

**AOWID** 奥威制冷



# CO<sub>2</sub>亚临界制冷关键技术和装备

The key technology & equipment  
of CO<sub>2</sub> subcritical refrigeration

## 提要 Abstract

- 一、关于制冷剂 About refrigerant
- 二、CO<sub>2</sub>亚临界制冷循环 CO<sub>2</sub> Subcritical refrigeration cycle
- 三、CO<sub>2</sub>螺杆制冷压缩机 CO<sub>2</sub> Subcritical refrigerant compressor
- 四、半封闭CO<sub>2</sub>亚临界螺杆制冷压缩机  
Semi-hermetic refrigerant subcritical CO<sub>2</sub> compressor
- 五、板壳式换热器 Plate-shell heat exchanger
- 六、不锈钢管/铝片翅片换热器  
Stainless steel tube / aluminum fin heat exchanger
- 七、CO<sub>2</sub>制冷工程的工厂化  
Factory construction of CO<sub>2</sub> refrigeration engineering

## 一、关于制冷剂 About refrigerant

### 制冷剂选择

The selection of refrigerants

- ◆政策法规 Policy & regulation
- ◆可持续性 Sustainability
- ◆安全风险 Safety risk
- ◆投资成本 Invested cost
- ◆运行经济性 Operating economy

## 一、关于制冷剂 About refrigerant

**安全风险 Safety risk**

**食品加工车间 Food process workshop**



2013年，吉林  
2013, Jilin



2013年，上海  
2013. Shanghai



## 一、关于制冷剂 About refrigerant

没有一种制冷剂是绝对安全的！

Non refrigerant is absolutely safe !

