

Nuclear power station cooling systems

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Abstract: Review of fresh patents on nuclear power station cooling systems and current problems & future of nuclear power stations.

Keywords: nuclear power station, cooling systems, patents.

While nuclear reactors have been generating power around the world for over 70 years, the current moment is one of potentially radical transformation for the technology. As electricity demand rises around the world for everything from electric vehicles to data centers, there's renewed interest in building new nuclear capacity, as well as extending the lifetime of existing plants and even reopening facilities that have been shut down. Efforts are also growing to rethink reactor designs, and 2025 marks a major test for so-called advanced reactors as they begin to move from ideas on paper into the construction phase. That's significant because nuclear power promises a steady source of electricity as climate change pushes global temperatures to new heights and energy demand surges around the world. Here's what to expect next for the industry.

China's State Council has approved five nuclear power projects - Xuwei Phase I, Lufeng Phase I, Zhaoyuan Phase I, San'ao Phase II and Bailong Phase I - with a total of 11 reactors. China National Nuclear Corporation (CNNC) said Phase I of its Xuwei plant in Jiangsu project will be "the world's first to couple a high-temperature gas-cooled reactor with a pressurised water reactor". The plant will mainly supply industrial heating in addition to electricity. The project plans to build two Hualong One pressurised water reactors and one high-temperature gas-cooled reactor. The project will be equipped with a steam heat exchange station, which will adopt the heat-to-electricity operation mode for the first time. Therefore that review is scrutinizing mainly China patent's documents for last years.

CN119042096 (A) - Marine work system siphon device for nuclear power station

The invention belongs to the technical field of siphoning devices, and particularly relates to a maritime work system siphoning device for a nuclear power station, which comprises a main pipeline system, a vacuum system and a siphoning breaking system, the main pipeline system is connected with the vacuum system, the main pipeline system is used for sucking forebay water into an in-plant circulating cooling water tunnel, and the vacuum system is used for establishing a vacuum state and a siphon state; the siphon destroying system is arranged in the vacuum system and used for destroying the siphon state. The device is easy and convenient to operate, the siphon device can be prevented from being mistakenly triggered due to unexpected conditions, and the problems that an existing device is complex in operation and high in operation risk are effectively solved.

CN222067164 (U) - Mechanical seal for high-pressure safety injection pump of nuclear power station.

The utility model relates to the technical field of mechanical seals, and discloses a mechanical seal for a high-pressure safety injection pump of a nuclear power station, which comprises a shaft sleeve, a gland, a static ring assembly, a movable ring assembly, an isolation cavity, a pumping piece and a heat exchanger. The shaft is sleeved with the shaft sleeve. And the gland is sleeved on the shaft sleeve. One side face of the gland abuts against one side face of the static ring assembly. The other side face of the static ring assembly abuts against one side face of the movable ring assembly. The pumping piece is arranged on the movable ring assembly in a sleeving mode. One side face of the isolation cavity abuts against one side face of the gland. The isolation cavity, the pumping piece, the static ring assembly and the movable ring assembly form a medium flowing cavity. One end of the heat exchanger is connected with the pump cavity; the other end of

the heat exchanger is connected with the gland. The heat exchanger communicates with the medium flowing cavity. The mechanical sealing reliability is improved by improving the internal environment temperature of the medium flowing cavity. And the pump cavity and an external heat source medium are prevented from transferring heat in the medium flowing cavity through the isolation cavity.

CN118979795 (A) - Discharge valve control method and system of nuclear power station

According to the valve control method and system of the nuclear power station steam turbine bypass system, a steam turbine is divided into a high-power mode and a low-power mode. When the steam turbine is in high power, the control mode of the bypass valve of the steam turbine is a temperature control mode, and the specific temperature control mode comprises a temperature quick starting mode and a temperature modulation starting mode. Under the working condition that a steam turbine is low in power or a nuclear power station has an accident, a steam turbine bypass valve control mode is a pressure control mode, and the pressure control mode determines that a valve of a bypass system is opened according to the pressure deviation between a pressure measurement value and a pressure setting value of a main steam pipeline; wherein under the low-power normal operation working condition of the steam turbine, the steam turbine bypass valve control mode is the normal operation mode of the pressure control mode, and when medium-pressure rapid cooling needs to be executed under the accident working condition, the steam turbine bypass valve control mode is the medium-pressure rapid cooling operation mode of the pressure control.

