STEAM, WATER, AND HYDROTHERMAL SYSTEMS pdf

1: Types of Steam | TLV - A Steam Specialist Company (International)

STEAM, WATER, AND HYDROTHERMAL SYSTEMS: Physics and Chemistry Meeting the Needs of Industry Proceedings of the 13th International Conference on the Properties of Water and Steam.

Types of Steam Contents: If water is heated beyond the boiling point, it vaporizes into steam, or water in the gaseous state. However, not all steam is the same. The properties of steam vary greatly depending on the pressure and temperature to which it is subject. In the article Principal Applications for Steam , we discussed several applications in which steam is used. In the sections that follow, we will discuss the types of steam used in these applications. Saturated dry steam results when water is heated to the boiling point sensible heating and then vaporized with additional heat latent heating. If this steam is then further heated above the saturation point, it becomes superheated steam sensible heating. Saturated Steam Dry As indicated by the black line in the above graph, saturated steam occurs at temperatures and pressures where steam gas and water liquid can coexist. In other words, it occurs when the rate of water vaporization is equal to the rate of condensation. Some of these are: Property Rapid, even heating through latent heat transfer Improved product quality and productivity Pressure can control temperature Temperature can be quickly and precisely established High heat transfer coefficient Smaller required heat transfer surface area, enabling reduced initial equipment outlay Originates from water Safe, clean, and low-cost Tips Having said this, it is necessary to be mindful of the following when heating with saturated steam: Heating efficiency may be diminished if steam other than dry steam is used for process heating. Contrary to common perception, virtually all of the steam generated from a boiler is not dry saturated steam, but wet steam, which contains some non-vaporized water molecules. Radiant heat loss causes some of the steam to condense. The generated wet steam thus becomes even more wet, and condensate also forms, which must be removed by installing steam traps at appropriate locations. Heavy condensate that falls out of the steam flow can be removed through drip leg steam traps. However, the entrained wet steam will reduce heating efficiency, and should be removed through point-of-use or distribution separation stations Steam that incurs pressure losses due to piping friction, etc. When steam is generated using a boiler, it usually contains wetness from non-vaporized water molecules that are carried over into the distributed steam. As the water approaches the saturation state and begins to vaporize, some water, usually in the form of mist or droplets, is entrained in the rising steam and distributed downstream. This is one of the key reasons why separation is used to dis-entrain condensate from distributed steam. Superheated Steam Superheated steam is created by further heating wet or saturated steam beyond the saturated steam point. This yields steam that has a higher temperature and lower density than saturated steam at the same pressure. Advantages of using superheated steam to drive turbines: To maintain the dryness of the steam for steam-driven equipment, whose performance is impaired by the presence of condensate To improve thermal efficiency and work capability, e. It is advantageous to both supply and discharge the steam while in the superheated state because condensate will not be generated inside steam-driven equipment during normal operation, minimizing the risk of damage from erosion or carbonic acid corrosion. In addition, as the theoretical thermal efficiency of the turbine is calculated from the value of the enthalpy at the turbine inlet and outlet, increasing the degree of superheating as well as the pressure raises the enthalpy at the turbine inlet side, and is thereby effective at improving thermal efficiency. Disadvantages of using superheated steam for heating:

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2: What is Geothermal? - Geothermal Resources Council

Steam, Water, and Hydrothermal Systems: Physics and Chemistry Meeting the Needs of Industry Proceedings of the 13th International Conference on the Properties of Water and Steam Edited by Peter Tremaine, Philip Hill, Donald E. Irish, P.V. Balakrishnan.

