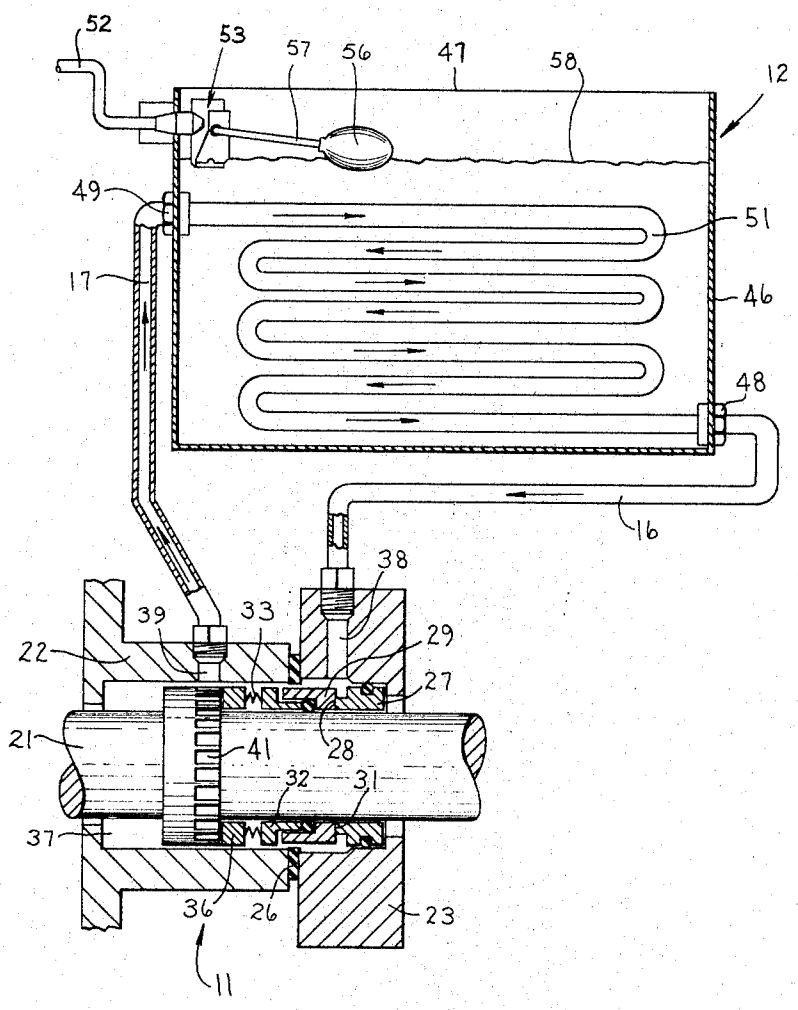
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COOLING SYSTEM FOR A STUFFING BOX SEAL

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COOLING SYSTEM FOR A STUFFING BOX SEAL

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ABSTRACT OF THE DISCLOSURE

An improved method and apparatus for cooling a rotating shaft seal wherein said seal comprises a first annular ring fixed to said shaft and a second nonrotatable annular ring in sealing engagement therewith. The ring members and the shaft are surrounded by a stuffing box defining an annular chamber therearound. The annular chamber is connected with supply and discharge lines which in turn are interconnected to a coil located within a heat exchanger so as to define a closed system for circulation of a primary coolant for cooling the seal, the primary coolant being circulated by means of an impeller fixed to the shaft for rotation therewith. The heat exchanger is supplied with a secondary coolant in liquid form which surrounds the coil whereby heat is transferred from the primary coolant to the secondary coolant with the secondary coolant being heated and a portion thereof becoming vaporized, the vaporizing action withdrawing heat from the remaining coolant and maintaining same at a temperature not exceeding its vaporizing temperature. Thus, the primary coolant is cooled within the heat exchanger to approximately the vaporization temperature of the secondary coolant and is then recirculated through the chamber and the seal.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to a new and improved method and apparatus for cooling a rotating shaft seal wherein a circulating primary coolant surrounds the seal and is then cooled within a heat exchanger by means of a secondary coolant, the secondary coolant preferably being water whereby the heat transferred thereto causes it to vaporize and escape as steam.

Description of the prior art

The cooling of rotating shaft seals by means of fluid heat exchangers is old and well known. However, most of the prior art heat exchangers, when used in combination with a rotating shaft seal, have been complicated and expensive. However, their use has been necessary in order to properly cool the seal so as to result in a desirable seal life.

