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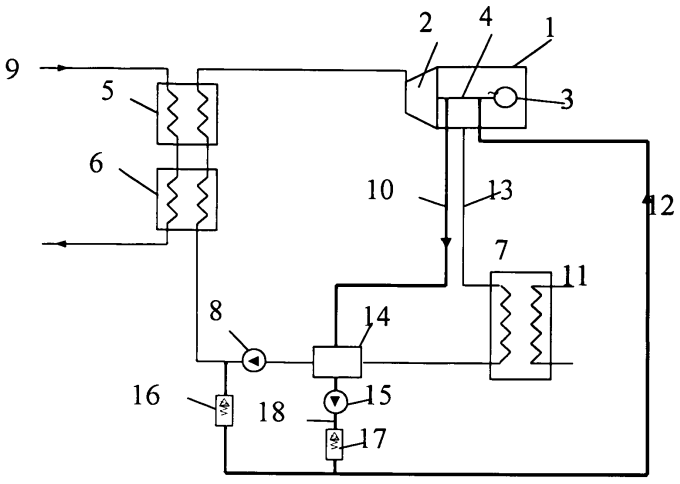
(54) Vapour power plant with hermetic turbogenerator

(57) The vapour power plant with hermetic turbogenerator, with the main thermal cycle that works with the low boiling point fluid and extends consecutively from the preheater (6) and evaporator (5) through the hermetic turbogenerator consisting of the vapour turbine (2) placed together with the electric generator (3) within a common hermetic casing (1), next through the condenser (7), working fluid buffer container (14), main cycle pump (8) and back to said preheater (6), whereby said electric generator (3) is cooled with the expanded vapour from the said turbine outlet and the inlet of the high pressure working fluid vapour into said common hermetic casing (1) is located in front of said turbine (2) and the outlet of the expanded working fluid vapour is in said common hermetic casing (1) located behind said electric generator (3), characterized by an additional, internal working fluid cycle that serves to lubricate the slide bearings contained in said hermetic turbogenerator and that consists of the slide bearings supplying piping (12) connected to the main working fluid cycle at the outlet of said main cycle pump (8), of the slide bearings housing (4), of the return piping (10) that directs the main portion of the working fluid liquid from said slide bearing housing (4) preferably to said working fluid buffer container (14), and of the emergency slide bearings supply piping (18) that connects said working fluid buffer container (14), through the emergency slide bearing supply pump (15), with said slide bearings supply piping (12), whereby said slide bearings supply piping (12) and said emergency slide bearings supply piping (18) contain non-return valves (16) and (17), respectively.



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Description

Background and general description

[0001] The invention relates to the vapour power plant with hermetic turbogenerator. The vapour power plant is based on the Organic Rankine Cycle (ORC), i.e. on the thermal power plant cycle that works with low boiling point fluids instead of water.

[0002] One known hermetic turbogenerator to work in vapour power plants that are based on the thermal power plant cycle with low boiling point fluids is disclosed in the Polish Patent Application P 390472. This hermetic turbogenerator consists of an electric generator and of a vapour turbine that are both placed in the hermetic casing of the turbogenerator. The electric generator is cooled with the working fluid vapour that has been expanded in the vapour turbine. The inlet of the high pressure vapour of the working fluid is arranged in the hermetic casing in front of the vapour turbine, and the outlet of the expanded vapour is positioned in the hermetic casing behind the electric generator. A system of power generation known from the description of the invention GB 1083239 is based on thiophene as the cycle working fluid that is heated and evaporated in a vapour generator, expanded in a turbine, cooled and condensed in a condenser and supplied back to the vapour generator. In that invention, thiophene is used to lubricate the turbine bearings. The invention does not relate to the hermetic generator and does not incorporate any piping system attached to the turbine bearings to return the lubricating fluid as its liquid phase. A portable micro power plant operating with mercury vapour as the working fluid is known from the invention US 29561550. The system incorporates a hermetic turbogenerator and its internal bearings are lubricated by the working fluid liquid that is, under low pressure, supplied from the condenser. The invention does not relate to the turbogenerator in which the electric generator is cooled with the working fluid vapour, and can not be applied to the cases where low boiling point fluids are used as the cycle working fluids. A power plant known from the invention US 20110047958 contains a vapour turbine with an electric generator, an evaporator, a condenser, a cycle pump, and is working with HFE as the cycle working fluid that is mixed with fluoric oil acting as lubricant for the bearings. A fraction of the working fluid with a high content of the lubricant is extracted from the evaporator and is used to lubricate the rolling bearings. A method to secure the lubrication of the high speed turbogenerator bearings is known from the international publication WO 9205342. In this method, for the case of the cycle working fluid pump emergency stoppage, the ORC turbogenerator rotor slide bearings are lubricated with the cycle working fluid supplied from the lower part of the evaporator upon the principle that the evaporator pressure would then increase. The solution does not apply to the hermetic turbogenerator in which the electric generator is cooled with the working fluid vapour, and it does not properly regard the thermal process inertia that excludes the rotor bearings emergency supply. A vapour power plant with the hermetic turbogenerator is known from the Polish Patent Application P 390472. In that solution, the electric generator placed together with the vapour turbine inside a hermetic casing is cooled with the expanded working fluid vapour. The inlet of the high pressure vapour is located in the hermetic casing upstream to the turbine inlet. The outlet of the expanded vapour is located in the hermetic casing downstream to the electric generator position. The expanded vapour of the working fluid flows around the electric generator and carries away heat emitted by the generator.

