HVAC cost

- **Estimating Labor Expenses for Repair Services**
  Estimating Labor Expenses for Repair Services Comparing Replacement Part Prices for Various Systems Reviewing Maintenance Plan Rates in Detail Exploring Payment Arrangements for Major Overhauls Analyzing Long Term Savings with Efficient Upgrades Investigating Seasonal Discounts from Service Providers Understanding Monthly Budgeting for HVAC Projects Balancing Initial Spending with Potential Savings Evaluating Total Costs for System Retrofits Preparing for Unexpected Repair Fees Weighing Return on Investment for Modern Equipment Identifying Hidden Expenses in Older Units
- **Understanding Local Building Code Requirements**
  Understanding Local Building Code Requirements Reviewing State Regulations for HVAC Installation Exploring County Permit Applications for Mobile Homes Navigating EPA 608 Certification Steps Recognizing UL Rated Components for Safety Determining Required Inspections for New Units Preparing Official Documents for System Upgrades Knowing When to Seek Professional Licensing Support Identifying Legal Mandates for Refrigerant Disposal Sorting Out Utility Guidelines for Meter Upgrades Meeting Deadlines for Permit Renewals Locating Reliable Compliance Resources for Homeowners
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Mobile homes, often characterized by their compact design and flexible living arrangements, are gaining popularity as a viable housing option. With this increase in demand comes the necessity for efficient and effective HVAC (heating, ventilation, and air conditioning) systems that cater specifically to the unique needs of mobile homes. As we delve into the importance of these systems, it becomes equally crucial to explore how homeowners can benefit from seasonal discounts offered by service providers to maintain or upgrade their HVAC systems.

The unique structure and layout of mobile homes present distinct challenges when it comes to climate control. Compact heat pumps are ideal for the limited space in mobile homes **mobile home hvac unit** ultraviolet radiation. Unlike traditional homes, mobile homes typically have less insulation and smaller spaces, making them more susceptible to temperature fluctuations. An appropriately designed HVAC system is essential for maintaining comfortable living conditions year-round. It ensures that during sweltering summers or chilly winters, residents have a refuge that provides both warmth and coolness at optimal efficiency.

Furthermore, the compact nature of mobile homes requires HVAC systems that are not only efficient but also space-conscious. Traditional systems may not fit well or perform optimally in such settings. Therefore, specialized units designed specifically for mobile homes are necessary. These units take into consideration aspects like limited space for ductwork and lower ceilings while providing robust performance.

Given these specialized needs, maintaining an efficient HVAC system in a mobile home can be costly without strategic planning. This is where investigating seasonal discounts from service providers becomes advantageous. Many service providers offer significant savings during off-peak seasons when demand for maintenance services tends to drop. For instance, homeowners might find discounts on new installations or routine maintenance checks during spring or fall, just before the extreme temperatures set in.

Taking advantage of these seasonal offers not only helps manage costs but also ensures that the HVAC systems are serviced regularly and remain in peak condition throughout the year. Regular maintenance checks can identify potential issues before they escalate into major problems requiring expensive repairs or replacements.

Moreover, some service providers may offer bundled services at discounted rates during certain times of the year. These packages could include everything from cleaning filters and checking refrigerant levels to inspecting electrical connections and calibrating thermostats- all crucial tasks that ensure an HVAC system runs efficiently.

To maximize benefits from seasonal discounts, homeowners should proactively research local service providers known for their expertise with mobile home HVAC systems. Building relationships with trusted companies can lead to exclusive deals or early access notifications about upcoming promotions.

In conclusion, understanding the importance of tailored HVAC solutions for mobile homes is vital due to their specific structural needs. By strategically leveraging seasonal discounts offered by service providers, homeowners can efficiently manage costs while ensuring their systems operate smoothly throughout all seasons. Such proactive approaches not only enhance comfort but also contribute significantly towards extending the lifespan of these critical home components-ultimately adding value to one's investment in a mobile home lifestyle.

Factors Influencing Labor Costs in Mobile Home HVAC Repairs —

Seasonal discount strategies are a prevalent marketing tool employed by service providers across various industries. These strategies are designed to attract customers during specific times of the year, often aligning with holidays or seasonal changes, and aim to boost sales, increase customer loyalty, and clear out inventory. Understanding these common approaches provides valuable insight into how businesses can effectively capitalize on seasonal consumer behavior.

One of the most widespread seasonal discount strategies is the use of holiday promotions. During major holidays such as Christmas, New Year's, Thanksgiving, and Easter, service providers offer significant discounts to entice customers who are already in a spending mindset. These promotions can take many forms, such as percentage discounts on services, bundled offers that provide more value for money, or exclusive access to new products or services at reduced rates. The psychological impact of holiday shopping traditions plays a crucial role here; consumers expect sales and often delay purchases until these periods to maximize their savings.

Another common strategy involves end-of-season sales. As one season transitions into another-such as summer turning into fall-service providers often offer reduced prices on services related to the outgoing season. For instance, travel agencies might provide discounted vacation packages at the end of summer when demand typically drops. By offering these discounts, businesses can maintain steady cash flow even during slower periods and reduce excess inventory or capacity.

Flash sales have also become an increasingly popular seasonal discount strategy. These short-term promotions create a sense of urgency among consumers by offering substantial discounts over a limited time frame. Often announced with little notice through digital channels like email marketing or social media platforms, flash sales target impulse buyers who respond well to immediate calls-to-action. This approach not only boosts short-term revenue but also increases customer engagement with brand communication channels.

Loyalty programs play another vital role in seasonal discount strategies. Service providers frequently use loyalty rewards systems to encourage repeat business during specific seasons by offering double points or exclusive discounts for members during peak shopping times. This strategy helps in retaining existing customers while simultaneously attracting new ones who perceive additional value in becoming loyal patrons.

Additionally, early-bird specials are employed by service providers seeking to secure bookings or commitments ahead of peak seasons. For example, hotels might offer discounted rates for guests who book months in advance before busy travel periods like summer vacations or winter holidays begin. This tactic ensures early revenue generation and assists businesses in better forecasting demand and managing resources efficiently.

In conclusion, seasonal discount strategies serve as powerful tools for service providers looking to optimize their operations throughout the year. By understanding consumer behavior patterns associated with different seasons and strategically planning promotions around these insights, businesses can enhance their competitiveness in the market while fostering stronger relationships with their clientele. Whether through holiday promotions, end-of-season sales, flash deals, loyalty program incentives, or early-bird specials-each approach offers unique advantages that cater to both customer desires and business objectives alike.

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Steps to Accurately Estimate Labor Expenses for HVAC

Repair Services

When considering the purchase or maintenance of HVAC systems for mobile homes, many homeowners are keen to understand how they might benefit from seasonal discounts offered by service providers. These discounts can significantly reduce costs, making it crucial to comprehend the factors that influence their availability and extent.

One primary factor is the seasonality itself. HVAC systems, which encompass heating, ventilation, and air conditioning units, are subject to fluctuations in demand based on the time of year. During peak seasons-summer for air conditioning and winter for heating-the demand surges as homeowners seek comfort amid extreme temperatures. Consequently, service providers have less incentive to offer discounts during these periods when their services are in high demand. In contrast, during off-peak seasons like spring and fall, when temperatures are milder and HVAC usage declines, companies often introduce discounts to stimulate business. This cyclical nature creates a predictable pattern where strategic timing can lead to substantial savings.

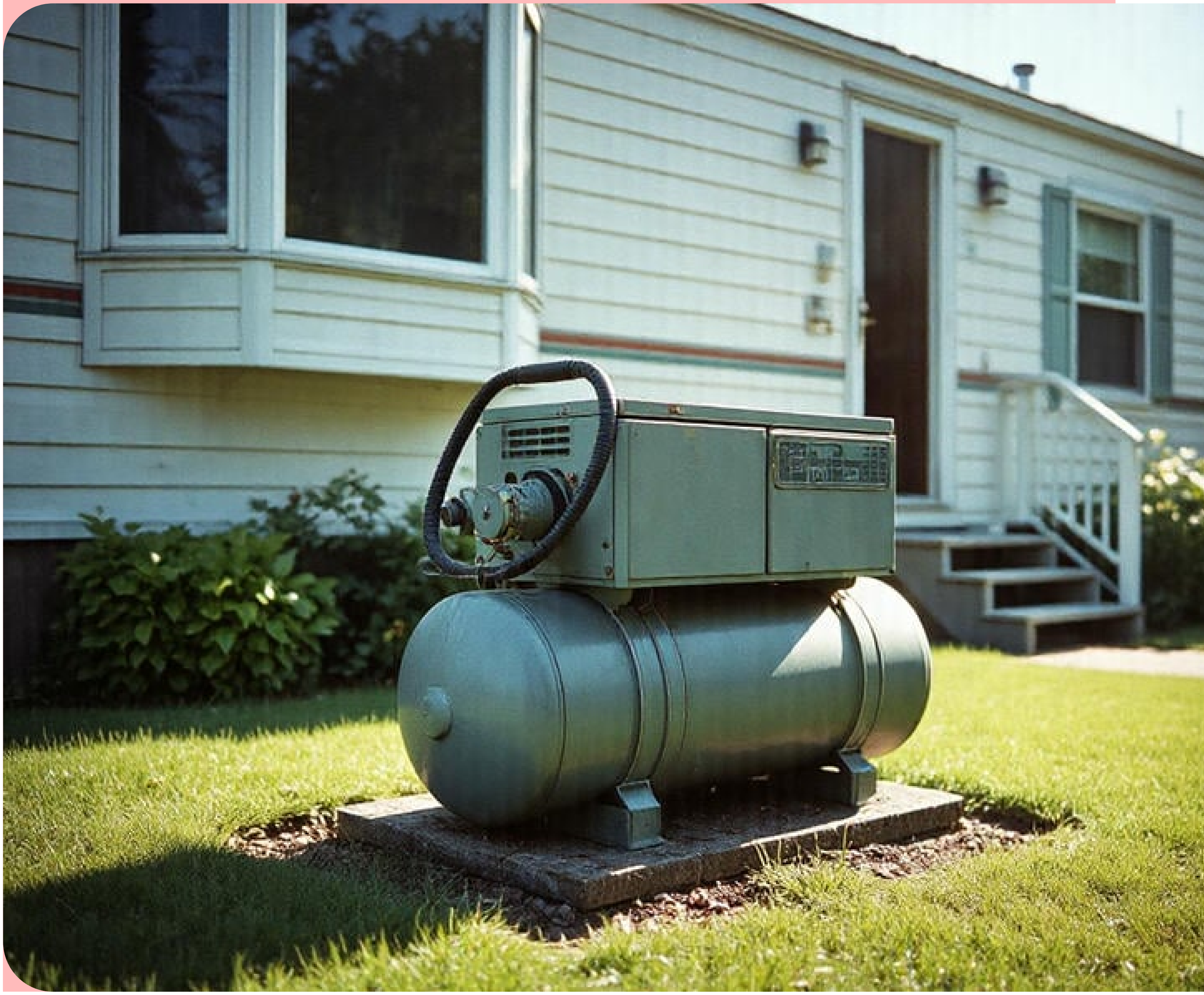
Another influential factor is inventory management. Service providers may need to clear out older models or excess stock before new products arrive. To do so efficiently, they might offer discounts on installations or upgrades for existing units in mobile homes. Consumers who keep an eye on product cycles can take advantage of these clearance sales.

