A lightweight underwater cooling assembly with a high cooling capacity comprises: an assembly of heat exchanger tubes (4) arranged in a submerged refrigerant boiling chamber (5); a thin walled water cooled condenser (6) in which refrigerant vaporized in the boiling chamber (5) is condensed and from which condensed refrigerant is recirculated into the boiling chamber (5); and a thin walled pressure compensating membrane (9) which maintains the fluid pressure ($P_{\text{sea}}$) within the boiling chamber (5) and condenser (6) substantially similar to the fluid pressure ($P_{\text{sea}}$) of the (sea) water surrounding the submerged refrigerant boiling chamber (5).
UNDERWATER COOLING ASSEMBLY

BACKGROUND OF THE INVENTION

[0001] The invention relates to an underwater cooling assembly. Underwater cooling assemblies are known from OTC paper 17359 “Subsea Gas Compression—Challenges and Solutions” presented by R. Fantoff at the Offshore Technology Conference held in Houston, USA on 2-5 May 2005 and from international patent applications WO/05/03870, WO/03/035335 and WO 2005/02497.

[0002] The known underwater cooling assemblies comprise heat exchangers that are cooled by the water surrounding the cooling assemblies.

[0003] A disadvantage of the known assemblies is that the (sea) water surrounding the assemblies may not flow at a high velocity along the outer surface of the assembly, which implies poor heat transfer. A further disadvantage of the known assemblies is that the heat exchangers have large wall thickness to withstand the internal and external pressure, which increases weight and implies poor heat transfer.

[0004] It is an object of the invention to provide an improved underwater cooling assembly, which has a high cooling capacity and cooling efficiency.

SUMMARY OF THE INVENTION

[0005] In accordance with the invention there is provided an underwater cooling assembly, comprising:

[0006] an assembly of heat exchanger tubes arranged in a submerged refrigerant boiling chamber;

[0007] a water cooled condenser in which refrigerant vaporized in the boiling chamber is condensed and from which condensed refrigerant is recirculated into the boiling chamber; and

[0008] a pressure compensating membrane which maintains the fluid pressure within the boiling chamber substantially similar to the fluid pressure of the water surrounding the submerged refrigerant boiling chamber.

[0009] The cooling assembly may be part of an underwater gas and/or crude oil production assembly and may be configured to cool a production stream of natural gas and/or crude oil and/or underwater equipment, such as one or more electrical motors and/or gas compressors.

[0010] Preferably, the condenser is an elongate thin walled substantially vertically oriented vessel with an internal permeable reinforcement frame and external cooling fins.

[0011] The boiling chamber and condenser may have an outer wall, which is less than 3 millimeters, preferably less than 2 millimeters, thick, thereby providing a light weight cooling assembly with a high cooling capacity.

[0012] These and other features, embodiments and advantages of the cooling assembly according to the invention are described in the accompanying claims, abstract and the following detailed description of a preferred embodiment in which reference is made to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

[0013] FIG. 1 depicts a schematic view of an underwater cooling assembly according to the invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

[0014] FIG. 1 depicts an underwater cooling assembly 1, which is connected to an underwater oil and/or gas production facility 2, which is mounted on the waterbottom 3.

[0015] The underwater facility comprises equipment, such as electrical motors and/or compressors that are to be cooled and which are connected to an assembly of heat exchanger tubes 4 that are arranged in a refrigerant boiling chamber 5. The facility 2 and heat exchanger tubes 4 together comprise a pressure vessel that can withstand the internal operational pressures as well as the external seawater pressure. The assembly surrounding the heat exchanger tubes 4 (consisting of 5, 6, 7, 8 and 9) is not a pressure vessel, in the sense that it is pressure compensated towards the seawater by means of a pressure compensating membrane 9, hence has insignificant pressure forces acting on it.

[0016] The refrigerant is a suitably selected liquid that boils at ambient seawater pressure at a temperature lower than the external wall temperature of heat exchanger tubes 4.

[0017] The hot fluid Fw that flows into the heat exchanger tubes 4 is cooled by the boiling refrigerant in the boiling chamber 5 and flows as a cooled fluid Fc into the under-water oil and/or gas production facility.

[0018] Due to violent boiling of the refrigerant a high heat transfer will be accomplished on the outer surfaces of the heat exchanger tubes 4.

[0019] The boiling chamber 5 is connected to a seawater cooled condenser 6 via a vaporized refrigerant outlet conduit 7 and a condensed refrigerant inlet conduit 8.

[0020] The boiling chamber 5 is equipped with a pressure compensating membrane 9, which maintains the fluid pressure within the boiling chamber –pbo, substantially similar to the fluid pressure psw of the seawater 10 surrounding the submerged refrigerant boiling chamber 5.

[0021] Since the pressure difference between the interior and exterior of the boiling chamber 5 is minimized by the pressure compensating membrane 9, the boiling chamber 5, the condenser 6, the vaporized refrigerant outlet tube 7 and the condensed refrigerant inlet tube 8 may have a relatively thin wall thickness, which enhances the cooling efficiency.

[0022] To further enhance the cooling efficiency of the assembly the condenser 6 is constructed as an elongate thin walled substantially vertically oriented vessel with an internal permeable reinforcement frame and external cooling fins. The boiling chamber 5 and condenser 6 may have an outer wall, which is less than 3 millimeters, preferably less than 2 millimeters, thick, thereby creating a light weight cooling assembly with a large cooling capacity.

1. An underwater cooling assembly, comprising:

   an assembly of heat exchanger tubes arranged in a submerged refrigerant boiling chamber;

   a water cooled condenser in which refrigerant vaporized in the boiling chamber is condensed and from which condensed refrigerant is recirculated into the boiling chamber; and

   a pressure compensating membrane which maintains the fluid pressure within the boiling chamber substantially similar to the fluid pressure of the water surrounding the submerged refrigerant boiling chamber.

2. The underwater cooling assembly of claim 1, wherein the assembly forms part of an underwater gas and/or crude oil production assembly.

3. The underwater cooling assembly of claim 2, wherein the assembly is configured to cool a production stream of natural gas and/or crude oil and/or underwater equipment, such as one or more electrical motors and/or gas compressors.

4. The underwater cooling assembly of claim 1, wherein the condenser is an elongate thin walled substantially verti-
cally oriented vessel with an internal permeable reinforcement frame and external cooling fins and wherein the pressure compensating membrane also keeps the pressure within the condenser substantially similar to the pressure of the surrounding water.

5. The underwater cooling assembly of claim 1, wherein the boiling chamber and condenser have an outer wall, which is less than 3 millimeters thick.

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