HISAKA

Plate Type Heat Exchangers for Power Generation

This beautiful night view is also supported by Hisaka's thermal technology...

We are helping power generation facilities advance toward the future.

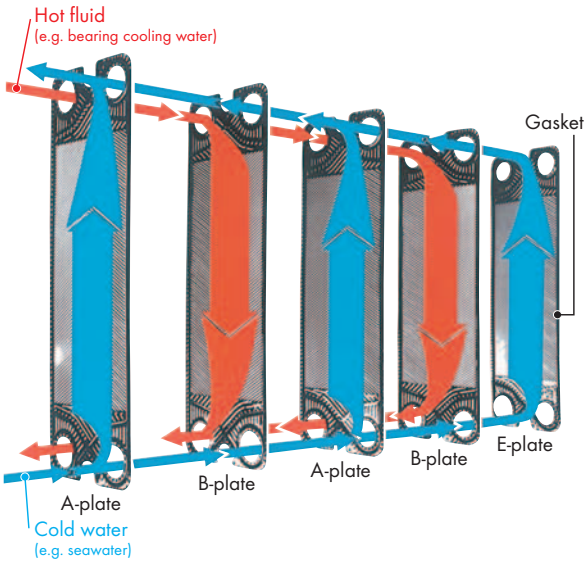
Everyone knows we receive a wide variety of benefits from sea. It is also with the help of the sea that Hisaka's plate type heat exchangers work. Our heat exchangers cool a large amount of heat generated in power stations, and play an important role in producing reasonable, efficient, safe and clean energy. They, of course, are friendly to the environment and sea life as well.

Hisaka has a wealth of know-how and experience in heat exchangers using seawater, such as central cooling systems for power stations, ships, and steelworks, district heating and cooling systems, ocean thermal energy conversion (OTEC) and other technology. Please feel free to contact us for further information.

Hisaka's plate type heat exchangers have made remarkable progress in the last half century.

In 1953, the first plate type heat exchanger developed in Japan was made by Hisaka with its own technology. In the beginning, the plate type heat exchanger only had a maximum flow rate of 100 m^3/h per unit and a maximum working pressure of 0.3 MPaG. Since then, Hisaka has constantly been striving to develop more highly advanced thermal technology and newer cutting-edge production lines. Now our plate type heat exchangers have dramatically improved performance with a maximum flow rate per unit of 5,000 m^3/h and a working pressure of 2.5 MPaG. In addition to this, a total of 40 types of plates are available. The great performance and variety allows for designs suitable for each of many different industrial needs, providing great benefits in effectiveness and economy.

The mechanism of efficient heat transfer



- Hot fluid (e.g. bearing cooling water) and cold fluid (e.g. seawater) are flowed through the four specified portholes at the four corners of each heat transfer plate. These heat transfer plates are made of press-formed thin sheets of metal with a high corrosion resistance (e.g. stainless steel or titanium). One plate can be used in two ways: either as an A-plate or, by turning it upside down, as a B-plate. Plate channels are formed between these heat transfer plates. The Hot fluid flows in the opposite direction to that of the cold fluid, and heat transfer is performed.
- A heat transfer plate has various corrugations and grooves for mechanical strength and its increased heat transfer area. The plate, with corrugations and spherical bumps on the surface, is designed to induce turbulence of the fluids in the plate channels, and therefore to achieve a very high heat transfer coefficient and the most efficient heat transfer.

  A gasket is mounted in the peripheral groove of the plate to seal the fluid in.

Features

- A high heat transfer coefficient (three to five times that of a tubular heat exchanger)

  This allows a smaller heat transfer area, thus lightness and compactness (one quarter of a tubular heat exchanger).
- The temperature approach between both fluids can be minimized to the extreme, even to only 1℃.

  (The excellent heat transfer efficiency allows the hot fluid to be cooled close to the seawater temperature.)
- A structure of the gasket to prevent two fluids from intermixing.
- Flexibility of the heat transfer area

  (The number of the plates can be simply increased or decreased according to the required duty.)
- Usable with seawater

  (The plates are made of corrosion-resistant metal such as titanium.)
- Easy to open and inspect without having to use heavy machinery

  (All heat transfer plates can be opened and visually inspected on an individual basis for hot and cold fluid sides.)
- Maintenance-free

  (Installation of anti-plugging and anti-fouling systems for the heat exchanger provides you with a greater sense of security.)

