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USE OF CO_2 TO REDUCE AMMONIA CHARGE IN REFRIGERATION UNITS

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ABSTRACT

In order to reduce the ammonia charge quantity, the design of NH_3/CO_2 secondary refrigeration unit is optimized, such as using new shell and plate unit heat exchangers including condensers, evaporator and oil cooler, shortening the refrigerant pipe line, eliminating the high pressure receiver, using high accuracy electric valve. The result shows that compared with same design cooling capacity of traditional ammonia refrigeration unit in the same condition the ammonia charge of same refrigeration unit reduces to 14%. This can improve the system operation safety.

I.INTRODUCTION

Ammonia has superior thermodynamic properties, but also certain risk such as its toxicity, flammability and explosively at certain density. Thus its charge is important. An NH_3/CO_2 refrigeration unit is environmental friendly, safe and welcomed by manufacturers and customers due to reduction in ammonia charge.

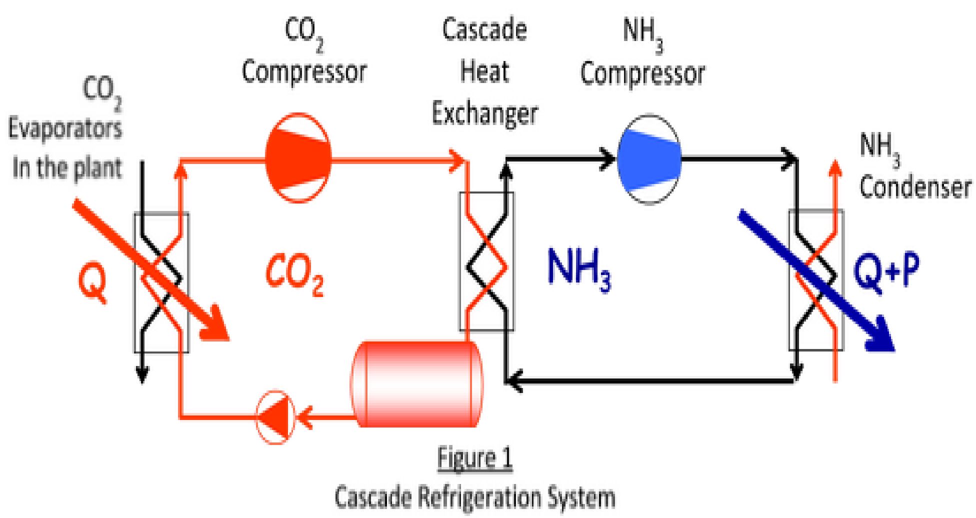

Figure 1 :- NH_3/CO_2 Indirect refrigerating system

II.HEAT EXCHANGER SELECTION

CONDENSER SELECTION

Evaporative condensers are commonly used in ammonia units. They use steel coils and can obtain high volume of ammonia. Besides the ammonia in connections between unit also increases the charge level. With the combination of traditional shell and tube condensers and open type cooling towers, the heat exchanging tubes on the water are susceptible to fouling and corrosion because of large volume of the condensers. Besides, during winter operation the freezing of cooling water is tough to tackle. Thus it cannot reduce ammonia charge efficiency.

NATURE235R units use shell and plate condensers from VAHTERUS and closes circuit cooling tower to avoid fouling and freezing during winter (for example propylene glycol to lower the freezing point).

These shell and plate condensers are common in high end market in Europe and America because of their compact design and applications over a wide range of media, pressure and temperature.

The volume of the shell and plate condenser is 70% to 80% smaller than equivalent condensers, so the ammonia charge can be reduced.