CN118670026 (A) - Adsorption type cold water heat exchange device for spent fuel pool of nuclear reactor

The invention belongs to the technical field of nuclear power station operation and safety auxiliary systems, and particularly relates to an adsorption type cold water heat exchange device for a nuclear reactor spent fuel pool.

Comprising a heat source driving part, a cooling water cooling part, a low-temperature cooling water part and a water loss and supplement device part, the heat source driving part is connected with the adsorption type cooling-water machine and provides a driving heat source for the adsorption type cooling-water machine, the cooling water cooling part is connected with the adsorption type cooling-water machine and provides cooling water for the adsorption type cooling-water machine, the low-temperature cooling water part is connected with the adsorption type cooling-water machine, and the water loss and supplement device part is connected with the cooling water cooling part. The adsorption type cold water heat exchange device has the beneficial effects that compared with the prior art, utilization of waste heat of the spent fuel pool under the accident working condition is achieved through the adsorption type refrigerating system, and the adsorption type cold water heat exchange device for the nuclear reactor spent fuel pool is provided from the aspects of safety, economy and the like.

CN118657963 (A) - Cooling circulation system of nuclear power station

The invention discloses a nuclear power station cooling circulation system which comprises a cooling mechanism, a pump unit, a water supplementing unit and a chemical adding assembly, and the cooling mechanism comprises a flow guide pipe and a water collecting chamber; the water supplementing unit comprises water supplementing grids, the water supplementing grids are communicated with the water collecting chamber, a connecting channel is arranged between every two adjacent water supplementing grids, and a communicating switch piece is arranged on each connecting channel. According to the cooling circulation system of the structure, low-temperature cooling water is supplied to the cooling mechanism through the multiple water supplementing grids, and therefore lost cooling water of the circulation system is supplemented; the opening and closing states of the connecting channels are controlled through the communicating switch pieces, so that the corresponding water supplementing grids conduct independent isolation

overhaul work or water supplementing operation, the circulating path of cooling water in the cooling system can be planned in cooperation with the communicating switch pieces, effective supply of the cooling water is guaranteed, and meanwhile smooth transition of the overhaul stage and the like is met. The cooling circulation system provided by the invention has good safety and stability.

CN118517439 (A) - Cooling isolation system for driving motor of primary helium fan of high-temperature gas cooled reactor nuclear power station

The invention relates to the field of high-temperature gas cooled reactor primary helium fan operation, and discloses a high-temperature gas cooled reactor nuclear power station primary helium fan driving motor cooling isolation system which is characterized in that during normal operation of a primary helium fan or after emergency shutdown of a reactor, a mistaken isolation event cannot occur, and over-temperature and over-pressure damage of a cooler is avoided; a primary loop pressure negative change rate over-limit event caused by pipe breakage of a main helium fan cooler and a primary loop pressure negative change rate over-limit event caused by faults of other equipment can be automatically distinguished; when a primary loop pressure negative change rate overrun event is caused by faults of other equipment, the main helium fan motor cooling isolation system does not act, and a normal cooling function is maintained; when the primary loop pressure negative change rate exceeds the limit due to the fact that the main helium fan motor cooler breaks the pipe, the isolation of the main helium fan cooling system meets the requirement of depth defense, and the first controller executes automatic isolation.

WO2024164504 (A1) - NUCLEAR POWER STATION DOUBLE-LAYER CONTAINMENT STRUCTURE FOR PASSIVE AIR COOLING, AND NUCLEAR POWER STATION USING SAME

A nuclear power station double-layer containment structure for passive air cooling, and a nuclear power station using same. The nuclear power station double-layer containment structure comprises a containment, air ports, and supports; the containment comprises an outer-layer containment; the air ports comprise air inlets; the outer side of the outer-layer containment is provided with air ducts; the air ducts are each provided with the air inlet; the supports are arranged at the outer side of the outer-layer containment. The air ducts are arranged on the outer-layer containment, and airflow is conveyed by using a method of forming a hole at the bottom of the outer-layer containment instead of providing a flow guide plate in an annular cavity between an inner-layer containment and the outer-layer containment, so that maintenance is simple and convenient, thereby avoiding inconvenience to installation and maintenance caused by a narrow space. By using the hard supports for fixing and supporting the external air ducts of the outer-layer containment, part of the bearing and supporting functions of the outer-layer containment can be undertaken.

