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RESEARCH ARTICLE

CLEANER PRODUCTION TOOL TECHNOLOGY CHANGE :A BETTER ECONOMICAL OPTION

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ABSTRACT

The global oil crisis in last decade has created energy and power crisis is forcing the people to look for energy efficient alternatives. Cleaner technology is the anticipate and prevent philosophy by way up gradation in order to improve the efficient use of natural resources and the energy sources within the industry. This paper represents one Dye Manufacturing Unit A at Vatva, Ahmedabad (Gujarat) India, in which one cleaner production tool, technology modification is applied for the efficient use of the boiler spare steam for the production of the ice. This paper will review the basic behind the ice manufacturing process by ammonia absorption system by the use of the spare steam from the boiler. This paper mainly offers the economic analysis for the said unit. It is beneficial for the unit A to set up their own ice plant by using their own energy source. The proposed modification will economically beneficial to the said unit.

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INTRODUCTION

Cleaner technology is any modification of a production process by way of installation of new equipment in order to improve the efficient use of natural resources and minimize waste, pollution and risk to human health. Cleaner production is the continuous application of preventive environmental strategy to processes and products to reduce risks to humans and environment. CP in industry is considered to encompass 5 general prevention practices: (www.agrifoodforum.net/publications/guide/f_chp1.pdf)

- Product modification
- Input substitution
- Technology change
- Good house keeping
- Recycling and recovery

This refrigeration for ice making in said unit is the application of the one of the CP tool named technology change

Refrigeration is the branch of science that deals with the process of reducing and maintaining the temperature of a space or a material below the temperature of the surrounding. (Arora and Domkundwar)

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Refrigeration plants using absorption principle have been around for many years with initial development taking place over 100 years ago. Although the majority of absorption cycles are based on water/ lithium bromide cycle, many application exists where ammonia vapour can be used especially where lower temperature are desirable.

In ammonia water system water is used and a solvent and ammonia is used as a refrigerant. The energy and environmental norms are becoming more and more stringent in all the countries. The concept of energy consumption tax and CO_2 emission tax is becoming a reality in western countries. The use of non-conventional and renewable sources of energy such as bio-mass, waste heat stream, solar energy are expected to rise substantially in near future.

On this background, the Ammonia Absorption Refrigeration Technology has generated a renewed interest and is being viewed as a viable alternative for economical refrigeration due to following features; (www.agrifoodforum.net/publications/guide/f_chp1.pdf)

1. Potential for waste heat utilization and heat recycling
2. Wide temperature range (+5 to -60 ^{0}C)
3. Ammonia is enviro-friendly refrigerant and is readily available
4. No specialized materials are required

PRINCIPLE OF AAR (http://www.guha.biz/schematicavar.gif)

Operation of the refrigeration cycle is conventional with high pressure liquid entering the liquid receiver from the condenser before passing to the evaporator where heat is absorbed from the process.

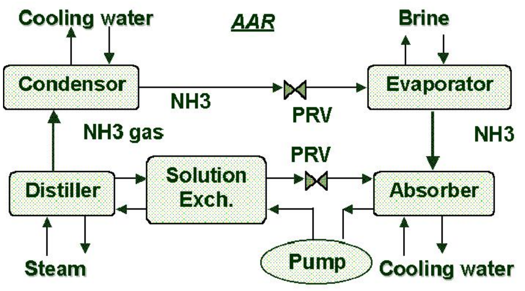

Fig. 1. Refrigeration Cycle (http://www.guha.biz/schematicavar.gif)

The remaining items in the system replace the conventional compressor to achieve "thermal" compression in three steps. (Hudson)

1. Absorption of the ammonia vapours in a weak ammonia water solution at evaporation pressure.
2. Transport of the strong ammonia water solution from evaporator pressure to condenser pressure.
3. Removal of the ammonia from the ammonia-water solution (Desorption) at condenser pressure, together with the purification of the ammonia by heat energy.