Competition among service providers also plays a critical role. In markets with numerous HVAC companies vying for customers' attention, businesses may offer competitive pricing or special promotions as a means to distinguish themselves from rivals. Homeowners can leverage this competition by comparing offers and choosing those that provide the best value for money.

Economic conditions further affect discount strategies. In times of economic downturns or uncertain financial climates, service providers might introduce more aggressive pricing tactics to attract budget-conscious consumers who may otherwise postpone non-essential expenditures like HVAC system upgrades or maintenance.

Lastly, technological advancements influence discount offers as well. With continuous improvements in energy efficiency and smart technology integrations within HVAC systems, newer models frequently replace older ones at accelerated rates. As a result, service providers might discount older models either as part of promotional packages or simply to make room for innovative products.

In conclusion, understanding the myriad factors influencing seasonal discounts for mobile home HVAC systems allows homeowners to make informed decisions about when and how they choose to invest in their home's climate control solutions. By considering elements such as seasonality, inventory management strategies, market competition dynamics, broader economic trends, and technological progression timelines, consumers can optimize their spending while ensuring comfort throughout the year.



Tools and Software for Estimating Labor Costs in Mobile Home HVAC Repairs

Seasonal discounts have become a staple in the retail and service industries, acting as incentives for consumers to make purchases during specific times of the year. These discounts offer considerable benefits that can be appealing to savvy shoppers looking to maximize their savings. Understanding these advantages can lead to more informed purchasing decisions and a better appreciation for the marketing strategies employed by service providers.

One of the most compelling benefits of availing seasonal discounts is cost savings. Consumers can purchase goods and services at reduced prices, which can significantly impact their budgets. For instance, buying winter clothing during end-of-season sales or securing travel packages during off-peak seasons allows consumers to enjoy high-quality products and experiences without breaking the bank. This financial relief is particularly beneficial for families and individuals who need to stretch their resources further while maintaining their standard of living.

Moreover, seasonal discounts often coincide with festive periods or holidays, aligning perfectly with consumer needs. During such times, people are typically in search of gifts, decorations, or travel options. Discounts make it feasible for consumers to purchase more items than they might usually afford, thereby enhancing their celebration experiences without undue financial strain. This aspect not only boosts consumer satisfaction but also fosters brand loyalty as customers associate positive experiences with particular retailers or service providers.

Another advantage lies in access to new products and trends at lower costs. Service providers often use seasonal discounts as an opportunity to clear out old stock and introduce new lines or services. For consumers eager to stay up-to-date with the latest trends-be it fashion, technology, or home décor-seasonal sales provide an avenue to do so affordably. This accessibility democratizes trend-following by making it available beyond those who can pay full price year-round.

Furthermore, seasonal discounts encourage strategic spending habits among consumers. By planning ahead and anticipating these discount periods, shoppers can avoid impulse buying throughout the year and instead focus on maximizing savings when prices drop. This practice not only leads to more thoughtful consumption but also teaches valuable budgeting skills that can be beneficial long-term.

Lastly, availing seasonal discounts contributes positively towards reducing waste through mindful consumption patterns prompted by well-planned purchases rather than spontaneous ones driven by immediate needs at higher costs later on.

In conclusion, the benefits of availing seasonal discounts are manifold-from tangible financial savings to enhanced accessibilities like current trends while fostering responsible shopping behaviors over time too! As service providers continue leveraging these opportunities within their marketing strategies successfully attracting customers' attention every season anew - it's evident why such practices hold great value both economically speaking (for consumer) but also culturally (within societies globally).

Case Studies: Examples of Labor Cost Estimation in Various Repair Scenarios

When it comes to maintaining a comfortable home environment, few elements are as crucial as a well-functioning HVAC system. These systems not only regulate temperature but also ensure the air quality within our living spaces. However, maintaining or upgrading your HVAC system can be a significant financial undertaking. For budget-conscious homeowners, securing the best deals on HVAC services is paramount. One effective strategy is investigating seasonal discounts from service providers.

Seasonal discounts on HVAC services are often tied to the fluctuating demand for heating and cooling throughout the year. During peak seasons-summer for air conditioning and winter for heating-service providers are overwhelmed with requests and may charge premium rates. Conversely, during off-peak times like spring and fall, when demand diminishes, many companies offer enticing discounts to attract customers.

To take advantage of these seasonal savings opportunities, timing is everything. Homeowners should plan ahead by scheduling routine maintenance or system upgrades during these non-peak periods. Not only does this approach help in securing lower prices due to reduced demand, but it also ensures that your HVAC system is in top condition before extreme weather hits.

Another tip for identifying the best deals is thorough research. Start by compiling a list of local service providers well in advance of when you intend to schedule work on your HVAC system. Visit their websites or call them directly to inquire about any upcoming promotions or discount programs they might offer during their slower months. Additionally, subscribing to newsletters from reputable companies can provide early notifications about special offers.

Moreover, negotiating with service providers can sometimes yield unexpected results. Many companies are willing to offer custom discounts if you ask directly, especially if you're bundling multiple services or signing up for ongoing maintenance plans. Don't shy away from discussing pricing options-after all, competition among providers can work in your favor.

Furthermore, loyalty programs and referrals can also lead to discounted rates. If you've had satisfactory experiences with certain companies in the past, inquire whether they have loyalty rewards for repeat customers or referral bonuses if you bring new clients their way.

In conclusion, while finding and securing the best deals on HVAC services requires some effort and strategic planning, significant savings are within reach through careful investigation of seasonal discounts offered by service providers. By understanding market dynamics and leveraging timing alongside proactive communication with service providers, homeowners can enjoy both comfort and cost-efficiency in managing their HVAC systems throughout the year.

Tips for Managing and Reducing Labor Expenses Without Compromising Quality

When exploring the allure of seasonal discounts from service providers, consumers often find themselves enticed by the promise of savings. However, while discounted services might seem like an opportunity too good to miss, there are potential pitfalls and considerations that should be carefully weighed before diving in.

First and foremost, quality can sometimes be compromised in exchange for a lower price. Service providers may offer discounts during off-peak seasons not just to increase demand but also to compensate for reduced staff or limited resources. As a consumer, it's crucial to ensure that the level of service you receive during a discounted period matches your expectations. A discounted rate should not imply a decline in quality; however, it is up to the consumer to verify this through reviews or by asking direct questions about what is included.

Another consideration is the fine print accompanying these discounts. Often, promotional offers come with restrictions or conditions that may not be immediately apparent. These could include specific timeframes when the service must be used, limitations on availability, or additional fees for certain features you might assume are standard. It's essential to read and understand all terms and conditions associated with any seasonal discount offer so that surprises don't emerge later on.

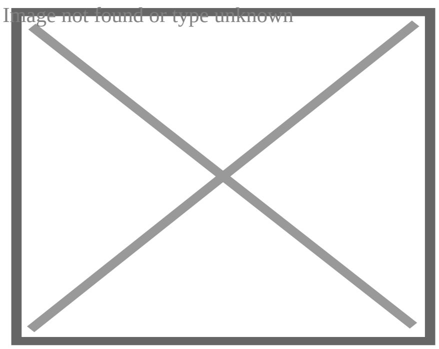
Timing is another crucial factor to consider when opting for seasonal discounts. While it may seem advantageous to purchase services at a lower price ahead of time, it's important to evaluate whether this aligns with your actual needs and schedule. For instance, purchasing discounted travel services months in advance can lead to complications if plans change unexpectedly. Flexibility often comes at a premium that discounted offers do not usually accommodate.

Moreover, there's always the risk of impulse buying driven by the fear of missing out on a good deal. Discounts tend to create an urgency that encourages quick decision-making without thorough evaluation. Before committing, it's wise to take a step back and assess whether the service being offered is genuinely necessary or beneficial at this point in time.

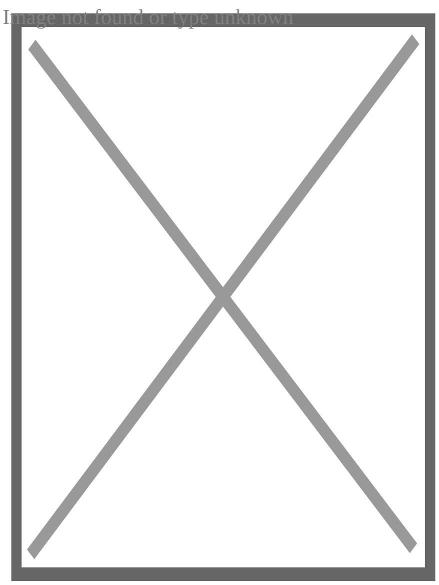
Lastly, consider how opting for discounted services aligns with your long-term goals and priorities. While saving money upfront can feel rewarding, it's important to reflect on whether these savings will contribute positively towards your broader financial objectives or lifestyle choices.

In conclusion, while seasonal discounts from service providers present opportunities for savings, they come with their own set of challenges that require careful navigation. By remaining vigilant about quality assurance, understanding all terms thoroughly, considering timing implications and resisting impulsive decisions based solely on cost reductions- consumers can make informed choices that serve their best interests both now and in the future.