Quality Assurance ISO 9001 certified

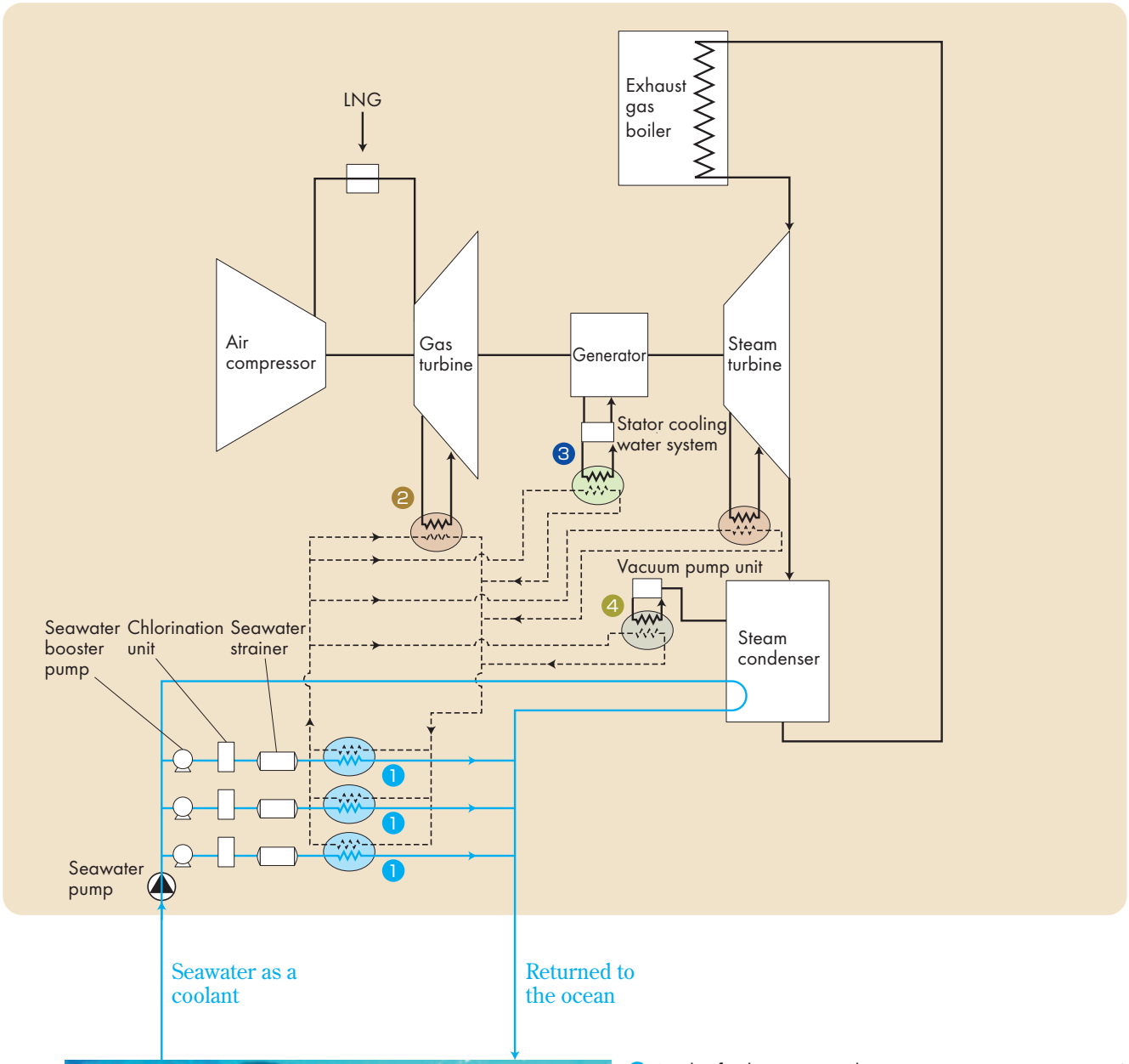
Hisaka has established a strict quality assurance system for manufacturing high-level high-quality products according to high-level technical standards. Products manufactured by Hisaka meet the requirements of the following laws and standards:

- The Japan Electricity Utilities Industry Law
- The Japan High Pressure Gas Safety Law
- The ASME "U" Stamp
- The Japan Pressure Vessel Code

Service Network

- We can quickly respond to your inquiries by our network System, which connects our plants, branches and branch sales offices. We also have a system for delivering components promptly and a comprehensive parts stock program for rapid shipment of spare parts.

Hisaka's plate type heat exchangers at work in a thermal power station



Cooler for Bearing Cooling Water

Application

This cooler is designed for a cooling system which collects all of the cooling water for every system within an entire power station and then cools it with seawater as a cooling medium.
Another cooling medium used to cool the cooling water can be water from a cooling tower or river depending on the plant location.

Examples of operating conditions

Example 1

Bearing cooling water	40℃→32℃	585m³/h	0.05MPa
Seawater	39℃←31℃	600m³/h	0.05MPa

Type of heat exchanger	Heat transfer area (m²)	Dimensions (mm)		
		W	L	H
Plate	752	1,290	3,700	3,400
S&T	1,000×2units	1,850×2units	5,800×2units	1,850

Example 2

Bearing cooling water	41℃→35℃	3,300m³/h	0.08MPa
Seawater	36℃←30℃	3,300m³/h	0.05MPa

Type of heat exchanger	Heat transfer area (m²)	Dimensions (mm)		
		W	L	H
Plate	1,089	1,570	5,200	3,600
S&T	2,000	2,500	15,000	2,500

Features of the equipment and recommendations on its operation

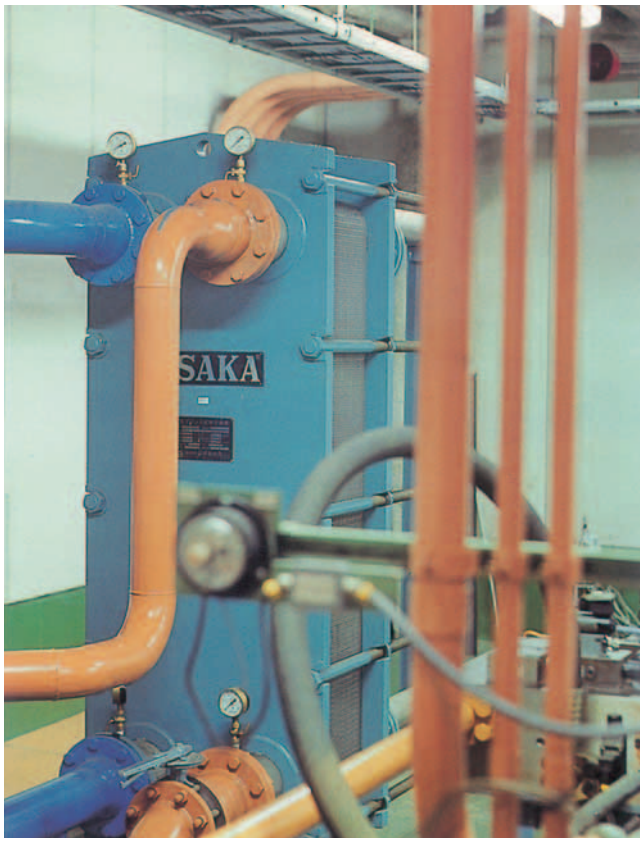
1) High performance, lightness and compactness of the cooler allow a smaller foot print. Therefore, the equipment offers significant advantages to customers in repowering or expanding an existing plant.
2) Maintenance work can be carried out within the installation space without having to provide space for pulling out tubes. No heavy machinery is required to perform maintenance.
3) Hisaka enables production of a large plate type heat exchanger which deals with a flow rate of up to 5,000 m³/h per unit. Thus it allows a reduced number of units and effective use of the installation area, depending on specifications.
4) The temperature approach between hot and cold fluids can be minimized to the extreme. The heat exchanger can be designed to produce a difference as low as 1℃ between the seawater inlet temperature and the bearing cooling water outlet temperature. This allows a lower volume of cooling water and smaller seawater pumps.
5) Hisaka recommends that a three-way flow-dividing valve be installed on the bearing cooling water side to control the bearing cooling water temperature. Then this keeps the flow rate of the seawater at a constant level and reduces the flow velocity of the seawater to prevent the heat exchanger from fouling.
6) Seawater contains debris such as seaweed, shellfish, microbes and contaminants, which may block the plate channels, so it is recommended that anti-plugging and anti-fouling systems be installed.