给制冷剂以充分的尊重

Deliver full respect to refrigerant

考虑制冷剂本身的特性

Consider characteristics of the refrigerant itself

## 一、关于制冷剂 About refrigerant

### NH<sub>3</sub>

- ◆ 自然工质 Natural refrigerant
- ◆ ODP=0
- ◆ GWP=0

- 不在末端  
**Not in end equipment**
- 小充注量  
**Less filling quantity**

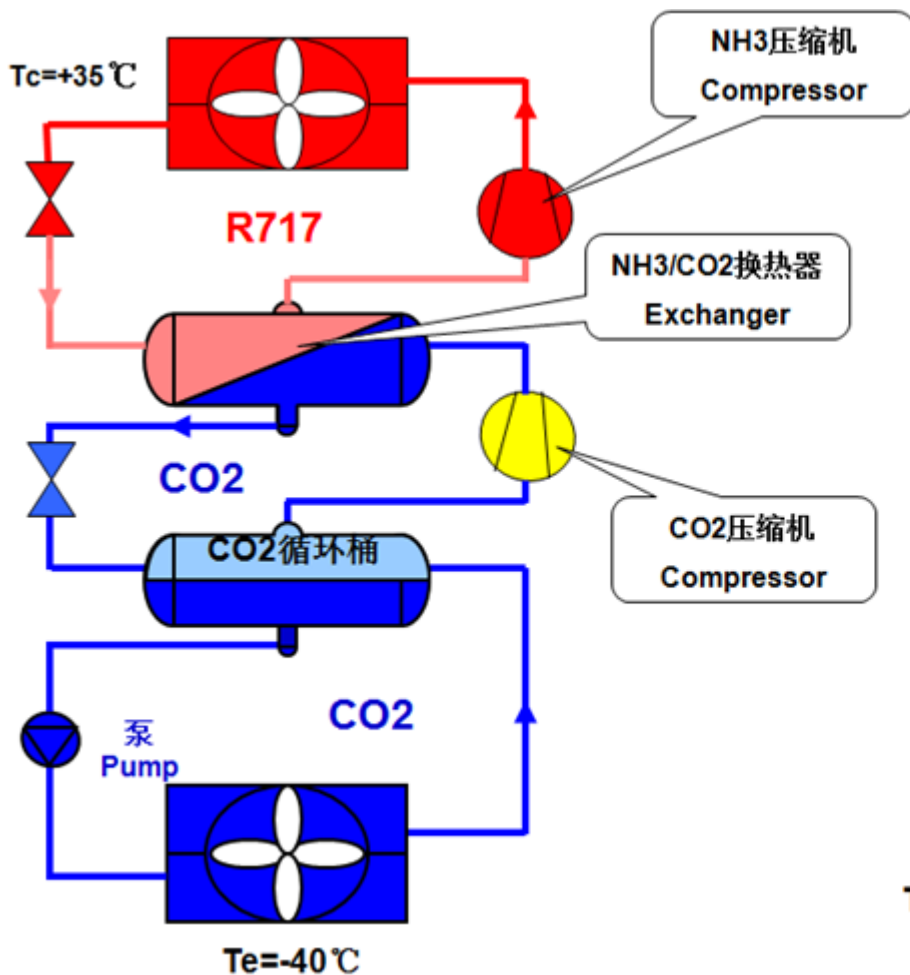
### CO<sub>2</sub>

- ◆ 自然工质 Natural refrigerant
- ◆ ODP=0
- ◆ GWP=1      0?    -1?

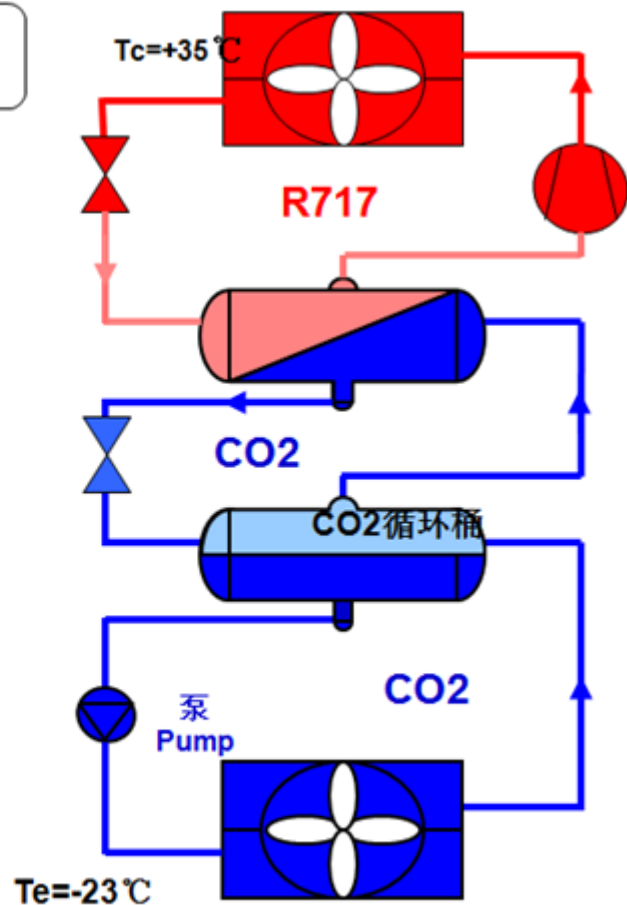
- 更高的压力  
**Higher pressure**
- 洁净度  
**Cleanliness**
- 无毒，但是。。。 **Non-toxic ,but ...**

