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单机双腔并联压缩式制冷/热泵系统的性能模拟研究 [刊,中]

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摘 要 为提升普通蒸汽压缩式制冷/热泵系统的性能,提出了一种单机双腔并联压缩式系统。通过建立系统循环的理论模型,分析出制冷和制热性能随着从级吸气压力,主、从级容积比的变化规律。结果显示,与普通单级压缩系统相比,双工作腔并联系统的制冷量、制热量分别提高 29.6%和 29.2%;制冷 EER、制热 COP 分别提高 8.0%和 2.8%;排气温度降低 $3\sim4$ °。最佳从、主级容积比的范围为 0.08 \sim 0.12。

关键词 双级压缩;并联;容积比;性能系数;热泵

Simulation Study on Single-Machine Two-chamber in-parallel Compression Refrigeration/Heat Pump System

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Abstract In order to improve the working performance of vapor compression refrigeration/heat pump system, a new system named single machine two-chamber in-parallel compression refrigeration/heat pump system was provided. An analysis model was set according to the theory of thermodynamics. The variation of cooling and heating performance with side-stage suction pressure and the most favorable volume ratio of side-stage to main-stage have been calculated. The results show that, compared with conventional single-stage compression system, cooling and heating capacity can increase 29.6% and 29.2%; cooling EER and heating COP can increase 8.0% and 2.8%; the discharge temperature decrease 3~4°C. The most favorable volume ratio of side-stage to main-stage is 0.08~0.12.

Keywords double-stage compression; parallel; volume ratio; cooling/heating performance;heat pump

多级立式大温差吸收式变温器性能分析[刊,中]

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摘 要 对现有吸收式换热器存在占地面积大、成本高、一次侧热水回水温度高等问题的原因进行了分析,指出问题根源在于吸收机内部存在大量"三角形"传热过程。介绍了全新的多级立式大温差发生-冷凝和蒸发-吸收基本单元,分析了其不仅能消除原吸收式换热器内不匹配的传热现象,而且做到结构紧凑的原理。由以上基本单元构建了新型吸收式换热器,称之为多级立式大温差吸收式变温器。建立了吸收式变温器的模拟分析模型,将其性能与传统单级吸收式换热器进行了比较。结果表明:吸收式变温器可制取的最低一次侧热水回水温度更低,从 26℃降至 20℃以下;总传热面积更小,当一次侧回水温度为 26℃时,吸收式变温器的总 KA(传热系数 K 与传热面积 A 的乘积)比单级吸收式换热器减小 25%~32%,与此同时溶液泵总功率比单级吸收式换热器高出 19%~48%,并没有显著增加。吸收式变温器相对于单级吸收式换热器具有明显性能优势。

关键词 传热面积;大温差;吸收式热泵;换热器

Performance Analysis on the Large Temperature Lift/Drop Multi-stage Vertical Absorption Temperature
Transformer

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Abstract The reasons for the problems of the existing absorption heat exchangers, such as excessively large size, high

manufacture costs, and high return temperature of the primary network hot water, were attributed to the "triangular heat transfer processes" inside the absorption heat pumps. The structures of new Multi-stage Vertical Large

Temperature Lift/Drop Generation-condensation And Evaporation-absorption Elementary Units were introduced, as well as their principles on how to eliminate the "triangular heat transfer processes" with a relatively compact structure. A new type of the absorption heat exchanger, called the Multi-stage Vertical Large Temperature Lift/Drop Absorption Temperature Transformer (ATT), was constituted by such elementary units. Simulation models for the ATT were built to compare its performance to the traditional single-stage absorption heat exchanger. Results showed that the ATT can reduce the minimum return temperature of the primary network hot water, from 26°C to under 20°C. When return temperature of the primary network hot water is 26°C, the ATT can reduce the total KA (heat transfer areas multiplied by heat transfer coefficients) by 25%~32%, while the powers of solution pumps inside the ATT were only increased by 19%~48%, which were not remarkable. The ATT has obvious performance advantages over the traditional single-stage absorption heat exchanger.