The basic system for cooling a seal generally comprises a primary closed coolant system having a cooling coil located within the heat exchanger tank with the opposite ends of the coil being interconnected to a chamber surrounding the seal. The primary coolant system contains a fluid therein, generally oil or water, which is recirculated through the system with the fluid absorbing heat in the region of this seal and then releasing this heat within the heat exchanger.

Most of the prior art heat exchangers used in combination with the above basic system have consisted of two basic types, the first involving an exchanger wherein a secondary coolant was recirculated, and the second involving an exchanger wherein a secondary coolant was disposed of as waste so as to necessitate a continuous supply of secondary fluid thereto.

The first type of heat exchanger mentioned above when

used in combination with the above-described primary cooling system involves a closed secondary cooling system, which secondary system comprises a tank surrounding the coil of the primary cooling system with the tank having inlet and outlet ports interconnected by a closed piping system whereby the secondary heat transfer medium or coolant, generally water, within the tank is continuously recirculated throughout the sytem. The secondary cooling system also generally contains grillwork, fins or similar heat transferring devices externally of the tank. Cooling thus occurs by the transfer of heat from the primary coolant to the secondary coolant within the tank, the hot secondary coolant then being circulated throughout the secondary cooling system with the grillwork or fins facilitating the transfer of heat therefrom so as to cool the secondary coolant whereby it may again enter the tank for additional cooling of the primary coolant.

These secondary cooling systems are expensive since the tank has to be of a rather large size in order to permit the transfer of the requisite amount of heat from the primary coolant. Further, these systems require that the external piping include large fins or similar cooling devices in order to transfer heat from the secondary cooling. Thus, the system is not only expensive to install and manufacture, but it also requires a substantial amount of space for mounting of the necessary equipment. Another disadvantage is that the secondary cooling system additionally requires a pump therein in order to recirculate the secondary heat transfer medium, or coolant, which in turn presents another potential maintenance problem.

The second type of heat exchanger mentioned above when used with the above-described primary cooling system involves the use of an open secondary cooling system. In this system, the coil of the primary cooling system is surrounded by a large tank which is supplied with a secondary cooling fluid, generally water. The tank is provided with an inlet supply line and a discharge or drain line. In operation, the secondary fluid is not recirculated but rather the tank is continuously supplied with fresh cool water from the inlet line whereby the water surrounds the coil of the primary system and is heated thereby, the heated water then being drawn off through the discharge line and disposed of. However, this system is expensive and undesirable since it also requires a large tank in surrounding relationship to the primary cooling coil in order to contain sufficient secondary cooling fluid to permit the transfer of the requisite amount of heat from the primary cooling fluid. Further, this system is extremely wasteful since the tank must be continuously supplied with large quantities of fresh water, which water is disposed of after being heated rather than being recirculated and reused. Furthermore, necessary drain lines and associated facilities must be provided for disposing of the heated water.

SUMMARY OF THE INVENTION

This invention relates to a new and improved method and apparatus for cooling a rotating shaft seal wherein the cooling is accomplished in a much simpler and more efficient manner than was previously known.

The apparatus involved for accomplishing the method of the present invention comprises a rotating shaft having a first annular seal member affixed thereto, which member is in sealing engagement with a second nonrotatable sealing ring member. The seal and shaft is surrounded by a stuffing box so as to define a chamber therebetween. The chamber is connected to supply and discharge lines which in turn are connected to a cooling coil so as to define a closed primary cooling system containing a primary heat transfer medium, or coolant, therein. An impeller is fixed to the shaft and rotates therewith whereby

the coolant within the primary system is caused to circulate throughout the system whereby the flowing fluid comes into contact with the seal and absorbs the frictional heat generated thereby, with the heat thus being transferred out of the chamber into the cooling coil. The cooling coil is surrounded by a heat exchanger tank which is filled with a secondary heat transfer medium, or coolant, in particular, water.

According to the method of the present invention, the heat exchanger tank is automatically and intermittently supplied with water to maintain a predetermined depth within the tank. Heat is then transferred from the primary coolant within the coil to the secondary coolant, or water, within the tank. The water within the tank is then heated until the same reaches is boiling temperature. The continual transfer of heat from the primary coolant to the secondary coolant results in boiling of the water within the tank whereby a portion thereof vaporizes and escapes from the system in the form of steam. The tank is automatically refilled with water, either hot or cold, so as to compensate for vaporization losses. Thus, since vaporization of water requires large quantities of heat and same are obtained solely from the body of unvaporized water, large quantities of heat can be efficiently transferred from the primary coolant while requiring only a small tank and small quantities of water.

Accordingly, the objects of the present invention are to provide:

(1) A new and improved method and apparatus for cooling a rotating shaft seal.