## 二、CO<sub>2</sub>亚临界制冷循环 Subcritical refrigeration cycle

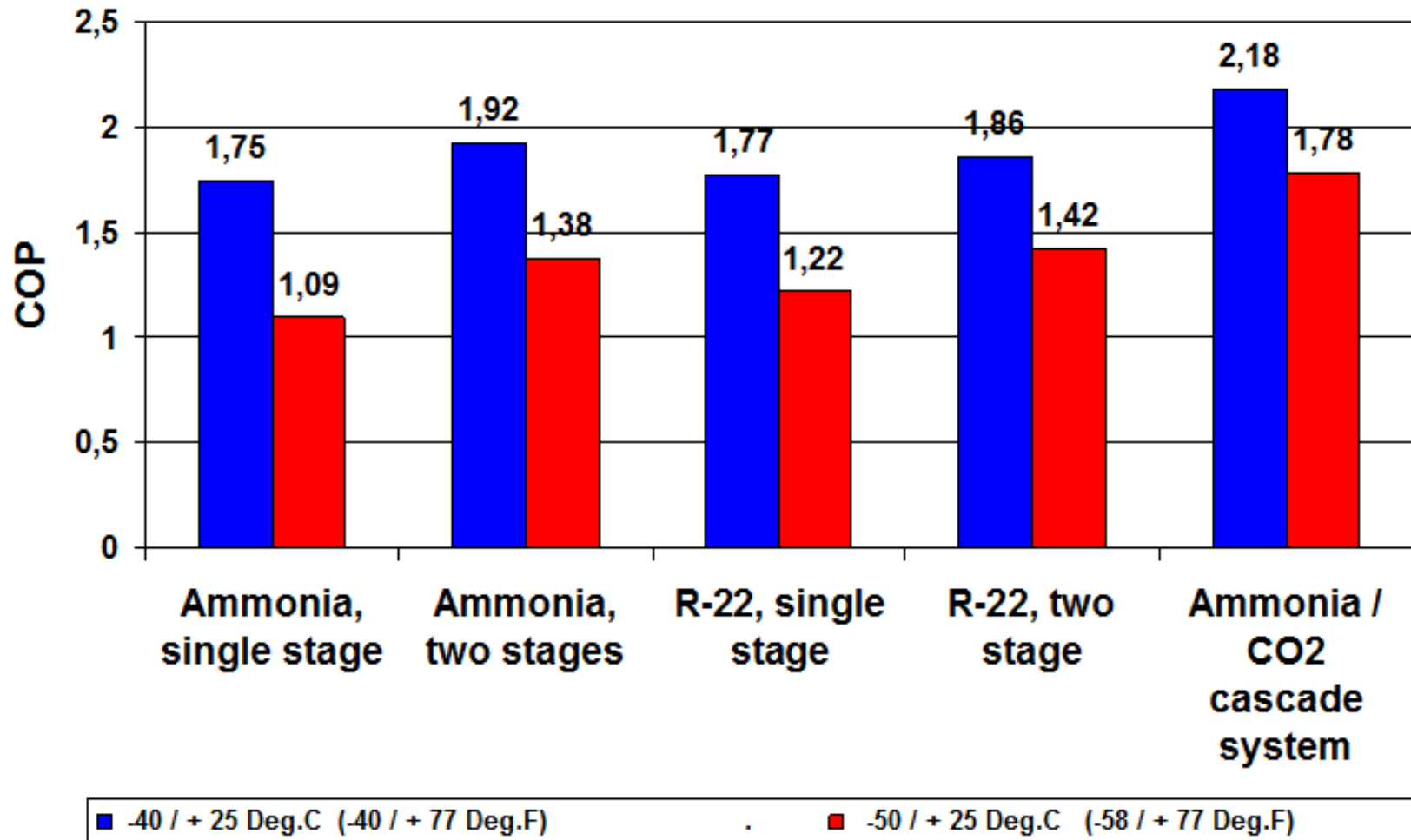
复叠循环 Cascade cycle



载冷剂循环 Secondary cycle



## 二、CO<sub>2</sub>亚临界制冷循环 Subcritical refrigeration cycle





## 二、CO<sub>2</sub>亚临界制冷循环

### Subcritical refrigeration cycle

#### 关键设备

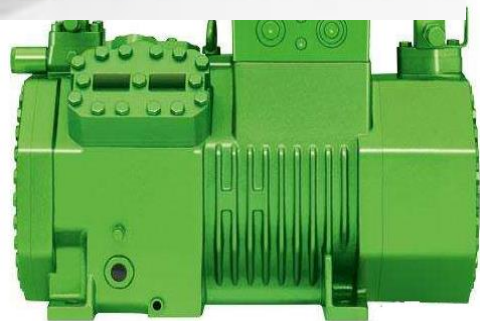
#### Key equipments

- |                                 |   |
|---------------------------------|---|
| ◆制冷压缩机                          | Refrigerant compressor                                |
| ◆复叠换热器<br>(CO <sub>2</sub> 冷凝器) | Cascade heat exchanger<br>(CO <sub>2</sub> Condenser) |
| ◆CO <sub>2</sub> 蒸发器<br>(空气冷却器) | CO <sub>2</sub> Evaporator<br>(Air cooler)            |