Oil Cooler

Application

This cooler is designed to cool lubricating oil for bearings of steam and gas turbines.

Hisaka's plate type heat exchangers are proven devices that have a long track record of use in ships and individual power stations (diesel power generation).



Examples of operating conditions

Example 1

Turbine oil	70℃→55℃	120m³/h	0.03MPa
Bearing cooling water	45℃←30℃	46m³/h	0.01MPa

Type of heat exchanger	Heat transfer area (m²)	Dimensions (mm)		
		W	L	H
Plate	58	580	1,870	1,600
S&T	138	500	4,000	500

Example 2

Turbine oil	64℃→45℃	126m³/h	0.08MPa
Bearing cooling water	37℃←32℃	190m³/h	0.07MPa

Type of heat exchanger	Heat transfer area (m²)	Dimensions (mm)		
		W	L	H
Plate	63	610	1,920	1,890
S&T	151	600	4,500	600

Features of the equipment and recommendations on its operation

1) High performance and compactness of the cooler allow reduced installation space. Besides, incorporation of our plate type heat exchanger into the unitized oil cooler makes the unit even smaller.
2) Titanium plates can be used for low quality cooling water with a high chlorine ion concentration.
3) It has a structure to prevent intermixing of two fluids. However, we recommend that you use a higher operating pressure at the oil side than is used for the cooling water to prevent unexpected intermixing of the two fluids in the unlikely event that the plate is damaged.

Cooler for Stator Cooling Water Systems

Application

Stator cooling water systems are used to cool stator coils of large-capacity turbine generators. Cooling water circulates through the stator coils to remove the heat generated by the rotating stator coils. This cooler is designed to cool the stator cooling water.

Examples of operating conditions

Example 1

Pure water	70℃→55℃	120m³/h	0.03MPa
Bearing cooling water	45℃←30℃	46m³/h	0.01MPa

Type of heat exchanger	Heat transfer area (m²)	Dimensions (mm)		
		W	L	H
Plate	16	450	1,000	1,000
S&T	—	—	—	—

Example 2

Pure water	66℃→46℃	168m³/h	0.05MPa
Bearing cooling water	46℃←35℃	300m³/h	0.10MPa

Type of heat exchanger	Heat transfer area (m²)	Dimensions (mm)		
		W	L	H
Plate	45	650	1,100	1,850
S&T	—	—	—	—

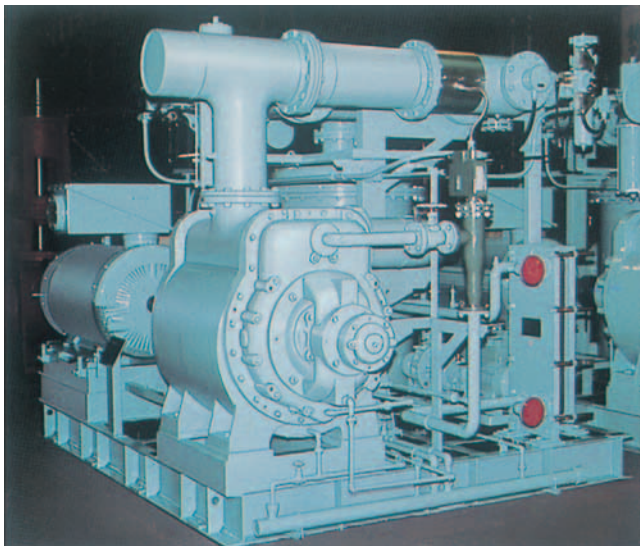
Features of the equipment and recommendations on its operation

1) High performance and compactness of the cooler allow a smaller stator cooling water system.
2) The conductivity of the stator cooling water is specified to be about 0.1 μs/cm. Hisaka's plate type heat exchangers have been applied to a pure water system of many semiconductor manufacturers, and pose no problem whatsoever using pure water.
3) The hot and cold fluids are operated as a counter-current flow. So the equipment can be designed so that the outlet temperature of the cold fluid is higher than inlet of the hot fluid, thus reducing the amount of cooling water necessary.

Seal Water Cooler for Vacuum Pumps for Steam Condensers

Application

This cooler is designed to cool seal water in steam condenser vacuum pumps, used to maintain vacuum in the condenser and reduce dissolved oxygen in the condensate.