High pressure ammonia leaving the fractionators column passes to the condenser for the cycle to continue. It is important to note that the system must maintain a thermal balance with total heat input balancing with the total heat rejected. This provides a simple check on the plant, as a variation would indicate a design error. (Hudson)

I.METHODOLOGY OF SINGLE STAGE AAR (Apte)

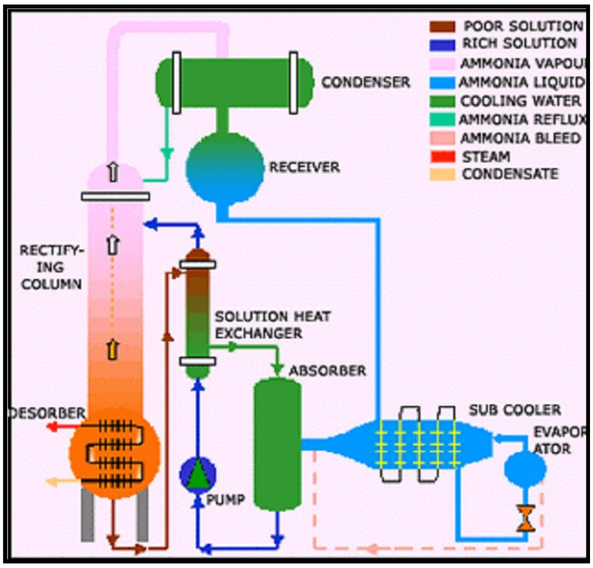

Fig. 2. Single Stage Ammonia Absorption Refrigeration Plant (Apte)

1. Liquid ammonia evaporates in the evaporator and cools the product.
2. Ammonia vapours from evaporate are used fro sub cooling the liquid ammonia supplied to evaporate this reduces liquid ammonia flash loss in the evaporator.
3. Ammonia vapours from sub cooler are absorbed by a spray of weak ammonia solution in water. The heat of absorption is removed by cooling water.
4. The strong ammonia solution formed after absorption is pumped to desorber.
5. Heat is supplied in the desorber to boil off the ammonia vapours from strong solution. These vapours also contain some water vapours due to affinity between ammonia and water.
6. The ammonia vapours are rectified in the rectifying column to remove the vapours and generate pure ammonia vapours with traces of water vapours.
7. These vapours are condensed and liquid ammonia is accumulating in the receiver.
8. The receiver supplies liquid ammonia to evaporator.
9. Weak ammonia solution left in the desorber is sent to absorber for absorption.
10. A solution heat exchanger is provided to cool the weak solution before entering the absorber and preheat the strong solution before entering the desorber.
11. The traces of water vapours during ammonia boil off in desorber accumulate in the evaporator. These are controlled by providing a bleed line from evaporator to absorber.

IV. APPLICATION RANGE (Apte)

Single stage Ammonia Absorption Refrigeration Plants normally cater to those applications having one or more chilling loads of nearly same temperature. Typically for applications ranging from +5 to -40 Deg. C, heat source temperature requirement varies from 95 Deg. C to 180 Deg. C, with normal cooling water as coolant for absorber and desorber. For temperatures lower than -40 Deg. C

V.ADVANTAGES OF AVAR (Apte)

There are a number of advantages for Ammonia Absorption Refrigeration Plants which need consideration:

- Economical operation
- Low maintenance
- Maximum reliability
- Low cost installation
- Low noise level
- Operational flexibility
- Design flexibility
- Oil free refrigeration system

VI.LIMITATIONS OF AVAR (Apte)

- Capital cost higher than mechanical plant
- More complex refrigeration system
- High grade heat required
- More space required
- Perception that it is outdated technology