Great Fountain Geyser is one of more than 10, hydrothermal features in Yellowstone. More than 10, hydrothermal features are found here, of which more than are geysers. Microorganisms called thermophiles, or heat lovers, make their homes in the hydrothermal features of Yellowstone. Many of these microorganisms are also called extremophiles because they inhabit environments that are extreme to human life. Imagine living in near-boiling temperatures, in hydrothermal features with the alkalinity of baking soda, or in water so acidic that it can burn holes in clothing; microorganisms in Yellowstone not only exist in such conditions, but require these extremes to thrive. There are five types of hydrothermal features readily visible in Yellowstone: Pools of geothermally heated water. Hot springs with constrictions in their plumbing, which causes them to periodically erupt to release the pressure that builds up. Hot springs that are acidic enough to dissolve the surrounding rock. Typically also lack water in their systems. Hot springs that rise up through limestone, dissolve the calcium carbonate, and desposit the calcite that makes the travertine terraces. These hot features lack water in their system, and instead constantly release steam. Learn how to adventure through Yellowstone safely. Hot Springs Hot springs are the most common hydrothermal features in Yellowstone. Beginning as precipitation, the water of a hot spring seeps through the bedrock underlying Yellowstone and becomes superheated at depth. An open plumbing system allows the hot water to rise back to the surface unimpeded. Convection currents constantly circulate the water, preventing it from getting hot enough to trigger an eruption. At times, fierce, boiling waters within a hot spring such as Crested Pool can explode, shooting water into the air, acting much like a geyser. It is believed, however, that in the case of Crested Pool, no constrictions block the flow of water to the surface. The intense blue color of some springs results when sunlight passes into their deep, clear waters. Blue, a color visible in light, is scattered the most and the color we see. So many individual microorganisms are grouped togetherâ€"trillions! Different types of thermophiles live at different temperatures within a hot spring and cannot tolerate much cooler or warmer conditions. Hydrothermal features are habitats for microscopic organisms called thermophiles: Mudpots, like Red Spouter in Lower Geyser Basin shown here, are acidic features with a limited water supply. Surface water collects in a shallow, impermeable usually due to a lining of clay depression that has no direct connection to an underground water flow. Thermal water beneath the depression causes steam to rise through the ground, heating the collected surface water. Hydrogen sulfide gas is usually present, giving mudpots their characteristic odor of rotten eggs. Some microorganisms use the hydrogen sulfide for energy. The microbes help convert the gas to sulfuric acid, which breaks down rock into clay. The result is a gooey mix through which gases gurgle and bubble. After coming upon Mud Volcano during his expedition to Yellowstone, Ferdinand Hayden described the mudpot as "the greatest marvel we have met with. Fumaroles or steam vents are the hottest hydrothermal features in Yellowstone. This feature has a history of shifting its location several times. It has been active since at least, often roaring in a noisy stream of hot vapor. Another wonderful place to enjoy the marvels of fumaroles is at Roaring Mountain, where fumaroles dots an entire mountainside. It is especially dramatic on cool days when the steam is more visible. Travertine Terraces Travertine terraces are formed from limestone. Thermal water rises through the limestone, carrying high amounts of the dissolved limestone calcium carbonate. At the surface, carbon dioxide is released and calcium carbonate is deposited, forming travertine, the chalky white mineral forming the rock of travertine terraces. The formations resemble a cave turned inside out. Colorful stripes are formed by thermophiles, or heat-loving organisms. Travertine formations grow much more rapidly than the more common sinter formations in the park because of the "soft" nature of limestone. Due to the rapid deposition, these features constantly and quickly change. Mammoth Hot Springs Terraces As one early visitor described the Mammoth Hot Springs terraces, "No human architect ever designed such intricate fountains as these. The water trickles over the edges from one to another, blending them together with the effect of a frozen waterfall. Mammoth Hot Springs are a surface expression of the deep volcanic forces at work in Yellowstone. Although these springs lie outside the caldera boundary, scientists surmise that the heat from the hot springs comes from the same magmatic system that fuels other Yellowstone thermal areas. A large fault system runs between Norris Geyser Basin and Mammoth, which may allow thermal water to flow between the two. Also, multiple basalt eruptions have occurred in this area. Thus, basalt may be a heat source for the Mammoth area. Thermal activity here is extensive and has been present for several thousand years. Terrace Mountain, northwest of Golden Gate, has a thick cap of travertine. The Mammoth Hot Springs Terraces extend all the way from the hillside where we see them today, across the historic Parade Ground, and down to Boiling River. There was some concern when construction began in on the fort site that the hollow ground would not support the weight of the buildings. Currently, there are several large sink holes fenced off can be seen on the historic Fort Yellowstone Parade Ground. Virtually wander around Mammoth Hot Springs, where the underlying limestone allow large terraces to form above ground. Geysers Sprinkled amid the hot springs are the rarest fountains of all, the geysers. What makes them rare and distinguishes them from hot springs is that somewhere, usually near the surface in the plumbing system of a geyser, there are one or more constrictions. Geysers are hot springs with constrictions in their plumbing, usually near the surface, that prevent water from circulating freely to the surface where heat would escape. Surrounding pressure also increases with depth, much as it does with depth in the ocean. Increased pressure exerted by the enormous weight of the overlying water prevents the water from boiling. As the water rises, steam forms. Bubbling upward, the steam expands as it nears the top of the water column. At a critical point, the confined bubbles actually lift the water above, causing the geyser to splash or overflow. This decreases pressure on the system, and violent boiling results. Tremendous amounts of steam force water out of the vent, and an eruption begins. The eruption stops when the water reservoir is depleted or when the system cools. There are more geysers in Yellowstone than anywhere else on earth. Old Faithful, certainly the most famous geyser, is joined by numerous others big and small, named and unnamed. Though born of the same water and rock, what is enchanting is how differently they play in the sky. Riverside Geyser, in the Upper Geyser Basin, shoots at an angle across the Firehole River, often forming a rainbow in its mist. Castle erupts from a cone shaped like the ruins of some medieval fortress. Grand explodes in a series of powerful bursts, towering above the surrounding trees. Echinus spouts up and out to all sides like a fireworks display of water. And Steamboat, the largest in the world, pulsates like a massive steam engine in a rare, but remarkably memorable eruption, reaching heights of to feet.