### 三、CO<sub>2</sub>亚临界制冷压缩机 CO<sub>2</sub> Subcritical refrigerant compressor



CO<sub>2</sub>半封闭往复式  
制冷压缩机  
Semi-hermetic  
Recip. compressor



CO<sub>2</sub>全封闭涡旋式  
制冷压缩机  
CO<sub>2</sub> Hermetic  
scroll compressor



目前最大的半封闭往复式CO<sub>2</sub>亚临界制冷压缩机

The maximal semi-hermetic co<sub>2</sub> Recip. Compressor  
理论排量Swept volume: 48.82m<sup>3</sup>/h(@50HZ)  
制冷量Capacity: 61kW(@-43/-10°C)

食品加工单冻机 IQF

产量规格Standard: 1000kg/h  
冷量需求Demedanded capacity : ~190kW(Te=-43°C)

### 三、CO<sub>2</sub>亚临界制冷压缩机 CO<sub>2</sub> Subcritical refrigerant compressor



开启螺杆式  
CO<sub>2</sub>制冷压缩机  
CO<sub>2</sub> open-type  
Screw compressor

半封闭螺杆式  
CO<sub>2</sub>制冷压缩机  
Semi-hermetic  
Screw compressor



## 四、半封闭CO2螺杆制冷压缩机

### Semi-hermetic screw CO2 compressor

奥威半封CO2螺杆压缩机使用条件 Working range of AOWID screw CO2 compressor

制冷剂 Refrigerant	R744 (CO <sub>2</sub> )	
最高排气压力//饱和温度 Dis. Max Pressue/Saturated Temp.	Bar(A) / °C	47.3 / +12
最高吸气压力//饱和温度 Suct. Max_Pressue/Saturated Temp	Bar(A) / °C	16.8 / -25
最低吸气压力//饱和温度 Suct. Min-Pressue/Saturated Temp、	Bar(A) / °C	6.3/ -52

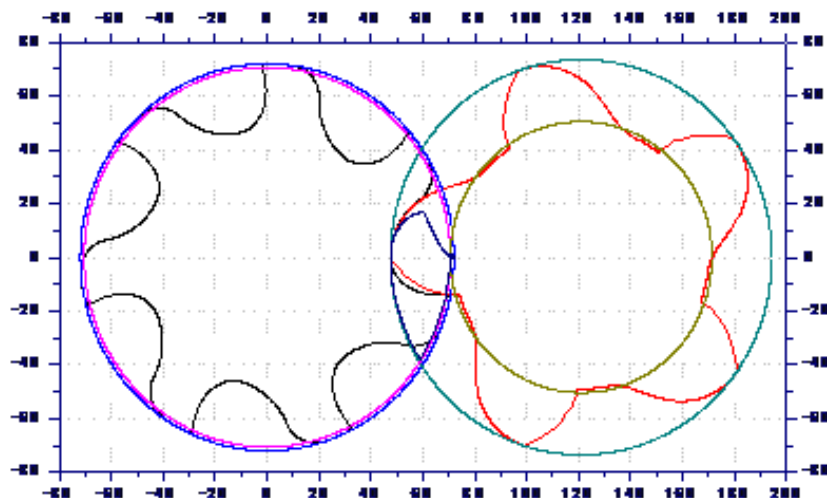
奥威半封闭CO2螺杆制冷压缩机型谱 Type spectrum of AOWID CO2 compressor

规格型号 Model	HSC12		HSC16		HSC20	
电机额定功率kW Nominal Power	70		135		220	
频率 Frequency	50Hz	70Hz	50Hz	70Hz	50Hz	60Hz
理论排量m <sup>3</sup> /h Swept volume	144.5	200	289	400	600	715
制冷量 Capacity kW	200	248	410	510	860	975
	(@-45/-19°C)	(@-45/-11°C)	(@-45/-19°C)	(@-45/-11°C)	(@-45/-19°C)	(@-45/-15°C)

## 四、半封闭CO<sub>2</sub>螺杆制冷压缩机 Semi-hermetic screw CO<sub>2</sub> compressor

螺杆转子型线  
Screw rotor profile

构造  
Structure



## 四、半封闭CO2螺杆制冷压缩机 Semi-hermetic screw CO2 compressor

滑动主轴承  
Main sleeve bearing

平衡活塞  
Balancing piston

内油道  
Interior Oil channel



推力轴承  
Thrust bearing



连接体  
Connector

Thermo-siphon cooling used high-stage refrigerant (such as NH<sub>3</sub>)