Keywords heat transfer areas; large temperature lift/drop;; absorption heat pump; heat exchanger

氯化钙/膨胀硫化石墨复合吸附剂非平衡吸附性能[刊,中]

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摘 要 研究中采用膨胀硫化石墨作为基质,研制了一种新型氯化钙复合吸附剂,研究中测试了氯化钙复合吸附剂的非平衡吸附性能。研究表明: 当冷凝温度由 25℃变化到 35℃,蒸发温度由-10℃变化到 15℃时,密度为400kg/m³、质量分数为 80%的氯化钙复合吸附剂样品的吸附量变化范围是 0.4015kg/kg~0.4585kg/kg,与采用膨胀石墨为基质的复合吸附剂相比,吸附量变化不大。实验中氯化钙/膨胀硫化石墨的吸附/解吸时间约为 3300s,与采用普通膨胀石墨相比,循环时间缩短了 33%。在冷凝温度为 30℃条件下,密度为 400kg/m³、质量分数为 80%氯化钙复合吸附剂最大 SCP(单位质量吸附剂制冷功率)为 65.75 W/kg,与采用普通膨胀石墨相比,SCP 提高了 48%。

关键词 吸附式制冷;复合吸附剂;吸附量;SCP

Non-equilibrium Adsorption Performance of Consolidated Composite CaCl₂/ENG-TSA Adsorbent

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Abstract A new type of consolidated composite adsorbent for CaCl₂ is developed by the matrix of ENG-TSA(Expanded natural graphite treated by the sulphuric acid). Adsorption performance of consolidated composite CaCl₂ was tested, and the results showed that for the sample with the density of 400kg/m³ and salt mass ratio of 80%, adsorption quantity ranges from 0.4015kg/kg to 0.4585kg/kg while the cooling temperature ranges from 25 to 35°C and evaporating temperature ranges from -10 to 15°C, respectively. The cycle adsorption quantity of consolidated CaCl₂ with ENG-TSA as matrix is similar with that of consolidated CaCl₂ with ENG as matrix, whereas the addition of ENG-TSA can greatly reduce cycle time as well as improve the specific cooling performance per kilogram adsorbent(SCP). The cycle time for the composite adsorbent of CaCl₂/ENG-TSA is around 3300 seconds, which is 33% reduced if compared with that for the adsorbent of CaCl₂/ENG. When the condensing temperature is 30°C, the maximum SCP for the adsorbent of CaCl₂/ENG-TSA is 65.75W/kg which is increased by 48% if compared with the adsorbent of CaCl₂/ENG.

Keywords adsorption; consolidated composite adsorbent; adsorption quantity; specific cooling power

R22 在矩形微细管内凝结换热的实验研究 [刊,中]

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摘 要 通过实验研究了 R22 在当量直径为 0.952 mm 水平不锈钢矩形管内的凝结换热过程。实验时的饱和温度为 40~50℃、质量流速为 200~800 kg/(m² • s)、干度为 0~1。研究结果表明: R22 的凝结换热系数随质量流速和干度的增大而增大,在较高干度区增大趋势更加明显,随饱和温度的增大凝结换热系数减小。然后将实验结果与三种已有换热关联式进行了对比,在与 R22 相比时发现,在相同实验工况下 R152a 的凝结换热系数大于 R22 的凝结换热系数。

关键词 凝结换热;微通道;实验研究;换热系数

Experimental Investigation on Heat Transfer of R22 during Condensation in a Rectangular Microchannel

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Abstract The paper reported heat transfer coefficients of R22 during condensation in a horizontal stainless steel rectangular microchannel with the hydraulic diameter of 0.952 mm. Tests were conducted with saturation

temperatures of 40-50°C, mass fluxes of 200-800 kg/m² s and vapor qualities from 0 to 1. The results show that heat transfer coefficients of R22 increase with mass flux and vapor quality especially in high vapor quality regions while decrease with the saturation temperature. The data were compared with three existing heat transfer correlations. Heat transfer coefficients of R152a are larger than the data of R22 when compared with the same experimental conditions.

