Application of Vortex Tube in Mine Cooling Jacket

Akash Shinde[1] Mandar Avhad[2] Sanket Shirke[3] Saroop Nair[4] Prof. Vinod S. Bhaskarwar[5]
[1,2,3,4,5]Department of Mechanical Engineering
[1,2,3,4,5]Lokmanya Tilak College of Engineering, India

Abstract— Refrigeration is the science of the producing and maintaining temperature below that of the surrounding atmosphere. This means the removing of heat from a substance to be cooled. Heat always passes downhill from a warm body to a cooler one, until both bodies are at same temperature. Not only pemisable today many human work spaces in offices and factory building are air conditioned and a refrigeration unit is the heart of the system. The evaporation carried away heat and cooled water. This system was used by Egyptian and by Indians in the south west. Natural ice from lakes and rivers was often cut during winter and stored in caves, straw lined and later in sawdust insulated building to be used as required. Though these methods of cooling all make used of natural phenomena they were used to maintain a lower temperature in a space or product and may properly called refrigeration. Nowadays there is need of more compact system as people are looking for smaller and less complicated system. Also due to increasing pollution and global warming, there is utmost need of less polluted and eco-friendly and compact refrigeration system in day to day life. And the most possible system that engineers are looking for is Vortex Tube Refrigeration System.

Key words: Vortex Tube, Mine Cooling Jacket

I. Introduction

Refrigeration and Air-conditioning play an important role in human life. They not only offered comfortable and healthy living environment but also become a necessity of life to survive for severe weather. The accelerated technical development and economic growth of most countries during last century has produced severe environmental problems. More ever manufacturing of new equipment is still with CFCs in these countries. In order to protect the environment it is important that non CFC refrigeration system designs are to be incorporated as early as possible and are to be developed for existing refrigerator freezes using suitable substitute refrigerance.

We have recognize that man made products contributing to man comfort have side effect threatening our health as a result of harming the environment ozone depletion and global warming. These concerns are the biggest driving forces for technical inovation in field of refrigeration and air conditioning.

CFCs were ideal fluids which satisfied almost all thermodynamic, thermo physical, chemical and economic criteria. Their chemical stability was considered to be one of their best qualities. They are still best from performance point of view.

Refrigerants which are new cannot be natural but refrigerants which are alternative could be almost nothing.Thus alternative refrigerants can be defined as refrigerants and refrigerating system which are practicable but which do not at present extent beyond certain niche markets.

II. Problem definition

Presently, there are two main types of solution to solve the damage of heat. The first one is the non-artificial cooling measures, which meaning mine ventilation. Ventilation cooling is applied in mines where the damage of heat is not very serious, but it may not reach the expected effectiveness.

The other way is artificial refrigeration cooling method, which can divided into artificial cooling water, artificial ice cooling, and compressed air cooling, each has it's own advantages and disadvantages, which may cause difference in security, increasing the difficulty to manage and overcome other shortage.

The two above-mentioned methods is achieved by using large machine equipment which are costly. And there are many other problems, such as large initial investment, high operating cost, noise pollution, poor cooling effect, difficult in moving and installing refrigeration equipment, potential safety hard and so on. Whether the cost of consumption or cooling effect, the existing cooling technology needs to be improved. Nowadays, with the deepening of the research on the cooling jacket, the lower cost and higher stability of it shows great prospects in mine cooling application.

III. Objectives

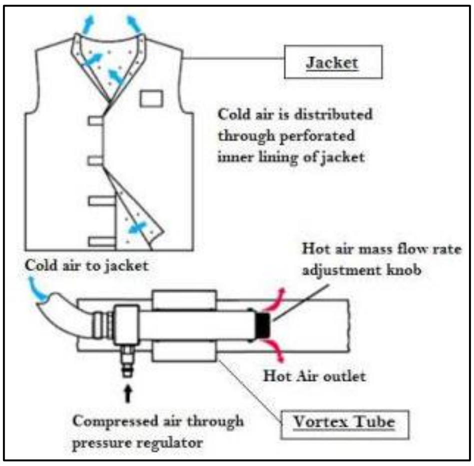
- To reduce the power consumption.
- To improve the working conditions around human body (workforce) and thereby increase their efficiency.
- Cost-Effective and compact type cooling system that would be reliable
- Plug and Play type of system.

IV. Research methodology

1) Step 1: Collecting data regarding Vortex Tubes.
2) Step 2: Basic calculation regarding vortex tube.
3) Step 3: Fabrication of Vortex tube to achieve maximum temperature drop.
4) Step 4: Deciding the type of Jacket suitable.

A. Components:

1) Tube
2) Material for jacket
3) Pressure regulator
4) Pipes and Couplings



B. Specifications of Vortex Tube

I.D. of vortex tube- 6 mm
O.D. of vortex tube- 20 mm
Tube length -146 mm
inlet hole on vortex tube - 3 mm

C. Specifications of Cold End Orifice

ID- 4 mm
OD-8 mm
Length — 38 mm

D. Specifications of Hot End Orifice

ID- 6 mm
OD- 20 mm
Length- 30 mm

E. Formulae Used

Area = (π/4) X D^2
Discharge (q) =A x V
Mass Flow Rate (m) = q x p
Temperature difference between Hot & Cold End=(ΔT)
Cooling effect (q) = m X Cp x ΔT
Temperature Difference between Hot End & Atmospheric Temp. — (Δt)
Velocity = (v)

V. FURTHER SCOPE

- It can be used further in Shipping Industry where a single person is continuously involved in Welding for providing continuous cooled air.
- It can be applied in forgings industry where environment is very hot.