About Heat exchanger



Tubular heat exchanger



Partial view into inlet plenum of shell and tube heat exchanger of a refrigerant based chiller for providing air-conditioning to a building

A **heat exchanger** is a system used to transfer heat between a source and a working fluid. Heat exchangers are used in both cooling and heating processes.[1] The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact.[2] They are widely used in space heating, refrigeration, air conditioning, power stations, chemical plants, petrochemical plants, petroleum refineries, natural-gas processing, and sewage treatment. The classic example of a heat exchanger is found in an internal combustion engine in which a circulating fluid known as engine coolant flows through radiator coils and air flows past the coils, which cools the coolant and heats the incoming air. Another example is the heat sink, which is a passive heat exchanger that transfers the heat generated by an electronic or a mechanical device to a fluid medium, often air or a liquid coolant.[3]

Flow arrangement

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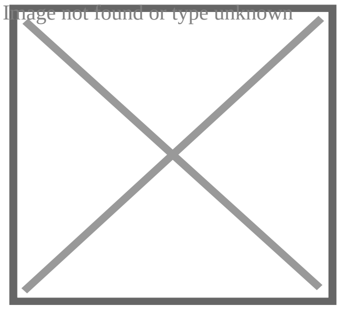

Countercurrent (A) and parallel (B) flows

There are three primary classifications of heat exchangers according to their flow arrangement. In *parallel-flow* heat exchangers, the two fluids enter the exchanger at the same end, and travel in parallel to one another to the other side. In *counter-flow* heat exchangers the fluids enter the exchanger from opposite ends. The counter current design is the most efficient, in that it can transfer the most heat from the heat (transfer) medium per unit mass due to the fact that the average temperature difference along any unit length is *higher*. See countercurrent exchange. In a *cross-flow* heat exchanger, the fluids travel roughly perpendicular to one another through the exchanger.

Fig. 1: Shell and tube heat e

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Fig. 1: Shell and tube heat exchanger, single pass (1–1 parallel flow)

Fig. 2: Shell and tube heat e

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Fig. 2: Shell and tube heat exchanger, 2-pass tube side (1–2 crossflow)

Fig. 3: Shell and tube heat e

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Fig. 3: Shell and tube heat exchanger, 2-pass shell side, 2-pass tube side (2-2 countercurrent)

For efficiency, heat exchangers are designed to maximize the surface area of the wall between the two fluids, while minimizing resistance to fluid flow through the exchanger. The exchanger's performance can also be affected by the addition of fins or corrugations in one or both directions, which increase surface area and may channel fluid flow or induce turbulence.

The driving temperature across the heat transfer surface varies with position, but an appropriate mean temperature can be defined. In most simple systems this is the "log mean temperature difference" (LMTD). Sometimes direct knowledge of the LMTD is not available and the NTU method is used.

Types

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Double pipe heat exchangers are the simplest exchangers used in industries. On one hand, these heat exchangers are cheap for both design and maintenance, making them a good choice for small industries. On the other hand, their low efficiency coupled with the high space occupied in large scales, has led modern industries to use more efficient heat exchangers like shell and tube or plate. However, since double pipe heat exchangers are simple, they are used to teach heat exchanger design basics to students as the fundamental rules for all heat exchangers are the same.

1. Double-pipe heat exchanger

When one fluid flows through the smaller pipe, the other flows through the annular gap between the two pipes. These flows may be parallel or counter-flows in a double pipe heat exchanger.

(a) Parallel flow, where both hot and cold liquids enter the heat exchanger from the same side, flow in the same direction and exit at the same end. This configuration is preferable when the two fluids are intended to reach exactly the same temperature, as it reduces thermal stress and produces a more uniform rate of heat transfer.

(b) Counter-flow, where hot and cold fluids enter opposite sides of the heat exchanger, flow in opposite directions, and exit at opposite ends. This configuration is preferable when the objective is to maximize heat transfer between the fluids, as it creates a larger temperature differential when used under otherwise similar conditions.[*citation needed*]

The figure above illustrates the parallel and counter-flow flow directions of the fluid exchanger.

2. Shell-and-tube heat exchanger

In a shell-and-tube heat exchanger, two fluids at different temperatures flow through the heat exchanger. One of the fluids flows through the tube side and the other fluid flows outside the tubes, but inside the shell (shell side).

Baffles are used to support the tubes, direct the fluid flow to the tubes in an approximately natural manner, and maximize the turbulence of the shell fluid. There are many various kinds of baffles, and the choice of baffle form, spacing, and geometry depends on the allowable flow rate of the drop in shell-side force, the need for tube support, and the flow-induced vibrations. There are several variations of shell-and-tube exchangers available; the differences lie in the arrangement of flow configurations and details of construction.

In application to cool air with shell-and-tube technology (such as intercooler / charge air cooler for combustion engines), fins can be added on the tubes to increase heat transfer area on air side and create a tubes & fins configuration.

3. Plate Heat Exchanger

A plate heat exchanger contains an amount of thin shaped heat transfer plates bundled together. The gasket arrangement of each pair of plates provides two separate channel system. Each pair of plates form a channel where the fluid can flow through. The pairs are attached by welding and bolting methods. The following shows the components in the heat exchanger.

In single channels the configuration of the gaskets enables flow through. Thus, this allows the main and secondary media in counter-current flow. A gasket plate heat exchanger has a heat region from corrugated plates. The gasket function as seal between plates and they are located between frame and pressure plates. Fluid flows in a counter current direction throughout the heat exchanger. An efficient thermal performance is produced. Plates are produced in different depths, sizes and corrugated shapes. There are different types of plates available including plate and frame, plate and shell and spiral plate heat exchangers. The distribution area guarantees the flow of fluid to the whole heat transfer surface. This helps to prevent stagnant area that can cause accumulation of unwanted material on solid surfaces. High flow turbulence between plates results in a greater transfer of heat and a decrease in pressure.

4. Condensers and Boilers Heat exchangers using a two-phase heat transfer system are condensers, boilers and evaporators. Condensers are instruments that take and cool hot

gas or vapor to the point of condensation and transform the gas into a liquid form. The point at which liquid transforms to gas is called vaporization and vice versa is called condensation. Surface condenser is the most common type of condenser where it includes a water supply device. Figure 5 below displays a two-pass surface condenser.

The pressure of steam at the turbine outlet is low where the steam density is very low where the flow rate is very high. To prevent a decrease in pressure in the movement of steam from the turbine to condenser, the condenser unit is placed underneath and connected to the turbine. Inside the tubes the cooling water runs in a parallel way, while steam moves in a vertical downward position from the wide opening at the top and travel through the tube. Furthermore, boilers are categorized as initial application of heat exchangers. The word steam generator was regularly used to describe a boiler unit where a hot liquid stream is the source of heat rather than the combustion products. Depending on the dimensions and configurations the boilers are manufactured. Several boilers are only able to produce hot fluid while on the other hand the others are manufactured for steam production.

Shell and tube

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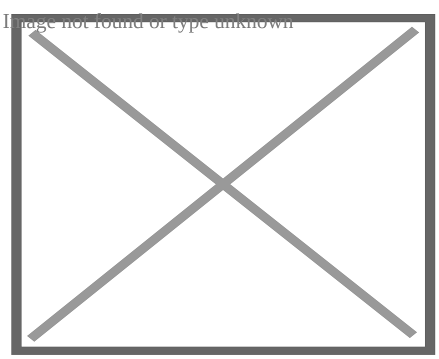
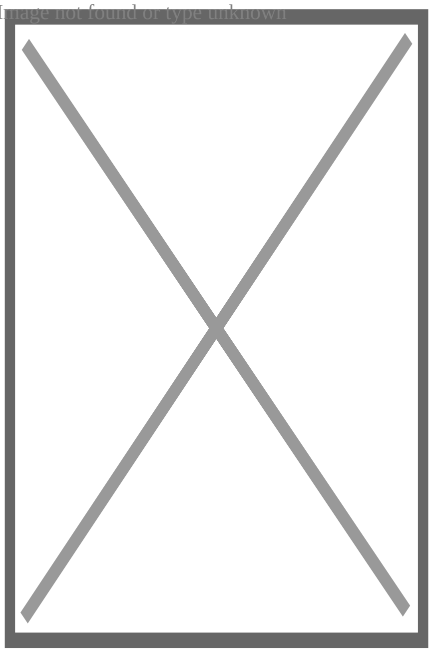
Main article: Shell and tube heat exchanger



A shell and tube heat exchanger



Shell and tube heat exchanger

Shell and tube heat exchangers consist of a series of tubes which contain fluid that must be either heated or cooled. A second fluid runs over the tubes that are being heated or cooled so that it can either provide the heat or absorb the heat required. A set of tubes is called the tube bundle and can be made up of several types of tubes: plain, longitudinally finned, etc. Shell and tube heat exchangers are typically used for high-pressure applications (with pressures greater than 30 bar and temperatures greater than 260 °C).[4] This is because the shell and tube heat exchangers are robust due to their shape.
Several thermal design features must be considered when designing the tubes in the shell and tube heat exchangers: There can be many variations on the shell and tube design. Typically, the ends of each tube are connected to plenums (sometimes called water boxes) through holes in tubesheets. The tubes may be straight or bent in the shape of a U, called U-tubes.

