gennem motorkølesystemet til den indre forbrændingsmotor og/eller ved tilpasning af massestrømningen af det primære varmeoverføringsmedium gennem varmepumpen (HP) og/eller ved tilpasning af massestrømningen af det sekundære varmeoverføringsmedium i den lukkede sløjfekreds til udnyttelse af spildvarmekilde.

5. Fremgangsmåde ifølge krav 4, kendetegnet ved, at massestrømningen af det primære varmeoverføringsmedium i varmefordelingskredsen tilpasses ved ændring af strømningshastigheden i varmefordelingskredsen og/eller massestrømningen af det sekundære varmeoverføringsmedium i den lukkede sløjfekreds tilpasses ved ændring af strømningshastigheden i den lukkede sløjfekreds, hvor hastigheden for varmeoverføringsmedium i varmefordelingsnetværk tilpasses ved omkobling og/eller ved justering af mindst én cirkulationspumpes effekt.

6. Fremgangsmåde ifølge krav 4, kendetegnet ved, at massestrømningen af det primære varmeoverføringsmedium i varmefordelingskredsen tilpasses ved hjælp af strømstrømningsregulering, hvor mindst en del af strømmen af det primære varmeoverføringsmedium i returledningen til varmefordelingskredsen omdirigeres til returledningen fra varmefordelingskredsen for at tilvejebringe en varmepumpe- (HP) omledningsforbindelse, og/eller hvor mindst en del af strømmen af det primære varmeoverføringsmedium fra varmepumpen (HP) omdirigeres til en fremføringsledning til varmefordelingskredsen for at tilvejebringe en motorkølesystem-omledningsforbindelse;

massestrømningen af det sekundære varmeoverføringsmedium i den lukkede

sløjfekreds til udnyttelse af spildvarmekilde tilpasses ved hjælp af strømstrømningsregulering, hvor mindst en del af strømmen af sekundært varmeoverføringsmedium omdirigeres i den lukkede sløjfekreds for at tilvejebringe en omledningsforbindelse til mindst én spildvarmegenvindingsenhed.

7. Fremgangsmåde ifølge krav 5 og 6, kendetegnet ved, at massestrømningsreguleringen af det primære varmeoverføringsmedium og/eller massestrømningsreguleringen af det sekundære varmeoverføringsmedium til termisk energibalancejustering bestemmes, styres og udføres af styreenheden, hvor positionen og/eller tilstanden af det automatiserede reguleringsmiddel justeres i forhold til varmeefterspørgslen i varmefordelingsnetværket.

8. Anordningsenhed til udnyttelse af spildvarme fra kraftvarmeværk, der omfatter:

mindst én indre forbrændingsmotor (ICE), der endvidere omfatter et motorkølesystem, udstødningssystem, et smøreoliekølesystem og et ladeluftkølesystem, hvor motorkølesystemet endvidere omfatter mindst én indstrømningsåbning og mindst én udløbsåbning;

mindst én højtemperaturvarmepumpe (HP) med vandkilde, hvor varmepumpen (HP) endvidere omfatter et smøreoliekølesystem, en fordamperenhed og en kondensatorenhed, og hvor kondenseringsenheden endvidere omfatter en indløbsåbning og en udløbsåbning;

og mindst én spildvarmegenvindingsenhed, fortrinsvis en varmeveksler (HE2) tilpasset til at blive forbundet med fordamperenheden i en lukket sløjfekreds;

hvor spildvarmegenvindingsenheden er tilpasset til at blive forbundet med mindst én fra gruppen af spildvarmekilder, der omfatter et udstødningssystem, smøreoliekølesystem og ladeluftkølesystem til opsamling af spildvarmekildens varme;

og fordamperenheden er tilpasset til at blive forbundet med spildvarmegenvindingsenheden i en lukket sløjfekreds til overføring af den opsamlede varme fra spildvarmegenvindingsenheden til fordamperenheden ved hjælp af et sekundært varmeoverføringsmedium i den lukkede sløjfekreds; **kendetegnet ved, at** udgangen fra kondenseringsenheden er tilpasset til at blive forbundet med indstrømningen til motorkølesystemet for overføring af varmen fra kondenseringsenheden til motorkølesystemet ved hjælp af et primært varmeoverføringsmedium i en varmefordelingskreds;

og indløbet til kondenseringsenheden og udløbet fra motorkølesystemet er tilpasset til at blive forbundet med varmefordelingskredsen, hvor varmefordelingskredsen endvidere omfatter mindst én termisk energimodtagelsesenhed, fortrinsvis en varmeforbruger (HC).