Examples of operating conditions

Example 1

Seal water	37℃→29℃	9.3m³/h	0.01MPa
Bearing cooling water	29℃←27℃	33m³/h	0.04MPa

Type of heat exchanger	Heat transfer area (m²)	Dimensions (mm)		
		W	L	H
Plate	16	390	600	1,080
S&T	75	500	2,000	500

Example 2

Seal water	43℃→37℃	10m³/h	0.02MPa
Bearing cooling water	36℃←33℃	20m³/h	0.03MPa

Type of heat exchanger	Heat transfer area (m²)	Dimensions (mm)		
		W	L	H
Plate	3	390	400	1,080
S&T	14	300	1,910	300

Features of the equipment and recommendations on its operation

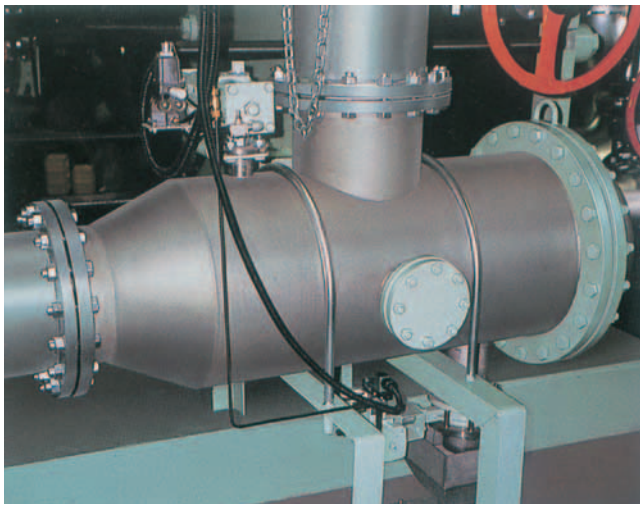
1) High performance and compactness of the cooler allow a smaller steam condenser vacuum pump unit.
2) The cooler can be easily opened for maintenance.

Anti-plugging System for Seawater

(automatic back-flushing type seawater strainer specially designed for Hisaka plate type heat exchangers)

Application

This system is designed to remove any debris such as seaweed, shellfish and contaminants contained in seawater so that they do not enter the plate type heat exchanger, preventing the plate channel inlet from plugging.



Working Principle

By changing the seawater flow direction in the strainer element, discharge the debris through the back-flushing valve.

Features

1) Back-flushing is automatically performed using the differential pressure gauge and timer settings.
2) Back-flushing requires 10% of the amount of water required for normal operation, allowing back-flushing to be performed during normal operation.
3) Use of cylindrical punching metal element allows a larger filtration area.
4) The punching metal element can be opened and cleaned without removing the main pipe during maintenance.

Cleaning Process

1) Normal operation: V1 fully opened and V2 fully closed

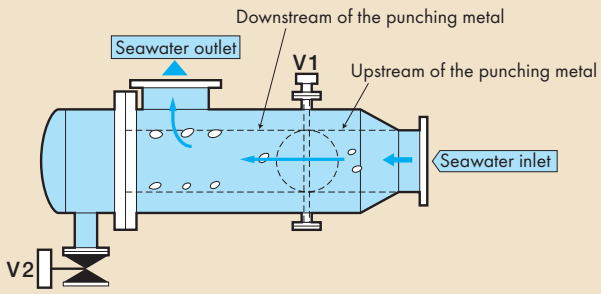
Seawater debris coming in through the seawater inlet is removed at the punching metal strainer zone behind the V1 butterfly valve while only filtered seawater is conducted through the seawater outlet to the heat exchanger.

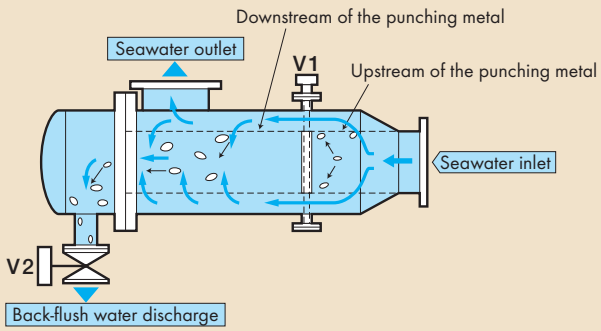
2) Cleaning operation: V1 fully closed and V2 fully opened

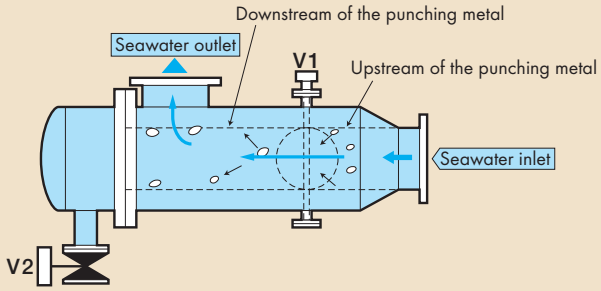
V1 is closed fully and V2 is opened fully, as controlled by the pressure differential and timer.
Only the filtered seawater obtained by removing debris at the punching metal strainer upstream of the butterfly valve flows out of the seawater outlet. At the same time, some of the filtered seawater back-flushes the debris deposited on the inner surface of the punching metal downstream of the butterfly valve and discharges it through the back-flush.

3) Normal operation: V1 fully opened and V2 fully closed

After back-flushing for a period of time set by the timer (a few tens of seconds), the system returns to normal operation. At this point, the debris remaining on the inner surface of the punching metal moves to the punching metal strainer zone downstream of the butterfly valve.







Anti-fouling System

(cleaning system with hot water circulation specially designed for Hisaka plate type heat exchangers)

Application

Film-like fouling caused by microbes in seawater, and deposition and proliferation of shellfish may contaminate the heat transfer surfaces, resulting in reduced heat transfer performance of the heat exchanger and also blockage of the plate channels.
This anti-fouling system can be installed to prevent such trouble.