3: How it Works: Water for Power Plant Cooling | Union of Concerned Scientists

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State-by-State Guides to Geothermal Energy Potential The uses to which these resources are applied are also influenced by temperature. The highest temperature resources are generally used only for electric power generation. However, there are many areas around the world where the gradient is higher, the temperature increases at a faster rate with depth below the ground. With better drilling technology geothermal resources at greater depth and temperature can be reached. Geothermal Power Plants Geothermal power plants use hydrothermal resources that have two common ingredients: We can use these resources by drilling wells into the Earth and piping the steam or hot water to the surface. Geothermal wells are typically one to two miles deep. There are three basic types of geothermal power plants: Dry steam plants use steam piped directly from a geothermal reservoir to turn the generator turbines. The first geothermal power plant was built in in Tuscany, Italy, where natural steam erupted from the Earth. Flash steam plants take high-pressure hot water from deep inside the Earth and convert it to steam to drive the generator turbines. When the steam cools, it condenses to water and is injected back into the ground to be used over and over again. Most geothermal power plants are flash steam plants. Binary cycle power plants transfer the heat from geothermal hot water to another liquid. The heat causes the second liquid to turn to steam which is used to drive a generator turbine. The current production of geothermal energy from all uses places third among renewables, following hydroelectricity and biomass, and ahead of solar and wind. Despite these impressive statistics, the current level of geothermal use pales in comparison to its potential. The key to wider geothermal use is greater public awareness and technical support. The EGS concept is to extract heat by creating a subsurface fracture system to which water can be added through injection wells. Creating an enhanced, or engineered, geothermal system requires improving the natural permeability of rock. Rocks are permeable due to minute fractures and pore spaces between mineral grains. Injected water is heated by contact with the rock and returns to the surface through production wells, as in naturally occurring hydrothermal systems. Direct use and Geothermal heat pumps. Direct Use Direct use, as the name implies, involves using the heat in the water directly without a heat pump or power plant for such things as heating of buildings, industrial processes, greenhouses, aquaculture fish farming and resorts. Direct, or non-electric, use of geothermal energy refers to the use of the energy for both heatng and cooling applications. Furthermore, direct-use applications such as fish farms, greenhouses, microbreweries, fruit and vegetable drying, spas, pulp and paper processing, and lumber drying offer attractve and innovative opportunities for local businesses and entrepreneurs. Direct-use geothermal energy projects leverage existing workforces and companies within the state. Their simple design and construction from off-the-shelf parts can utilize local engineering firms, geologists, drilling operators, construction trades, pipefitters, technicians, and welders. A rough prediction of potential job opportunites created by installing direct-use systems may be 3 temporary jobs per MWth during construction, with 1 full-time job per MWth for ongoing operation. Geothermal heated facilities have the potential to stimulate economies through increased tax revenues, the creation of new businesses and local jobs, tourism, agriculture, and enhanced community involvement. Directly using geothermal energy in homes and commercial operations, such as food production from local agriculture, can offset imported energy, keeping jobs, dollars, and other benefits in local communities. Geothermal direct-use projects produce near-zero emissions. Depending on the existing heating fuels being offset, this may result in annual emissions reductions of anywhere between 1, tons if offsettng natural gas to 9, tons if offsettng electricity of CO2 saved per MWth of installed geothermal direct-use capacity. Applications of geothermal direct use may include district heating, snow melting, spas and pools, agriculture, food processing, and other uses. Reliable and Sustainable Heat Source. Geothermal heating projects last for decadesâ€”typically 25 years or moreâ€" providing reliable energy at a low, stable price. This can provide price certainty and insulate consumers and the economy from more unpredictable fluctuations in fossil fuel prices. Heat Pumps Geothermal heat pumps use the natural insulating properties of the earth from just a few feet underground to as much as several hundred feet deep, offering a unique and highly efficient renewable energy technology for heating and cooling. Heat is taken from the building and transferred to the ground in the summer. The system is reversible, and heat is taken from the ground and used in the building in the winter. The system only moves heat, which is much more efficient than using a fuel or electricity to create heat. Geothermal heat pumps can support space heating and cooling needs in almost any part of the country. So a typical home system can avoid metric tons of CO_2 emissions. There is no combustion in a geothermal heat pump; therefore there is no chance of carbon-monoxide poisoning. By adding high-efficiency air cleaners with geothermal, these systems can improve inside air quality. Unlike other geothermal technologies, heat pumps are not limited by geography or geology. They can be installed in most locations in any of the 50 states or territories of the U. The lifespan of a geothermal system is usually greater than 24 years. A conventional furnace will last years with regular maintenance. The ground loop of the geothermal system has a warranty of 50 years. These loops are made up of high-density polyethylene pipe, the same pipe which is used in city gas lines. Unlike air conditioners, there is no outdoor unit. Geothermal units are very smooth and quiet in operation. Geothermal Heat Pumps use the earth or groundwater as a heat source in winter and a heat sink in summer. Accurate data is not available on the current number of these systems; however, the rate of installation is thought to be between 10, and 40, per year. Information furnished by the Geo-Heat Center.

4: Water Heating - Hydro-Thermal Corp.

Hydro-Thermal's heating systems are used in a variety of industries including ethanol, starch, pulp and paper, meat and poultry, food and beverage, chemical, metal, and more. Learn more: Award-Winning, Innovative, Direct Steam Injection Hydroheaters and Systems.