Keywords condensation heat transfer; microchannel; experimental investigation; heat transfer coefficients

分液隔板结构对分液冷凝系统性能的影响 [刊,中]

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摘 要 分液冷凝器(liquid-vapor separation condenser LSC)是一种带分液隔板的平行流换热器,它可实现在冷凝过程中分段排出冷凝液,提高冷凝区域的制冷剂干度。利用标准焓差实验室,对比研究了采用不同分液隔板结构的分液冷凝器对整个制冷系统性能的影响。在保持室内侧工况不变(干/湿球温度为 26.7℃/19.4℃)条件下,改变室外侧干球温度 29~41℃,分别考察了 3 个具有不同分液隔板结构冷凝器的壁温和压降、系统耗功、制冷量及能效比(EER)的变化规律。实验结果表明,发现具有不同孔径结构分液隔板的冷凝器可以具有不同的热力性能,也可以具有相近的热力性能,设计合理的分液隔板可使冷凝器的冷凝段壁温几乎不变,且端压降最小。其系统的制冷剂流量最大,且制冷量和 EER 最高。由此可见,汽液分离的效果会使冷凝器获得更均匀的流量分配,降低两相流动阻力,提高制冷系统整体性能。

关键词 分液隔板;冷凝器;制冷系统;流量分配;系统性能

The Effect of Liquid-vapor Separation Baffles Structure in Air-conditioning System

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Abstract Liquid-vapor separation condenser (LSC) is a kind of parallel flow heat exchanger with liquid-vapor separation baffles in its headers, which can drain away the condensate in time during condensation process. This paper experimentally studied the performances of three refrigeration systems employing three parallel-flow condensers with different liquid-vapor separation baffles in the standard air enthalpy difference lab. The indoor dry bulb and wet bulb temperature fixed at 26.7°C and 19.4°C, the outdoor dry bulb temperature varied from 29°C to

41°C. The refrigerant tube wall temperatures and pressure drops of the three condensers were investigated, as well as their power consumption, cooling capacity and energy efficiency ratio. The results indicated the performance of the LSC may be the same or not with the different liquid-vapor separations. Once an excellent design for the LSC was done, its wall temperature kept quasi-constant, and pressure drop was also minimum. Further, the system with the LSC can obtain maximum system refrigerant mass flow rate, as well as the maximum cooling capacity and EER.

Keywords liquid-vapor separation baffles; condenser; refrigeration system; flow distribution; system performance

横纹管氨水降膜吸收温度场与浓度场计算与测量[刊,中]

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摘 要 根据降膜吸收传质双膜模型,分析了氨气热量、质量和动量传递过程中相关物理量的变化规律和传递机理。建立了氨气降膜吸收过程能量、质量守恒方程组,使方程组离散化,然后利用 Gauss-Seidel 迭代法求解。得到了光滑管和横纹管降膜吸收氨水溶液氨质量分数沿降膜管高度的变化曲线。并绘出了横纹管降膜吸收过程氨水溶液和冷却水模拟计算温度随降膜管无量纲高度的变化曲线。横纹管相比光滑管在相同工况下有较强的降膜吸收性能,吸收能力在冬夏季节分别提高了 118.5%和 167.7%。实验结果表明,2 号横纹管氨水溶液与冷却水沿降膜管高度的模拟计算温度与测量温度在溶液降膜吸收过程中吻合良好。

关键词氨水;降膜;吸收;温度场;质量分数;横纹管

Calculation and Measurement of Temperature Field and Mass Fraction Field about Aqua Ammonia Falling
Film Absorption based on Transversally Grooved Tube

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Abstract According to double membrane mass transfer model of falling film absorption, change law and transport mechanism were analyzed on related physical quantities during ammonia's heat, mass and momentum transfer process. Energy and mass conservation equations were established for ammonia gas falling film absorption, and equations discretization was made. Subsequently Gauss-Seidel iterative method was used to solve these equations.