## Unitary motor

## ◆ 变频调节 VVVF

## Patent of invention





## 四、半封闭C02螺杆制冷压缩机 Semi-hermetic screw C02 compressor

### 奥威C02制冷压缩机组 Screw compress unit of AOWID



油泵  
Oil pump

油分离器  
Oil separator

电机热虹吸冷却  
Motor thermo-siphon cooling

螺杆压缩机  
Screw compressor



板壳式热虹吸油冷却器  
Thermo-siphon plate-shell oil cooler

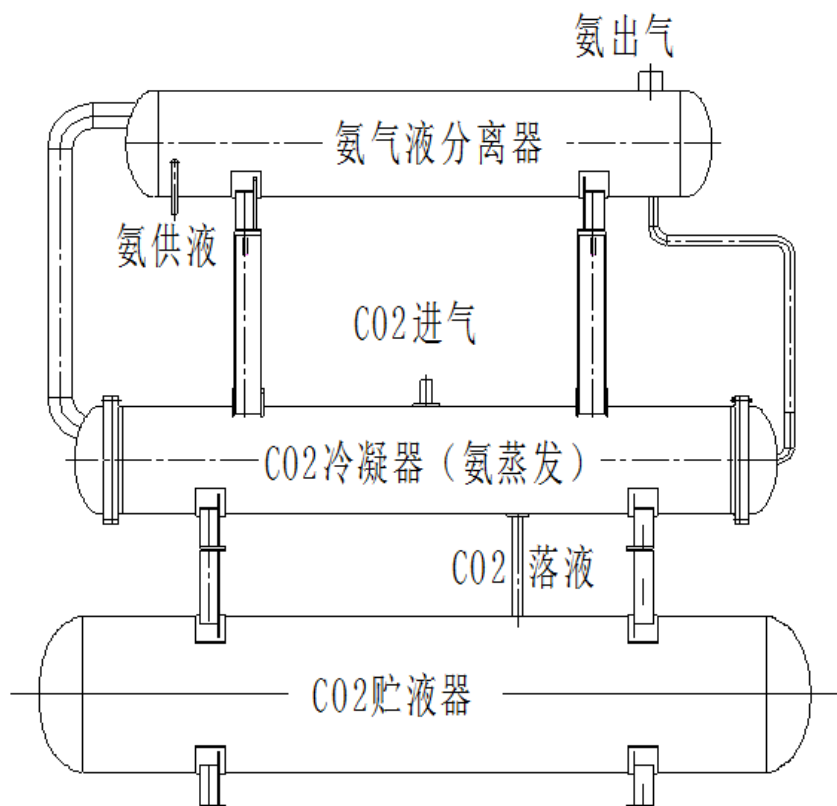
油过滤器  
Oil filter



## 五、板壳式换热器 Plate-shell heat exchanger

### 传统壳管式CO2冷凝器

### Conventional shell-tube CO2 condenser



### 壳管式存在的弊端

The disadvantages of shell-tube

◆ 体积庞大，尤其是高度尺寸

Bulky, especially the height

◆ 氨充注量大带来的风险

The risk of Large amount NH<sub>3</sub>

◆ 轧管和焊接导致的泄漏风险

Leakage risk from Pipe milled & welding

CO<sub>2</sub>泄漏，与氨生成氨基甲酸铵  
 $\text{CO}_2 + \text{NH}_3 \longrightarrow \text{NH}_2\text{CONH}_4$