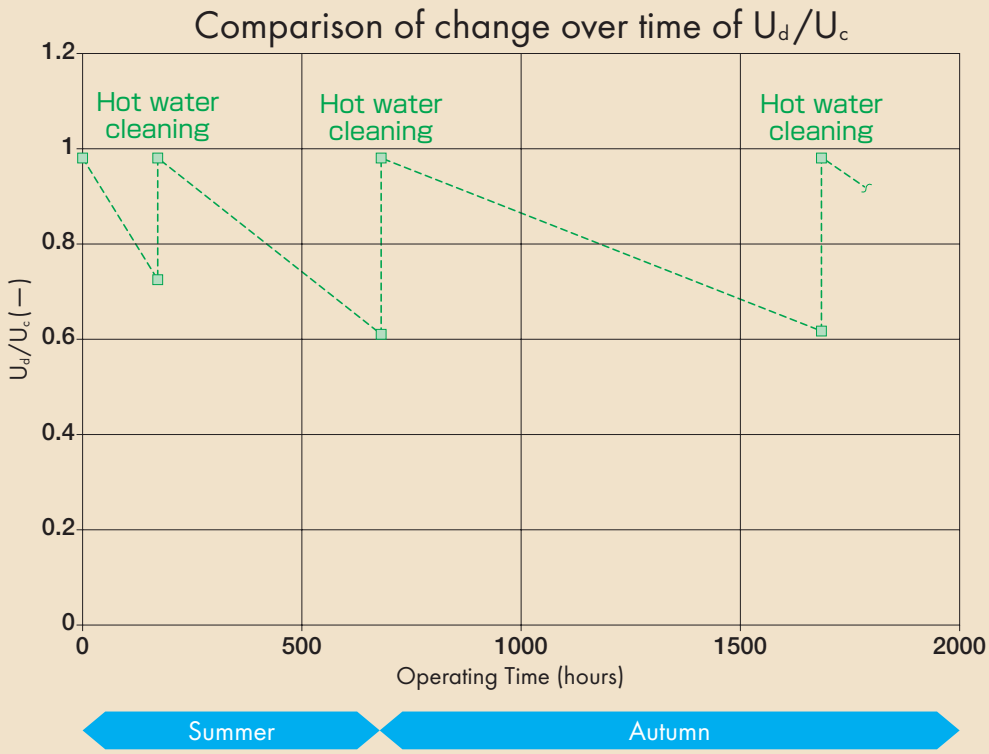
Working principle of Anti-fouling

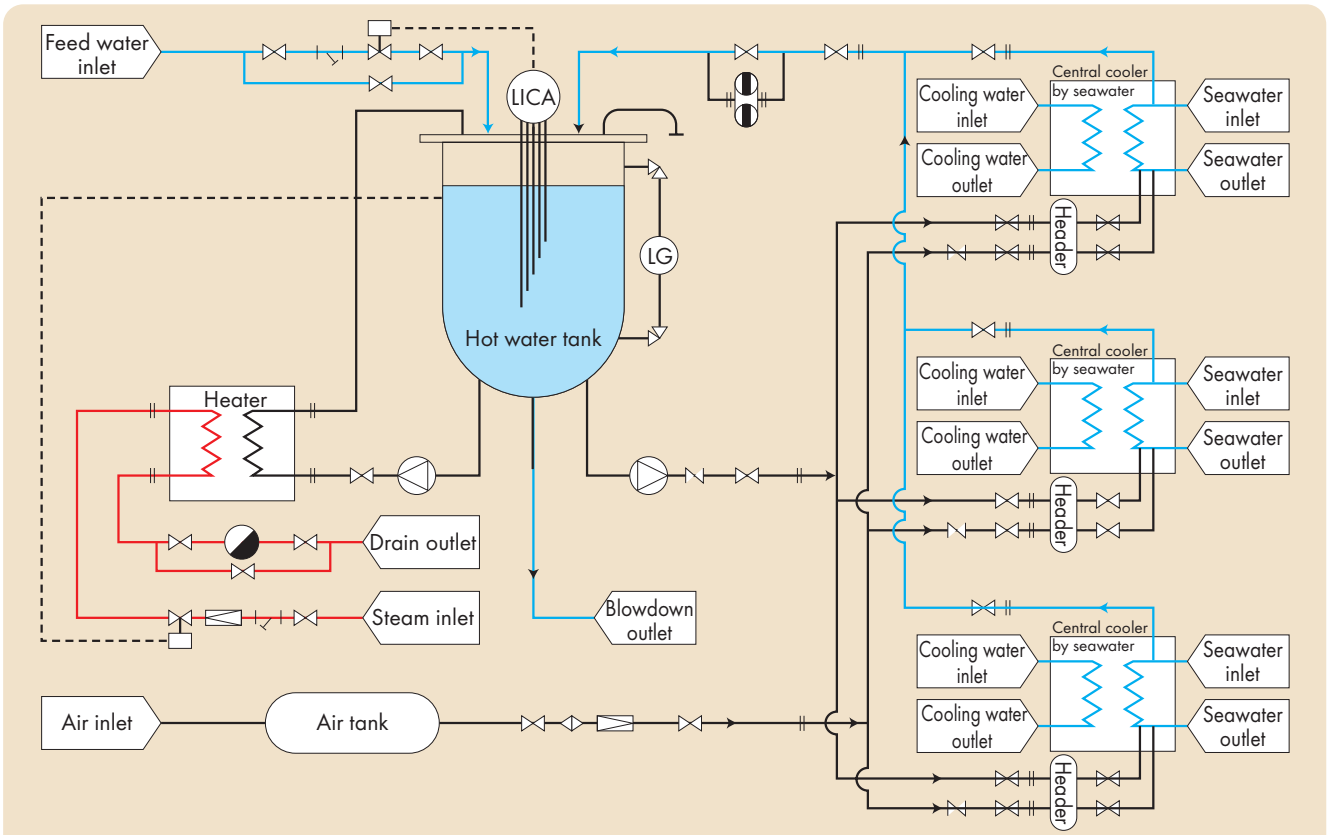
Hot water circulation can raise the ambient temperature to kill fungi and young shellfish.
This mechanism allows anti-fouling of the heat transfer surfaces by retention of hot water in the plate type heat exchanger.

Features

Chlorination, which is the most widely used anti-fouling method, is increasingly difficult to inject because of its environmental impact. Hot water circulation is an anti-fouling method that neither uses any chemicals nor harms the environment.

Example of Operational Data





Cleaning Process Sequence

1) One of the plate type heat exchangers in operation is stopped.
2) Seawater in the stopped plate type heat exchanger is blown down.
3) The temperature of the cleaning water (hot water) is raised to between 40 and 60℃using the heater.
4) The hot cleaning water is circulated for 60 minutes.
5) Air bubbling is performed.
6) The cleaning water is blown down.
7) The cleaned heat exchanger is returned to normal operation.