9. Anordningsenhed til udnyttelse af spildvarme fra kraftvarmeværk ifølge krav 8, **kendetegnet ved, at** varmefordelingskredsen omfatter mindst én fremføringsledning og mindst én returledning, hvor fremføringsledningen og returledningen forbinder udløbet fra motorkølesystemet og indløbet til kondenseringsenheden via mindst én varmeforbruger (HC), hvor det primære varmeoverføringsmedium cirkulerer i varmefordelingskredsen til at overføre varmekildevarme til varmeforbrugeren (HC);

udløbet fra motorkølesystemet er operativt forbundet med varmefordelingskredsens fremføringsledning;

indløbet til kondenseringsenheden er operativt forbundet med mindst én returledning fra varmefordelingskreds;

udgangen fra kondenseringsenheden er operativt forbundet med indstrømningen til motorkølesystemet, hvor varmefordelingskredsen omfatter et primært varmeoverføringsmedium;

og varmeveksleren (HE2) er inkorporeret i udstødningssystemet for at modtage mindst en del af røggasvarmen, hvor varmeveksleren (HE2) er operativt forbundet med fordamperenheden i den lukkede sløjfekreds, der omfatter et sekundært varmeoverføringsmedium, hvor varmen opsamlet i varmeveksleren (HE2) overføres til fordamperenheden ved hjælp af cirkulation af sekundært varmeoverføringsmedium i den lukkede sløjfekreds, og endvidere varmen fra kondenseringsenheden overføres til motorkølesystemet ved hjælp af cirkulation af primært varmeoverføringsmedium i hovedfordelingskredsen, hvor temperaturen på det primære varmeoverføringsmedium ved indstrømning til motorkølesystemet i alt væsentligt er højere end 60 °C, når den indre forbrændingsmotor (ICE) og varmepumpen (HP) er tændt og drives ved driftsbetingelser.

10. Anordningsenhed til udnyttelse af spildvarme fra kraftvarmeværk ifølge krav 8, **kendetegnet ved, at** den lukkede sløjfe endvidere omfatter en supplerende varmeveksler (HE3), hvor den supplerende varmeveksler (HE3) er tilpasset til at blive forbundet med et ydre kølesystem (CT1), hvor det ydre kølesystem (CT1) er tilpasset til at blive forbundet med et smøreoliekølesystem til den indre forbrændingsmotor (ICE), smøreoliekølesystem til varmepumpe (HP) og/eller ladeluftkølesystem til indre forbrændingsmotor (ICE).

11. Anordningsenhed til udnyttelse af spildvarme fra kraftvarmeværk ifølge krav 9 og 10, **kendetegnet ved, at** varmefordelingskredsen omfatter en flerhed af varmeforbrugerne (HC) i parallel forbindelse og/eller i seriel forbindelse;

varmefordelingskredsen omfatter en flerhed af varmepumperne (HP) i parallel forbindelse og/eller i seriel forbindelse, hvor fordamperenhedens lukkede sløjfekreds omfatter en flerhed af varmevekslere (HE2, HE3) i parallel forbindelse og/eller i seriel forbindelse, og hvor mindst én af kondenseringsenhedens udløbsåbninger er operativt forbundet med indstrømningen til den indre forbrændingsmotors (ICE) kølesystem.

12. Anordningsenhed til udnyttelse af spildvarme fra kraftvarmeværk ifølge krav 11, **kendetegnet ved, at** den indre forbrændingsmotor (ICE) er designet som en gasdrevet motor, der kører på et gasbrændstof valgt fra gruppen omfattende en naturgas, flydende gas, deponigas, trægas eller biogas, hvor motorkølesystemet er designet som et motorkappekølesystem til den indre forbrændingsmotor (ICE); det primære varmeoverføringsmedium i en foretrukken udførelsesform er vand; det sekundære varmeoverføringsmedium i en foretrukken udførelsesform er en blanding af vand og glycol; og mindst én af varmevekslerne (HE2) er designet som en kondenseringsvarmeveksler (HE2), hvor udstødningssystemet endvidere omfatter mindst én ventilator (F1) til røggasudledning.