Variation curve of aqua ammonia solution mass fraction along falling film tube height was obtained about smooth tube(SMT) and transversally grooved tube(TGT). The temperature of aqua ammonia and cooling water at different dimensionless height was obtained for falling film absorption of transversally grooved tube. TGT has strong falling film absorption performance in the same conditions compared with that of SMT. Absorptive capacity in winter and summer season increased by 118.5% and 167.7% respectively. The experimental results showed that the predicted temperatures of aqua ammonia and cooling water agree well with the measured temperature in the falling film absorption process.

Keywords aqua ammonia; falling film; absorption; temperature field; mass fraction; transversally grooved tube

基于循环水能级的非标工况下水环热泵系统能耗研究[刊,中]

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摘 要 为了研究非标工况下水环热泵系统能耗规律,以循环水作为研究基础,依据建立的循环水能量方程,利用线性传递函数方法建立系统能耗方程。理论结果表明:系统能耗随负荷率变化呈非线性规律且冬季的影响更显著;受负荷率的影响系统能耗随循环水能量变化会出现畸变特征显著影响系统节能性。为了确定畸变工况点出现范围与持续时间,选取天津地区工程进行实验测试,利用循环水能级方法分析系统能耗变换规律。实验结果表明:针对此类建筑,畸变工况点出现在能级 4~5 范围内持续时间不超过系统总运行时间的 10%;辅助热源容量按建筑热负荷 55%选取将更具有合理性。

关键词 水环热泵;非标准工况;循环水能量 ;线性传递函数;系统能耗 ;循环水能级方法

Research for Energy Consumption of Water-loop Heat Pump System Based on Circulating-water Energy Gap under Nonstandard Conditions

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Abstract In order to study the energy consumption law of water-loop heat pump system under nonstandard conditions, the circulating water was selected as the research foundation and on the basis of the circulating water energy equations, the system energy consumption equations were built by using a linear transfer function method. The

theoretical results show that the change law is nonlinear between the system energy consumption and load rate, and it will more remarkable in winter; because the effect of load rate on the energy consumption, with the circulating water energy changing, the change law of system energy consumption will appear a distortion characteristic, which significantly affect system energy saving. In order to determine the range and lasting time of distortion condition point, an engineering was selected in Tianjin as the experiment object, and the test data was analyzed by energy gap method of circulating water. The experimental results show that for this building, the distortion condition point is in the range of 4~5 level, and its lasting time is less 10% of the total run time; the capacity of auxiliary heat source is reasonable with 55% of building heat load.

Keywords water-loop heat pump; nonstandard condition; circulating water energy; linear transfer function; energy consumption; energy gap method of circulating water

分体式空调器使用 R290 作为制冷剂的泄漏研究 [刊,中]

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摘 要 HCFCs 和 HFCs 类制冷剂存在 ODP 和 GWP 值比较高的缺点。R290 具有良好的环保性能,但是其易燃易爆的特点是其使用的最大阻碍。为确定室内机发生泄漏所形成的燃爆范围,开展实体实验,研究了在不同房间面积、不同泄漏位置,不同泄漏速度条件下,R290 泄漏到室内浓度分布情况。结果表明,室内机发生泄漏时,仅在其附近可能形成燃爆区域。燃爆范围仅存在于泄漏过程中,一旦泄漏停止后,燃爆范围会迅速消失。

关键词 制冷剂;泄漏;分体式空调;连接头;蒸发器;R290

Leakage Research of Split-type Air-conditioner using R290 as Refrigerant

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Abstract The ozone depletion potential (ODP) and global warming potential (GWP) of HCFCs and HFCs are higher than hydrocarbons (HCs). R290 is perfect in environmental protection and energy saving performance. In order to determine the combustible region of leaked R290 from indoor unit of air-conditioner, a test room was established in this study. The distribution of R290 concentration was studied after it leaked in the room with different room area, installation height of indoor unit, location of the leakage and different leakage rate. The results showed that combustible region is limited only in the region very close to the indoor unit, and combustible region only exists during the leakage process, which will quickly disappear once the leakage stops.

