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Investigation On Possibilities Of Cooling Effect From Oxygen Lines In A Municipal Hospital

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Abstract— Consumption of energy in the world is increasing day by day, which results in faster depletion of energy resources. This problem to some extent can be tackled by using Waste Heat Recovery System. Waste Heat recovery process consists of using waste heat produced from a system for pre-heating or cooling the liquid or gas in same system or other. Large size capacity oxygen tanks are installed in hospitals for supplying oxygen gas. The liquefied oxygen produces cold energy while converting into gas can be exploited. The present case study shows theoretically approximately 3TR of cold energy produced can be used for cooling the nearby rooms around the cryogenic oxygen tank. This will certainly reduce significant electricity consumption in the hospitals and offer human comfort. Such simply cooled air may be delivered to OPDs and/or waiting areas.

Index Terms— Waste heat recovery, Cold energy, Liquified oxygen,evaporator,axial fan,duct,cooling.

1 Introduction

Invention of oxygen cylinder was one of the most important development in the field of medical practice. Oxygen is used as a life saving medicines to hospitals. An oxygen cylinder is an oxygen storage vessel, which holds liquid oxygen under high pressure.

Liquid oxygen is obtained by fractional distillation at a temperature near -183℃.Liquid oxygen is denoted as LOX, LOx or Lox in aerospace, gas industries and submarines. Its colour is pale blue and is strongly paramagnetic. Liquid oxygen has density of 1.141$\frac{g}{cm^3}$ .It is cryogenic with freezing point of -218℃ (54.36K) an a boiling point of -183℃(90.19K) at 1atm[4].

Oxygen is produced by an air separation unit through liquefaction of atmospheric air and then oxygen is separated by cryogenic distillation. The oxygen obtained is stored in cryogenic liquid oxygen can also be produced non cryogenically using selective adsorption processes[5].

Cryogenic storage tank are installed in hospitals in order to supply oxygen gas to patients. Large amount of cold energy from liquefied oxygen is released to the surrounding which results in formation of ice at the outer of evaporator.

The purpose of this paper is to analyse the possibilities of using the cold energy from liquefied oxygen for cooling the nearby rooms by installing axial fan and duct

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2 Literature Review

The ways in which waste heat is used for cooling has been analysed. Brayton Rankine cycle is coupled with ammonia water absorption chiller in order to produce low temperature inlet for compressor of brayton cycle which results in high efficiency of the cycle.

Diesel generator is linked with vapour absorber chiller to produce cooling effect.The waste heat of exhaust gas from diesel genset and the coolent flowing in the cylinder jacket of engine is used in the generator of the vapour absorption chiller in order to heat the ammonia water solution. The weak solution from the generator comes in contact with absorber thereby releasing latent heat of condensation.So the absorber is cooled by circulation water. This results in air conditioning from absorption chiller and hence reduces the energy cost by 35% with 80% efficiency[6].

Replacement of mechanical refrigeration with proposed system which provides cold energy from LNG , in LNG fuelled vechicle [2] . The temperature of the refrigerated compartment could be dropped lower than -20 C when the LNG consumption rate was greater than 5.607 kg/h. When the power output of the proposed natural gas engine (CY4102CNG) is greater than 25 kW under the full-load operating condition, then the original mechanical refrigeration unit (Carrier Viento 200) could be totally substituted by the proposed self-refrigeration system.Hongbo, et al. has further proposed on LNG- fuelled trucks where cold energy is used to cool the drivers cab. The gasified natural gas which is recycled between two heat exchanger several times act as a heat transfer medium to transfer heat from ethylene to LNG. The heated natural gas enters truck engine to produce power . Ethylene solution in the Heat exchanger extracts cold energy and then pass it to the air cooler. The maximum refrigerating capacity is 4.1 kW so long as the LNG flow rate is larger than 20.9 kg/h which provides the same refrigerating capacity as mechanical refrigeration [1]

Cold energy of LNG is used in frozen desalination process. Frozen desalination refers to a process in which fresh water extracted by harvesting and melting the ice crystals from the chilled feed i.e sea water//brackish water. Cold energy released from the LNG during re-gasification can be used in desalination process in order to minimize the energy consumption. Thermal desalination process can be replaced by this frozen desalination [3].