Q&A

Related to design

Q1 Why do plate type heat exchangers have high performance?

A The corrugations and spherical bumps on the heat transfer surfaces induce turbulence in the fluid, resulting in a highly turbulent flow. This is a contributing factor to an excellent heat transfer coefficient of the plate type heat exchanger.
The high turbulence in the fluid also serves to prevent scales from being deposited on the plates.
These patterns on the plate are designed for the most efficient heat transfer.
In water-water duty, the overall heat transfer coefficient (U-value) is 4,500 to 8,000 W/m²°C under normal operating conditions.

Q2 What should be done to prevent clogging of the inlet and deposition of scales in using seawater?

A Debris (e.g. seaweed, shellfish and contaminants) contained in seawater may clog the seawater inlet of the plate channels in the plate type heat exchanger. Therefore this debris must be removed.
For this purpose, an automatic back-flushing type seawater strainer should be installed. A strainer made of punching metal element with a mesh size of 2 to 3 mm is suitable.
Among effective measures for scaling by microorganisms in seawater are dosage of sodium hypochlorite by the electrolysis of seawater and hot water circulation.

Related to manufacturing

Q1 How is a plate type heat exchanger manufactured?

A
1) A heat transfer plate is pressed with a 20,000- or 40,000-ton precision hydraulic press machine.
2) The outer edge of the pressed heat transfer plate is trimmed with a 1000-ton press machine.
3) A sealing gasket is mounted on the heat transfer plate.
4) The frames (the fixed and movable frames) are made of carbon steel sheets cut to the required dimensions with a precision gas cutter and machined in a machining center.
5) The heat transfer plate is suspended between the fixed frame plate and the movable frame plate and is tightened with bolts to the required tightening length.
6) A pneumatic test is carried out for detection of cracks and other defects of the plates.
7) After pressure test, a plate type heat exchanger is completed with painting made.

Q2 What standards and code apply to our plate type heat exchangers?

A Hisaka's plate type heat exchangers comply with the domestic and foreign pressure vessel norms: the Japan Electricity Utilities Industry Law, the Japan High Pressure Gas Safety Law, the ASME "U" Stamp, and the Japan Pressure Vessel Code Class I.

Related to testing

Q1 What method and what criteria are used for testing plate type heat exchangers?

A
1) For heat transfer plates, the chemical composition and mechanical properties of the material are checked by reviewing the mill certificate. During the pressing process, the stencils from the material manufacturer are replaced by our unique lot numbers to identify all the plates manufactured. One heat transfer plate from each lot is inspected to measure its pressing depth after the start of the pressing the plates to make sure that it meets our standards.
Titanium plates are also tested for any crack by dye penetrant testing. Immediately after the start of the pressing the plates, one out of three plates, then one of ten plates, and for more than 30 plates one out of every thirty plates is subjected to the same test. At the final stage, these plates are subjected to an pneumatic test as part of the post-assembly testing.
2) For gaskets, the dimensions and physical properties of one gasket from each lot are measured by the gasket manufacturer. We confirm in the manufacturer's inspection records that they meet our own standards. We also check the manufacturer's name, the material, and the date of manufacturing stenciled on all gaskets. The shape and dimensions of heat transfer plates and gaskets are periodically measured since they are molded products whose molds are directly subject to deterioration over time. If necessary, the molds are repaired or renewed.
3) For frames, the chemical composition and mechanical properties of the steel material are checked by reviewing the mill certificate. After gas cutting the frame, we verify the test/inspection reports from suppliers corresponding to our standard.

Related to maintenance

Q1 When should the gaskets be replaced?

A The typical life time of a gasket is 5 to 7 years under operating conditions at up to 70℃. So we recommend that spare gaskets be made available after five years of operating your heat exchanger, as a guideline.

Q2 If a leakage occurs, what should be done to stop it?

A
1) If the leakage is caused by deterioration of the gasket, retightening may be carried out as an emergency measure (within the specified tightening length stamped on the nameplate on the equipment). If this action does not stop the leakage, the doubtful gaskets must be replaced.
2) If the leakage results from a crack in the plate, the damaged plate may be removed together with either the plate just before or behind the damaged plate as an emergency measure, tightening the plates on a temporary basis.
3) Hisaka's plate type heat exchangers allow for on-site replacement of gaskets.

Q3 How can plates be opened and cleaned?

A If you find that performance of your heat exchanger has decreased, clean the surfaces of the plates.
Any decrease of the performance can be discovered by checking for temperature and pressure drops. Determine an appropriate interval for carrying out inspections based on operating conditions.
To clean the plates, first of all open the heat exchanger, and then select one of the following two methods:
1) Brush cleaning, a method of cleaning the plate with a suitable brush (non-metallic brush) while pouring tap water onto it;
2) Jet water cleaning. For further information, see our Instruction Manual.

Maintenance Services

Our total maintenance programs complete with a sense of security and reliability

SPARE PARTS & MAINTENANCE

PHONE:++81-729-66-8905
FAX: ++81-729-66-8923
➡Please let us know the Mfg No.

HISAKA WORKS,LTD. HEAT EXCHANGER DIV.
2-1-48,Higashi konoike-cho,Higashi Osaka-city.578-0973 Osaka Japan

⬆Sticker attached to the equipment upon shipment
This sticker will be attached to each plate type heat exchanger upon shipment to provide you with information for any future inquiries.

⬆Arattaro, our promotional character

To keep your plate type heat exchangers in excellent condition, Hisaka uses its extensive expertise, developed over many years, for its maintenance program to offer a wealth of services such as opening and cleaning, upgrade, and on-site services.
We provide a wide variety of services including consulting, especially a pickup and delivery service for reconditioning and regasketing of plates in which your heat exchangers are collected to our service facilities, maintained and repaired, and returned to you in optimum condition, to help keep your "Plate Type" heat exchangers in perfect condition from every conceivable angle. You can choose services suited to your operating conditions and circumstances to continue operating your equipment at its optimum condition in versatile processes. Do not hesitate to contact us for the details.