This heat energy, known as geothermal energy, can be found almost anywhereâ€”as far away as remote deep wells in Indonesia and as close as the dirt in our backyards. Many regions of the world are already tapping geothermal energy as an affordable and sustainable solution to reducing dependence on fossil fuels, and the global warming and public health risks that result from their use. For example, as of more than 11, megawatts MW of large, utility-scale geothermal capacity was in operation globally, with another 11, MW in planned capacity additions on the way [1]. These geothermal facilities produced approximately 68 billion kilowatt-hours of electricity, enough to meet the annual needs of more than 6 million typical U. Geothermal plants account for more than 25 percent of the electricity produced in both Iceland and El Salvador [2]. Geothermal plants account for more than 25 percent of the electricity produced in Iceland. In thousands of homes and buildings across the United States, geothermal heat pumps also use the steady temperatures just underground to heat and cool buildings, cleanly and inexpensively. Heat is continually produced in this layer, mostly from the decay of naturally radioactive materials such as uranium and potassium. Energy Information Administration, Annual Energy Review The areas with the highest underground temperatures are in regions with active or geologically young volcanoes. These "hot spots" occur at tectonic plate boundaries or at places where the crust is thin enough to let the heat through. The Pacific Rim, often called the Ring of Fire for its many volcanoes, has many hot spots, including some in Alaska, California, and Oregon. Nevada has hundreds of hot spots, covering much of the northern part of the state. These regions are also seismically active. Earthquakes and magma movement break up the rock covering, allowing water to circulate. As the water rises to the surface, natural hot springs and geysers occur, such as Old Faithful at Yellowstone National Park. Seismically active hotspots are not the only places where geothermal energy can be found. There is a steady supply of milder heatâ€”useful for direct heating purposesâ€”at depths of anywhere from 10 to a few hundred feet below the surface virtually in any location on Earth. Even the ground below your own backyard or local school has enough heat to control the climate in your home or other buildings in the community. In addition, there is a vast amount of heat energy available from dry rock formations very deep below the surface 4â€”10 km. Using the emerging technology known as Enhanced Geothermal Systems EGS , we may be able to capture this heat for electricity production on a much larger scale than conventional technologies currently allow. While still primarily in the development phase, the first demonstration EGS projects provided electricity to grids in the United States and Australia in If the full economic potential of geothermal resources can be realized, they would represent an enormous source of electricity production capacity. In , the U. National Renewable Energy Laboratory NREL found that conventional geothermal sources hydrothermal in 13 states have a potential capacity of 38, MW, which could produce million MWh of electricity annually [4]. State and federal policies are likely to spur developers to tap some of this potential in the next few years. The Geothermal Energy Association estimates that projects now under development around the country could provide up to 2, megawatts of new capacity [3]. As EGS technologies improve and become competitive, even more of the largely untapped geothermal resource could be developed. Not only do geothermal resources in the United States offer great potential, they can also provide continuous baseload electricity. According to NREL, the capacity factors of geothermal plantsâ€”a measure of the ratio of the actual electricity generated over time compared to what would be produced if the plant was running nonstop for that periodâ€”are comparable with those of coal and nuclear power [5]. With the combination of both the size of the resource base and its consistency, geothermal can play an indispensable role in a cleaner, more sustainable power system. Salt Wells geothermal plant in Nevada. Department of Energy How geothermal energy is captured Geothermal springs for power plants. Once this heated water is forced to the surface, it is a relatively simple matter to capture that steam and use it to drive electric generators. Geothermal power plants drill their own holes into the rock to more effectively capture the steam. There are three basic designs for geothermal power plants, all of which pull hot water and steam from the ground, use it, and then return it as warm water to prolong the life of the heat source. In the simplest design, known as dry steam, the steam goes directly through the turbine, then into a condenser where the steam is condensed into water. In a second approach, very hot water is depressurized or "flashed" into steam which can then be used to drive the turbine. In the third approach, called a binary cycle system, the hot water is passed through a heat exchanger, where it heats a second liquidâ€”such as isobutaneâ€”in a closed loop. Isobutane boils at a lower temperature than water, so it is more easily converted into steam to run the turbine. These three systems are shown in the diagrams below. The three basic designs for geothermal power plants: Department of Energy The choice of which design to use is determined by the resource. If the water comes out of the well as steam, it can be used directly, as in the first design. If it is hot water of a high enough temperature, a flash system can be used; otherwise it must go through a heat exchanger. Since there are more hot water resources than pure steam or high-temperature water sources, there is more growth potential in the binary cycle, heat exchanger design. The largest geothermal system now in operation is a steam-driven plant in an area called the Geysers, north of San Francisco, California. Despite the name, there are actually no geysers there, and the heat that is used for energy is all steam, not hot water. Although the area was known for its hot springs as far back as the mids, the first well for power production was not drilled until By , 26 power plants had been built, for a capacity of more than 2, MW. Because of the rapid development of the area in