(2) A new and improved method, as aforesaid, wherein the cooling is accomplished by utilizing the heat of vaporization.

(3) A new and improved method, as aforesaid, wherein a recirculating primary coolant absorbs the heat from the seal and transfers the heat to a secondary coolant for vaporizing the latter.

(4) A new and improved method, as aforesaid, wherein the secondary coolant comprises water which is vaporized and escapes from the system as steam.

(5) A new and improved method, as aforesaid, wherein only a small heat exchanger tank need be provided for containing secondary coolant therein in surrounding relationship to a coil containing the primary coolant.

(6) A new and improved method, as aforesaid, wherein the cooling is accomplished by a small quantity of secondary coolant.

(7) A new and improved method, as aforesaid, wherein the cooling is accomplished without requiring any discharge or drain lines for the secondary coolant.

(8) A new and improved method, as aforesaid, wherein the cooling is economically and efficiently accomplished.

(9) A new and improved method, as aforesaid, which results in a greatly simplified and more efficient cooling apparatus.

Other objects and purposes of this invention will be apparent to persons acquainted with devices of this type upon reading the following specification and examining the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

The drawing is a schematic diagram partially in cross section illustrating a typical apparatus used for carrying out the improved cooling method of the present invention.

The following description will utilize certain terminology for convenience in reference only, which terminology will not be limiting. For example, the words "upwardly," "downwardly," "rightwardly" and "leftwardly" will refer to directions in the figure when reference is made thereto. The words "inwardly" and "outwardly" will refer to directions toward and away from, respectively, the geometric center of the apparatus or the associated components thereof. Said terminology will include the words above specifically mentioned, derivatives thereof and words of similar import.

DETAILED DESCRIPTION

A typical apparatus employing the method according to the present invention is illustrated in the drawing wherein there is shown a conventional shaft seal arrangement indicated generally at **11** in combination with a heat exchanger indicated generally at **12**. The seal arrangement **11** and the heat exchanger **12** are interconnected by supply and discharge lines **16** and **17**, respectively, so as to permit the shaft seal to be cooled.

Considering the shaft seal arrangement **11** in detail, there is illustrated a rotating shaft **21** surrounded by a stationary stuffing box **22** and a stationary gland **23**, which members are separated by means of a gasket **26**.

A stationary annular sealing member **27** having a transverse sealing face **28** thereon is positioned within the gland **23** in surrounding relationship to the shaft **21**. A similar complementary rotating seal member **29** having a transverse sealing face **31** thereon is rotatably fixed to the shaft **21**. The seal face **31** of the rotating seal member **29** is biased into sealing engagement with the stationary seal face **28** by means of a retainer sleeve **32**, which sleeve in turn is biased by a compressed spring **33** having the opposite ends thereof abutting against the retainer sleeve **32** and a collar **36**, respectively.

The stuffing box **22** and the gland **23** coact with the shaft **21** so as to define a chamber **37** therearound, which chamber surrounds the seal formed between the coacting faces **28** and **31**, respectively. Gland **23** is additionally provided with an inlet passage **38** therein, one end of which opens into the chamber **37** in the region of the sealing faces **28** and **31**. The other end of the inlet passage **38** is connected to the supply line **16**. A similar outlet passage **39** is formed in the stuffing box **22** so as to interconnect the chamber **37** to the discharge line **17**.

Chamber **37** is additionally provided with an impeller **41** therein, which impeller has radially directed vanes or blades thereon. The impeller **41** is affixed to the shaft **21** for rotation therewith and is preferably located substantially adjacent to the outlet passage **39** so as to effectively pump primary coolant from the chamber **37** into the discharge line **17** for circulating the coolant between the chamber **37** and the heat exchanger **12** via the supply and discharge lines **16** and **17**, respectively.

The heat exchanger **12** generally comprises a tank **46** of any desired configuration, the top **47** of the tank being open to the atmosphere or to a low pressure system. The tank is provided wtih fittings **48** and **49** on walls thereof to which is connected the respective ends of the supply and discharge lines **16** and **17**, respectively. A heat transfer means **51**, preferably in the form of a coil, is positioned within the tank with the opposite ends thereof connected to the fittings **48** and **49**. The chamber **37**, the discharge line **17**, the coil **51**, and the supply line **16** thus form a closed primary system which houses or contains therein a primary heat transfer medium, or coolant, preferably oil or water.