Keywords refrigerant; leak; split-type air-conditioner; connector; evaporator; R290

毛细管网在闭式冷却塔中的应用分析[刊,中]

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摘 要为解决闭式冷却塔在冬天停机时排水不尽易冻裂和遇腐蚀性工质易损坏的问题,将工程塑料毛细管网技术引入闭式冷却塔。根据理论计算设计了毛细管网闭式冷却塔,并且进行了实物模块的性能试验。研究表明:在单台塔体大小相同的条件下,两台毛细管网闭式冷却塔能够达到一台常规管径紫铜管闭式冷却塔的散热能力,且换热器部分的成本相差无几,由于毛细管网闭式冷却塔具有防腐、抗冻、阻垢、降噪的优势,所以具有良好的技术经济性。

关键词 闭式冷却塔;毛细管网;热性能;实验

Analysis of Capillary-network Applied in the Closed Cooling Tower

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Abstract In order to solve the frost crack problem in winter and the tube corrosion problem of corrosive medium in closed cooling towers, engineering plastic capillary-network technology is introduced to the tower. A capillary-networked closed cooling tower was designed by theoretical calculation and the performance of real model has been tested. Research indicates that the heat-exchange ability of two capillary-networked closed cooling towers is similar to a normal closed cooling tower's with copper-tubes of the same size. The cost of the heat-exchanger for both towers is almost the same. On account of the capillary-networked closed cooling towers can prevent corrosion, frost crack, foreign matters, and reduce noise. The capillary-networked closed cooling towers have better technical and economic performance.

Keywords closed cooling tower; capillary network; thermal properties; test

生命周期内混合动力燃气热泵碳排放研究[刊,中]

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摘 要 采用生命周期评价的方法,针对一种混合动力燃气热泵系统在全生命周期的碳排放进行了评估。基于生命周期 (LCA) 评价理论,确定了系统边界,建立了系统生命周期内碳排放核算模型。得到了系统在生产阶段、运输安装阶段、运行阶段和回收利用阶段的碳排放当量。结果表明:系统在运行使用阶段 CO₂-eq 排放量最大,为 35387.6kg,大约占据了整个生命周期的 84%,主要来源为电力和天然气的使用; 生产安装阶段 CO₂-eq 排放量次之,约为 6187kg,运输安装及废弃阶段碳排放量很小,几乎可以忽略。因此,要降低系统在全生命周期中的温室气体排放量,应重点放在对电力和天然气的合理使用和新能源的开发上。对比分析了其与单独电力驱动热泵在全生命周期内的碳排放量。分析结果表明:在全生命周期内,混合动力燃气热泵与单独电力驱动热泵相比碳减排量约为 20430.9kg。最后,进一步讨论了系统的碳减排方法和减排潜力。

关键词 生命周期;热泵;碳排放;混合动力

Life Cycle Carbon Emissions Research of Hybrid-power Gas Engine Heat Pump

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Abstract Life cycle assessment method was used to evaluate the full life cycle carbon emissions of a kind of hybrid-power gas engine heat pump. With the system boundaries and the accounting mode established based on the life cycle (LCA) assessment, the carbon equivalent emissions in the periods of production, transportation and installation, operation and recycling of the system are figured out respectively. The results show that the system CO₂-eq emissions (35387.6kg) is the highest in running phase, accounting for approximately 84% of the entire life time, and the main source is from the usage of electricity and natural gas; followed by the production phase which are approximately 6178kg; the transportation-installation phase and disposal phase can be neglected because of their low carbon emissions. Therefore, in order to reduce the greenhouse gas emissions of the system in the full life time, more attentions should be paid to the rational use of electricity and natural gas and the development of new energy.

Secondly, its carbon emissions are compared with separate power-driven heat pump, and the analysis results show that hybrid-power gas engine heat pump could reduce 20430.9kg carbon emissions. Finally, carbon emission reduction method and emission reduction potential of the system are further discussed.