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3 THEORETICAL ANALYSIS

Oxygen cylinder along with evaporator, an open system is set up in hospitals so that the liquefied oxygen converts into gas while passing through evaporator, where it absorbs heat from atmosphere and the gas is further supplied for different applications. During this process, ice is formed at the initial part of the evaporating coil due to heat transfer between coil and the surrounding. The cold energy rejected by coil while absorbing latent heat from the surrounding air is used for conditioning the air. This can be done by incorporating a blower, a duct along with insulation thereby avoiding formation of ice.

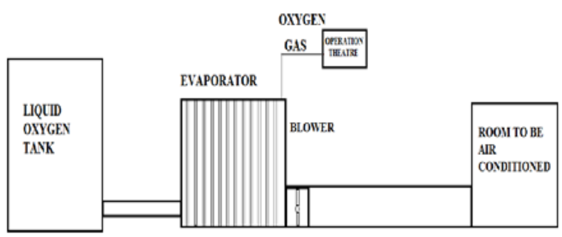


Fig 1- Proposed System(Case 1)

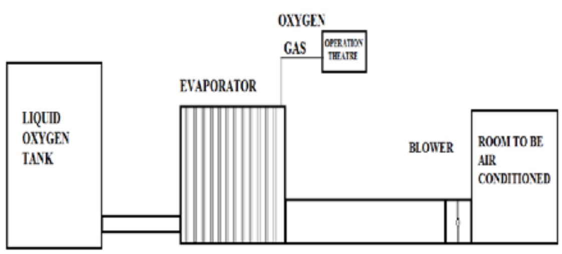


Fig 2 –Proposed System (Case 2)

The details of oxygen cylinder and evaporator are given below:-

1) OXYGEN CYLINDER:-Cryogenic tank which contains liquid oxygen under pressure.

Capacity- 11 kL
Weight -5250 Kg
Operating Fluid –LOx (Liquid Oxygen)
M.a.w.p(Maximum allowable working pressure) =17$\frac{kg}{cm^2}$
Temperature = -196℃

2) EVAPORATOR

Dimensions-
Length:-214cm
Width:-120cm
Height:-540cm

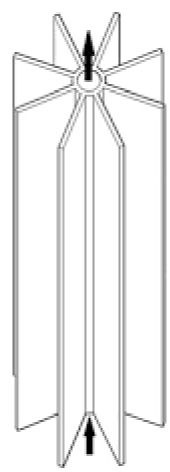
3) TUBES

No of Tubes =84
Circumference:-11cm

4) FINS

Each tube is surrounded by 8 fins

Length:-5.2cm
Thickness:-2mm



Fins

Fig 2 -The structure of the star-shaped finned tube heat exchanger

Given Table 1 below shows the details regarding oxygen supplied to the hospitals for 21 days.

Table 4.1-Oxygen Consumption Calculation:-

	Date	Supplied Qty(ℓ)
1.	29/6/16	3850
2.	1/7/16	1400
3.	3/7/16	3542
4.	6/7/16	1893
5.	7/7/16	5347
6.	8/7/16	2283
7.	9/7/16	2583
8.	10/7/16	1796
9.	12/7/16	4019
10.	14/7/16	2132
11.	16/7/16	2365
12.	18/7/16	2311
13.	20/7/16	3642
14.	22/7/16	2680
15.	23/7/16	2362
16.	25/7/16	5288
17.	26/7/16	1200
18.	27/7/16	2055
19.	28/7/16	3064
20.	30/7/16	1781
21.	31/7/16	2513
Total	21 days	58108

