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Run Vapour Absorption Machine (Vam) Using Waste Heat In Paint Shop

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ABSTRACT

One of the oldest methods to mechanically cool a space is with absorption technology. A Vapor absorption chiller (VAM) is a machine to produce chilled water using waste heat source from the oven. Currently paint shop uses three oven namely as ED, primer & Top Coat to bake the car body in conditioned environment. Current system gives the exhaust gases 280°C-340°C directly to the atmosphere without using for other purpose. This can be used for various purposes in paint shop like as heat water for clean the car body, chilling system, etc. The proposed system is to reuse exhaust air for hot water generation at temperature of 110°C. Heat energy for total hot water heating is 1253 KW, realize the energy potential of waste heat and use it in proper way. Hence this proposed system gives what way to use heat energy for cooling in summer and heating in winter condition. It seems unreasonable to achieve cooling with heat, but that is what happens inside an absorption chiller. A fluid pair lithium bromide and water is used in commercial VAM. The refrigerant used as water & because of this it experiences a phase change and causes the effect of cooling. Source of heat used to separate the two fluids (water-lithium bromide); when they are mixed in a near vacuum environment. Proposed system use collected waste heat to VAM to chill out water for further usages. Using WHR system energy recovers up to 1930.75kw/hr. Chilling load available through VAM is 550kW/hr. This reuse of heat will save the energy along with the CNG consumption required for boiler to heat the water. These machines use only small fraction of electricity as compared to the conventional VCR chillers. Vapor absorption systems work with non-CFC eco-friendly refrigerants such as water or ammonia.

***Keywords*—Vapor absorption, cooling by waste heat, absorption chiller, Energy conservation, Li-Br chill**

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I. INTRODUCTION

In paint shop, there are three oven namely ED (Electro Deposition) oven, Primer oven & top coat oven to bake a paint on the car body. For better deposition of the paint on the car body oven plays a very important role, to bake the paint on the car body continuous supply of hot air from the incinerator is coming into the respective oven as per requirement & remaining high temperature gases are exhausted into the atmosphere. The temperature of the exhaust gases are up to 280˚C-340˚C. These high temperature exhaust gases can be used for the pre-cooling of chilled water supplied by chiller. We cool the exhaust gases up to 115˚C. When temperature of exhaust gases goes below to 105˚C, it condensate so use this potential in other work. Generally now a day's exhaust heat from the oven directly goes in to the atmosphere, due to this the temperature of environment increases, & directly effect on global warming. To reduce the global warming, the exhausted heat from oven used for the heat hot water to use in chiller. Accordingly we saving in fuel, energy, space of component, and run chiller without power i.e. in less consumption of electricity. A vapor absorption chiller (VAM) is a machine to produce chilled water using waste heat source from the oven. Current system gives the exhaust gases directly to the atmosphere without using for other purpose. The exhausted flue gas is around 280°C -340°C. This heat source can be used for various purposes in paint shop like as heat water for clean the car body, chilling system, etc. The proposed system is to reuse exhaust air for hot water generation. The hot water generated will be at temperature of 110°C approx. The generated hot water can be used for pre-treatment and oil conservation process.

