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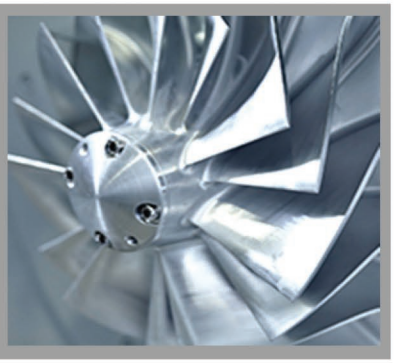


机械蒸汽再压缩技术
MVR TECHNOLOGY

南通三圣石墨设备科技股份有限公司
Nantong Sunshine Graphite Equipment Technology Co,.Ltd.

三圣旗下全资、控股、参股企业:

公司简介

南通三圣石墨(集团)是集环保技术开发、工程设计、石墨设备制造、碳素材料生产于一体的高新技术集团。集团公司已于 2010 年通过证监局备案正式进入上市辅导期。旗下的南通市环境工程设计院有限公司擅长各类工业环保技术的解决方案。主体公司南通三圣石墨设备科技股份有限公司长期从事工业废酸资源回收利用等工程总承包的一体化服务。

南通三圣工业园区图

合作伙伴

德国艾伯纳有限公司是世界著名的热过程技术工程公司与制造企业。其丰富卓越的业务范围包括蒸发、结晶、煅烧、真空冷却、热能回收、真空脱气、真空制造等。在该领域拥有独到的专有技术，技术水平领先于国际，拥有很大的全球市场份额，并在中国化纤行业具有很高的知名度。

瑞士赛普制盐和蒸发装置公司汇集欧洲资深化工专家与业内领导者，致力于一系列完整的工程设计咨询服务，包括基础工程设计、关键设备及工艺装置的交付工程服务。其丰富卓越的专业领域涵盖氯碱行业、冶金行业、水处理行业等。

中德合资艾伯纳三圣（南通）环保有限公司整合和发挥各方优势，采用世界先进的环保科技和科学的管理理念，经营环保、化工及其他工业用环保系统及设备的开发、生产和销售。以具有国际市场竞争力的高品质环保专用产品满足中国和世界对环保产品日益增长的需求。

中德合资艾伯纳三圣（南通）环保有限公司厂区图

机械蒸汽再压缩技术

简称 MVR 技术，通过压缩机对蒸发器产生的二次蒸汽做功，使二次蒸汽的压力和温度升高。升温了的二次蒸汽又对物料加热产生蒸发，从而达到二次蒸汽的汽化潜热循环使用的目的。采用此法的装置系统只在开始阶段需要生蒸汽供给，等到装置正常运行，只消耗压缩机电耗，整个系统不需要生蒸汽补给。MVR 法适用于蒸汽不可用或蒸汽成本高的地区，对任何单效或多效蒸发应用领域具有完全替代性。

机械蒸汽再压缩技术的特点

和多效蒸发装置相比，机械蒸汽再压缩装置具有以下优点：

- 运行成本低/能耗效率高
- 处理产品质量高/蒸汽冷凝液质量高
- 环境友好
- 锅炉房投资成本低/冷却水消耗量低
- 紧凑型厂区布置，建设费用低
- 操作运行容易，开车/停车简单
- 操作弹性大/装置寿命长

机械蒸汽再压缩技术在工业化领域中的应用

- 氯碱行业(盐水浓缩)，
- 制盐行业（卤水提浓）
- 化工行业（溶液浓缩）
- 海水淡化
- 纸张干燥
- 回收特殊金属
- 元明粉生产制备
- 环保技术（废水浓缩）
- 食品和饮料行业（牛奶、乳浆，蔗糖溶液等）
- 石化行业

MVR Introduction

MVR is the short form of mechanical vapor recompression. It increases the temperature and pressure of the vapour by compression the vapour from the evaporator. This vapor evaporates the solution again by heat exchange and achieves circulation and reuses the latent heat of the vapor. The evaporation system by MVR technology utilizes live steam at the beginning, when it enters into normal operation, the entire system only consumes electricity other than any live stream. The MVR system is recommended for applications where the availability of steam is restricted or expensive，which can also replace any one-effect or multi-effect evaporation systems.