CN118486231 (A) - Nuclear power station fuel pool demonstration device

The invention, which relates to the technical field of nuclear power maintenance, discloses a nuclear power station fuel pool demonstration apparatus comprising a cooling pool and a fuel storage container. A cooling medium is contained in the cooling pool, a visible window convenient for observing internal operation of the cooling pool is arranged on the cooling pool, and the cooling pool is used for simulating a nuclear power plant fuel pool; the fuel storage container is located in the cooling pool and used for simulating a storage grillwork containing a fuel assembly, a plurality of storage hole channels are formed in the fuel storage container, a storage sleeve is correspondingly arranged at the position of each storage hole channel, and the storage hole channels are used for being communicated with the storage sleeves and the cooling pool. According to the

nuclear power station fuel pool demonstration device, the actual operation environment of the nuclear power station fuel pool is simulated, and the actual problems that no actual verification environment exists after new tools are developed and no operation drilling environment exists after fishing personnel are trained are solved.

CN118325375 (A) - Seawater-erosion-resistant composite coating and preparation method thereof

The invention relates to the technical field of nuclear power, in particular to a seawater-erosion-resistant composite coating and a preparation method thereof. The composite coating comprises a high-entropy alloy layer and an epoxy resin layer coated on the high-entropy alloy layer. The preparation method comprises the following steps that firstly, a low-pressure cold spraying method is adopted for spraying a base body, and a mixed powder coating is formed; 2, the mixed powder coating is subjected to induction remelting in-situ synthesis of the high-entropy alloy coating; and thirdly, the surface of the high-entropy alloy is coated with a layer of epoxy resin. The coating formed by the method is good in sealing performance, high in corrosion resistance and suitable for a seawater cooling system of a nuclear power station.

ZA202308705 (B) - ACTIVE AND PASSIVE COOPERATIVE COOLING METHOD FOR NUCLEAR POWER PLANT, AND ULTIMATE HEAT SINK SYSTEM

An active and passive cooperative cooling method for a nuclear power plant, and an ultimate heat sink system. In the method, in the case of a design basis accident, when the pressure boundary of a primary loop is complete, heat energy in a containment is led out into a heat sink by means of an active secondary loop charging and discharging system; and in the case of a station-blackout beyond design basis accident, when the pressure boundary of the primary loop is complete, a passive secondary loop natural circulation system is automatically started, and

the heat transferred from the containment to the active secondary loop charging and discharging system is led out into the heat sink. The passive secondary loop natural circulation system is additionally provided and, in the case of a station-blackout beyond design basis accident, when the pressure boundary of the primary loop is complete, can be automatically started such that the heat transferred from the containment to the active secondary loop charging and discharging system is led out into the heat sink so as to achieve the active and passive cooperative cooling effect to accelerate removal of heat in the containment in an accident, thereby improving the safety of a nuclear power plant.

CN118148936 (A) - Method for determining optimal operation mode of circulating cooling water pump in nuclear power station

The invention provides a method for determining the optimal operation mode of circulating cooling water pumps in a nuclear power station, and the method comprises the steps: obtaining a first curve of the change of unit output net electric power along with the seawater temperature when N circulating cooling water pumps operate before a first seasonal working condition is switched to a second seasonal working condition, one of the first season working condition and the second season working condition is a winter working condition, and the other one is a summer working condition; after the first season working condition is switched to the second season working condition, a second curve that the unit output net electric power changes along with the seawater temperature when the M circulating cooling water pumps operate is obtained, and M and N are different positive integers; and determining a critical temperature for switching the first seasonal working condition and the second seasonal working condition according to at least one intersection point of the first curve and the second curve. The operation mode of the circulating cooling water pump is optimized according to the unit output net electricity power, so that auxiliary electricity is saved, and the unit power generation benefit is improved.