II. LITERATURE REVIEW

John Leslie et al. 1810 [1] He took H_2SO_4 with water in different jar & connected with coupling. H2so4 have great affinity with water, using this property it absorb water Vapor from other jar. So this is principle of removing evaporated water Vapor without compressor or pump. Absorbent used in this system is H_2SO_4, which has to be reused by heating to get rid of absorbed water Vapor for the continuous operation. In 1878, Windhausen uses this principle to prepare absorption refrigeration system. It uses H_2SO_4 as absorbent. **Ferdinand Carre, [2**] in 1860 invents aqua- ammonia absorption system. Water is strong absorbent of NH_3. He took two vessels that are connected by using coupling. NH_3 is exposed with water which is kept in another vessel. Without using compressor to drive the vapors, evaporation of NH_3 is done by using the water, which has strong absorption potential. Use the liquid pump for increase the pressure of strong solution. For separation of water & ammonia from each other, the strong solution is heated in generator & pass through the rectification column. Due to this action ammonia Vapor condensate &recycled. Negligible power used by pump, hence system runs virtually on low grade energy. Initially system run on steam & then introduces the system of oil & natural gas.**Preetham P. Rao, [3] et al.** Paint oven consume typically over 20% of the total energy spent in the paint shop. It was observed that the carriers are almost as heavy as the bodies they carry, and hence a very large portion of energy is spent to heat them up within the oven. A numerical evaluation of the thermal behaviour of the carriers with shroud showed that the shroud is indeed useful in conserving energy. A detailed analysis and physical tests are required to determine the extent of this potential throughput increase.**W. Chekiroua, R. Boussehainb, M. Feidtb, A. Karaalia, N. Boukheita [4]et al.** The performance coefficient of double bed adsorption refrigeration cycle is better. The simulation results give a rough description for the complex relationships of parameters in adsorption simple and heat recovery systems. It is useful for the design of such systems. It is possible to estimate the performance of an adsorption refrigerating cycle, which can be easily transported to any type of adsorbate and several types of adsorbent, especially activated carbons. **MA Guang-yua, CAI Jiu-jua, ZENG Wen-weia, DONG Huia [5] et al.** The rate recovery of coking and sintering process is relatively low, should strengthen research and extension in coke dry quenching technology and grade recovery and cascade utilization of sintering waste heat resources. The recovery and utilization of waste heat in scientifically way should depend on the first and second law of thermodynamics and accord to the quantity, temperature correspond and cascade utilization. It is the fundamental of the recovery and utilization of waste heat of iron & steel industry.**François Boudéhenn, Hélène Demasles, Joël Wyttenbach, Xavier Jobard, David Chèze, Philippe Papillon [6] et al.** This article presents the development of 5 kW cooling capacity, using ammonia-water absorption chillier for solar cooling applications. The last experimental tests with adapted control strategy showed results close to numerically expected. The next step is to develop an optimized control strategy that is maximizing performance of the chillier in various real operating conditions.**Boonrit Prasartkaew [8] et al.** To gain the experience and know how to build the absorption chillers, an out-of-ordered chiller was renovated and setup for this current experimental study. The performance of these chillers was investigated under the local weather condition and the concentration of strong solution of 59% was used in this study. The results show that the cooling capacity of these current chillers satisfies the cooling load of the conditioning room. To obtain the high coefficient of performance, these chillers should be operated at 85C of hot water temperature.**R.Ram Kumar, K.Balaji [9] et al.** The analysis shows, nearly 75 tons/year amount of fuel saved by using the vapour absorption refrigeration system and also power required for vapour compression system eliminated. From this study determine amount of heat energy is lost from turbine exhaust and it condensate in the condenser. The exhaust heat energy of turbine is converted to cooling effect using vapour absorption refrigeration system and to replace the vapour compression refrigeration system. **K.Balaji, R.Senthil Kumar [10] et. al.** Most of the energy usages of industry by using fossil fuel & increased price will be recovers by utilizing of waste heat sources. Steam turbines used in sugar industries gives measurable amount thermal energy. Use VAM of single effect Li-Br with water system to get cooling by the use of waste heat. Here hypothetical design based on the cooling effect required for DC thyrist motor in a sugar industry. Energy saving are measured in terms of effectiveness of waste heat use and cop of system.

III. CONCEPT AND MECHANISM

A. Concept:

Basic need for any industry is to conserve the energy to overcome increased cost of energy per day. Concept behind the Vapor absorption machine is to reuse of waste heat exhausted through ovens in atmosphere. Exhaust heat energy is around 932kW by considering 90% efficiency approximately 840kW energy can be utilized in Vapor absorption machine for cooling purpose. With 0.6 COP (coefficient of performance) we can use 500Kw i.e. 240 TR energy for process of cooling. This recovered energy can be utilized for overcome the booth issue in summer condition. Currently, temperature of exhaust gases from oven is ranging from 280˚C -340˚C. This heat energy is used to cool the air which is obtained by chiller. Finally energy required for cooling in chiller will be saving.

B. Mechanism:

Current System design does not allow recovery or reuse of the high temperature gas as shown in the fig.1

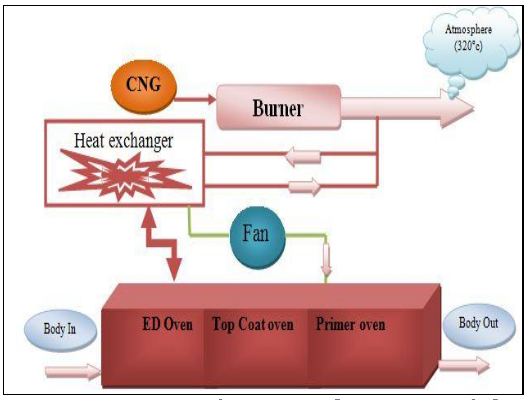

Fig.1 Current Oven exhaust system [source: VW India]

By installing Vapor absorption machine ~500kW Heat energy equivalent can be recovered. This will be used to cooling in booth as shown in fig 2.