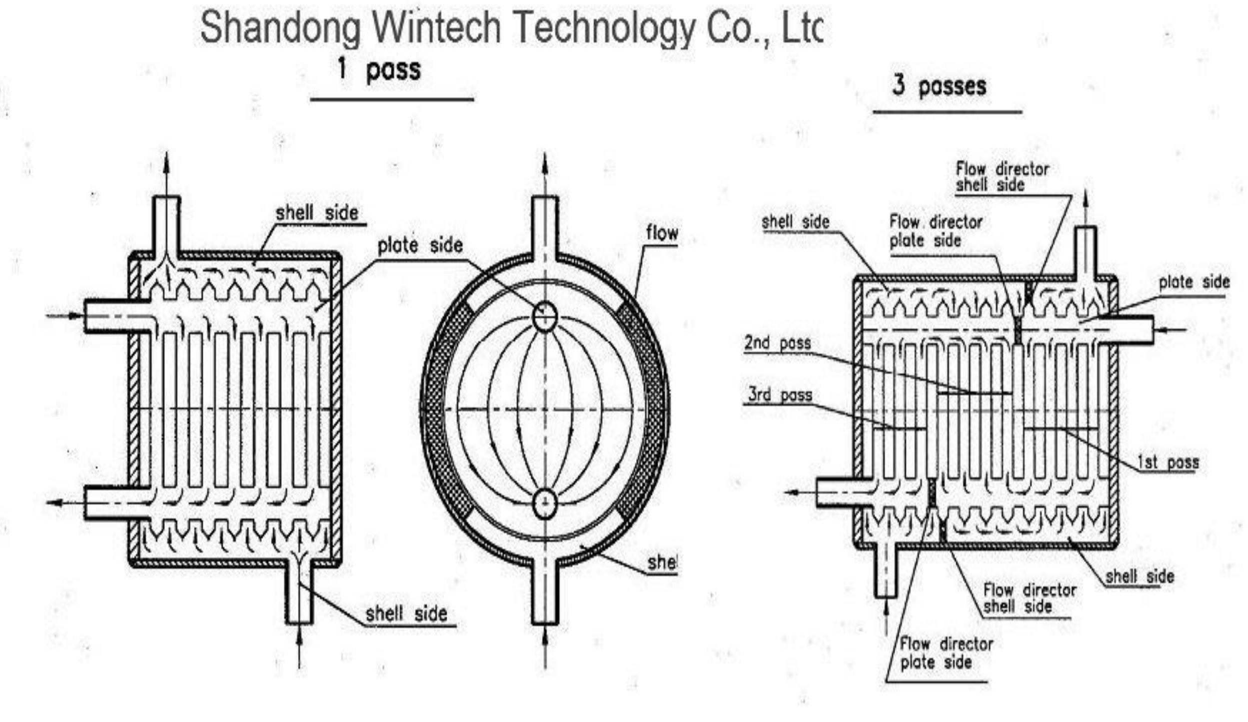

Figure 2:- Structure of Shell and plate type condenser

III.SELECTION OF AMMONIA EVAPORATOR

To further reduce the ammonia charge, these units also use the shell and plate evaporators that have the function of separation.