[0003] The goal of the present invention is, for the standard ORC power plant of moderate power output, to provide a solution that (1) enables an effective lubrication of the slide bearings enclosed in the hermetic turbogenerator that is cooled with the working fluid vapour of the power plant cycle, that (2) provides effective protection of the turbogenerator bearings lubrication in case of the power plant cycle emergency stoppage, that (3) works without lubricants other than the cycle working fluid and that (4) works without the effect of lowering the power plant efficiency.

[0004] According to the present invention, the ORC power plant contains the main thermal cycle of the working fluid, whereby that cycle works with the low boiling point working fluid and extends from the preheater and evaporator through the vapour turbine, the latter being placed together with the electric generator in a common hermetic casing to form the hermetic turbogenerator, next through the condenser, the working fluid buffer container, the main cycle pump and back to the preheater. The electric generator is cooled by the expanded vapour of the working fluid, whereby the high pressure vapour inlet is located in the common hermetic casing upstream to the turbine and the expanded vapour outlet of the common hermetic casing is located downstream to the electric generator position. By virtue of the present invention, the ORC power plant described above contains an additional, internal cycle of the working fluid that serves for the slide bearing lubrication and that consists of the slide bearings supplying piping, the latter being attached to the main working fluid cycle downstream to the main cycle pump, of the slide bearings housing and of the return piping which directs the main portion of the working fluid liquid from the slide bearings to the working fluid buffer container and back to the main cycle pump. The remaining portion of the working fluid liquid that, in the slide bearings labyrinth seals, expands to the vapour phase is directed from the hermetic casing to the condenser, jointly with the working fluid vapour having been expanded in the turbine. An additional, emergency supplying piping that incorporates an emergency working fluid pump then connects the working fluid buffer container and the slide bearing supplying piping. The emergency pump is activated in case of cycle pump failure during the power plant operation. Both the slide bearing supply-

ing piping and emergency supplying piping include non-return valves directly prior to piping connection point.

[0005] The advantage of the present invention lies in continuous, long lasting lubrication of the turbogenerator slide bearings, in contrast to the relevant situation with the known hermetic turbogenerator. This advantage effectively reduces maintenance requirements in cases where the ORC power plant with hermetic turbogenerator is used in real industrial conditions. In line with the present invention, the relevant ORC power plant solution enables the working fluid liquid as lubricant to be supplied to the slide bearings at much higher pressure than that of the slide bearings exterior. The homogeneity and cleanliness of the working fluid, thus the unlowered efficiency of the power plant, are the advantage of the solution with the working fluid as lubricant for the hermetic turbogenerator slide bearings, when no other lubricant is needed. There is then no need to seal the bearings to avoid mixing of lubricant with the working fluid vapour. Complicated systems of the lubricating oil sequestration and separation used in standard bearing arrangements are eliminated. Moreover, as operation of such oil sequestration and separation systems is not perfect, lubrication of the turbogenerator bearings with the working fluid eliminates the need to periodically replace the working fluid in the power plant cycle as result of the working fluid contamination that worsens the power plant efficiency. An essential improvement according to the present invention is provided by the solution that protects the turbogenerator slide bearings against consequences of the power plant cycle pump failure.

[0006] The invention is presented in more detail through a description of its preferred embodiment supported by a drawing that shows the vapour power plant incorporating the additional, internal working fluid cycle for the turbogenerator slide bearing lubrication.