CN221075234 (U) - Sealing mechanism and nuclear power station nuclear island equipment cooling water system wave box

The utility model discloses a sealing mechanism and a nuclear power station nuclear island equipment cooling water system wave box, and relates to the technical field of cooling water system wave boxes, a sealing assembly comprises an installation part and a fixing part connected in the installation part, one side of the fixing part is connected with a fixing bolt, and the outer side of the fixing bolt is provided with a first reset spring. A sealing piece is arranged in the mounting piece, and a second reset spring is mounted on the outer portion of the sealing piece. The cooling part comprises cooling water pump equipment and an equipment cooling water user installed on the left side of the cooling water pump equipment, and a heat exchanger is installed on the other side of the equipment cooling water user. The mounting piece comprises a mounting body and a sleeving hole formed in the mounting body, and a drainage hole is formed in the lower side of the sleeving hole. The problems that water quality is polluted due to the fact that jet fluid is directly discharged into the sea, the pH value of cooling water is reduced due to the fact that air enters the fluctuation box through negative pressure, and manual correction and discharging are needed are solved.

CN221057154 (U) - Telescopic mechanism and nuclear power station cooling equipment

The utility model discloses a telescopic mechanism and nuclear power station cooling equipment, and relates to the technical field of nuclear power station cooling, the telescopic mechanism comprises a telescopic assembly, a driving assembly, a telescopic assembly and a locking assembly; the main body assembly comprises a finned tube, a fin group and an operation platform; the heat exchange assembly comprises a heat exchange pipe and a connecting column set. The utility model has the beneficial effects that a plurality of groups of telescopic finned tubes can be placed in the heat exchange tubes, the number of fins can be

controlled at any time, the finned tubes do not need to be taken out of the heat exchange tubes for adjustment, the cooling efficiency and corresponding pressure loss of a cooling system can be adjusted at any time, the cooling efficiency is improved, the energy consumption is reduced, and the cost is reduced. And the requirements of nuclear power station operation safety and environmental protection are met.

CN118072997 (A) - Cooling equipment determination method and device, computer equipment and storage medium

The invention relates to a cooling equipment determination method and device, computer equipment and a storage medium, and the method comprises the steps: obtaining a state parameter of a cold source in a cooling system in a nuclear power station in a fault state, and screening a plurality of to-be-cooled equipment in the nuclear power station according to the state parameter and a preset screening condition, at least one target cooling device is determined. Wherein the state parameters comprise flow parameters and/or temperature parameters, and the preset screening conditions are determined according to the types of the state parameters. In the method, the state parameters can reflect the current state of the cooling system, so that the method for screening the to-be-cooled equipment according to the screening conditions and the state parameters can improve the accuracy of determining the to-be-cooled range. When a cold source accident occurs, due to the fact that the temperature of the cooling system rises, the cooling capacity of the cooling system on the cooling equipment is limited, the method can guarantee normal operation of the nuclear power unit, and meanwhile the effect of the cooling system can be exerted to the maximum extent.

CN117968275 (A) - Nuclear power station waste heat utilization system and method

The invention provides a nuclear power station waste heat utilization system and method, the system comprises a heat pump, a first circulation system and a

second circulation system, and equipment cooling water flows back to an equipment cooling water system after flowing through the heat pump; the first circulating system comprises a first circulating pipeline and a water chilling unit, the output end of the heat pump communicates with the input end of the water chilling unit, the output end of the water chilling unit communicates with the input end of the heat pump, and the water chilling unit is used for receiving heated circulating water and returning the cooled circulating water to the heat pump after absorbing heat; the first circulating pipeline is provided with first switching valves at the input end and the output end of the heat pump; the second circulating system comprises a second circulating pipeline and at least one user side, the second circulating pipeline flows through the heat pump and is used for conveying the heated circulating water to the user side and then returning the cooled circulating water flowing out of the user side to the heat pump, and the second circulating pipeline is provided with second switching valves at the input end and the output end of the heat pump. Therefore, nuclear power unit heat efficiency is improved.