Consumption per day = $\frac{Total\ Quantity\ Supplied}{No\ of\ Days}$

$$= \frac{58108}{21}\ {}^{l}\!/_{day}$$

$$= 2767\ {}^{l}\!/_{day}$$

$$= 2.767\frac{m^3}{day}$$

Consumption per hour = $0.1153\frac{m^3}{day}$

Density of Lox $= 1141\frac{kg}{m^3}$

Mass Flow rate ($\dot{m}$) :- Consumption per hour $\times$ Density

$$= 0.1153 \times 1141$$

$$= 131.5\frac{kg}{hr}$$

Available cooling capacity from Lox is obtained from the below equation

$$Q = m\,C_p\,\Delta T$$

$$where\ m = mass\ flow\ rate$$

$$C_p = Specific\ heat\ \frac{Kj}{Kg\ K}$$

$$\Delta T = Temperature\ difference$$

$$Q = 131.5 \times 1.7 \times (298 - 90)$$

$$= 12.99\ Kj/\sec$$

$$= \frac{12.99}{3.516} TR$$

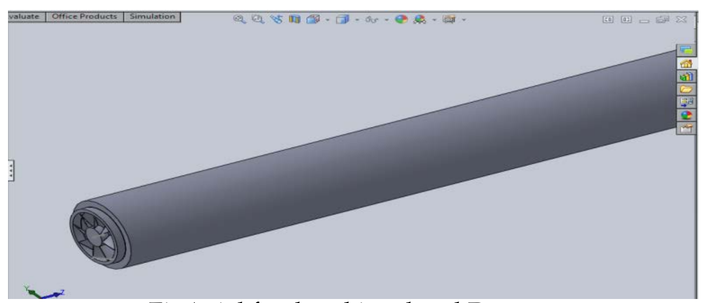
$$= 3.7\ TR$$

From the papers,we have understood that 1 ton of refrigeration has the capacity to cool 100sq.ft.
∴3 TR of refrigeration has the capacity to cool 300sq.ft .

4 Modelling

The cold energy obtained from system is approximately 11KW which can be used for cooling the nearby rooms .So the cold energy obtained from the system is given to meter room and examination room

According to the room size ,axial fan and insulated duct is modeled in solidworks



FigAxial fand and insulated Duct

5 Simulation

After modelling the proposed system in solid works , we have to simulate the system in ansys to check whether there is any heat loss while cold energy is passing through insulated duct. Material used for insulation is PIR(Polyisocyanurate).The step is to set the simulation process as a 3-D steady and turbulent problem.

Viscous -Reliazable k-e, Standard wall

Temperature-275k

Pressure atmospheric pressure

velocity-5.15m/s

flow media - air

3D pressure-based, steady

Solution method-simple, first order

The flow of air through insulated duct is considered as turbulent. Assuming temperature of air as 275K ,velocity of air is 5 m/s obtained from discharge formula i.e.(Q = V x A)

6 RESULTS

After simulation of the system, it is observed that there is only minimal decrease in temperature at the outlet. From the fig below we see that inlet and outlet temperature is nearly same that means there is no loss of energy as the cold air passes through the insulated duct. But there is decrease in temperature along y axis ,i.e. the cold air adjacent to the insulated duct which shows that there is heat loss due to convection.

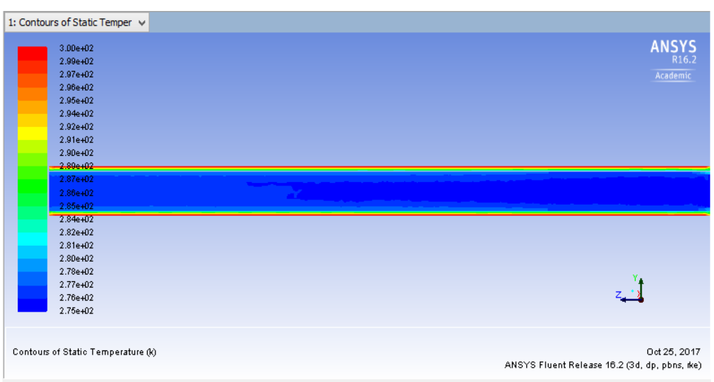


Fig-contours of temperature

7 CONCLUSION

The primary aim of this work is energy conservation and waste heat recovery. Theoratical study is made and preliminary system is simulated to check the possibilities of recovering cold energy from the liquefied oxygen tanks/cylinders in a hospital and utilizations of this recovered cold energy for aircooling to deliver it into common areas of hospitals.

The conclusions to be drawn from this investigation are as follows.

1) From theoretical point of view, the proposed system provides a cold energy of approximately 3 TR.
2) Outlet temperature obtained from simulation provides negliagble temperature decrease This means there is no loss of heat while passing through duct.
3) By installing an axial fan and duct along with insulation can provide cool air to the nearby room and there would be no formation of ice
4) Further will study the simulation of insulated duct when the fan is kept after the insulated duct

7. ACKNOWLEDGMENTS

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