- Tube diameter: Using a small tube diameter makes the heat exchanger both economical and compact. However, it is more likely for the heat exchanger to foul up faster and the small size makes mechanical cleaning of the fouling difficult. To prevail over the fouling and cleaning problems, larger tube diameters can be used. Thus to determine the tube diameter, the available space, cost and fouling nature of the fluids must be considered.
- Tube thickness: The thickness of the wall of the tubes is usually determined to ensure:
  - There is enough room for corrosion
  - That flow-induced vibration has resistance
  - Axial strength
  - Availability of spare parts

    - Hoop strength (to withstand internal tube pressure)
    - Buckling strength (to withstand overpressure in the shell)
- Tube length: heat exchangers are usually cheaper when they have a smaller shell diameter and a long tube length. Thus, typically there is an aim to make the heat exchanger as long as physically possible whilst not exceeding production capabilities. However, there are many limitations for this, including space available at the installation site and the need to ensure tubes are available in lengths that are twice the required length (so they can be withdrawn and replaced). Also, long, thin tubes are difficult to take out and replace.
- Tube pitch: when designing the tubes, it is practical to ensure that the tube pitch (i.e., the centre-centre distance of adjoining tubes) is not less than 1.25 times the tubes' outside diameter. A larger tube pitch leads to a larger overall shell diameter, which leads to a more expensive heat exchanger.
- Tube corrugation: this type of tubes, mainly used for the inner tubes, increases the turbulence of the fluids and the effect is very important in the heat transfer giving a better performance.
- Tube Layout: refers to how tubes are positioned within the shell. There are four main types of tube layout, which are, triangular (30°), rotated triangular (60°), square (90°) and rotated square (45°). The triangular patterns are employed to give greater heat transfer as they force the fluid to flow in a more turbulent fashion around the piping. Square patterns are employed where high fouling is experienced and cleaning is more regular.
- Baffle Design: baffles are used in shell and tube heat exchangers to direct fluid across the tube bundle. They run perpendicularly to the shell and hold the bundle, preventing the tubes from sagging over a long length. They can also prevent the tubes from vibrating. The most common type of baffle is the segmental baffle. The semicircular segmental baffles are oriented at 180 degrees to the adjacent baffles forcing the fluid to flow upward and downwards between the tube bundle. Baffle spacing is of large thermodynamic concern when designing shell and tube heat exchangers. Baffles must be spaced with consideration for the conversion of pressure drop and heat transfer. For thermo economic optimization it is suggested that the baffles be spaced no closer than 20% of the shell's inner diameter. Having baffles spaced too closely causes a greater pressure drop because of flow redirection. Consequently, having the baffles spaced too far apart means that there may be cooler spots in the corners between baffles. It is also important to ensure the baffles are spaced close enough that the tubes do not sag. The other main type of baffle is the disc and doughnut baffle, which consists of two concentric baffles. An outer, wider baffle looks like a doughnut, whilst the inner baffle is shaped like a disk. This type of baffle forces the fluid to pass around each side of the disk then through the doughnut baffle generating a different type of fluid flow.
- Tubes & fins Design: in application to cool air with shell-and-tube technology (such as intercooler / charge air cooler for combustion engines), the difference in heat transfer between air and cold fluid can be such that there is a need to increase

heat transfer area on air side. For this function fins can be added on the tubes to increase heat transfer area on air side and create a tubes & fins configuration.

Fixed tube liquid-cooled heat exchangers especially suitable for marine and harsh applications can be assembled with brass shells, copper tubes, brass baffles, and forged brass integral end hubs.[*citation needed*] *(See: Copper in heat exchangers).*

Plate

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Main article: Plate heat exchanger

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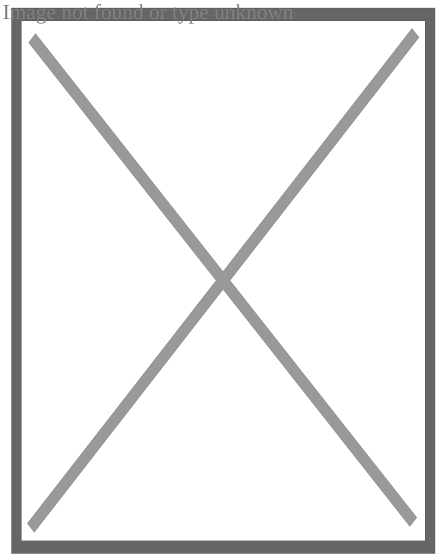

Conceptual diagram of a plate and frame heat exchanger

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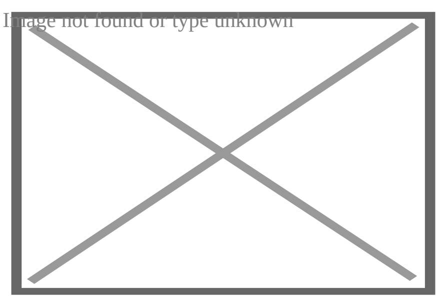
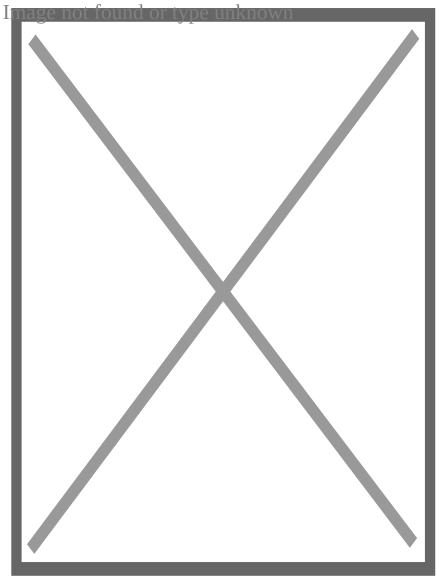


A single plate heat exchanger



An interchangeable plate heat exchanger directly applied to the system of a swimming pool

Another type of heat exchanger is the plate heat exchanger. These exchangers are composed of many thin, slightly separated plates that have very large surface areas and small fluid flow passages for heat transfer. Advances in gasket and brazing technology have made the plate-type heat exchanger increasingly practical. In HVAC applications, large heat exchangers of this type are called *plate-and-frame*; when used in open loops, these heat exchangers are normally of the gasket type to allow periodic disassembly, cleaning, and inspection. There are many types of permanently bonded plate heat exchangers, such as dip-brazed, vacuum-brazed, and welded plate varieties, and they are often specified for closed-loop applications such as refrigeration. Plate heat exchangers also differ in the types of plates that are used, and in the configurations of those plates. Some plates may be stamped with "chevron", dimpled, or other patterns, where others may have machined fins and/or grooves.

When compared to shell and tube exchangers, the stacked-plate arrangement typically has lower volume and cost. Another difference between the two is that plate exchangers typically serve low to medium pressure fluids, compared to medium and high pressures of shell and tube. A third and important difference is that plate exchangers employ more countercurrent flow rather than cross current flow, which allows lower approach temperature differences, high temperature changes, and increased efficiencies.

Plate and shell

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A third type of heat exchanger is a plate and shell heat exchanger, which combines plate heat exchanger with shell and tube heat exchanger technologies. The heart of the heat exchanger contains a fully welded circular plate pack made by pressing and cutting round plates and welding them together. Nozzles carry flow in and out of the platepack (the 'Plate side' flowpath). The fully welded platepack is assembled into an outer shell that creates a second flowpath (the 'Shell side'). Plate and shell technology offers high heat transfer, high pressure, high operating temperature, compact size, low fouling and close approach temperature. In particular, it does completely without gaskets, which provides security against leakage at high pressures and temperatures.

Adiabatic wheel

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A fourth type of heat exchanger uses an intermediate fluid or solid store to hold heat, which is then moved to the other side of the heat exchanger to be released. Two examples of this are adiabatic wheels, which consist of a large wheel with fine threads rotating through the hot and cold fluids, and fluid heat exchangers.

Plate fin

[edit]
Main article: Plate fin heat exchanger

This type of heat exchanger uses "sandwiched" passages containing fins to increase the effectiveness of the unit. The designs include crossflow and counterflow coupled with various fin configurations such as straight fins, offset fins and wavy fins.

Plate and fin heat exchangers are usually made of aluminum alloys, which provide high heat transfer efficiency. The material enables the system to operate at a lower temperature difference and reduce the weight of the equipment. Plate and fin heat exchangers are mostly used for low temperature services such as natural gas, helium and oxygen liquefaction plants, air separation plants and transport industries such as motor and aircraft engines.

Advantages of plate and fin heat exchangers:

- High heat transfer efficiency especially in gas treatment
- Larger heat transfer area
- Approximately 5 times lighter in weight than that of shell and tube heat exchanger. [*citation*
- Able to withstand high pressure

Disadvantages of plate and fin heat exchangers:

- Might cause clogging as the pathways are very narrow
- Difficult to clean the pathways

- Aluminium alloys are susceptible to Mercury Liquid Embrittlement Failure

Finned tube

[edit]

The usage of fins in a tube-based heat exchanger is common when one of the working fluids is a low-pressure gas, and is typical for heat exchangers that operate using ambient air, such as automotive radiators and HVAC air condensers. Fins dramatically increase the surface area with which heat can be exchanged, which improves the efficiency of conducting heat to a fluid with very low thermal conductivity, such as air. The fins are typically made from aluminium or copper since they must conduct heat from the tube along the length of the fins, which are usually very thin.

The main construction types of finned tube exchangers are:

- A stack of evenly-spaced metal plates act as the fins and the tubes are pressed through pre-cut holes in the fins, good thermal contact usually being achieved by deformation of the fins around the tube. This is typical construction for HVAC air coils and large refrigeration condensers.
- Fins are spiral-wound onto individual tubes as a continuous strip, the tubes can then be assembled in banks, bent in a serpentine pattern, or wound into large spirals.
- Zig-zag metal strips are sandwiched between flat rectangular tubes, often being soldered or brazed together for good thermal and mechanical strength. This is common in low-pressure heat exchangers such as water-cooling radiators. Regular flat tubes will expand and deform if exposed to high pressures but flat microchannel tubes allow this construction to be used for high pressures.[5]

Stacked-fin or spiral-wound construction can be used for the tubes inside shell-and-tube heat exchangers when high efficiency thermal transfer to a gas is required.

In electronics cooling, heat sinks, particularly those using heat pipes, can have a stacked-fin construction.

Pillow plate

[edit]

A pillow plate heat exchanger is commonly used in the dairy industry for cooling milk in large direct-expansion stainless steel bulk tanks. Nearly the entire surface area of a tank can be integrated with this heat exchanger, without gaps that would occur between pipes welded to the exterior of the tank. Pillow plates can also be constructed as flat plates that are stacked inside a tank. The relatively flat surface of the plates allows easy cleaning, especially in sterile applications.

The pillow plate can be constructed using either a thin sheet of metal welded to the thicker surface of a tank or vessel, or two thin sheets welded together. The surface of the plate is welded with a regular pattern of dots or a serpentine pattern of weld lines. After welding the enclosed space is pressurised with sufficient force to cause the thin metal to bulge out around the welds, providing a space for heat exchanger liquids to flow, and creating a characteristic appearance of a swelled pillow formed out of metal.

Waste heat recovery units

[edit]

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A waste heat recovery unit (WHRU) is a heat exchanger that recovers heat from a hot gas stream while transferring it to a working medium, typically water or oils. The hot gas stream can be the exhaust gas from a gas turbine or a diesel engine or a waste gas from industry or refinery.

Large systems with high volume and temperature gas streams, typical in industry, can benefit from steam Rankine cycle (SRC) in a waste heat recovery unit, but these cycles are too expensive for small systems. The recovery of heat from low temperature systems requires different working fluids than steam.

An organic Rankine cycle (ORC) waste heat recovery unit can be more efficient at low temperature range using refrigerants that boil at lower temperatures than water. Typical organic refrigerants are ammonia, pentafluoropropane (R-245fa and R-245ca), and toluene.