CN117972990 (A) - Method for evaluating service life of cooling water expansion joint of nuclear power emergency diesel engine

The invention belongs to the field of nuclear power station equipment management, and particularly relates to a nuclear power emergency diesel engine cooling water expansion joint service life evaluation method which comprises the following steps: step 1, determining the operation condition of an inner rubber layer of an expansion joint; according to the data information of the diesel engine cooling water expansion joint, the operation condition of an inner rubber layer of the diesel engine cooling water expansion joint is determined; 2, carrying out a high-temperature accelerated aging test on an inner rubber layer material, and establishing an aging model; 2, carrying out a high-temperature accelerated aging test on the inner rubber layer according to the operation condition information of the inner rubber layer in the step 1, and establishing an aging model of aging

performance indexes and aging time at the operation temperature; 3, performing a product assessment test to obtain a critical value of the aging performance index of the cooling water expansion joint; and 4, substituting the critical value of the aging performance index into the aging model, and calculating the total life of the expansion joint. The method can guide life evaluation of the cooling water expansion joint of the nuclear power emergency diesel engine through practice, and provides technical guidance for life management of the nuclear power emergency diesel engine.

JP2024054880 (A) - LAKE-BOTTOM DEEP SMALL NUCLEAR REACTOR ELECTRIC POWER GENERATION SYSTEM MANUFACTURED AT FACTORY THROUGH INFORMATION SHARING BY AI THAT PROTECTS SAFETY OF RESIDENT AND ENVIRONMENT BY AUTOMATIC WATER FEEDING FROM LAKE WATER AND COOLING DEVICE EVEN IF ACCIDENTAL SITUATION OCCUR

To start a project for manufacturing a next-generation small nuclear reactor, that is resistive to an attack, safe and brought under radioactivity control, secures safety for wastes and residents, and can be started at low cost in a short period, in units at factories by public and private sectors together as it is an urgent theme to compatibly secure electric energy sources and achieve "CN Carbon Neutral" because of the Russia-Ukraine war although it is unexpected and nuclear power stations are targeted in the war. According to the present invention, a project team that solves subjects needs to be started up first. The subjects consist of: 1. development of a unit type small module nuclear reactor SMR; 2. test installation of deep underground nuclear electric power generation at a hydraulic power station lake bottom or the site of a disused mine; 3. systemization of nuclear power generation abolition and radioactivity measurement; 4. total coast calculation and

comparison with other electric power; and 5. monitoring of whether radioactive contamination is caused by the use of cooling.

CN117854782 (A) - Million-kilowatt high-temperature gas cooled reactor nuclear power station

The invention belongs to the field of nuclear energy engineering design and construction, and particularly relates to a million-kilowatt high-temperature gas cooled reactor nuclear power station. A helium purification process and a helium path heat exchange process are adopted, and traditional multi-time heat exchange cooling to meet step-by-step adsorption and removal of impurity gases such as hydrogen, carbon monoxide, water, carbon dioxide, nitrogen, oxygen, methane, tritium, Kr and Xe is replaced with synchronous adsorption and removal of various impurity gases under the high-temperature condition. In addition, the tritium content in a primary loop can be obviously reduced, and the heat loss of a helium purification column is reduced; the heat exchanger system can safely and reliably operate in an ultrahigh-pressure working environment, and meanwhile has excellent heat exchange performance. The nitrogen-filling and oxygen-controlling system can control the oxygen content in the containment vessel and improve the safety of the reactor core under the working condition of an over-design-basis accident of upper and lower crevices of the primary loop of the reactor building.

CN117738836 (A) - Condensate water coupling energy-gathering power station for conventional island of boiling water reactor nuclear power station

The invention provides a boiling water reactor nuclear power station conventional island condensate water coupling energy gathering power station which is characterized in that a plurality of branch drainage pipelines are arranged on a main drainage pipeline used for cooling seawater of a nuclear power station, each branch drainage pipeline is correspondingly provided with a turbine, and the turbines are jointly coupled to a turbine coupler; a plurality of input shafts of the turbine coupler are connected to the corresponding turbines, and an output shaft of

the turbine coupler is connected with the generator. Energy of cooling seawater of the nuclear power station can be recycled, the flow speed can be increased when the seawater is discharged and enters the thin branch drainage pipelines, so that the turbines are impacted, and finally the generators are jointly driven to operate through coupling of the turbines to generate electric energy.