Description of the preferred embodiment

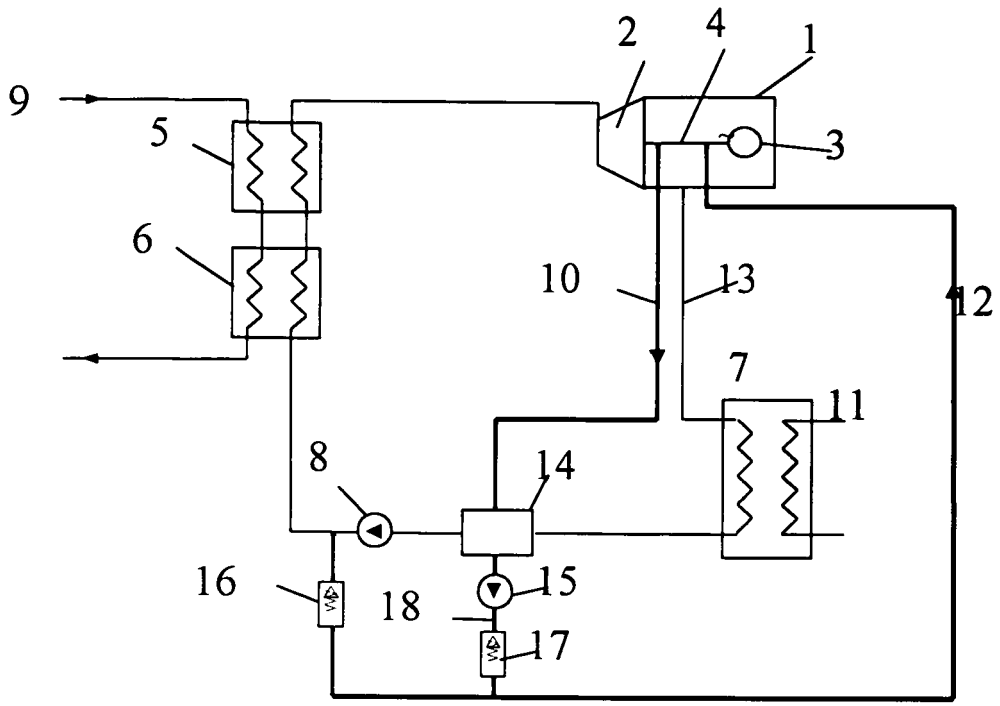
[0007] The main working fluid cycle of the ORC power plant converts low temperature heat into mechanical energy that is then transformed into electrical energy. A special working fluid, mostly of organic nature, circulates in that cycle. The working fluid liquid that flows through the preheater **6** and next through the evaporator **5** extracts heat from the supplying energy carrier **9.** The working fluid being then in form of the hot working fluid vapour is directed to the turbine **2** that, due to the working fluid vapour expansion, generates mechanical power. The turbine **2** drives the electric generator **3** by means of the common shaft connecting the turbine and generator rotors. Both the turbine **2** and electric generator **3** are placed in the common turbogenerator casing **1.** The electric generator **3** is cooled with the expanded working fluid vapour coming from the turbine outlet. The expanded working fluid vapour leaves the turbogenerator casing **1** and is directed, via the piping **13,** to the condenser **7** where it is cooled and condensed to liquid phase with help of the cooling fluid **11.** The resulting working fluid liquid flows from the condenser **7** through the buffer container **14** to the main cycle pump **8** that raises the working fluid pressure. The pressurized working fluid liquid is then directed to the preheater **6** and the whole working fluid circulation is repeated.

[0008] The main working fluid cycle is supplemented by an additional, internal working fluid cycle that serves for lubrication of the turbogenerator slide bearings. The slide bearings supply piping **12** is connected to the outlet of the main cycle pump **8** and is used to supply the pressurized working fluid liquid to the slide bearings housing **4.** The pressurized working fluid liquid lubricates the turbogenerator slide bearings and, at the same time, its pressure drops. Then, the main portion of the working fluid liquid is from the slide bearings housing returned to the buffer container **14** by using the return piping **10.** The remaining portion of the working fluid liquid that, in the labyrinth seals of the slide bearings housing, expands to the vapour phase is, together with the working fluid vapour of the main cycle, directed to the condenser **7.** The slide bearings supply piping **12** is additionally connected with the working fluid buffer container **14** via the emergency supply piping **18** that incorporates the emergency supply pump **15.** Both the slide bearings supply piping **12** and the emergency supply piping **18,** upstream to their connection point, are equipped with non-return valves, **16** and **17** respectively. In case of the main cycle pump failure, or when the working fluid pressure in the main cycle unexpectedly drops because of other reasons, the power plant control system decouples the electric generator from the electric network and activates the emergency supply pump **15** to allow for a safe stoppage of rotating elements of the turbogenerator.

Claims

1. **The vapour power plant with hermetic turbogenerator,** with the main thermal cycle that works with the low boiling point fluid and extends consecutively from the preheater and evaporator through the hermetic turbogenerator consisting of the vapour turbine placed together with the electric generator within a common hermetic casing, next through the condenser, working fluid buffer container, main cycle pump and back to said preheater, whereby said electric generator is cooled with the expanded vapour from the said turbine outlet and the inlet of the high pressure working fluid vapour into said common hermetic casing is located in front of said turbine and the outlet of the expanded working fluid vapour is in said common hermetic casing located behind said electric generator, **characterized by** an additional, internal working fluid cycle that serves to lubricate the slide bearings contained in said hermetic turbogenerator and that consists of the slide bearings supplying piping (12) connected to the main working fluid

cycle at the outlet of said main cycle pump (8), of the slide bearings housing (4), of the return piping (10) that directs the main portion of the working fluid liquid from said slide bearing housing (4) preferably to said working fluid buffer container (14), and of the emergency slide bearings supply piping (18) that connects said working fluid buffer container (14), through the emergency slide bearing supply pump (15), with said slide bearings supply piping (12), whereby said slide bearings supply piping (12) and said emergency slide bearings supply piping (18) contain non-return valves (16) and (17), respectively.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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- PL P390472 **[0002]**
- GB 1083239 A **[0002]**
- US 29561550 B **[0002]**
- US 20110047958 A **[0002]**
- WO 9205342 A **[0002]**