VII. RESULTS AND DISCUSSION

Boiler Specification at Unit A

- Registry of boiler GT -3269
- Type: - package
- Rating: - 127.2 m^2
- Pune: - 1994
- Max pressure (work):-10.54 $kgms/cm^2$
- Grit area: - 5.04 m^2
- Fuel: - Lignite
- Calorific value: - 2400 KCal / kg
- Cost of lignite: - 1.5 Lakh / Month
- Boiler capacity: - 4 ton / hr
- Steam production 4 ton / hr
- Steam consumed: - 1.5 ton /hr
- Steam spared: - 2.5 ton / hr

Ice Data

Ice requirement / batch: - 50 ton / batch
Cost of ice / kg: - 45 paisa

For 40 ton of ice per day

▪ Ton of refrigeration:-
=65 TR Assuming, COP = 0.6
▪ Heat requirement in the generator
= 375 KW
▪ Steam requirement
= 14.4 Ton / day
= 0.6 Ton / hour

Economic Analysis

▪ **Initial capital cost**

From the case study,

1 TR = 30,000 Rs.
Consider 1 TR = 40,000 Rs.
So, for 65 TR = 26, 00,000 Rs.
Initial capital cost: - 26, 00,000 Rs.

▪ **Annual cost of ice**

Price in terms of ice: - 450 Rs. / Ton

Monthly cost of ice
= 5, 40,000 Rs. / Month
Annual cost of ice = 64, 80,000

▪ **Operating cost**

Steam requirement = 0.6 Ton / Hour
Therefore, Energy requirement
= 13, 50,000 KJ/Hour
Considering boiler efficiency n = 40 %
Equivalent energy required
= 33, 75,000 KJ / Hour
Equivalent coal requirement
= 337.5 Kg / Hour
= 8.1 Ton / Day
Operating cost = 13859.1 Rs. / Day

▪ **Annual saving**

Ice cost for 40 Ton / Day
= 18000 Rs. /Day
Saving day =4141 Rs. /Day
Annual saving = 1490760 Rs.

Therefore,

▪ Annual saving = 1490760 Rs.
▪ Total capital cost = 26, 00,000
▪ Payback period = 21 Months

For 20 Ton of Ice

Similarly, for the 20 ton of Ice
▪ Ton of refrigeration =32 TR
▪ Assuming COP = 0.6
▪ Heat requirement in the generator
=186.66 KW
▪ Steam requirement
= 0.3 Tons / Hour

Economic Analysis

▪ Initial capital cost
= 13, 00,000 Rs.
▪ Annual saving
= 745560 Rs. / Year
▪ Operating cost
= 6939.5 Rs. / Day
(Considering boiler efficiency n = 40 %)

Therefore,

▪ Annual saving = 745380 Rs.
▪ Total capital cost = 13, 00,000 Rs.
▪ Payback period = 21 Months

(Note:-In the initial capital cost calculation interest rate is not considered.)

Assumptions

1. In the initial capital cost calculation interest rate is not considered
2. Average boiler efficiency is 4 %
3. COP for refrigeration system is 0.4
4. Steam supplied by boiler is low pressure steam about 2 to 3 Kg / Cm^2

VIII. RESULTS

	40 Ton/ day	20 Ton /day
TR	65	32
Initial Capital Cost	26,00,000 Rs	13, 00,000 Rs.
Operating Cost	13859.1 Rs. Per day	6939.5 Rs. Per day
Annual Saving	14,90,760 Rs.	7,45,380 Rs.
Pay Back Period	21 Months	21 Months

IX. Conclusion

Absorption Refrigeration Plant offers a number of advantages at temperatures below 0ºC and where waste heat or cheap steam is available, significant running costs savings can be made.

This proves the use of the CP tool which is useful for save money, using cheap steam for the efficient utilization of the heat from the boiler. By this economic analysis of the particular unit it can conclude that by using this AAR system which will operate by the waste steam from the boiler the company can get the ice at the cost of 0.35 Paise /kg.

Presently the company is buying ice at the cost of 0.45 Paise / kg. The payback period is of 21 months. It can be concluded that this ammonia absorption plant is economically beneficial and viable for this dye manufacturing unit A at Vatva Ahmedabad (Gujarat).

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