CN220553300 (U) - Emergency water cooling device for nuclear power station

An emergency cooling water device for a nuclear power station comprises a high-level reservoir, a water diversion pipe and a hydroelectric generation device, the water diversion pipe introduces a water body of the high-level reservoir into a site of the nuclear power station, a plurality of water diversion branch pipes are arranged at the tail end of the water diversion pipe, and the water diversion branch pipes provide pressurized cooling water for nuclear power station equipment in an emergency state. Therefore, the safety level of a normal water cooling system and a plant is reduced, emergency water cooling pumps are reduced, and the engineering cost is saved. In addition, the hydroelectric generation device is installed at the head end and/or the tail end of the water diversion pipe, an emergency power supply is provided for the nuclear power station, the high-reliability hydroelectric generation device is used for replacing an emergency diesel generator which is high in cost and complex in maintenance, cost is saved, and safety is improved.

CN117627746 (A) - Nuclear power station secondary side residual heat removal system based on jet technology driving ORC (organic Rankine cycle)

The invention discloses a nuclear power station secondary side waste heat removal system for driving ORC based on a jet technology, and belongs to the technical field of nuclear power station safety. Comprising a passive natural circulation system and an organic Rankine circulation system, the passive natural circulation system comprises a passive natural circulation loop composed of a

steam generator and a vertical tube cooler which are communicated in sequence, and the organic Rankine circulation system comprises an efficient heat exchanger, an air cooling heat exchanger, an ORC turbine, an ORC generator, an ORC condenser and a gas-liquid ejector. Wherein the steam generator, the efficient heat exchanger, the air cooling heat exchanger and the vertical pipe cooler form a secondary side water circulation loop, and the efficient heat exchanger, the ORC turbine, the ORC generator, the ORC condenser and the gas-liquid ejector form an organic Rankine cycle loop; the active system and the passive system are mutually backed up, secondary side waste heat can be timely discharged, the heat discharging effect is good, and the safety and reliability of the system are greatly guaranteed.

The report, *The Path to a New Era for Nuclear Energy*, shows the fresh impetus behind nuclear in the form of new policies, projects, investments and technological advances, such as small modular reactors (SMRs). It provides a comprehensive assessment of the current situation, identifying the major challenges that need to be addressed to build on the current momentum and enable a new era to take hold. This includes insights on how to finance new nuclear projects while ensuring reliable and diversified supply chains for building and fuelling them.

“It’s clear today that the strong comeback for nuclear energy that the IEA predicted several years ago is well underway, with nuclear set to generate a record level of electricity in 2025,” said IEA Executive Director Fatih Birol. “In addition to this, more than 70 gigawatts of new nuclear capacity is under construction globally, one of the highest levels in the last 30 years, and more than 40 countries around the world have plans to expand nuclear’s role in their energy systems. SMRs in particular offer exciting growth potential. However, governments and industry must still overcome some significant hurdles on the path to a new era for



nuclear energy, starting with delivering new projects on time and on budget – but also in terms of financing and supply chains.”

As the world’s second-largest source of low-emissions electricity after hydropower, nuclear power today produces just under 10% of global electricity supply. The increasing use of electricity – to power everything from industry and air conditioning to electric vehicles and data centres amid the rise of artificial intelligence – is accelerating the growth in power demand, which is set to rise six times as fast as overall energy consumption in the coming decades, based on today’s policy settings. New generation capacity from a range of technologies will be needed to keep pace with the rapid demand growth, including those that can provide firm and flexible output such as nuclear.

Most of the existing nuclear power fleet today is in advanced economies, but many of those plants were built decades ago. Meanwhile, the global map for nuclear is changing, with the majority of projects under construction in China, which is on course to overtake both the United States and Europe in installed nuclear capacity by 2030.

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