the s, and the technology used, the steam resource has been declining since The plants at the Geysers use an evaporative water-cooling process to create a vacuum that pulls the steam through the turbine, producing power more efficiently. But this process loses 60 to 80 percent of the steam to the air, without re-injecting it underground. While the steam pressure may be declining, the rocks underground are still hot. To remedy the situation, various stakeholders partnered to create the Santa Rosa Geysers Recharge Project, which involves transporting 11 million gallons per day of treated wastewater from neighboring communities through a mile pipeline and injecting it into the ground to provide more steam. The project came online in , and in provided enough additional electricity for approximately , homes [7]. One concern with open systems like the Geysers is that they emit some air pollutants. Hydrogen sulfideâ€”a toxic gas with a highly recognizable "rotten egg" odorâ€—along with trace amounts of arsenic and minerals, is released in the steam. Salt can also pose an environmental problem. At a power plant located at the Salton Sea reservoir in Southern California, a significant amount of salt builds up in the pipes and must be removed. While the plant initially put the salts into a landfill, they now re-inject the salt back into a different well. With closed-loop systems, such as the binary cycle system, there are no emissions and everything brought to the surface is returned underground. Direct use of geothermal heat. Geothermal springs can also be used directly for heating purposes. Geothermal hot water is used to heat buildings, raise plants in greenhouses, dry out fish and crops, de-ice roads, improve oil recovery, aid in industrial processes like pasteurizing milk, and heat spas and water at fish farms. In Klamath Falls, Oregon, and Boise, Idaho, geothermal water has been used to heat homes and buildings for more than a century. On the east coast, the town of Warm Springs, Virginia obtains heat directly from spring water as well, using springs to heat one of the local resorts [8]. In Iceland, virtually every building in the country is heated with hot spring water. In fact, Iceland gets more than 50 percent of its primary energy from geothermal sources [9]. In Reykjavik, for example population , , hot water is piped in from 25 kilometers away, and residents use it for heating and for hot tap water. Pseudopanax Ground-source heat pumps. A much more conventional way to tap geothermal energy is by using geothermal heat pumps to provide heat and cooling to buildings. Either air or antifreeze liquid is pumped through pipes that are buried underground, and re-circulated into the building. In the summer, the liquid moves heat from the building into the ground. In the winter, it does the opposite, providing pre-warmed air and water to the heating system of the building. More complicated, but more effective, systems use compressors and pumpsâ€”as in electric air conditioning systemsâ€—to maximize the heat transfer. In regions with temperature extremes, such as the northern United States in the winter and the southern United States in the summer, ground-source heat pumps are the most energy-efficient and environmentally clean heating and cooling systems available. Far more efficient than electric heating and cooling, these systems can circulate as much as 3 to 5 times the energy they use in the process. Department of Energy found that heat pumps can save a typical home hundreds of dollars in energy costs each year, with the system typically paying for itself in 8 to 12 years. Tax credits and other incentives can reduce the payback period to 5 years or less [10]. More than , ground-source heat pumps supply climate control in U. While this is significant, it is still only a small fraction of the U. For example, despite their long-term savings, geothermal heat pumps have higher up-front costs. Finally, many heating and cooling installers are simply not familiar with the technology. However, ground-source heat pumps are catching on in some areas. In rural areas without access to natural gas pipelines, homes must use propane or electricity for heating and cooling. Heat pumps are much less expensive to operate than these conventional systems, and since buildings are generally widely spread out, installing underground loops is often not an issue. Underground loops can be easily installed during construction of new buildings as well, resulting in savings for the life of the building. Furthermore, recent policy developments are offering strong incentives for homeowners to install these systems. The economic stimulus bill, Emergency Economic Stabilization Act of , included an eight-year extension through of the 30 percent investment tax credit, with no upper limit, to all home installations of EnergyStar certified geothermal heat pumps [11]. The future of geothermal energy Geothermal energy has the potential to play a significant role in moving the United States and other regions of the world toward a cleaner, more sustainable energy system. It is one of the few renewable energy technologies that can supply continuous, baseload power. Additionally, unlike coal and nuclear plants, binary geothermal plants can be used a flexible source of energy to balance the variable supply of renewable resources such as wind and solar. Binary plants have the capability to ramp production up and down multiple times each day, from percent of nominal power down to a minimum of 10 percent [1]. The costs for electricity from geothermal facilities are also becoming increasingly competitive. Energy Information Administration EIA projected that the levelized cost of energy LCOE for new geothermal plants coming online in will be less than 5 cents per kilowatt hour kWh , as opposed to more than 6 cents for new natural gas plants and more than 9 cents for new conventional coal [12]. There is also a bright future for the direct use of geothermal resources as a heating source for homes and businesses in any location. However, in order to tap into the full potential of geothermal energy, two emerging technologies require further development: An approach to capturing the heat in dry areas is known as enhanced geothermal systems EGS or "hot dry rock". The hot rock reservoirs, typically at greater depths below the surface than conventional sources, are first broken up by pumping high-pressure water through them.