The refrigerant is boiled by the heat source in the evaporator to produce super-heated vapor. This fluid is expanded in the turbine to convert thermal energy to kinetic energy, that is converted to electricity in the electrical generator. This energy transfer process decreases the temperature of the refrigerant that, in turn, condenses. The cycle is closed and completed using a pump to send the fluid back to the evaporator.

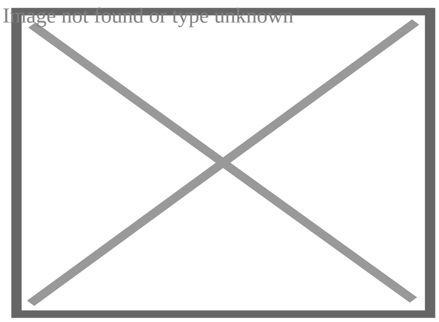
Dynamic scraped surface

[edit]

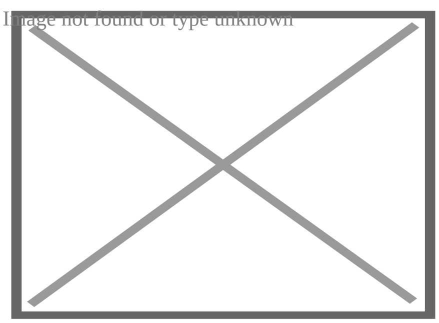
Another type of heat exchanger is called "(dynamic) scraped surface heat exchanger". This is mainly used for heating or cooling with high-viscosity products, crystallization processes, evaporation and high-fouling applications. Long running times are achieved due to the continuous scraping of the surface, thus avoiding fouling and achieving a sustainable heat transfer rate during the process.

Phase-change

[edit]



Typical kettle reboiler used for industrial distillation towers



Typical water-cooled surface condenser

In addition to heating up or cooling down fluids in just a single phase, heat exchangers can be used either to heat a liquid to evaporate (or boil) it or used as condensers to cool a vapor and condense it to a liquid. In chemical plants and refineries, reboilers used to heat incoming feed for distillation towers are often heat exchangers.[6][7]

Distillation set-ups typically use condensers to condense distillate vapors back into liquid.

Power plants that use steam-driven turbines commonly use heat exchangers to boil water into steam. Heat exchangers or similar units for producing steam from water are often called boilers or steam generators.

In the nuclear power plants called pressurized water reactors, special large heat exchangers pass heat from the primary (reactor plant) system to the secondary (steam plant) system, producing steam from water in the process. These are called steam generators. All fossil-fueled and nuclear power plants using steam-driven turbines have surface condensers to convert the exhaust steam from the turbines into condensate (water) for re-use.[8][9]

To conserve energy and cooling capacity in chemical and other plants, regenerative heat exchangers can transfer heat from a stream that must be cooled to another stream that must be heated, such as distillate cooling and reboiler feed pre-heating.

This term can also refer to heat exchangers that contain a material within their structure that has a change of phase. This is usually a solid to liquid phase due to the small volume difference between these states. This change of phase effectively acts as a buffer because it occurs at a constant temperature but still allows for the heat exchanger to accept additional heat. One example where this has been investigated is for use in high power aircraft electronics.

Heat exchangers functioning in multiphase flow regimes may be subject to the Ledinegg instability.

Direct contact

[edit]

Direct contact heat exchangers involve heat transfer between hot and cold streams of two phases in the absence of a separating wall.[10] Thus such heat exchangers can be classified as:

- Gas – liquid
- Immiscible liquid – liquid
- Solid-liquid or solid – gas

Most direct contact heat exchangers fall under the Gas – Liquid category, where heat is transferred between a gas and liquid in the form of drops, films or sprays.[4]

Such types of heat exchangers are used predominantly in air conditioning, humidification, industrial hot water heating, water cooling and condensing plants.[11]

Phases[12]	Continuous phase	Driving force	Change of phase	Examples
Gas – Liquid	Gas	Gravity	No	Spray columns, packed columns
			Yes	Cooling towers, falling droplet evaporators
		Forced	No	Spray coolers/quenchers
		Liquid flow	Yes	Spray condensers/evaporation, jet condensers

Liquid	Gravity	No	Bubble columns, perforated tray columns
		Yes	Bubble column condensers
	Forced	No	Gas spargers
	Gas flow	Yes	Direct contact evaporators, submerged combustion

Microchannel

[edit]

Microchannel heat exchangers are multi-pass parallel flow heat exchangers consisting of three main elements: manifolds (inlet and outlet), multi-port tubes with the hydraulic diameters smaller than 1mm, and fins. All the elements usually brazed together using controllable atmosphere brazing process. Microchannel heat exchangers are characterized by high heat transfer ratio, low refrigerant charges, compact size, and lower airside pressure drops compared to finned tube heat exchangers.[*citation needed*] Microchannel heat exchangers are widely used in automotive industry as the car radiators, and as condenser, evaporator, and cooling/heating coils in HVAC industry.

Main article: Micro heat exchanger

Micro heat exchangers, **Micro-scale heat exchangers**, or **microstructured heat exchangers** are heat exchangers in which (at least one) fluid flows in lateral confinements with typical dimensions below 1 mm. The most typical such confinement are microchannels, which are channels with a hydraulic diameter below 1 mm. Microchannel heat exchangers can be made from metal or ceramics.[13] Microchannel heat exchangers can be used for many applications including:

- high-performance aircraft gas turbine engines[14]
- heat pumps[15]
- Microprocessor and microchip cooling[16]
- air conditioning[17]

HVAC and refrigeration air coils

[edit]

One of the widest uses of heat exchangers is for refrigeration and air conditioning. This class of heat exchangers is commonly called *air coils*, or just *coils* due to their often-serpentine internal tubing, or condensers in the case of refrigeration, and are typically of the finned tube type. Liquid-to-air, or air-to-liquid HVAC coils are typically of modified crossflow arrangement. In vehicles, heat coils are often called heater cores.

On the liquid side of these heat exchangers, the common fluids are water, a water-glycol solution, steam, or a refrigerant. For *heating coils*, hot water and steam are the most common, and this heated fluid is supplied by boilers, for example. For *cooling coils*, chilled water and refrigerant are most common. Chilled water is supplied from a chiller that is potentially located very far away, but refrigerant must come from a nearby condensing unit. When a refrigerant is used, the cooling coil is the evaporator, and the heating coil is the condenser in the vapor-compression refrigeration cycle. HVAC coils that use this direct-expansion of refrigerants are commonly called *DX coils*. Some *DX coils* are "microchannel" type.[5]

On the air side of HVAC coils a significant difference exists between those used for heating, and those for cooling. Due to psychrometrics, air that is cooled often has moisture condensing out of it, except with extremely dry air flows. Heating some air increases that airflow's capacity to hold water. So heating coils need not consider moisture condensation on their air-side, but cooling coils *must* be adequately designed and selected to handle their particular *latent* (moisture) as well as the *sensible* (cooling) loads. The water that is removed is called *condensate*.

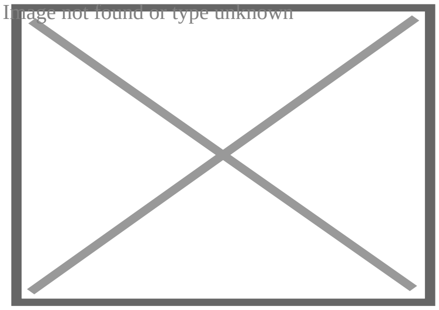
For many climates, water or steam HVAC coils can be exposed to freezing conditions. Because water expands upon freezing, these somewhat expensive and difficult to replace thin-walled heat exchangers can easily be damaged or destroyed by just one freeze. As such, freeze protection of coils is a major concern of HVAC designers, installers, and operators.

The introduction of indentations placed within the heat exchange fins controlled condensation, allowing water molecules to remain in the cooled air.[18]

The heat exchangers in direct-combustion furnaces, typical in many residences, are not 'coils'. They are, instead, gas-to-air heat exchangers that are typically made of stamped steel sheet metal. The combustion products pass on one side of these heat exchangers, and air to heat on the other. A *cracked heat exchanger* is therefore a dangerous situation that requires immediate attention because combustion products may enter living space.

Helical-coil

[edit]



Helical-Coil Heat Exchanger sketch, which consists of a shell, core, and tubes (Scott S. Haraburda design)

Although double-pipe heat exchangers are the simplest to design, the better choice in the following cases would be the helical-coil heat exchanger (HCHE):

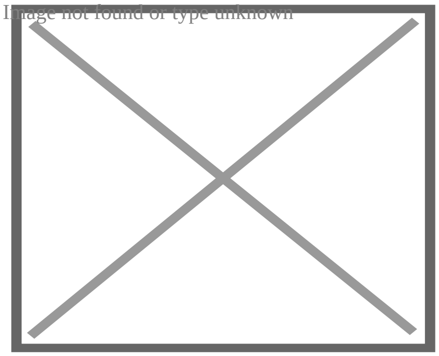
- The main advantage of the HCHE, like that for the Spiral heat exchanger (SHE), is its highly efficient use of space, especially when it's limited and not enough straight pipe can be laid.[19]
- Under conditions of low flowrates (or laminar flow), such that the typical shell-and-tube exchangers have low heat-transfer coefficients and becoming uneconomical.[19]
- When there is low pressure in one of the fluids, usually from accumulated pressure drops in other process equipment.[19]
- When one of the fluids has components in multiple phases (solids, liquids, and gases), which tends to create mechanical problems during operations, such as plugging of small-diameter tubes.[20] Cleaning of helical coils for these multiple-phase fluids can prove to be more difficult than its shell and tube counterpart; however the helical coil unit would require cleaning less often.