The tank **46** also has an inlet line **52** connected near the upper edge thereof with the inlet line having a valve **53** located at the end thereof for controlling the flow of secondary coolant through the line **52** into the interior of the tank **46**. The valve **53** can be of any conventional design and, as illustrated, is operated in a conventional manner by a float **56** which is connected to the valve by means of an intermediate lever **57**, the float maintaining a position approximately along the upper surface of the fluid level **58**. The inlet line **52** supplies a liquid secondary coolant, preferably water, to the tank whereby the tank is maintained substantially full of water at all times. The float controlled valve **53** will automatically open to allow more water to flow from the inlet line **52** into the tank as the float **56** moves downwardly due to a decrease in the water level within the tank. Refilling the

tank so that the water level **58** resumes its normal height will, of course, cause the float **56** to rise simultaneously therewith whereby the valve **53** will be closed. The valve **53** is designed to open and refill the tank before the water level **58** drops below the uppermost portion of the coil **51**.

OPERATION

The new seal cooling method of the present invention will now be described in detail in conjunction with the apparatus illustrated in the drawing.

To permit cooling of the seal members **27** and **29**, the chamber **37** is provided therearound, which chamber communicates with the supply and discharge passages **16, 17** and the heat transfer coil **51** so as to form a closed system containing therein a primary coolant, which will normally be a liquid such as oil or water. The primary coolant within the system is circulated in a generally clockwise direction (as illustrated by the arrows in the drawing) by means of the impeller **41** fixedly secured to the rotating shaft **21**. The coolant passing through the supply line **16** and the inlet passage **38** is at its lowest temperature such that when it leaves the passage **38** it comes into direct contact with the sealing members **27** and **29**, respectively, whereby the primary coolant absorbs a maximum amount of heat from the seal members so as to maintain the seal members at a cool or uniform operating temperature. The heated coolant then moves axially along the chamber **37** (leftwardly in the drawing) and is pumped out of the chamber by the impeller **41** into the discharge line **17** whereby it flows therethrough into the coil **51** located within the heat exchanger **12**. The primary coolant then passes through the several coils of the heat transfer coil **51** whereby the heat of the primary coolant is transferred therefrom such that the primary coolant is again at a lower temperature when it leaves the heat exchanger by means of the fitting **48** so as to again enter the supply line **16**.

The tank **46** of the heat exchanger **12** is substantially filled with a secondary coolant the same being in liquid form and usually water. The fluid level is continuously and automatically maintained at a depth such that the liquid secondary coolant always surrounds the coils of the heat transfer means **51**. The temperature of the primary coolant when it enters the coil **51** through the inlet fitting **49** is substantially greater than the temperature of the secondary coolant contained therearound, such as, in some typical operating conditions, a temperature of 400–600° F. Thus, heat is transferred from the primary coolant into the secondary coolant whereby the temperature of the secondary coolant is consequently increased while the temperature of the primary coolant is decreased. The secondary coolant is heated until vaporization occurs, whereby it escapes from the system as a vapor and carries large quantities of the unwanted heat with it. Further, since the primary cooling circuit is a closed system, the primary coolant can be superheated without creating any vaporization problems.

Analyzing this in more detail, the temperature of the water entering the tank **46** through the inlet pipe **52** may, for example, be taken as being in the order of 60° F. Due to the large temperature difference between the primary coolant (400 to 600° F.) entering the coil **51** and the water (60° F.) entering the tank **46**, heat transfer will occur from the primary coolant to the secondary coolant (water) whereby the temperature of the water will be substantially increased, while a substantial decrease will occur in the temperature of the primary coolant. Each B.t.u. of heat transferred from the primary coolant will raise the temperature of 1 pound of water 1° F. Thus, the temperature of the water within the tank **46** will be rapidly increased until the water reaches a temperature of 212° F. Since the top **47** of the tank **46** is open to the atmosphere, the water temperature will not exceed 212° F. under normal atmospheric conditions but will, upon the transfer of additional heat from the primary coolant to the water, commence to boil whereby the water will be vaporized and escape from the system as steam.

However, the vaporization of a pound of water requires the transfer of 970 B.t.u. from the primary coolant to the water. Thus, in the present invention, each pound of water entering the tank **46** through the inlet line **52** absorbs 152 B.t.u. in undergoing a temperature increase from 60° F. to 212° F. and further absorbs an additional 970 B.t.u. before being completely vaporized and escaping from the system in the form of steam. Thus, each pound of water in the secondary system is capable of absorbing or receiving from the primary coolant a total of 1122 B.t.u. Of course, when the system illustrated in the drawing is operated under steady and continuous conditions, the temperature of the water within the tank **46** is maintained substantially and approximately at 212° F. with a small amount of fresh water being continuously added by means of the valve **53** so as to compensate for the vaporization losses. Further, the primary coolant, when leaving the tank **46** via the fitting **48**, will have been sufficiently cooled that it will leave the tank at a temperature of approximately 212° F.