Keywords life cycle assessment; heat pump; carbon emissions; hybrid-power

常规空调热泵系统的 R32 替代研究述评 [刊,中]

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摘 要 R32由于具有ODP为零、GWP值小于 R410A等优越的环境性能,逐渐被认识到可以用于替代 R410A。这里对 R410A和 R32的循环性能、润滑油的选用、可燃性、充注量、换热器性能等相关问题进行了综述。大量研究表明,与 R410A系统相比,R32系统的压缩机耗功略高,制冷量较高,同时排气温度也高出很多,具有极大的替代 R410A的潜力。然而,相关研究也指出要使其能够在大范围推广使用,除了要有效解决排气温度过高的问题之外,还需要解决其微可燃性在设计应用中所受到的限制。通过解读国内外法规政策发现,国内外对 R32的充注量限制有放宽的趋势,这对 R32在常规空调热泵系统中替代 R410A和 R22的研究工作将是一个巨大的推动。

关键词 制冷剂替代; 空调; 热泵; R410A; R32

Review of the Application of R32 on Air Conditioners and Heat Pump Systems

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Abstract R32 has a number of advantages compared to R410A, such as zero ODP and less GWP value. It is now regarded as a

possible substitute refrigerant for R410a. This paper presents a comprehensive review of the application of R32 on air conditioners and heat pumps by comparing both operational performances, such as the system efficiency and the requirement of refrigerant charge, between systems using R32 and R410a, and physical characteristics, such as lubrication oil preference and flammability, between both refrigerants. The comparison indicates although systems using R32 have slightly higher energy consumption and discharge temperature of compressor, it has much larger cooling capacity than that using R410a. Hence, R32 is ideal to replace R410A. However, there are still limitations for spreading the application of R32, such as the possible deterioration of system performance caused by a high compressor discharge temperature and the restriction on the refrigerant charge amount due to the A2L level flammability of R32. Nonetheless, domestic and international legislations tend to set less restriction for the application of R32. This tendency will certainly promote researches on using R32 to replace R410A in domestic air conditioner and heat pump systems.

Keywords refrigerant substitution; air conditioner; heat pump; R410A; R32

多联式空调(热泵)机组非稳态制热性能实验方法研究[刊,中]

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摘 要采用季节性能评价指标体系是多联式空调(热泵)机组(以下简称:多联机)性能评价的发展方向。针对在季节性能评价指标体系下多联机制热性能实验中存在的问题,分析现行国内外相关标准对非稳态制热性能实验方法的优缺点,指出欧洲及 ISO 标准规定的非稳态制热性能实验方法更能客观地反映多联机的制热性能,而且可操作性强,可重复性好;同时分析采用欧洲及 ISO 标准规定的非稳态制热性能式验方法对我国多联机性能评价可能带来的影响,进而提出我国多联机非稳态制热性能实验方法的总体框架和尚需解决的问题。

关键词 多联式空调(热泵)机组; 制热;性能实验 ; 非稳态

Research on Unstable Heating Test of Multi-Split Air-condition (Heat Pump) Unit

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Abstract Seasonal performance evaluation index is taken as the direction to evaluate multi-split air-condition (heat pump) units (Hereinafter referred to as: VRF) in the future. The challenge on unstable heating performance test for VRF unit is discussed when seasonal performance evaluation index is used. Advantages and disadvantages of unstable heating performance test methods in relevant standards are analyzed. The conclusion indicates that the unstable heating performance test methods in EN and ISO standards reflect the heating performance of VRF units more objectively, and are with good operability and repeatability. Potential effect of the unstable heating performance test method in EN and ISO standards on the development of VRF in China is investigated. The outline and issues of Chinese unstable heating performance test method for VRF units are suggested.

Keywords multi-split air-condition (heat pump) unit; heating; performance test; unstable

变流量多蒸发器制冷系统仿真通用快速算法研究 [刊,中]