Advantages of MVR

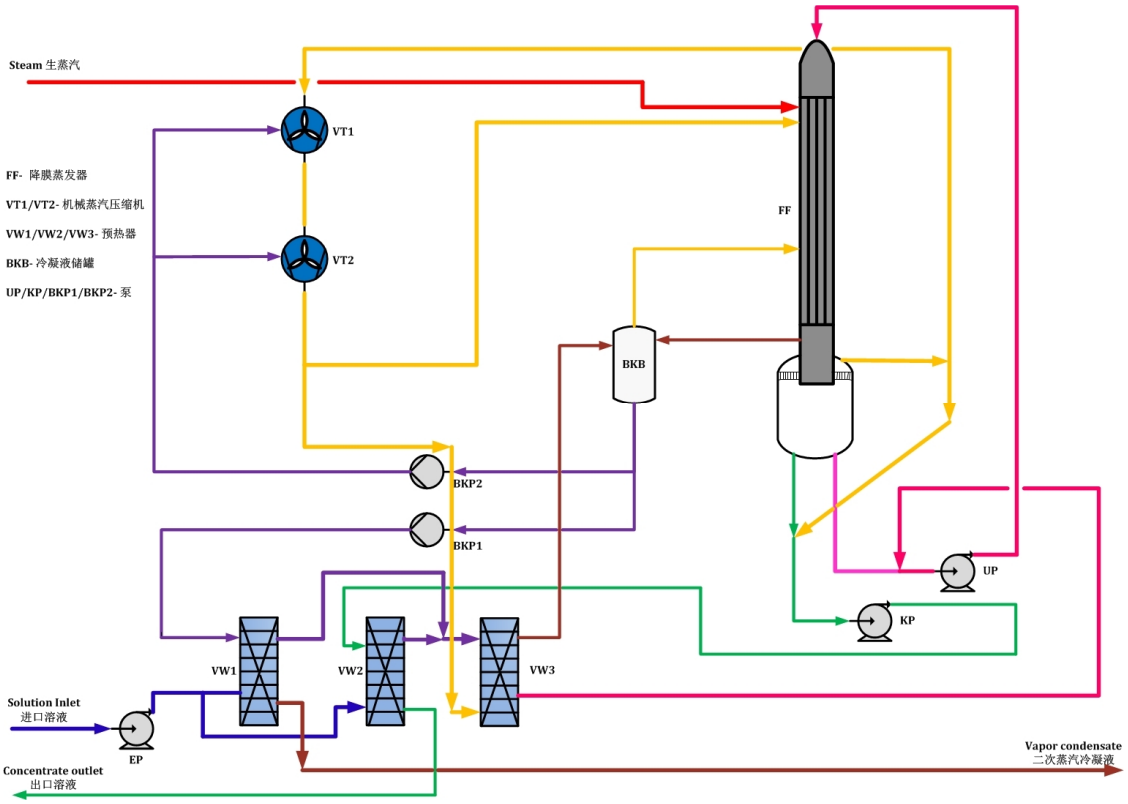
Compared to traditional evaporation methods (multi-effect arrangement, thermal vapour recompression), reasons for using MVR

- Low operating costs/ high energy efficiency
- High product quality/high condensate quality
- High environmental compatibility
- Low investment costs for boiler house/Low cooling water consumption
- Low building costs due to compact design and lay-out of the plant
- Easy operation/start-up/shut-down
- High operational flexibility/ Long lifetime

Applications of MVR in chemical industries

- The chlor-alkaline industry (evaporation of saline solutions)
- The salt works industry (concentration of brine solution)
- The chemical industry (evaporation of aqueous solutions)
- Seawater desalination
- Paper drying
- Recycling of special metals
- Sodium sulphate powder production
- Environmental technology (concentration of waste water)
- Food and beverages industry (evaporation of milk, whey, sugar solutions etc.)
- Petrochemical industry

机械蒸汽再压缩技术工艺流程



Process Flow Diagram of MVR

机械蒸汽再压缩装置流程图

机械蒸汽再压缩技术工艺原理

1. 预热

稀溶液可以用几个换热器加热到特定温度，然后进入蒸发阶段。

2. 机械蒸汽再压缩蒸发

机械蒸汽再压缩蒸发提供一个极其高效的溶液浓缩技术。通常机械蒸汽再压缩装置的成本高于相对应的蒸汽驱动蒸发器。可是，随着机械蒸汽再压缩装置生承载增加，和蒸汽驱动蒸发器的价格差将降低。尽管机械蒸汽再压缩蒸发器很少用在小功率蒸发上，它更适用于中型至大型的蒸发器。

3. 分离

分离器用于分离二次蒸汽中的固体杂质。根据处理溶液的性质，可以使用不同结构的分离器。

4. 真空系统

维持整个系统的真空度，从装置中抽出部分空气，不凝气体以及溶液带入的气体，以达到系统稳定的蒸发状态。

5. 泵

输送待蒸发的溶液以及浓缩后的溶液。根据不同性质的溶液选择不同类型的泵。

6. 压缩系统

专有的压缩机能够压缩二次蒸汽到更高的温度，压强，使之有更大的热焓值。根据需要的流量大小和压缩比例，几个不同种类的压缩机可以被考虑。考虑价格原因，单个离心压缩机和多个高压风扇通常被使用。这些设备提供的流量范围为 3，000 到 500，000m3/hr，提供的压力比率为 1.1 到 2.5，可以增温多达 10 度。另外，几个压缩机串联可以提供更高的增压。

7. 控制系统

机械蒸汽再压缩蒸发控制系统控制中心，通过对马达转速的调节，阀门，流量计，温度，压力的控制，以达到自动蒸发，清洗，停机等操作。自动报警，自动保护系统不受损伤，保持系统动态平衡。

8. 清洗系统

不同的溶液蒸发一段时间后，可能会发生结垢现象，一般说 99%以上的结垢都是可以通过添加化学溶剂除去，一般可以使用 CIP 原位清洗或者拆除清洗。

MVR unit operation

1. **Preheat**

The dilute solution can to be heated to the certain temperature via several heat exchangers before sending to evaporation operation.