5: Direct Steam Injection Hydroheaters & JetCookers - Hydro-Thermal Corp.

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Hyperthermophile and Thermophile Life has traditionally been seen as driven by energy from the sun, but deep-sea organisms have no access to sunlight, so they must depend on nutrients found in the dusty chemical deposits and hydrothermal fluids in which they live. Previously, benthic oceanographers assumed that vent organisms were dependent on marine snow , as deep-sea organisms are. This would leave them dependent on plant life and thus the sun. Some hydrothermal vent organisms do consume this "rain", but with only such a system, life forms would be very sparse. Compared to the surrounding sea floor, however, hydrothermal vent zones have a density of organisms 10, to , times greater. Hydrothermal vent communities are able to sustain such vast amounts of life because vent organisms depend on chemosynthetic bacteria for food. The water from the hydrothermal vent is rich in dissolved minerals and supports a large population of chemoautotrophic bacteria. These bacteria use sulfur compounds, particularly hydrogen sulfide , a chemical highly toxic to most known organisms, to produce organic material through the process of chemosynthesis. The ecosystem so formed is reliant upon the continued existence of the hydrothermal vent field as the primary source of energy, which differs from most surface life on Earth, which is based on solar energy. However, although it is often said that these communities exist independently of the sun, some of the organisms are actually dependent upon oxygen produced by photosynthetic organisms, while others are anaerobic. Giant tube worms Riftia pachyptila cluster around vents in the Galapagos Rift The chemosynthetic bacteria grow into a thick mat which attracts other organisms, such as amphipods and copepods , which graze upon the bacteria directly. Larger organisms, such as snails , shrimp , crabs , tube worms , fish especially eelpout , cutthroat eel , ophidiiforms and Symphurus thermophilus , and octopuses notably Vulcanoctopus hydrothermalis , form a food chain of predator and prey relationships above the primary consumers. The main families of organisms found around seafloor vents are annelids , pogonophorans , gastropods , and crustaceans , with large bivalves , vestimentiferan worms, and "eyeless" shrimp making up the bulk of nonmicrobial organisms. They have no mouth or digestive tract, and like parasitic worms, absorb nutrients produced by the bacteria in their tissues. About billion bacteria are found per ounce of tubeworm tissue. Tubeworms have red plumes which contain hemoglobin. Hemoglobin combines with hydrogen sulfide and transfers it to the bacteria living inside the worm. In return, the bacteria nourish the worm with carbon compounds. Two of the species that inhabit a hydrothermal vent are Tevnia jerichonana, and Riftia pachyptila. One discovered community, dubbed " Eel City ", consists predominantly of the eel Dysommina rugosa. Though eels are not uncommon, invertebrates typically dominate hydrothermal vents. Eel City is located near Nafanua volcanic cone , American Samoa. It has been proposed that before the North American plate overrode the mid-ocean ridge , there was a single biogeographic vent region found in the eastern Pacific. The examples of convergent evolution seen between distinct hydrothermal vents is seen as major support for the theory of natural selection and of evolution as a whole. Although life is very sparse at these depths, black smokers are the centers of entire ecosystems. More complex life forms, such as clams and tubeworms , feed on these organisms. The organisms at the base of the food chain also deposit minerals into the base of the black smoker, therefore completing the life cycle. No sunlight penetrates that far into the waters. Instead, the bacteria, part of the Chlorobiaceae family, use the faint glow from the black smoker for photosynthesis. This is the first organism discovered in nature to exclusively use a light other than sunlight for photosynthesis. The latter uses iron sulfides pyrite and greigite for the structure of its dermal sclerites hardened body parts , instead of calcium carbonate. This armor plating probably serves as a defense against the venomous radula teeth of predatory snails in that community. Animal-bacterial symbiosis[edit] Hydrothermal vent ecosystems have enormous biomass and productivity; but this rests on the symbiotic relationships that have evolved at vents. Deep-sea hydrothermal vent ecosystems differ from their shallow-water and terrestrial hydrothermal counterparts due to the symbiosis that occurs between macro invertebrate hosts and chemoautotrophic microbial symbionts in the former. Instead, the microbial life found at hydrothermal vents are chemosynthetic; they fix carbon by using energy from chemicals such as sulfide, as opposed to light energy from the sun. In other words, the symbiont converts inorganic molecules H2S, CO2, O to organic molecules that the host then uses as nutrition. However, sulfide is an extremely toxic substance to most life on Earth. For this reason, scientists were astounded when they first found hydrothermal vents teaming with life in Scientists are therefore now studying how the microbial symbionts aid in sulfide detoxification therefore allowing the host to survive the otherwise toxic conditions. Work on microbiome function shows that host-associated microbiomes are also important in host development, nutrition, defense against predators, and detoxification. In return, the host provides the symbiont with chemicals required for chemosynthesis, such as carbon, sulfide, and oxygen. In the early stages of studying life at hydrothermal vents, there were differing theories regarding the mechanisms by which multicellular organisms were able to acquire nutrients from these environments, and how they were able to survive in such extreme conditions. In , it was hypothesized that the chemoautotrophic bacteria at hydrothermal vents might be responsible for contributing to the diet of suspension feeding bivalves. For instance, in , clam gill tissue was confirmed to contain bacterial endosymbionts; [30] in vent bathymodiolid mussels and vesicomyid clams were also found to carry endosymbionts. They also have a bright red plume, which they use to uptake compounds such as O, H2S, and CO2, which feed the endosymbionts in their trophosome. Remarkably, the tubeworms hemoglobin which incidentally is the reason for the bright red color of the plume is capable of carrying oxygen without interference or inhibition from sulfide, despite the fact that oxygen and sulfide are typically very reactive. In , it was discovered that this is possible due to zinc ions that bind the hydrogen sulfide in the tubeworms hemoglobin, therefore preventing the sulfide from reacting with the oxygen. It also reduces the tubeworms tissue from exposure to the sulfide and provides the bacteria with the sulfide to perform chemoautotrophy. Organisms living at the edge of hydrothermal vent fields, such as pectinid scallops, also carry endosymbionts in their gills, and as a result their bacterial density is low relative to organisms living nearer to the vent. Furthermore, not all host animals have endosymbionts; some have episymbionts -- symbionts living on the animal as opposed to inside the animal. Shrimp found at vents in the Mid-Atlantic Ridge were once thought of as an exception to the necessity of symbiosis for macroinvertebrate survival at vents. That changed in when they were discovered to carry episymbionts [36]. Since then, other organisms at vents have been found to carry episymbionts as well, [37] such as Lepetodrilis fucensis. Bathmodiolid mussels are an example of a host that contains methanotrophic endosymbionts; however, the latter mostly occur in cold seeps as opposed to hydrothermal vents. While chemosynthesis occurring at the deep ocean allows organisms to live without sunlight in the immediate sense, they technically still rely on the sun for survival, since oxygen in the ocean is a byproduct of photosynthesis. However, if the sun were to suddenly disappear and photosynthesis ceased to occur on our planet, life at the deep-sea hydrothermal vents could continue for millennia until the oxygen was depleted. Biological theories[edit] The Deep Hot Biosphere[edit] At the beginning of his paper The Deep Hot Biosphere, Thomas Gold referred to ocean vents in support of his theory that the lower levels of the earth are rich in living biological material that finds its way to the surface. Therefore, thermal energy flux is a permanent agent and contributed to the evolution of the planet, including prebiotic chemistry. By metabolism he meant a cycle of chemical reactions that release energy in a form that can be harnessed by other processes. A major limitation to this hypothesis is the lack of stability of organic molecules at high temperatures, but some have suggested that life would have originated outside of the zones of highest temperature. Experimental research and computing modeling indicate that the surfaces of mineral particles inside hydrothermal vents have similar catalytic properties to enzymes and are able to create simple organic molecules, such as methanol CH3OH and formic acid HCO2H , out of the dissolved CO2 in the water. The hot solutions were emanating from an active subseafloor rift. The highly saline character of the waters was not hospitable to living organisms. Frederick Grassle, at the time at WHOI , returned to the same location to investigate the biological communities discovered two year earlier. The first dive was targeted at one of those anomalies. On a subsequent dive, William Normark and Thierry Juteau discovered the high temperature vents emitting black mineral particle jets from chimneys; the black smokers. The discovery of a vent in the Pacific Ocean offshore of Costa Rica , named the Medusa hydrothermal vent field after the serpent-haired Medusa of Greek mythology , was announced in April Distribution of hydrothermal vents. This map was created by making use of the InterRidge ver.