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摘 要 针对目前变流量制冷系统仿真算法设计研究不多以及通用性不足,提出一种物理意义明确且通用的迭代算法(简称为 ALG-I)及其变种算法(简称为 ALG-II)。对迭代变量的选择,迭代判据的确定给出了操作准则和方法。对算法流程的关键步骤进行了详细阐述。ALG-I 与 ALG-II 具有相似特性但需要的仿真时间不同。仿真结果表明,提出的算法能适用于任意数目蒸发器的变流量制冷系统仿真,且仿真时间未随蒸发器个数增大而急剧增加,表明算法具有与蒸发器个数无关的通用特性。从控制分析需要快速响应的要求来看,对于一拖一系统, ALG-II 比 ALG-I 有优势,而对于一拖多系统,ALG-I 则比 ALG-II 有优势。最后,系统对连续变化的控制变量(包括膨胀阀开度及压缩机转速)的合理响应表明提出的算法可以有效地用于 VRF 系统的能耗与控制仿真。

关键词 制冷系统;变制冷剂流量;仿真;通用算法;控制分析

A Generalized Algorithm for the Simulation of Multi-evaporator Variable Refrigerant Flow Systems

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Abstract A generalized algorithm called ALG-I as well as a companion algorithm called ALG-II, for simulation of variable refrigerant flow (VRF) systems were proposed. Firstly, the principles and methods to find the criteria of iterative calculation and choose the variables of iterative calculation were introduced. Then, the standard algorithm was organized by some proper combination between the iterative variables and the iterative criteria, and the critical steps of the algorithm were described in detail. ALG-I and ALG-II have very similar characteristics except time-consuming. Simulation results revealed that the models established are feasible and effective to simulate the VRF systems with different number of evaporators, which indicates the proposed system algorithms are generic and evaporator-number independent. For the VRF system with only one evaporator, the much larger time consuming of the ALG-I weakened the potential for control analysis applications, while for the multi-evaporator VRF system, the ALG-I has advantages over the ALG-II. Finally, tests also showed the proposed algorithms good ability responding to varying control variables including the openness of the throttling valves and speed of the compressor. It is concluded that the system model is feasible to be applied and lays solid foundation for the studies including performance and control analysis of the VRF systems.

Key words refrigeration system; variable refrigerant flow; simulation; generic algorithm; control analysis

汽-气液滴形管与圆管外凝结换热的研究[刊,中]

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摘 要为了研究管型对汽-气凝结换热的影响和强化汽-气凝结换热过程,建立了汽-气在液滴形管与圆管外凝结换热所形成的气液膜的厚度及换热系数沿管壁分布的综合数学模型。通过有限差分的方法,以天然气燃烧产生的烟气为例对两种管型进行了计算比较。在有效换热面积相等的情况下,与圆管相比,液滴形管上半部分管径小,压力梯度大,有利于排液,下半部分表面曲率大,亦有利于排液;液滴形管表面形成的气膜薄,液膜亦薄,珠状凝结区域大,液珠尺寸小,凝结换热系数大;液滴形管对显热传递亦有一定的强化作用。通过实验对计算结果进行了比较验证,结果表明该模型亦适用于椭圆管和其它汽-气混合流体种类。

|关键词 强化换热;凝结换热;有限差分;液滴形管;气液膜厚度

The Research on Vapor-gas Condensation Heat Transfer over a Drop-shaped or Circular Tube

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Abstract In order to study the effects of tube type on vapor-gas condensation heat transfer and strengthen vapor-gas condensation heat transfer, the present paper establishes the integrated model of gas liquid film thickness and heat transfer coefficient along the wall when vapor-gas mixed fluid crosses vertically both circular tube and drop-shaped tube and condensation occurred. Through the finite difference method, the calculation and comparison are carried out with flue gas from natural gas combustion as an example. In the circumstance that the effective heat transfer area is same, compared with circular tube, diameter is smaller on upper half of drop-shaped tube and pressure gradient is greater, which is helpful for drainage; surface curvature is larger on lower half of drop-shaped tube, which is also helpful for drainage. Gas film on surface of drop-shaped tube is thinner, and liquid film is also thinner; drop-wise condensation area is larger and droplet size is smaller, so condensation heat transfer coefficient is greater. Besides, drop-shaped tube also has certain enhancement to sensible heat transfer. The calculation results are compared and verified by experiment, and this model is also suitable for oval tube and other kinds of vapor-gas mixed fluid.