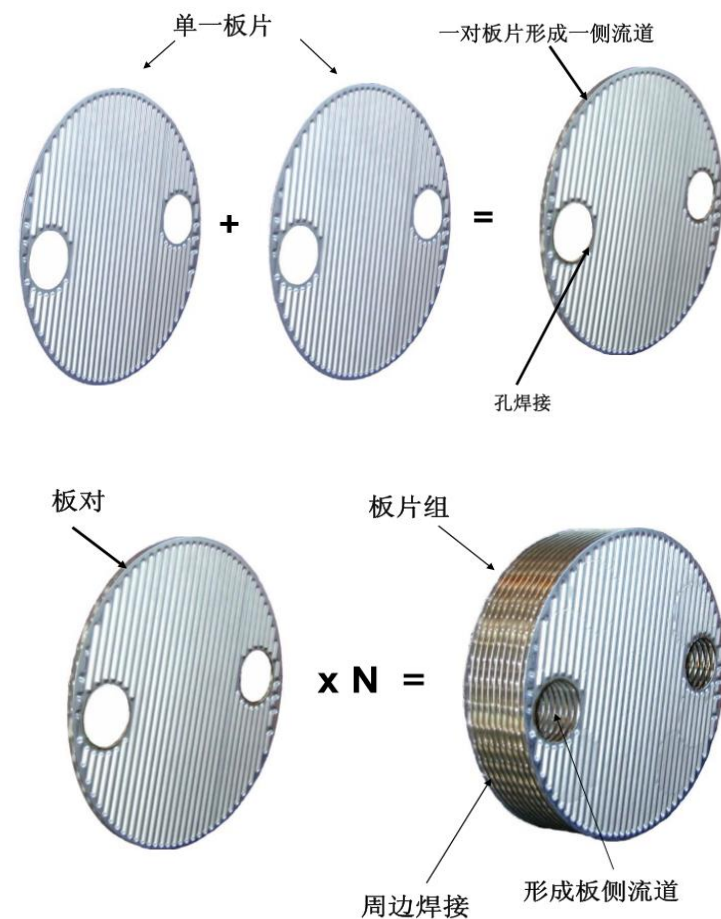
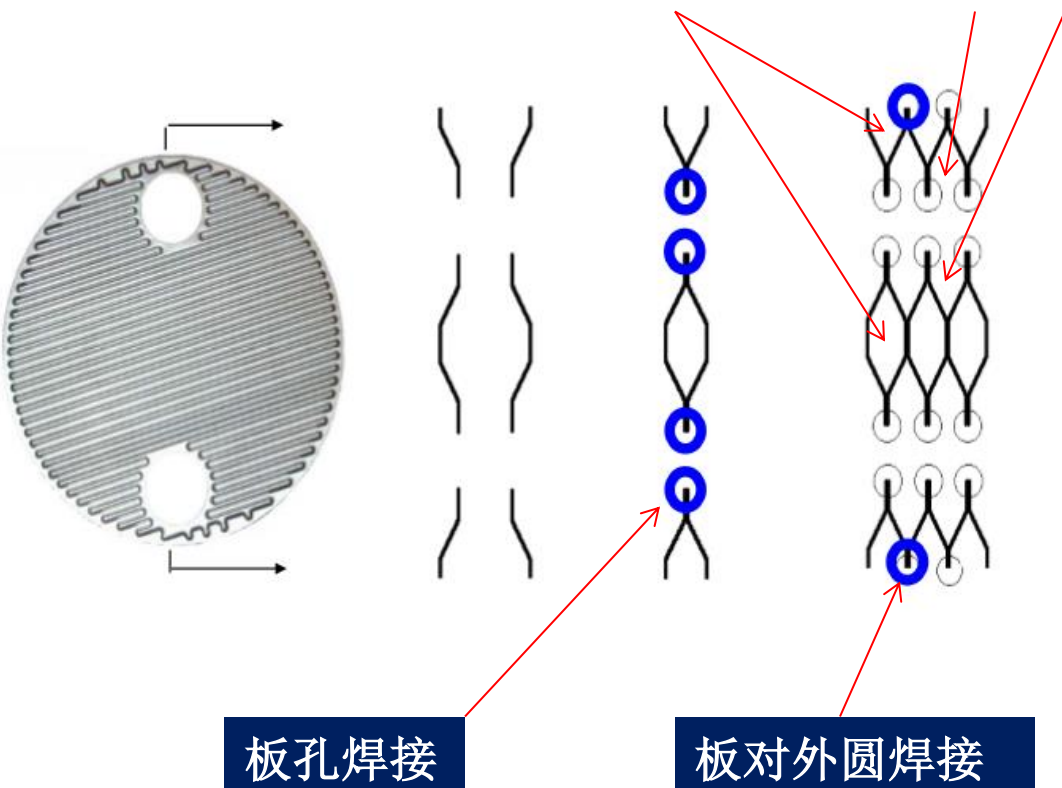