Opening, Cleaning and Assembling

For Heat Exchanger, Type UX-90, with a heat transfer area of 277 m2

Precautions on opening, cleaning and assembling:

The total time required for this work is about 12 hours.

This work requires 6 workers.

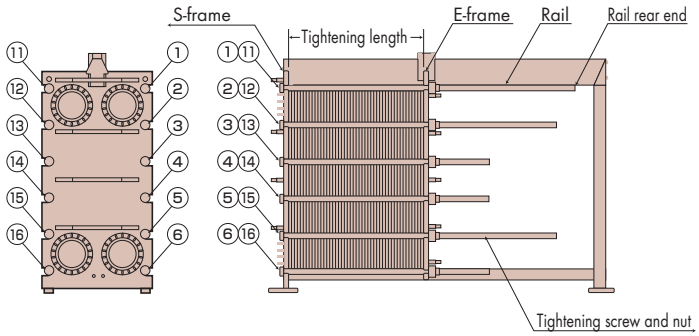
For the exact number of workers required for each task, see the appropriate line of the table.

Prepare: ratchet spanners, hoses, cloths, brushes, grease, and convex rules (? 2 m).

Before beginning the work, make sure that

(1) the fluids have been drained and that

(2) all the pressure gauges show 0 MPaG.



Task	Step	Actions	
Opening ●Workers: 2 ●Replacement workers: 4 ●Time required: 1.5 hours ●Cumulative time: 1.5 hours	1	Loosen the nuts on screws 1, 16, 11 and 6 and remove the nuts and bolts.	
	2	Loosen nuts 2 and 15 by 20 mm simultaneously.	Note: Loosen the nuts while adjusting their tightening length so that the difference among the tightening length for the bolts is 20 mm or less.
	3	Loosen nuts 5 and 12 by 20 mm simultaneously.	
	4	Loosen nuts 3 and 14 by 20 mm simultaneously.	
	5	Loosen nuts 4 and 13 by 20 mm simultaneously.	
	6	When nuts 2, 3, 4, 5, 12, 13, 14 and 15 have all come loose, remove bolts 3, 4, 13 and 14. Leave bolts 2, 5, 12 and 15 in position.	
	7	Loosen nuts 2 and 15 by another 20 mm simultaneously.	Note: Loosen the nuts while adjusting their tightening length so that the difference among the tightening length for the bolts is 20 mm or less.
	8	Loosen nuts 5 and 12 by another 20 mm simultaneously.	
	9	Repeat Steps 7 and 8 until the bolts have been removed.	
	10	Move the E-frame to the rail rear end.	
		Note: If the E-frame sticks to the E-plate, remove the E-frame from the E-plate before moving it to prevent deformation of the E-plate when moving the E-frame.	
Cleaning ●Workers: 3 ●Replacement workers: 3 ●Time required: 6 hours ●Cumulative time: 7.5 hours	1	Move one of the plates to the E-frame side.	
	2	Remove dirt deposited on the front and back sides of the plate with water.	
	3	If the dirt cannot be removed with water, use a brush to wipe off the dirt and rinse the plate.	
	4	Move the cleaned plate to the E-frame side.	
	5	Repeat Steps 1 to 4 for all the other plates.	
Cleaning Check ●Workers: 2 ●Replacement workers: 4 ●Time required: 2 hours ●Cumulative time: 9.5 hours	1	Move one of the plates to the S-frame side	
	2	Check the gasket surface and the back side of the gasket grooves on the plate for any debris such as contaminants, seaweed, sand, and shellfish. Check also that the gasket is set in place on the plate.	
	3	If there is any debris deposited on the gasket and plate, wipe off it with a cloth. And fix any dislodged gasket on the plate with an adhesive.	
	4	Move the wiped plate to the S-frame side.	
	5	5 Repeat Steps 1 to 4 for all the other plates.	
Assembling ●Workers: 2 ●Replacement workers: 4 ●Time required: 2.5 hours ●Cumulative time: 12 hours	1	Apply grease to all the bolts.	
	2	Set bolts 2, 5, 12 and 15 in place on the frame.	
	3	For bolts 2, 5, 12 and 15, adjust the nuts to make their tightening length identical.	
	4	Tighten nuts 2 and 15 by 5 mm simultaneously.	Note: Tighten the nuts while adjusting their tightening length so that the difference in the length the bolts are tightened remains 5 mm or less.
	5	Tighten nuts 5 and 12 by 5 mm simultaneously.	
	6	Repeat Steps 4 and 5 until you feel strong resistance when tightening the nuts.	
	7	Set the bolts 3, 4, 13 and 14 in place on the frame.	
	8	For the bolts 3, 4, 13 and 14, adjust the nuts to make their tightening length identical.	
	9	Tighten nuts 3 and 14 by 5 mm simultaneously.	Note: Tighten the nuts while adjusting their tightening length so that the difference among the tightening length for the bolts is 5 mm or less.
	10	Tighten nuts 4 and 13 by 5 mm simultaneously.	
	11	Repeat Steps 9 and 10 until you feel strong resistance when tightening the nuts.	
	12	Repeat Steps 4 to 11 until each of their specified tightening length is exceeded by 20 mm.	
	13	Set the bolts 1, 6, 11 and 16 in place on the frame.	
	14	Tighten nuts 1 and 16 by 5 mm simultaneously.	Note: Tighten the nuts while adjusting their tightening length so that the difference among the tightening length for the bolts is 5 mm or less.
	15	Tighten nuts 11 and 6 by 5 mm simultaneously.	
	16	For the bolts 1, 6, 11 and 16, adjust the nuts until each of their specified tightening length is exceeded by 20 mm.	
	17	Repeat Steps 4 to 11, 14, and 15 until each of their specified tightening length is achieved.	

Corporate Profile

Corporate name
Hisaka Works, Ltd.