6: How Geothermal Energy Works | Union of Concerned Scientists

Explanation: Hydrothermal resources are wet reservoirs at moderate depths containing steam and hot water under pressure at temperatures upto about o C. These systems are further subdivided depending upon whether steam or hot water is dominant product.

Direct Steam Injection for Water Heating Hard water issues, loss of production, plant shutdowns, and damage to your reputation are a few of the many consequences of not having water at critical temperatures exactly when you need it. If you depend on unlimited hot water at precise temperatures and required flow rates, we have your solution. Not only will you have all the hot water you need, but our heaters are self-cleaning and need far less maintenance and upkeep than any heat exchanger. Our solutions will replace large tanks, spargers or heat exchangers with a much smaller footprint and far greater energy efficiency. For more information on our advanced direct steam injection technology, click here. Heating products utilizing direct steam injection The type of heater you need is dependent on how it will be used. No matter what your application, Hydro-Thermal has the solution for every application involving water heating. Here is what makes each solution unique: The EZ Heater and EZ Skid System share the unique benefits of our other heaters, including internal modulation and self cleaning ability. Adjustable pressure drop to control the shear high or low High steam capacity High solids capability Hydroheater has a liquid turndown of 2: If a greater turn-down is required consult Hydro-Thermal Engineering. Please contact Hydro-Thermal for more details. For more information on the Hydroheater, click here. If a customer requires 3A certified equipment, then we recommend our Sanitary Hydroheater. Food and beverage processing, water heating if 3A certification is required Volume capability: Up to 20, cP Rating: Tri-clamp connections, but I-Line connections are available upon request. Self-draining from multiple orientations and designed for easy CIP. For high vibration applications remote mount positioners are available. Alternative positioners are available depending on unique processing conditions or upon request. With instantaneous heating when you need it, our products are ideal for anywhere maintaining a precise temperature is critical. Our most popular heating applications include: During cleaning and wash down at a facility, it is common to run out of hot water. The spargers or heat exchangers are not flexible enough to account for the varying conditions of wash down versus normal production. In the resources section below, there is a central hot water document with more information. For temperature specific operations, Hydro-Thermal has you covered. We understand the importance of meeting proper wash down or sanitation temperatures to avoid fines or recalls. If getting hot water to a specific location is an issue, then we have your solution. Our technology can utilize a small slip steam off of your central hot water system and bring water up to the exact temperature that is required. The EZ Hose Station also eliminates the need for steam piping to each individual hose drop while providing accurate and safe temperature control from a single location with steam-safety features integrated directly into the system. We can heat the fluid going into the tank; re-circulate the tank to maintain a specific temperature, or leave the tank cold and heat the liquid exiting the tank, producing hot water on demand. Many customers see a return on investment ROI in less than three months.