## 五、板壳式换热器 Plate-shell heat exchanger

### 板束结构 Plate beam structure

板组外侧（壳侧）  
Outside of plate

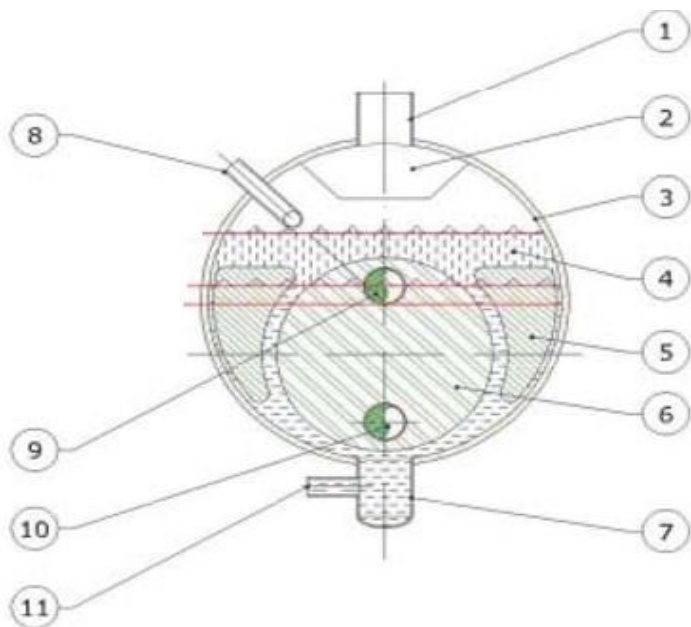
板组内侧（板侧）  
Inside of plate



## 五、板壳式换热器 Plate-shell heat exchanger

CO<sub>2</sub>冷凝器 Condenser

板束 Plate beam



优点 Advantage

- ◆高承压能力  
High withstand pressure
- ◆可靠性提高  
High reliability
- ◆大幅度降低高度尺寸  
Reduced the height
- ◆减小氨充注量  
Reduce ammonia charge

- |   |   |
|---|---|
| 1. 氨出气管 NH <sub>3</sub> Suct. pipe          | 2. 气分装置 Gas separator                         |
| 3. 壳体 Shell                                 | 4. 氨液位 NH <sub>3</sub> liquid level           |
| 5. 填充料 Filling material                     | 6. 板束 Plate beam                              |
| 7. 集油包 Oil gathering                        | 8. 氨液入口 NH <sub>3</sub> inlet                 |
| 9. CO <sub>2</sub> 进气 CO <sub>2</sub> Inlet | 10. CO <sub>2</sub> 出液 CO <sub>2</sub> outlet |
| 11. 放油口 Oil drain                           |   |