Established
May 1942

Business fields
Heat exchangers, evaporation/distillation/condensation systems, systems for dyeing and finishing, dehydrators/dryers, food processing machines, valves, and pumps.

Capital
4,150,000,000 yen

Number of shares issued
32,732,000 shares

Stock exchange listings
Tokyo Stock Exchange (1st Section), Osaka Securities Exchange (1st Section)

Annual sales
18,000,000,000 yen

Number of employees
430

Industrial properties
Domestic patents 344 patents registered
Domestic utility model rights: 70 designs registered
Foreign patents: 69 patents registered

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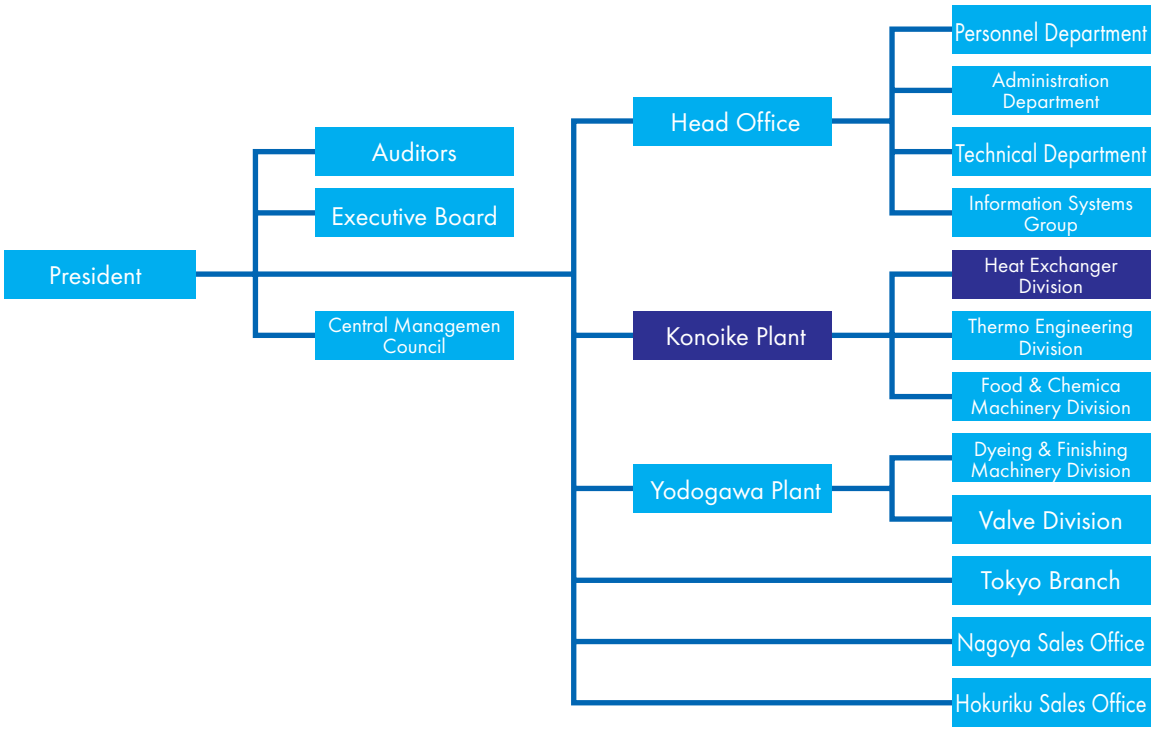
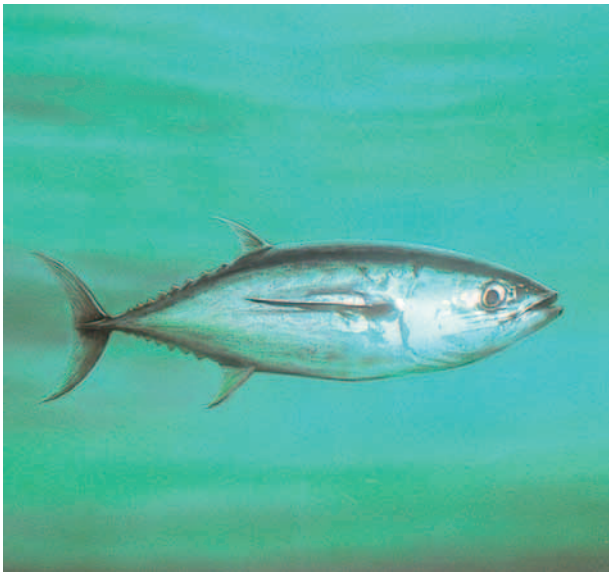
Scales of Plants
Konoike Plant: 25,600 m² of land
Yodogawa Plant: 14,300 m² of land

Organization Chart





Credit: Kaiyukan, Osaka

Did tuna fish invent the heat exchanger?

The secret of their ability to swim at more than 100 km/h……

A tuna fish has an organ in its body like a heat exchanger known as a "rete mirabile," which consists of many arterial and venous capillary vessels arranged in parallel. Excellent heat exchange is performed by hot arterial blood flowing in the opposite direction to that of cold venous blood with a thin partition in between. This mechanism allows the fish to keep its muscle temperature higher than the surrounding cold seawater. So it is capable of making powerful muscular movements at any moment. It is this sophisticated system that allows the tuna fish to swim at high speed for a long period, swim at very high speed instantaneously (the tuna fish holds the speed record together with the skipjack) and chase its prey easily and vertically in water despite a great temperature difference of water.

Among fishes and animals that have a "heat exchanger" are:

- Fish: tuna, skipjack, bluefin
- Animals: whales, cranes, wild ducks, seagulls, anteaters and oryxes.

References
Akira Ochiai and Masaru Tanaka, Ichthyology - Volume II, Koseisha Koseikaku
Toru Omori, Tuna fish Essays, Seizando

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URL: http://www.hisaka.co.jp/

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Hisaka Works, Ltd., Heat Exchanger Division, are ISO 9001 certified for its quality system for all products including plate type heat exchangers.

Agent

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