In comparison, in most of the prior art seal cooling devices, the secondary coolant, or water, often entered the heat exchanger tank at, for example, approximately 60° F. and exited from the tank at approximately 120° F. Thus, each pound of water was capable of absorbing only 60 B.t.u. On the other hand, the method of the present invention permits each pound of water to absorb approximately 1122 B.t.u., this being approximately 18 times more absorption capacity than was possessed in heat exchangers used in prior conventional seal cooling systems.

Thus, it is readily apparent that the cooling method according to the present invention permits the heat exchanger fluid capacity to be greatly minimized, in particular, the tank size is greatly decreased and the amount of secondary coolant or water supplied to the tank is approximately only five percent of the quantity of coolant required in the prior art systems. Further, since the secondary coolant exits from the system of the present invention as steam, no drain or discharge lines are necessary for conducting or transferring the coolant to a waste or storage area.

Further, while the present invention has been described using water as the secondary coolant, it will of course be recognized that other fluids possessing similar physical and vaporization properties could be used as the secondary coolant if so desired. For obvious reasons, however, it will be preferred to use as heat transfer media liquids which can be permitted to vaporize into the atmosphere although collecting and condensing means can be provided where other media are used.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. The method for cooling a rotating shaft seal wherein said seal comprises an annular seal ring fixed to a rotating shaft and in sealing engagement with a stationary seal ring, the seal rings being surrounded by a stuffing box defining a chamber between the box and the shaft with said chamber being connected to a heat exchanger by means of supply and discharge lines, respectively, with said lines being connected to a heat transfer means located within a heat exchanger tank, the heat transfer means and the supply and discharge lines and the chamber defining a closed system containing a primary coolant therein for absorbing heat from said seal and for transferring said heat to a secondary coolant located within said tank in surrounding relationship to said heat transfer means, said method comprising the steps of:

feeding a primary coolant into the region of said seal;

heating said primary coolant by means of the heat generated by said seal;

transferring said heated primary coolant to a heat exchanger;

supplying said heat exchanger with a secondary coolant in liquid form;

vaporizing said secondary coolant by transferring heat energy thereto from said primary coolant and permitting said vapor to escape; and

returning said cooled primary coolant to said seal.

2. The method according to claim 1, wherein said primary coolant is at a temperature approximately equal to the vaporization temperature of the secondary coolant upon leaving the heat exchanger.

3. The method according to claim 1, comprising the additional step of permitting said vaporized secondary coolant to escape to the atmosphere.

4. The method according to claim 1, including the step of automatically refilling said heat exchanger tank with secondary coolant so as to compensate for vapor escaping therefrom.

5. The method according to claim 1, wherein said secondary coolant is supplied to said tank at a temperature below its vaporization temperature and further including the step of heating said secondary coolant from said supply temperature to said vaporization temperature by transferring heat energy from said primary coolant to said secondary coolant.

6. The method according to claim 1, wherein the secondary coolant supplied to said heat exchanger tank is water.

7. The method according to claim 1, wherein said secondary coolant supplied to the heat exchanger tank is water, and further including the steps of permitting said vaporized water to escape to the atmosphere, automatically refilling said heat exchanger tank with water to compensate for vapor escaping therefrom, and permitting said primary coolant to leave said heat exchanger at a temperature approaching the vaporization temperature of the water.

8. The combination comprising a rotating shaft, a stuffing box surrounding said shaft and defining a chamber therebetween, a first annular sealing ring within said chamber mounted on said shaft for rotation therewith, a second annular sealing ring nonrotatably fixed within said chamber, said first and second sealing rings having

sealing faces thereon, spring means biasing said sealing faces into abutting sealing engagement, a heat exchanger, supply and discharge coolant lines interconnecting said heat exchanger and said chamber, an impeller positioned within said chamber and affixed to said shaft for rotation therewith, the improvement wherein said heat exchanger comprises:

a tank;

heat transfer means mounted within said tank and having opposite ends thereof connected to said supply and discharge lines so as to define a closed primary coolant system for continuously circulating a primary coolant between said seal and said tank; and

supply means connected to said tank for feeding a secondary liquid coolant thereto;

said secondary coolant substantially filling said tank and completely surrounding said heat transfer means, said heat transfer means transferring heat energy from said primary coolant to said surrounding secondary coolant causing said secondary coolant to vaporize;

an opening in said tank above the surface of said secondary coolant for permitting said vapor to escape therefrom but the walls of said tank contacted by said secondary coolant being imperforate whereby there are no means providing escape from said tank for said secondary coolant in liquid condition.

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