These have been used in the nuclear industry as a method for exchanging heat in a sodium system for large liquid metal fast breeder reactors since the early 1970s, using an HCHE device invented by Charles E. Boardman and John H. Germer.[21] There are several simple methods for designing HCHE for all types of manufacturing industries, such as using the Ramachandra K. Patil (et al.) method from India and the Scott S. Haraburda method from the United States.[19][20]

However, these are based upon assumptions of estimating inside heat transfer coefficient, predicting flow around the outside of the coil, and upon constant heat flux.[22]

Spiral

[edit]



Schematic drawing of a spiral heat exchanger

A modification to the perpendicular flow of the typical HCHE involves the replacement of shell with another coiled tube, allowing the two fluids to flow parallel to one another, and which requires the use of different design calculations.[23] These are the Spiral Heat Exchangers (SHE), which may refer to a helical (coiled) tube configuration, more generally, the term refers to a pair of flat surfaces that are coiled to form the two channels in a counter-flow arrangement. Each of the two channels has one long curved path. A pair of fluid ports are connected tangentially to the outer arms of the spiral, and axial ports are common, but optional.[24]

The main advantage of the SHE is its highly efficient use of space. This attribute is often leveraged and partially reallocated to gain other improvements in performance, according to well known tradeoffs in heat exchanger design. (A notable tradeoff is capital cost vs operating cost.) A compact SHE may be used to have a smaller footprint and thus lower all-around capital costs, or an oversized SHE may be used to have less pressure drop, less pumping energy, higher thermal efficiency, and lower energy costs.

Construction

[edit]

The distance between the sheets in the spiral channels is maintained by using spacer studs that were welded prior to rolling. Once the main spiral pack has been rolled, alternate top and bottom edges are welded and each end closed by a gasketed flat or conical cover bolted to the body. This ensures no mixing of the two fluids occurs. Any leakage is from the periphery cover to the atmosphere, or to a passage that contains the same fluid.[25]

Self cleaning

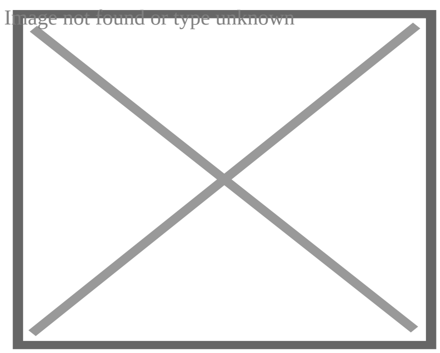
[edit]

Spiral heat exchangers are often used in the heating of fluids that contain solids and thus tend to foul the inside of the heat exchanger. The low pressure drop lets the SHE handle fouling more easily. The SHE uses a “self cleaning” mechanism, whereby fouled surfaces cause a localized increase in fluid velocity, thus increasing the drag (or fluid friction) on the fouled surface, thus helping to dislodge the blockage and keep the heat exchanger clean. "The internal walls that make up the heat transfer surface are often rather thick, which makes the SHE very robust, and able to last a long time in demanding environments."[*citation needed*] They are also easily cleaned, opening out like an oven where any buildup of foulant can be removed by pressure washing.

Self-cleaning water filters are used to keep the system clean and running without the need to shut down or replace cartridges and bags.

Flow arrangements

[edit]



A comparison between the operations and effects of a **cocurrent and a countercurrent flow exchange system** is depicted by the upper and lower diagrams respectively. In both it is assumed (and indicated) that red has a higher value (e.g. of temperature) than blue and that the property being transported in the channels therefore flows from red to blue. Channels are contiguous if effective exchange is to occur (i.e. there can be no gap between the channels).

There are three main types of flows in a spiral heat exchanger:

- **Counter-current Flow**: Fluids flow in opposite directions. These are used for liquid-liquid, condensing and gas cooling applications. Units are usually mounted vertically when condensing vapour and mounted horizontally when handling high concentrations of solids.
- **Spiral Flow/Cross Flow:** One fluid is in spiral flow and the other in a cross flow. Spiral flow passages are welded at each side for this type of spiral heat exchanger. This type of flow is suitable for handling low density gas, which passes through the cross flow, avoiding pressure loss. It can be used for liquid-liquid applications if one liquid has a considerably greater flow rate than the other.

- **Distributed Vapour/Spiral flow:** This design is that of a condenser, and is usually mounted vertically. It is designed to cater for the sub-cooling of both condensate and non-condensables. The coolant moves in a spiral and leaves via the top. Hot gases that enter leave as condensate via the bottom outlet.

Applications

[edit]

The Spiral heat exchanger is good for applications such as pasteurization, digester heating, heat recovery, pre-heating (see: recuperator), and effluent cooling. For sludge treatment, SHEs are generally smaller than other types of heat exchangers.[*citation needed*] These are used to transfer the heat.

Selection

[edit]

Due to the many variables involved, selecting optimal heat exchangers is challenging. Hand calculations are possible, but many iterations are typically needed. As such, heat exchangers are most often selected via computer programs, either by system designers, who are typically engineers, or by equipment vendors.

To select an appropriate heat exchanger, the system designers (or equipment vendors) would firstly consider the design limitations for each heat exchanger type. Though cost is often the primary criterion, several other selection criteria are important:

- High/low pressure limits
- Thermal performance
- Temperature ranges
- Product mix (liquid/liquid, particulates or high-solids liquid)
- Pressure drops across the exchanger
- Fluid flow capacity
- Cleanability, maintenance and repair
- Materials required for construction
- Ability and ease of future expansion
- Material selection, such as copper, aluminium, carbon steel, stainless steel, nickel alloys, ceramic, polymer, and titanium.[26][27]

Small-diameter coil technologies are becoming more popular in modern air conditioning and refrigeration systems because they have better rates of heat transfer than conventional sized condenser and evaporator coils with round copper tubes and aluminum or copper fin that have been the standard in the HVAC industry. Small diameter coils can withstand the higher pressures required by the new generation of environmentally friendlier refrigerants. Two small diameter coil technologies are currently available for air conditioning and refrigeration products: copper microgroove[28] and brazed aluminum microchannel.[*citation needed*]

Choosing the right heat exchanger (HX) requires some knowledge of the different heat exchanger types, as well as the environment where the unit must operate. Typically in the manufacturing industry, several differing types of heat exchangers are used for just one process or system to derive the final product. For example, a kettle HX for pre-heating, a double pipe HX for the 'carrier' fluid and a plate and frame HX for final cooling. With sufficient knowledge of heat exchanger types and operating requirements, an appropriate selection can be made to optimise the process.[29]

Monitoring and maintenance

[edit]

Online monitoring of commercial heat exchangers is done by tracking the overall heat transfer coefficient. The overall heat transfer coefficient tends to decline over time due to fouling.

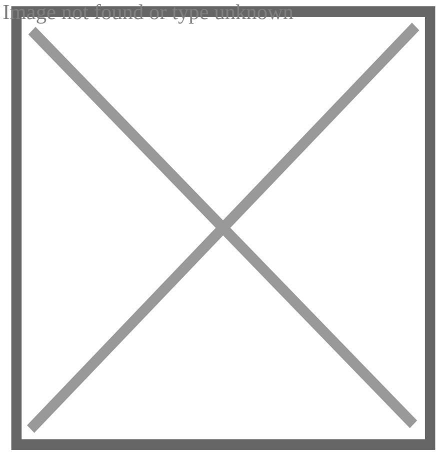
By periodically calculating the overall heat transfer coefficient from exchanger flow rates and temperatures, the owner of the heat exchanger can estimate when cleaning the heat exchanger is economically attractive.

Integrity inspection of plate and tubular heat exchanger can be tested in situ by the conductivity or helium gas methods. These methods confirm the integrity of the plates or tubes to prevent any cross contamination and the condition of the gaskets.

Mechanical integrity monitoring of heat exchanger tubes may be conducted through Nondestructive methods such as eddy current testing.

Fouling

[edit]
Main article: Fouling



A heat exchanger in a steam power station contaminated with macrofouling

Fouling occurs when impurities deposit on the heat exchange surface. Deposition of these impurities can decrease heat transfer effectiveness significantly over time and are caused by:

- Low wall shear stress
- Low fluid velocities
- High fluid velocities
- Reaction product solid precipitation
- Precipitation of dissolved impurities due to elevated wall temperatures

The rate of heat exchanger fouling is determined by the rate of particle deposition less re-entrainment/suppression. This model was originally proposed in 1959 by Kern and Seaton.

Crude Oil Exchanger Fouling. In commercial crude oil refining, crude oil is heated from 21 °C (70 °F) to 343 °C (649 °F) prior to entering the distillation column. A series of shell and tube heat exchangers typically exchange heat between crude oil and other oil streams to heat the crude to 260 °C (500 °F) prior to heating in a furnace. Fouling occurs on the crude side of these exchangers due to asphaltene insolubility. The nature of asphaltene solubility in crude oil was successfully modeled by Wiehe and Kennedy.[30] The precipitation of insoluble asphaltenes in crude preheat trains has been successfully modeled as a first order reaction by Ebert and Panchal[31] who expanded on the work of Kern and Seaton.

Cooling Water Fouling. Cooling water systems are susceptible to fouling. Cooling water typically has a high total dissolved solids content and suspended colloidal solids. Localized precipitation of dissolved solids occurs at the heat exchange surface due to wall temperatures higher than bulk fluid temperature. Low fluid velocities (less than 3 ft/s) allow suspended solids to settle on the heat exchange surface. Cooling water is typically on the tube side of a shell and tube exchanger because it's easy to clean. To prevent fouling, designers typically ensure that cooling water velocity is greater than 0.9

m/s and bulk fluid temperature is maintained less than 60 °C (140 °F). Other approaches to control fouling control combine the "blind" application of biocides and anti-scale chemicals with periodic lab testing.

Maintenance

[edit]

Plate and frame heat exchangers can be disassembled and cleaned periodically. Tubular heat exchangers can be cleaned by such methods as acid cleaning, sandblasting, high-pressure water jet, bullet cleaning, or drill rods.

In large-scale cooling water systems for heat exchangers, water treatment such as purification, addition of chemicals, and testing, is used to minimize fouling of the heat exchange equipment. Other water treatment is also used in steam systems for power plants, etc. to minimize fouling and corrosion of the heat exchange and other equipment.

A variety of companies have started using water borne oscillations technology to prevent biofouling. Without the use of chemicals, this type of technology has helped in providing a low-pressure drop in heat exchangers.

Design and manufacturing regulations

[edit]

The design and manufacturing of heat exchangers has numerous regulations, which vary according to the region in which they will be used.