7: Hydrothermal Systems - Yellowstone National Park (U.S. National Park Service)

These systems are central to many areas of scientific study and industrial application, including electric power generation, industrial steam systems, hydrothermal processing of materials, geochemistry, and environmental applications.

Hydrothermal features are habitats for microscopic organisms called thermophiles: The Geysers of Yellowstone. Colorado Associated University Press. Mapping change at Mammoth Hot Springs using aerial photographs and visual observations Yellowstone Science. The Bridge Bay spires: Collection and preparation of a scientific specimen and museum piece Yellowstone Science. Underwater dynamics in Yellowstone Lake hydrothermal vent geochemistry and bacterial chemosynthesis. Hotbed of chaos or reservoir of resilience?: Yellowstone National Park, WY: Geologic Hazards and the Yellowstone GeoEcosystem. Geochemistry and dynamics of the Yellowstone National Park hydrothermal system. Controls on geyser periodicity. Control of hydrothermal fluids by natural fractures at Norris Geyser Basin. Yellowstone Science 14 4. A journey toward the center of the Earth: Strangeness and beauty in the hidden deeps. Sublacustrine geothermal activity in Yellowstone Lake: Studies past and present. Using historical aerial photographs to detect change. Microbial ecology and energetics in Yellowstone hot springs. Protocols for geologic hazards response by the Yellowstone Volcano Observatory. US Geological Survey Circular

STEAM, WATER, AND HYDROTHERMAL SYSTEMS pdf

8: Hydrothermal vent - Wikipedia

The EZ Heater is designed specifically for water heating and is the driving force behind the EZ Skid System. The EZ Heater and EZ Skid System share the unique benefits of our other heaters, including internal modulation and self cleaning ability.

Water for Power Plant Cooling In the United States, 90 percent of electricity comes from thermoelectric power plantsâ€”coal, nuclear, natural gas, and oilâ€”that require cooling. The remaining ten percent is produced by hydroelectric and other renewable energy facilities. Some renewable energy technologies are thermoelectric as well, including certain types of concentrating solar, geothermal, and biomass power plants. Why is cooling necessary? Thermoelectric power plants boil water to create steam, which then spins turbines to generate electricity. The heat used to boil water can come from burning of a fuel, from nuclear reactions, or directly from the sun or geothermal heat sources underground. Once steam has passed through a turbine, it must be cooled back into water before it can be reused to produce more electricity. Colder water cools the steam more effectively and allows more efficient electricity generation [1] Types of cooling Even though all thermoelectric plants use water to generate steam for electricity generation, not all plant cooling systems use water. There are three main methods of cooling: Once-through systems take water from nearby sources e. Once-through systems were initially the most popular because of their simplicity, low cost, and the possibility of siting power plants in places with abundant supplies of cooling water. Wet-recirculating or closed-loop systems reuse cooling water in a second cycle rather than immediately discharging it back to the original water source. Most commonly, wet-recirculating systems use cooling towers to expose water to ambient air. Some of the water evaporates; the rest is then sent back to the condenser in the power plant. In the western US, wet-recirculating systems are predominant. Dry-cooling systems use air instead of water to cool the steam exiting a turbine. Dry-cooled systems use no water and can decrease total power plant water consumption by more than 90 percent. In power plants, lower efficiencies mean more fuel is needed per unit of electricity, which can in turn lead to higher air pollution and environmental impacts from mining, processing, and transporting the fuel. In , most US dry-cooling installations were in smaller power plants, most commonly in natural gas combined-cycle power plants. In , some 30 percent of electricity generation involved once-through cooling, 45 percent recirculating cooling, and 2 percent dry-cooling. In some cases, those same power plants also produced electricity using non-steam systems, such as combustion turbines.

9: Hydrothermal Features - Yellowstone National Park (U.S. National Park Service)

Yellowstone was set aside as the world's first national park because of its hydrothermal wonders. The park contains more than 10, thermal features, including the world's greatest concentration of geysers as well as hot springs, mudpots, and steam vents.

STEAM, WATER, AND HYDROTHERMAL SYSTEMS pdf

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