## 五、板壳式换热器 Plate-shell heat exchanger

NH<sub>3</sub>冷凝器 Condenser

氨充注量  
更大幅度降低  
**Less NH<sub>3</sub>**





## 六、不锈钢管/铝片翅片换热器 Stainless steel tube / aluminum fin heat exchanger

### C02空气冷却器 Air cooler

设计压力 Design pressure 52 Bar

液压胀管 Hydraulic expanding

氩弧自动焊管 Argon arc welded pipe

高精度翅片冲压  
High precision fin stamping

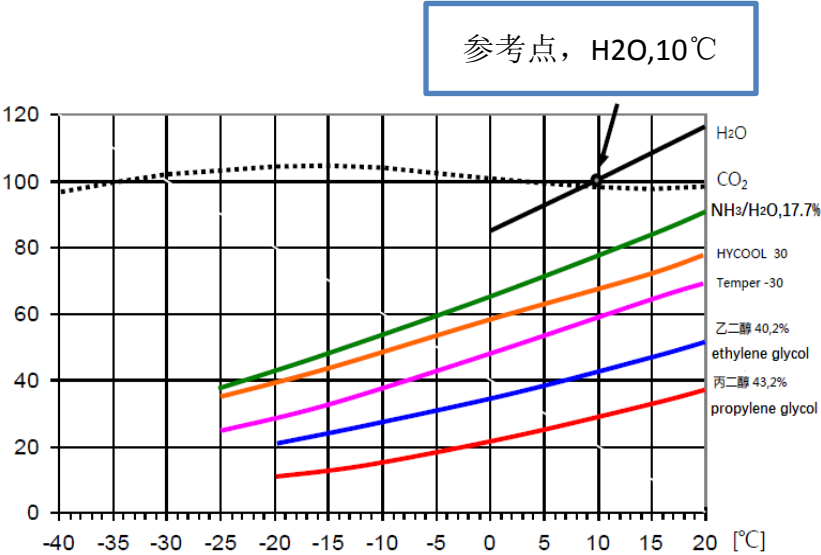


# 六、不锈钢管/铝片翅片换热器 Stainless steel tube / aluminum fin heat exchanger

C02空冷器换热  
Heat transfer condition  
About C02 air cooler

制冷剂侧的温度梯度

相对传热效率 %



制冷剂 Refrigerant	出口状态 Outlet status		蒸发器阻力 Evaporator resistance bar/°C	进口状态 Inlet status	
	温度 E. Temp.	饱和压力 Saturation P.		温度 E. Temp.	饱和压力 Saturation P.
R717 (NH3)	-40°C	0.717 bar	0.10/2.50	-37.50 °C	0.817 bar
R22 (F-22)	-40°C	1.049 bar	0.10/1.97	-38.03 °C	1.149 bar
R744 (CO2)	-40°C	10.067 bar	0.10/0.27	-39.73 °C	10.167 bar

液压胀—贴合性好  
Hydraulic expanding—Fit well  
C02侧温度梯度小  
Small temperature gradient in CO2 side  
C02侧传热性能好  
Heat transfer well in CO2 side

## 七、CO2制冷工程的工厂化

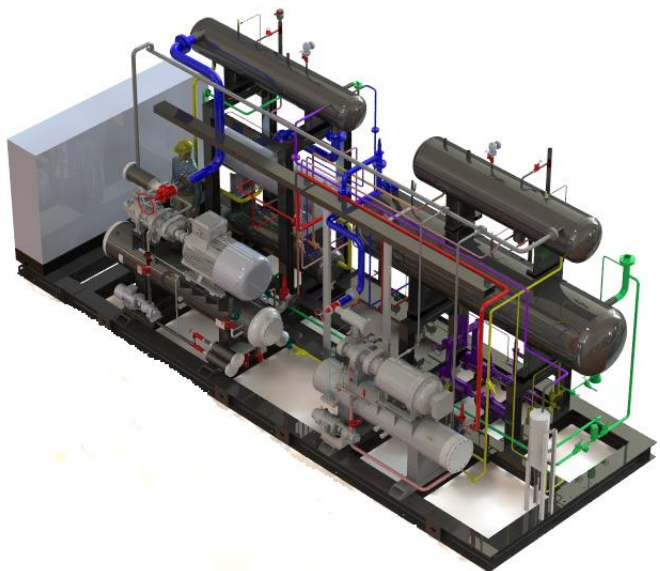
### Factory construction of CO2 refrigeration engineering

- 洁净度  
Cleanliness
- 高密封性  
**seal** completly



#### 工厂化的制作 Factory construction

- ◆ 精细化、定制化设计  
Customized design
- ◆ 高度集成的撬装机组  
Integrated skid mounted unit
- ◆ 现场的有限、快速施工  
Limited , rapid site construction



设计图样  
**Design pattern**

## 七、CO<sub>2</sub>制冷工程的工厂化 Factory construction of CO<sub>2</sub> refrigeration engineering

工厂制作 Factory production



工程施工 Construction site



NH<sub>3</sub>/CO<sub>2</sub> 复叠制冷撬装机组 Cascade refrigeration unit



## 七、CO2制冷工程的工厂化

Factory construction of CO2 refrigeration engineering

NH3制冷/CO2 载冷撬装机组  
NH3 refrigeration  
/CO2 secondary unit



Thank you

谬误之处，敬请斧正

Please correct any errors that you find .