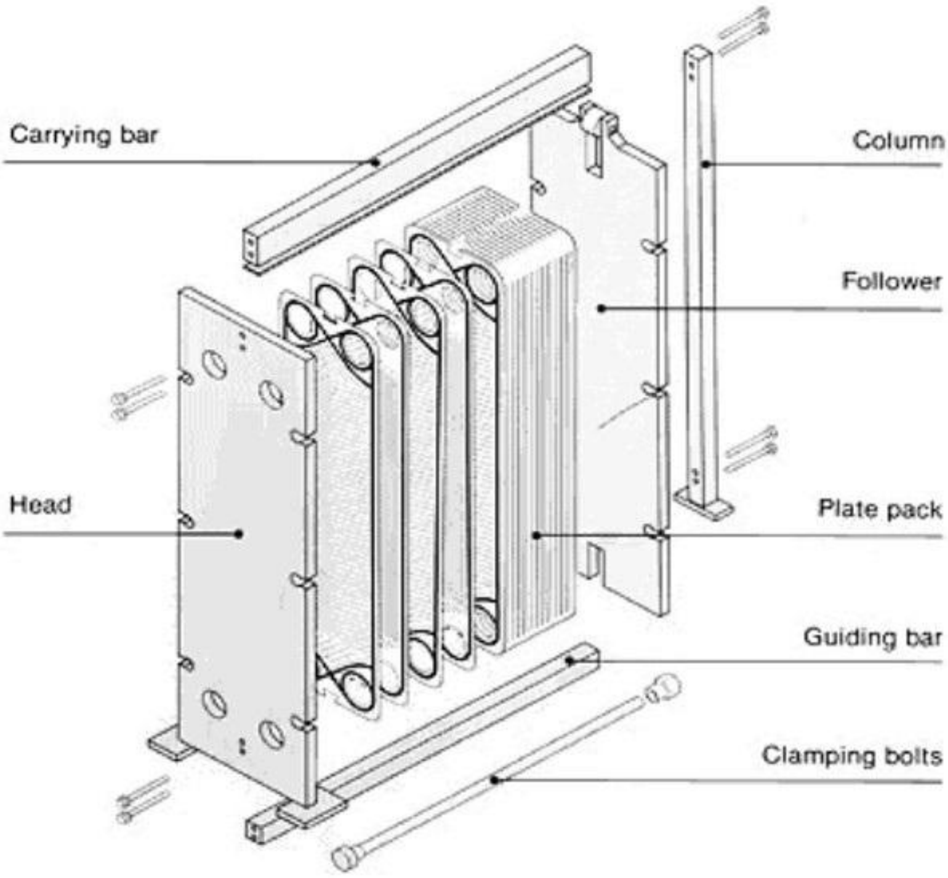

Figure 3:- Shell and plate type Evaporator

IV.OIL COOLING

Water cooled oil cooler are used. Compared with thermo siphon oil cooling in the traditional ammonia system not only does it reduce the amount of ammonia for oil cooling but also pipe length of the ammonia receiver. As in condensers, shell and plate heat exchanger are used instead of shell and tube.

V.SYSTEM SIMPLIFICATION

The design of compressor unit system and the structure is also thought through in order to further reduce ammonia charge. Smaller high efficiency vertical oil separator is used. Ammonia receiver is eliminated. The system is based on a common frame work to reduce the pipe length. Electrical motorized valve replace the traditional shut-off valves. These methods all have the effect of reducing ammonia charge.

VI.CALCULATION AND OF AMMONIA CHARGE COMPARISON

Ammonia charge calculation

The design condition of the unit is: T_e = -35°C, T_c = 35°C, cooling capacity = 233.5KW ammonia flow rate = 612.4Kg/h

Table 1: Calculation results of refrigeration unit

COMPONENT	Ammonia charge (kg)
Compressor	0.3
Vertical oil separator	2
Shell and plate condenser	12
Flash tank eco	15
Shell and plate evaporator	35
Pipeline	5
Total	69.3

VII.CALCULATION OF AMMONIA CHARGE FOR TRADITIONAL UNITS

In a traditional unit, the charge in the receiver is recommended to be 0.5-1 times of the system hourly circulating volume. The receiver charge ratio is 0.7. The volume of the receiver is

$V = m*f*v/\psi = 612.4*1/1.7/0.7 = 514dm^3$ (1)

V - receiver volume, dm^3

M - Ammonia flow rate, kg/h

f - Hourly system circulating volume factor

v - Specific volume of ammonia, dm^3/kg

ψ - Charge ratio of receiver

Assuming the charge ratio for the receiver is 0.5, the mass M of ammonia is:

$M = V*\psi*/v = 514*0.5/1.7 = 152kg$

Thus the charge level of new unit is only45.6% of a traditional system.

Table 2 shows the circulation of ammonia charge in a brine water unit with plate heat exchangers under the same working conditions, with the same refrigerant, compressor oil cooling method (thermo siphon),

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evaporative condenser, thermo siphon receiver and high pressure receiver. To compare both, the ammonia charge level in the new unit is 14.1% of the traditional.

Table 2: Calculation result of traditional refrigeration unit

Component	Ammonia charge(Kg)
Compressor	0.3
Vertical oil separator	2
Thermo siphon receiver	29
Evaporative condenser	33
Shell and tube oil cooler	34
High pressure receiver	152
Shell and tube economizer	17
Brine water evaporator(Plate +phase separator)	204
Pipe line	20
Total	491.3

VIII.SUMMARY

The analysis is summarized below:

1. Equipment with water cooled condenser and oil coolers, closed circuit cooling and new plate heat exchangers, the ammonia charge level in the newly designed refrigeration unit can be reduced to 14% of the traditional amount.
2. With lower ammonia charge, less area is affected during leakage; on the other hand, it is easier to control and handle when it happens. So, it makes the unit safer.

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