Design and manufacturing codes include: ASME Boiler and Pressure Vessel Code (US); PD 5500 (UK); BS 1566 (UK);[32] EN 13445 (EU); CODAP (French); Pressure Equipment Safety Regulations 2016 (PER) (UK); Pressure Equipment Directive (EU); NORSOK (Norwegian); TEMA;[33] API 12; and API 560.[*citation needed*]

In nature

[edit]

Humans

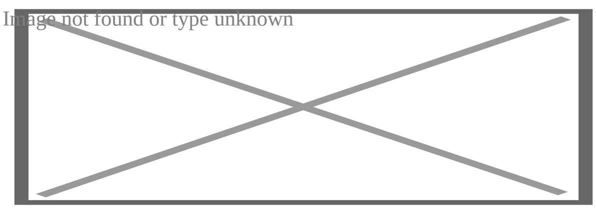
[edit]

The human nasal passages serve as a heat exchanger, with cool air being inhaled and warm air being exhaled. Its effectiveness can be demonstrated by putting the hand in front of the face and exhaling, first through the nose and then through the mouth. Air exhaled through the nose is substantially cooler.[34][35] This effect can be enhanced with clothing, by, for example, wearing a scarf over the face while breathing in cold weather.

In species that have external testes (such as human), the artery to the testis is surrounded by a mesh of veins called the pampiniform plexus. This cools the blood heading to the testes, while reheating the returning blood.

Birds, fish, marine mammals

[edit]



Counter-current exchange conservation circuit

Further information: Counter-current exchange in biological systems

"Countercurrent" heat exchangers occur naturally in the circulatory systems of fish, whales and other marine mammals. Arteries to the skin carrying warm blood are intertwined with veins from the skin carrying cold blood, causing the warm arterial blood to exchange heat with the cold venous blood. This reduces the overall heat loss in cold water. Heat exchangers are also present in the tongues of baleen whales as large volumes of water flow through their mouths.[36][37] Wading birds use a similar system to limit heat losses from their body through their legs into the water.

Carotid rete

[edit]

Carotid rete is a counter-current heat exchanging organ in some ungulates. The blood ascending the carotid arteries on its way to the brain, flows via a network of vessels where heat is discharged to the veins of cooler blood descending from the nasal passages. The carotid rete allows Thomson's gazelle to maintain its brain almost 3 °C (5.4 °F) cooler than the rest of the body, and therefore aids in tolerating bursts in metabolic heat production such as associated with outrunning cheetahs (during which the body temperature exceeds the maximum temperature at which the brain could function).[38] Humans with other primates lack a carotid rete.[39]

In industry

[edit]

Heat exchangers are widely used in industry both for cooling and heating large scale industrial processes. The type and size of heat exchanger used can be tailored to suit a process depending on the type of fluid, its phase, temperature, density, viscosity, pressures, chemical composition and various other thermodynamic properties.

In many industrial processes there is waste of energy or a heat stream that is being exhausted, heat exchangers can be used to recover this heat and put it to use by heating a different stream in the process. This practice saves a lot of money in industry, as the heat supplied to other streams from the heat exchangers would otherwise come from an external source that is more expensive and more harmful to the environment.

Heat exchangers are used in many industries, including:

- Waste water treatment
- Refrigeration
- Wine and beer making
- Petroleum refining
- Nuclear power

In waste water treatment, heat exchangers play a vital role in maintaining optimal temperatures within anaerobic digesters to promote the growth of microbes that remove pollutants. Common types of heat exchangers used in this application are the double pipe heat exchanger as well as the plate and frame heat exchanger.

In aircraft

[edit]

In commercial aircraft heat exchangers are used to take heat from the engine's oil system to heat cold fuel.[40] This improves fuel efficiency, as well as reduces the possibility of water entrapped in the fuel freezing in components.[41]

Current market and forecast

[edit]

Estimated at US$17.5 billion in 2021, the global demand of heat exchangers is expected to experience robust growth of about 5% annually over the next years. The market value is expected to reach US$27 billion by 2030. With an expanding desire for environmentally friendly options and increased development of offices, retail sectors, and public buildings, market expansion is due to grow.[42]

A model of a simple heat exchanger

[edit]

A simple heat exchange [43][44] might be thought of as two straight pipes with fluid flow, which are thermally connected. Let the pipes be of equal length *L*, carrying fluids with heat capacity C_i Image not found or type unknown (energy per unit mass per unit change in temperature) and let the mass flow rate of the fluids through the pipes, both in the same direction, be j_i Image not found or type unknown (mass per unit time), where the subscript *i* applies to pipe 1 or pipe 2.

Temperature profiles for the pipes are $T_1(x)$ Image not found or type unknown and $T_2(x)$ Image not found or type unknown where x is the distance along the pipe. Assume a steady state, so that the temperature profiles are not functions of time. Assume also that the only transfer of heat from a small volume of fluid in one pipe is to the fluid element in the other pipe at the same position, i.e., there is no transfer of heat along a pipe due to temperature differences in that pipe. By Newton's law of cooling the rate of change in energy of a small volume of fluid is proportional to the difference in temperatures between it and the corresponding element in the other pipe:

$$\displaystyle \frac{du_1}{dt}=\gamma (T_2-T_1)$$

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$$\displaystyle \frac{du_2}{dt}=\gamma (T_1-T_2)$$

Image not found or type unknown

(this is for parallel flow in the same direction and opposite temperature gradients, but for counter-flow heat exchange countercurrent exchange the sign is opposite in the second equation in front of $\displaystyle \gamma (T_1-T_2)$ Image not found or type unknown), where $u_i(x)$ Image not found or type unknown is the thermal energy per unit length and ? is the thermal connection constant per unit length between the two pipes. This change in internal energy results in a change in the temperature of the fluid element. The time rate of change for the fluid element being carried along by the flow is:

$$\displaystyle \frac{du_1}{dt}=J_1\frac{dT_1}{dx}$$

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$$\displaystyle \frac{du_2}{dt}=J_2\frac{dT_2}{dx}$$

Image not found or type unknown

where $J_i=C_ij_i$ Image not found or type unknown is the "thermal mass flow rate". The differential equations governing the heat exchanger may now be written as:

$$\displaystyle J_1\frac{\partial T_1}{\partial x}=\gamma (T_2-T_1)$$

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$$J_2\frac{\partial T_2}{\partial x}=\gamma (T_1-T_2).$$

Since the system is in a steady state, there are no partial derivatives of temperature with respect to time, and since there is no heat transfer along the pipe, there are no second derivatives in *x* as is found in the heat equation. These two coupled first-order differential equations may be solved to yield:

$$T_1=A-\frac{Bk_1}{k}\,e^{-kx}$$

$$T_2=A+\frac{Bk_2}{k}\,e^{-kx}$$

where $k_1=\gamma /J_1$, $k_2=\gamma /J_2$,

$$k=k_1+k_2$$

(this is for parallel-flow, but for counter-flow the sign in front of k_2 is negative, so that if $k_2=k_1$, for the same "thermal mass flow rate" in both opposite directions, the gradient of temperature is constant and the temperatures linear in position *x* with a constant difference (T_2-T_1) along the exchanger, explaining why the counter current design countercurrent exchange is the most efficient)

and *A* and *B* are two as yet undetermined constants of integration. Let T_{10} and T_{20} be the temperatures at x=0 and let T_{1L} and T_{2L} be the temperatures at the end of the pipe at x=L. Define the average temperatures in each pipe as:

$$\overline{T}_1=\frac{1}{L}\int_0^L T_1(x)dx$$

$$\overline{T}_2=\frac{1}{L}\int_0^L T_2(x)dx.$$

Using the solutions above, these temperatures are:

$$T_{10}=A-\frac{Bk_1}{k}$$

$$T_{20}=A+\frac{Bk_2}{k}$$

$$T_{1L}=A-\frac{Bk_1}{k}e^{-kL}$$

$$T_{2L}=A+\frac{Bk_2}{k}e^{-kL}$$

$$\overline{T}_1=A-\frac{Bk_1}{k^2L}(1-e^{-kL})$$

$$\overline{T}_2=A+\frac{Bk_2}{k^2L}(1-e^{-kL})$$

Choosing any two of the temperatures above eliminates the constants of integration, letting us find the other four temperatures. We find the total energy transferred by integrating the expressions for the time rate of change of internal energy per unit length:

$$\displaystyle \frac dU_1dt=\int _0^L\frac du_1dt\,dx=J_1(T_1L-T_10)=\gamma L(\overline T$$

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$$\displaystyle \frac dU_2dt=\int _0^L\frac du_2dt\,dx=J_2(T_2L-T_20)=\gamma L(\overline T$$

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By the conservation of energy, the sum of the two energies is zero. The quantity $\displaystyle \overline T_2-\overline T_1$ Image not found or type unknown is known as the *Log mean temperature difference*, and is a measure of the effectiveness of the heat exchanger in transferring heat energy.

See also

[edit]

- Architectural engineering
- Chemical engineering
- Cooling tower
- Copper in heat exchangers
- Heat pipe
- Heat pump
- Heat recovery ventilation
- Jacketed vessel
- Log mean temperature difference (LMTD)
- Marine heat exchangers
- Mechanical engineering
- Micro heat exchanger
- Moving bed heat exchanger
- Packed bed and in particular Packed columns
- Pumpable ice technology
- Reboiler
- Recuperator, or cross plate heat exchanger
- Regenerator
- Run around coil
- Steam generator (nuclear power)
- Surface condenser
- Toroidal expansion joint
- Thermosiphon
- Thermal wheel, or rotary heat exchanger (including enthalpy wheel and desiccant wheel)
- Tube tool
- Waste heat

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Heating, ventilation, and air conditioning

Fundamental concepts	○ Air changes per hour ○ Bake-out ○ Building envelope ○ Convection ○ Dilution ○ Domestic energy consumption ○ Enthalpy ○ Fluid dynamics ○ Gas compressor ○ Heat pump and refrigeration cycle ○ Heat transfer ○ Humidity ○ Infiltration ○ Latent heat ○ Noise control ○ Outgassing ○ Particulates ○ Psychrometrics ○ Sensible heat ○ Stack effect ○ Thermal comfort ○ Thermal destratification ○ Thermal mass ○ Thermodynamics ○ Vapour pressure of water

Technology

- Absorption-compression heat pump
- Absorption refrigerator
- Air barrier
- Air conditioning
- Antifreeze
- Automobile air conditioning
- Autonomous building
- Building insulation materials
- Central heating
- Central solar heating
- Chilled beam
- Chilled water
- Constant air volume (CAV)
- Coolant
- Cross ventilation
- Dedicated outdoor air system (DOAS)
- Deep water source cooling
- Demand controlled ventilation (DCV)
- Displacement ventilation
- District cooling
- District heating
- Electric heating
- Energy recovery ventilation (ERV)
- Firestop
- Forced-air
- Forced-air gas
- Free cooling
- Heat recovery ventilation (HRV)
- Hybrid heat
- Hydronics
- Ice storage air conditioning
- Kitchen ventilation
- Mixed-mode ventilation
- Microgeneration
- Passive cooling
- Passive daytime radiative cooling
- Passive house
- Passive ventilation
- Radiant heating and cooling
- Radiant cooling
- Radiant heating
- Radon mitigation
- Refrigeration
- Renewable heat
- Room air distribution
- Solar air heat
- Solar combisystem
- Solar cooling
- Solar heating