VI. MEASUREMENT & CALCULATIONS:-

Sr no.	Pressure range (bar)	Inlet temp (°c)	Hot end temp (°c)	Cold end temp (°c)	Temp difference	Velocity (m/s)
1	8-7	33	41	26	15	14.7
2	7-6	33	39	29	10	14.0
3	6-5	33	38	28	10	13.8
4	5-4	33	36	29	7	12.9
5	4-3	33	35	28	7	12.8

Sr no.	Pressure range(bar)	Cold end Temp diff (▲T)	Hot end Temp diff (▲t)	Cooling effect (kW)	Heating effect (kW)
1	8-7	15	8	7.56x10^(-3)	4.03x10^(-3)
2	7-6	10	6	5.04x10^(-3)	3.02x10^(-3)
3	6-5	10	5	5.04x10^(-3)	2.52x10^(-3)
4	5-4	7	3	3.52x10^(-3)	1.51x10^(-3)
5	4-3	7	2	3.52x10^(-3)	1.00x10^(-3)

VII. CALCULATIONS

Pressure Range = (8-7 bar)
Temperature Difference (ΔT) = 15 °C
Area = (π/4) x D^2
= (π/4) x 0.006^2
= 2.83 x 1O"(-5)m^2
T(atm) = T(inlet) = 33 °C
Velocity = 14.7 m/s
Discharge (q) = A X V
= [2.83 x 10^(-5)m^2] X 14.7
= 4.156 x 10^(-4) (m^3)/s
Mass Flow Rate (m) = q x p
= [4.156 x 10^(-4)] x 1.207
= 5.0167 X 10^(-4) kg/S
Cooling Effect (q) = m x Cp x ΔT
= 5.0167 x 10^(-4) x 1.005 X15
= 7.56 X l0^(-3) kW.

Time (t) = 5 min
= 300 sec.
Heating Effect (Q) = m x Cp x Δt
= 5.0167 x 10^(-4) x 1.005 x 8
= 4.033 x l0^(-3) kW.

VIII. RESULT & DISCUSSION

The atmospheric air is enters in AHU through damper with atmospheric temperature and velocity then it enters in AHU cabinet through the prefilter which reduced the velocity but temperature is constant, then the same air is pass over the evaporating coil which result in heat transfer with temperature and velocity drop. From figure 3 and figure 4 the results shows that Form experimental measurement of temperature and velocity of design AHU at different location Figure 3 Temperature variation with respective damper opening at different location

Figure 3 Velocity variation with respective damper opening at different location

IX. CONCLUSION

A simple model of the vortex tube is describe that captures the physics related to onepossible operating mechanism. The model is shown to faithfully reproduce a limitedset of data if two empirical parameters are adjusted. The semiemperical model is subsequently used to evaluate the potential performance benefit associated with replacing the throttling valve in a refrigeration system with an appropriately optimized vortex tube. An experimental study on the temperature separation in the vortex tube has been carried out and this research finding can be summarized as follows:

1) Temperature difference increases with increase in inlet pressure.
2) Availability destruction decreases with increase in tube length due to the increase intemperature difference. -
3) Efficient working point of the existing design is at a cold mass fraction 0.84 for aninlet pressure of 5bar.
4) Availability destruction is less in the case of vortex tube operation with two nozzlesthan with one nozzle due to the increase in temperature difference.
5) The increase of the number of inlet nozzles led to higher temperature separation in thevortex tube.
6) Using the tube with insulation to reduce energy loss to surroundings gave a highertemperature separation in the tube than that without insulation around 2-3 0C for thecold tube and 2-5 0C for the hot tube.
7) A small cold orifice (d/D=0.4) yielded higher backpressure while n large cold orifice(d/D=0.7, 0.8, 0.9) allowed high tangential velocities into the cold tube, resultingin lower thermal energy separation in the tube.
8) The performance of a conventional vapor compression refrigeration cycle cannot beaugmented through the application of a vortex tube because no temperature separationcan occur beneath the vapor dome.
9) The performance of a vapor compression cycle operating in the near super-criticalregion such as a carbon dioxide refrigeration cycle, is negligibly increased by theapplication of a vortex tube.

REFRENCES

[1] SarathSasi "Experimental Investigation of Vortex Tube Refrigeration" International Journal of Emerging Engineering Research and Technology Volume 2, Issue 6, September 2014, PP 176-186
[2] Chetan D Bhimate, "An Experimental Modeling andInvestigation of Change in Working Parameters on the Performanceof Vortex Tube"International Journal of Advanced MechanicalEngineering .ISSN 2250-3234 Volume 4, Number 3 (2014), pp. 343-34
[3] Ch.NaveenkumarFabrication and Experimental Analysis of a Vortex Tube Refrigeration system October 2016 | IJIRT | Volume 3 Issue 5 | ISSN: 2349-6002
[4] International Journal of Mechanical Engineering and Technology (IJMET)Volume 6, Issue 7, Jul 2015, pp. 99-104, Article ID: IJMET_06_07_011