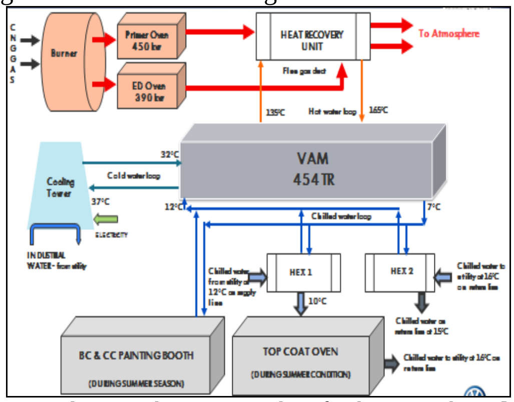

Fig.2 Proposed Vapor Absorption Machine for the oven exhaust [source: VW India]

Fig. 3 shows the schematic of Vapor Absorption Machine in which exhaust waste heat will be used cooling purpose where exhaust heat at 280˚C -340˚C. Fan is used to draw air from return line of booth which will be fed into the Vaporabsorption machine to cool and then it will be send to air handling unit. And connected in main line so that air is reused & consumption of CNG gas is reduced along with saving in cost of CNG.

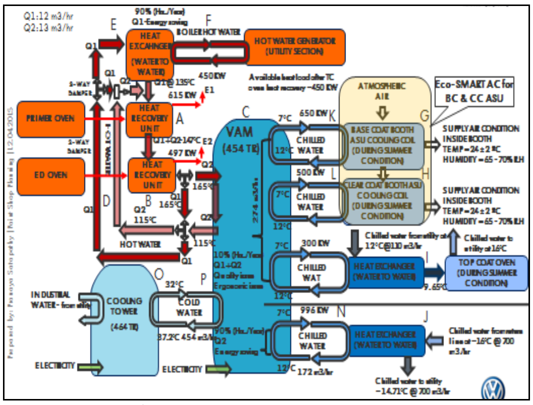

Fig. 3 Schematic of Vapor Absorption Machine [source: VW India]

The above schematic shows the concept of Vapor absorption machine to be installed. Capacity of VAM 464 TR, which is to be used for the solution of problems in paint booth. Heat Recovery Unit is in two nos, to provide the required temperature in Vapor Absorption Machine.

The main heart of the proposed Vapor Absorption Machine is the Lithium bromide with water solution. The purpose of selecting this type of solution is that we will get a highest efficiency compare to ammonia water system. Generally commercial industry used Li-Br/water system. Lithium Bromide and water is mostly popular but the evaporator temperature is limited to minimum of 5˚C. Two outstanding features of LiBr-water are non-volatility absorbent of LiBr (No need of rectifier) & extremely high heat of vaporization of water (refrigerant).

As water is refrigerant, the system must be operated under the vacuum condition. At high concentration, the solution is prone to crystallization, to avoid this condition add more extra salt e.g. ZnBr, Zncl2. By addition of third component in basic LiBr-water solution pushes the crystallization limit away from the normal operating zone. Hence the strong solution can be cooled in heat exchanger to near absorber temperature without salt crystallization. Thus improving performance, the Cop is high (0.7-0.9) as compared to ammonia-water (0.5-0.6). COP & effectiveness are the two important terms while selecting the Vapor Absorption Machine. COP for LiBr/H2O is larger than NH3/H2O, & is given as follows.

$$COP = Qe / (Qg + Wp) \quad (1)$$

Where, COP- Coefficient of performance

Qe-Heat absorbed in evaporator

Qg- Heat supplied in generator

Wp- Work done by pump

Neglecting the pump work then

$$COP = Qe / Qg \quad (2)$$

Calculations:

A. Exhaust Energy (Q) = ρ x V x Cp x ΔT (3)
B. Mass Flow Rate (Ma) = volume flow rate / specific volume (4)
C. Cooling Required = Ma x (H2-H1) n (5)
D. Heating Required = Ma x Cp x (T2-T1) (6)
E. Moisture Added = Ma x (Ms2- Ms1) (7)
F. Moisture Removed = Ma x (Ms1- Ms2) (8)

Where,

Exhaust air flow rate (V) Nm3/hr

HRU inlet & outlet temperature (ΔT) ºC

Density of air (ρ) Kg/ Nm3

Specific heat of air (Cp) Kcal/Kg ºC

Equivalent Exhaust energy (Q) KW

Considering 90% efficiency KW

Mass flow rate (Ma) Kg/ Sec

Cooling / heating required kW

Moisture Added / removed Kg/Sec

Heat load requirement:

Average CNG consumption per day

Average CNG consumption per hour

IV. CONCLUSION

As the heat recovery from the system is huge so the potential of energy recovery can be realized. The recovered heat can be used to cooling process using VAM. The wastage of such a high heat content energy can be prevented. The current situation is that schematic flow through the system is finalized and cooling, heating load of Vapor Absorption Machine is in process which will help in to further process.

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