- Air conditioner inverter
- Air door
- Air filter
- Air handler
- Air ionizer
- Air-mixing plenum
- Air purifier
- Air source heat pump
- Attic fan
- Automatic balancing valve
- Back boiler
- Barrier pipe
- Blast damper
- Boiler
- Centrifugal fan
- Ceramic heater
- Chiller
- Condensate pump
- Condenser
- Condensing boiler
- Convection heater
- Compressor
- Cooling tower
- Damper
- Dehumidifier
- Duct
- Economizer
- Electrostatic precipitator
- Evaporative cooler
- Evaporator
- Exhaust hood
- Expansion tank
- Fan
- Fan coil unit
- Fan filter unit
- Fan heater
- Fire damper
- Fireplace
- Fireplace insert
- Freeze stat
- Flue
- Freon
- Fume hood
- Furnace
- Gas compressor
- Gas heater
- Gasoline heater
- Grease duct

Components

- Grille

Measurement and control

- Air flow meter
- Aquastat
- BACnet
- Blower door
- Building automation
- Carbon dioxide sensor
- Clean air delivery rate (CADR)
- Control valve
- Gas detector
- Home energy monitor
- Humidistat
- HVAC control system
- Infrared thermometer
- Intelligent buildings
- LonWorks
- Minimum efficiency reporting value (MERV)
- Normal temperature and pressure (NTP)
- OpenTherm
- Programmable communicating thermostat
- Programmable thermostat
- Psychrometrics
- Room temperature
- Smart thermostat
- Standard temperature and pressure (STP)
- Thermographic camera
- Thermostat
- Thermostatic radiator valve

Professions, trades, and services

- Architectural acoustics
- Architectural engineering
- Architectural technologist
- Building services engineering
- Building information modeling (BIM)
- Deep energy retrofit
- Duct cleaning
- Duct leakage testing
- Environmental engineering
- Hydronic balancing
- Kitchen exhaust cleaning
- Mechanical engineering
- Mechanical, electrical, and plumbing
- Mold growth, assessment, and remediation
- Refrigerant reclamation
- Testing, adjusting, balancing

Industry organizations

- AHRI
- AMCA
- ASHRAE
- ASTM International
- BRE
- BSRIA
- CIBSE
- Institute of Refrigeration
- IIR
- LEED
- SMACNA
- UMC

Health and safety

- Indoor air quality (IAQ)
- Passive smoking
- Sick building syndrome (SBS)
- Volatile organic compound (VOC)

See also

- ASHRAE Handbook
- Building science
- Fireproofing
- Glossary of HVAC terms
- Warm Spaces
- World Refrigeration Day
- Template:Home automation
- Template:Solar energy

About Energy consumption

For electric consumption, see Electric energy consumption.

Energy consumption is the amount of energy used.[1]

Biology

[edit]

In the body, energy consumption is part of energy homeostasis. It derived from food energy. Energy consumption in the body is a product of the basal metabolic rate and the physical activity level. The physical activity level are defined for a non-pregnant, non-lactating adult as that person's total energy expenditure (TEE) in a 24-hour period, divided by his or her basal metabolic rate (BMR):[2]

\displaystyle \textPAL=\frac \textTEE/24h\textBMR

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Demographics

[edit]

Topics related to energy consumption in a demographic sense are:

- World energy supply and consumption
- Domestic energy consumption
- Electric energy consumption

Effects of energy consumption

[edit]

- Environmental impact of the energy industry
    - Climate change
- White's law

Reduction of energy consumption

[edit]

- Energy conservation, the practice of decreasing the quantity of energy used
- Efficient energy use

See also

[edit]

- Energy efficiency
- Energy efficiency in transport
- Electricity generation
- Energy mix
- Energy policy
- Energy transformation

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[edit]

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Energy

- History
- Index
- Outline

Fundamental concepts

- Conservation of energy
- Energetics
- Energy
  - Units
- Energy condition
- Energy level
- Energy system
- Energy transformation
- Energy transition
- Mass
  - Negative mass
  - Mass–energy equivalence
- Power
- Thermodynamics
  - Enthalpy
  - Entropic force
  - Entropy
  - Exergy
  - Free entropy
  - Heat capacity
  - Heat transfer
  - Irreversible process
  - Isolated system
  - Laws of thermodynamics
  - Negentropy
  - Quantum thermodynamics
  - Thermal equilibrium
  - Thermal reservoir
  - Thermodynamic equilibrium
  - Thermodynamic free energy
  - Thermodynamic potential
  - Thermodynamic state
  - Thermodynamic system
  - Thermodynamic temperature
  - Volume (thermodynamics)
  - Work

Types	- Binding
	  - Nuclear
	- Chemical
	- Dark
	- Elastic
	- Electric potential energy
	- Electrical
	- Gravitational
	  - Binding
	- Interatomic potential
	- Internal
	- Ionization
	- Kinetic
	- Magnetic
	- Mechanical
	- Negative
	- Phantom
	- Potential
	- Quantum chromodynamics binding energy
	- Quantum fluctuation
	- Quantum potential
	- Quintessence
	- Radiant
	- Rest
	- Sound
	- Surface
	- Thermal
	- Vacuum
	- Zero-point

Energy carriers	- Battery
	- Capacitor
	- Electricity
	- Enthalpy
	- Fuel
	  - Fossil
	  - Oil
	- Heat
	  - Latent heat
	- Hydrogen
	  - Hydrogen fuel
	- Mechanical wave
	- Radiation
	- Sound wave
	- Work

Primary energy	◦ Bioenergy
	◦ Fossil fuel
	    ◦ Coal
	    ◦ Natural gas
	    ◦ Petroleum
	◦ Geothermal
	◦ Gravitational
	◦ Hydropower
	◦ Marine
	◦ Nuclear fuel
	    ◦ Natural uranium
	◦ Radiant
	◦ Solar
	◦ Wind

Energy system components	◦ Biomass
	◦ Electric power
	◦ Electricity delivery
	◦ Energy engineering
	◦ Fossil fuel power station
	    ◦ Cogeneration
	    ◦ Integrated gasification combined cycle
	◦ Geothermal power
	◦ Hydropower
	    ◦ Hydroelectricity
	    ◦ Tidal power
	    ◦ Wave farm
	◦ Nuclear power
	    ◦ Nuclear power plant
	    ◦ Radioisotope thermoelectric generator
	◦ Oil refinery
	◦ Solar power
	    ◦ Concentrated solar power
	    ◦ Photovoltaic system
	◦ Solar thermal energy
	    ◦ Solar furnace
	    ◦ Solar power tower
	◦ Wind power
	    ◦ Airborne wind energy
	    ◦ Wind farm

Use and supply	- Efficient energy use
	  - Agriculture
	  - Computing
	  - Transport
	- Energy conservation
	- Energy consumption
	- Energy policy
	  - Energy development
	- Energy security
	- Energy storage
	- Renewable energy
	- Sustainable energy
	- World energy supply and consumption
	- Africa
	- Asia
	- Australia
	- Canada
	- Europe
	- Mexico
	- South America
	- United States

Misc.	- Carbon footprint - Energy democracy - Energy recovery - Energy recycling - Jevons paradox - Waste-to-energy - Waste-to-energy plant

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Visit Jefferson County PA

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Driving Directions From Kohl's to Royal Supply Inc

Driving Directions From Happys Appliances & Mattresses Outlet to Royal Supply Inc

Driving Directions From Target to Royal Supply Inc

Driving Directions From AT&T Store to Royal Supply Inc

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https://www.google.com/maps/dir/Visit+Jefferson+County+PA/Royal+Supply+Inc/@41.1
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90.480394!2d38.4956035!3e2

Reviews for Royal Supply Inc

Royal Supply Inc

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Terry Self

(1)

Horrible workmanship, horrible customer service, don't show up when they say they are. Ghosted. Was supposed to come back on Monday, no call no show. Called Tuesday and Wednesday, left messages both days. Nothing. Kinked my line, crooked to the pad and house, didn't put disconnect back on, left the trash.....

Royal Supply Inc

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bill slayton

(1)

Went to get a deadbolt what they had was one I was told I'd have take it apart to lengthen and I said I wasn't buying something new and have to work on it. Thing of it is I didn't know if it was so that it could be lengthened said I didn't wanna buy something new I had to work on just to fit my door. He got all mad and slung the whole box with part across the room. A real business man. I guess the owner approves of his employees doing as such.

Royal Supply Inc

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Ae Webb

(5)

Royal installed a new furnace and air conditioner just before we got our used mobile home. Recently, the furnace stopped lighting. Jared (sp?) made THREE trips to get it back to good. He was so gracious and kind. Fortunately for us it was still under warranty. BTW, those three trips were from Fenton, Missouri to Belleville, Illinois! Thanks again, Jared!

Royal Supply Inc

Image not found or type unknown

Toney Dunaway

(5)

This is another amazing place where we will do much more business. They are not tyrannical about the totally useless face diapers, they have a great selection of stock, they have very knowledgeable staff, very friendly staff. We got the plumbing items we really needed and will be getting more plumbing items. They also have central units, thermostats, caulking, sealants, doors, seems everything you need for a mobile home. We've found a local treasure and will be bringing much more business. Their store is clean and tidy as well!

Royal Supply Inc

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Gidget McCarthy

(5)

Very knowledgeable, friendly, helpful and don't make you feel like you're inconveniencing them. They seem willing to take all the time you need. As if you're the only thing they have to do that day. The store is clean, organized and not cluttered, symmetrical at that. Cuz I'm even and symmetricals biggest fan. It was a pleasure doing business with them and their prices are definitely reasonable. So, I'll be doing business with them in the future no doubt.

Investigating Seasonal Discounts from Service Providers**View GBP**

Royal Supply Inc

Phone : +16362969959

City : Fenton

State : MO

Zip : 63026

Address : Unknown Address

Google Business Profile

Company Website : **https://royal-durhamsupply.com/locations/lenexa-kansas/**