2. **MVR Evaporation**

MVR evaporation provides an extremely energy efficient technique for the concentration of solids in water. Usually the capital cost of an MVR system is higher than a comparable steam driven evaporator. However, as the capacity of the system increases the relative cost difference decreases. Although MVR evaporators are seldom chosen for small duties, the concept is often used for medium to large capacity evaporators.

3. **Separation**

The separator is used for separating vapor and liquid from the evaporation column. Based on the properties of the solution, different separators can be chosen, such as centrifugal separator, gravitational separator or the separators with specific structures.

4. **Vacuum system**

This system maintains the vacuum degree of the whole MVR system, some portion of the air, inert gas and solution entraining gas is sucked from the system, thus achieve the systematic stable and evaporative state.

5. **Pump**

Pumps transfer the solution to be evaporated and the concentrated solution. Different pumps should be chosen based on different properties of the solution.

6. **Compression system**

The secondary vapor is compressed by proprietary compressor to a higher temperature and pressure with larger enthalpy. According to required flow rate and compression ratio, several types of compressors can be considered. Single-stage centrifugal compressor and high pressure fans are generally used for cost reasons. These machines are capable of a wide range of flow rates (eg. 3,000 to 500,000 m^3/hr), at pressure ratios of 1.1 to 2.5, and can have a temperature increase of up to 10K. Additionally, several compressors in line can be utilized to provide larger pressure increase.

7. **Control system**

By controlling of the speed of motor and valves, flow meters, temperature and pressure instrumentations, MVR control system can achieve self-evaporation, cleaning and shut down. Automatic alarm protects the system in emergency situation and keeps the system in safe operation.

8. **Cleaning system**

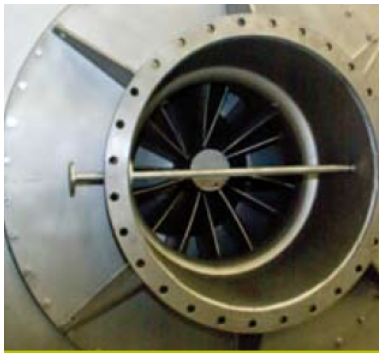
After the solution evaporating some time, the evaporator may have fouling. Normally, above 99% of the fouling can be removed by adding chemical solvent. Thus, CIP in situ cleaning or pull down cleaning can be utilized.

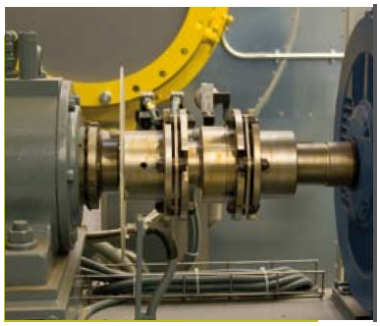
专有压缩机

专有进口机械压缩机是全球同类产品中高质量产品，可以针对蒸发装置调整制造。

1. 产品特性

- 防护外壳气密性设计，高达0.1bar(abs.)
- 高圆周速率的转子用来提高压缩效率
- 水力喷射用作运行期间清洗转子和再次降低温度
- 低磨损曲径密封垫片
- 对于更大的压力升高或更大的体积流量，可以串联或并联压缩机
- 专有压缩石油汽化的滚动轴承和平面摩擦轴承使设计速率远高于临界滚动速率和在速率调整时的低振动运行速率





2. 应用实例

应用邻域：乳制品

- 加热媒介：蒸汽
- 体积流量：53628m^3/s
- 密度：0.1709 kg/m^3
- 压强变化量：64.81 mbar
- 马达动力:560kw
- 叶轮直径：1650mm
- 吸入温度：66.4° C
- 温度升高：4.85° C
- 转速：3000 rpm
- 功率：86%

The proprietary compressor

The proprietary mechanical vapor compressors are of high quality throughout the world, which are also specially adjusted to the needs of evaporation plant.

1. Special characteristics

- Vacuum-proof housing design, up to 0.1bar (abs.)
- Rotors for extremely high circumferential speeds for increasing the efficiencies
- Water jets for cleaning the rotors and for temperature recooling during operation
- Low-wear labyrinth seals
- Optional connections in series or parallel possible for larger pressure differences or volumetric flows
- Patented compression oil vaporization both for rolling bearings as well as for plain friction bearings enable design speeds well above the critical bearing speed and low vibration operation even during speed adjustment

2. Application sample

Application field: dairy

- Medium: steam
- Volume flow: 53628m³/s
- Density： 0.1709 kg/m³
- Differential pressure: 64.81 mbar
- Motor power: 560kw
- Impeller diameter: 1650mm
- Suction temperature: 66.4° C
- Temperature rise: 4.85° C
- Speed: 3000 rpm
- Efficiency: 86%

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