DRAWINGS

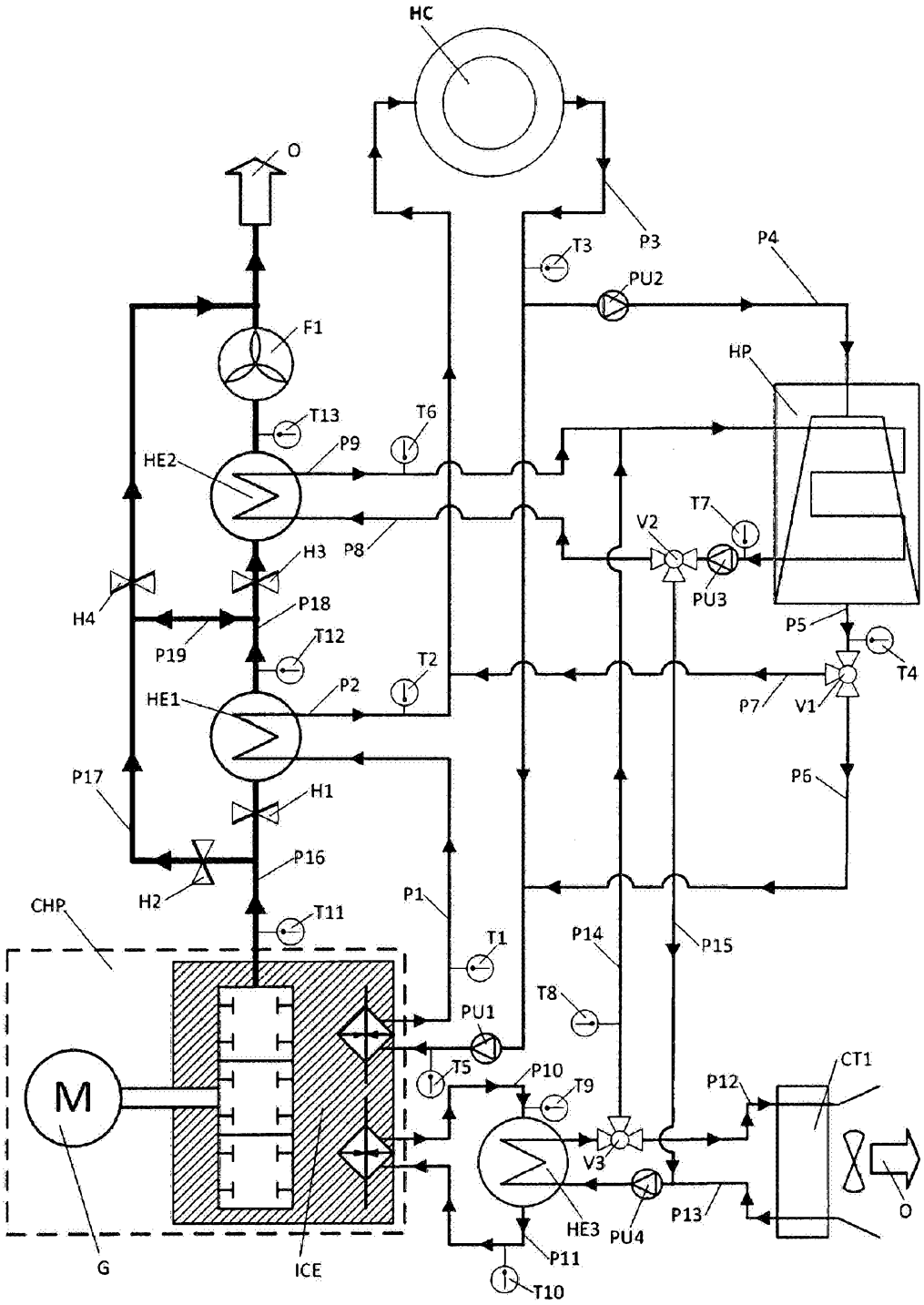


Fig.1