Keywords heat transfer enhancement; Condensation Heat Transfer; finite difference; drop-shaped tube; gas liquid film thickness

采用变频压缩机的风冷冰箱系统性能研究[刊,中]

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摘 要通过实验及模拟手段,对采用变频压缩机的风冷冰箱在压缩机不同转速时的耗电量、功率及开机率进行了研究。同时还研究了压缩机在不同转速条件下,冰箱的冷藏室、冷冻室、果蔬室及制冰室等主要间室内的温度变化情况。实验结果表明: 当压缩机在最优运转速度时,冰箱的各个间室温度变化能控制在良好的范围内,其中冷藏室平均温度为4.1℃,最大温度波动为3.4℃、果蔬室平均温度6.1℃,最大温度波动为1.0℃。在各个测试间室温度满足国家标准要求的条件下,变频压缩机可以使该风冷冰箱的耗电量达到0.908kWh/d左右(不带负载)。另外冰箱系统的软件模拟结果与实验数据相比,当压缩机转速为3000r/min时,最大偏差为16.2%,而在压缩机转速为1900r/min时,模拟和测试结果吻合较好,其偏差降为8.6%。此实验结果验证了模拟软件的可靠性,同时也表明冰箱系统模型仍需进一步优化。

关键词 变频压缩机;风冷冰箱;节能;实验

An Experimental Analysis of a Frost-free Refrigerator using a Variable Capacity Compressor

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Abstract A frost-free refrigerator with a variable capacity compressor(VCC) is studied based on the results from experiments and simulation. Analyses are conducted in terms of the system energy consumption, power and running percentage under several different compressor speeds. Moreover, the temperature variation in fresh food storage, freezer, fruit vegetable and the ice-making

compartments is also discussed under different compressor running speeds respectively. The experimental results show that the temperature variation in all the compartments could be kept in a reasonable scope when the compressor is running at an optimal speed. The average temperature of the fresh food storage compartment is 4.1°C with a maximum deviation of 3.4°C and the average temperature in the fruit vegetable compartment is 6.1°C with a max deviation of 1.0°C. With the help of VCC the energy consumption of this—frost-free refrigerator can reach 0.908kWh/day when the temperatures in all the compartments reach the national standard requirement. What's more, compared to the experimental result the simulated system energy consumption is higher by 16.2% when the compressor runs at 3000r/min, however it drops to 8.6% when the compressor speed is set at 1900r/min. The comparison results prove the reliability of the simulation software and also indicate the importance of further work on system model optimization.

Keywords variable capacity compressor; frost-free refrigerator; energy saving; experimental analysis

降低液体真空冷却过程中失水量的方法研究 [刊,中]

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摘 要 通过实验研究了不同形式的滤网在液体真空冷却过程中降低失水的效果。实验中采用圆柱形容器并控制液面高度为定值,通过改变片状滤网在容器中的位置来研究失水情况;同时研究了能够阻挡容器侧壁气泡的柱状滤网及综合状滤网对失水的影响;为便于有效比较失水量,提出过压度、实际失水率及失水效率等概念。实验结果表明:将片状滤网置于失水终了的液面处,其降低失水的效果最好;柱状及综合状滤网与片状滤网相比,能够进一步降低失水量。

关键词 真空冷却;失水率;过压度;失水效率

The Methods Research of Decreasing Water Loss during Liquid Vacuum Cooling Process

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Abstract The effect of different forms of strainer on reducing water loss during liquid vacuum cooling process was studied. Using cylindrical containers and keeping the liquid height at a fixed value in the experiments, the situation of the water lose was studied by changing the position of the flaky strainer. The influence for water loss of the columnar and comprehensive-shaped strainers which can resist bubbles from the sidewall was also studied. To compare the water loss effectively, the concepts of overpressure degree, actual water lose rate and water lose efficiency were put forward. The experimental results show that when flaky strainer is located at the liquid surface at the end of the losing water process, the effect of decreasing water loss is the best, and the columnar and comprehensive-shaped strainers can further reduce the water loss compared with the flaky strainer.

Keywords	vacuum cooling; water lose rate; overpressure degree; water lose efficiency