Optimizing the Cooling System for Compressor

Manivel R* and Prasanna S.C
Department of Mechanical Engineering, M. Kumarasamy college of Engineering, Karur, India.
***Corresponding author: E-Mail: manivelrajj@gmail.com**

ABSTRACT

In recent times, researcher had done lot of study in heat exchanger performance improvement for different systems. It is found that the heat exchanger performance primarily depends on fin configuration, fin pitch and size, distributor configuration of heat exchangers. The idea behind in this paper is to optimizing the cooling system for compressor, in this research work going to improve the performance of the compressor by considering the different climatic areas temperature, compressor pin size, shape and varying different parameters.

KEY WORDS: Ambient conditions, Heat load, Heat exchanger design, Heat transfer and heat transfer coefficient.

1. INTRODUCTION

Compressor is a device that converts input power (from Electrical motor or engines) to pressure energy. In compressors, > 90 % of input power is converted to heat. This heat is carried away by lubricating oil and compressed air. The Temperature of oil and air is controlled by heat exchanger. Generally air or water is used as cooling medium in heat exchanger to cool the hot oil and compressed air.

The heat exchanger should be designed to keep the temperature of air and oil within a range for optimum performance of compressor and the range varies with change in ambient conditions.

In compressor, the heat generated during compression process is carried away by lubricating oil and compressed air. The cooling system design is the important system which determines the compressor overall performance. The cooling system consists of; Heat exchanger, Plenum box (Shroud), Fan.

Literature Survey: Literature details collected to understand the how heat exchanger performance are influenced by various parameters and methods followed to predict/improve the heat exchanger performance.

Literature survey indicates that, the heat exchanger performance influenced by; Ambient conditions, Inlet flow losses, Heat exchanger geometry, Orientation of heat exchanger with respect to fan, and Distance between fan and plenum.

Cooling System Design:

Heat Exchanger: The temperature of oil and air is controlled by heat exchanger for critical working of the compressor. In heat exchangers design, the calculation of total heat transfer rate Q is important. The heat transfer rate is given by,

$Q = U. A. LMTD$

Where, U - Overall Heat transfer co-efficient ($W/(m^2.K)$), A - Heat transferring area (m^2),

LMTD - Logarithmic mean temperature difference between the hot and cold fluids.

Cooling System function: The cooling has two functions; Cooling the compressed air, Cooling the lubricating oil.

The oil cooler and air cooler are independent of each other, but cooled by the air flow of a common fan in air cooled compressors. The fan is driven by an independent electric motor.

Cooling System Design Configuration: Two types of cooling system configuration are available. The choice of cooling system depends on design layout and compactness; Forced Draft Cooling system, Induced draft cooling system.

Forced Draft cooling system: Air is forced towards the cooler. The fans are installed in the cooler inlet stream. The air flow is not uniform through the heat exchanger and the escape velocity from the heat exchanger top is low which leads to hot air recirculation.

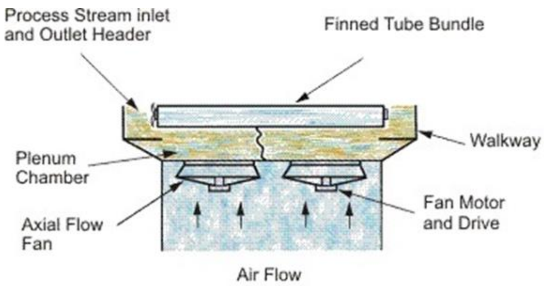

Figure.1. Forced Draft cooling system

Induced Draft cooling system: In induced draft cooling system, air is pulled through the cooler. The fans are installed above the cooler. The air flow is uniform through the heat exchanger because of high escape velocity from the heat exchanger.

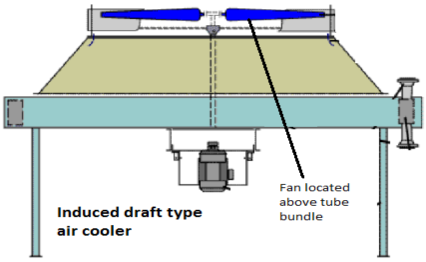

Figure.2. Induced Draft cooling system

Climatic Conditions Study:

Table.1. Ambient Temperature and Relative humidity Study

Place	RH %	Amb. Temp ^{0}C	Pressure Dew point Temperature ^{0}C			
			7 bar	8.5 bar	10.5 bar	12 bar
Delhi	73	34	67	72	76	80
	25	41	52	56	60	64
Ahemadabad	76	32	65	70	74	78
	52	40	66	71	76	80
Jaipur	70	32	63	68	72	76
	36	39	57	62	66	70
Gwalior	76	34	68	73	77	81
	40	42	63	68	72	76
Kolkata	85	32	68	73	77	81
	71	35	67	72	77	81
Hyderabad	79	28	61	66	70	73
	47	37	61	65	70	73
Chennai	80	28	61	66	70	74
	64	32	61	66	70	74
Trichy	82	30	64	69	73	77
	63	37	67	72	77	80
Mumbai	86	31	67	72	76	80
	69	32	63	68	72	76
Rajasthan	69	32	63	68	72	76
	31	42	57	62	66	70

Pressure Dew Point Mapping: Pressure dew point for different operating pressure is mapped to arrive design point. To arrive the design point for wide range of ambient conditions, the difference between ambient and pressure dew point temperature is found and tabulated.

Table.2. Pressure Dew Point Mapping

Pressure Dew point Temperature - (Amb+ x) ^{0}C				
Place	7 bar	8.5 bar	10.5 bar	12 bar
Delhi	33	38	42	46
	11	15	19	23
Ahemadabad	33	38	42	46
	26	31	36	40
Jaipur	31	36	40	44
	18	23	27	31
Gwalior	34	39	43	47
	21	26	30	34
Kolkata	36	41	45	49
	32	37	42	46
Hyderabad	33	38	42	45
	24	28	33	36
Chennai	33	38	42	46
	29	34	38	42
Trichy	34	39	43	47
	30	35	40	43

Mumbai	36	41	45	49
	31	36	40	44
Rajasthan	31	36	40	44
	15	20	24	28

Heat Exchanger Design: Two heat exchanger fin configuration are taken for design consideration. One is rectangular fin and other one is with offset fin.

Geometric Parameters of Heat Exchanger: The geometric parameters for rectangular and offset fin are considered as below.

Table.3. Geometric parameters for rectangular and offset fin

S.No	Parameter	Rectangular fin		Offset fin		Unit
		Air Cooler	Oil Cooler	Air Cooler	Oil Cooler	
1	Heat Transfer	1.9	10.3	2.24	19.2	Kw
2	Pressure drop	1604	848	1656	5332	pa

Table.4. Geometric Parameters of Heat Exchanger Oil and Air Cooler

S.No	Parameter	Oil cooler		Air Cooler		Unit
		Hot side	Cold side	Hot side	Cold side	
1	Mass flow rate	0.5	0.65	0.2	0.15	Kg / sec
2	Density of fluid	835.5	1.066	8.067	1.066	Kg / m3
3	Viscosity	0.011056	0.00002	0.00002085	0.00002	N.s / m2
4	Prandl number	136	0.692	0.692	0.692	
5	Specific heat capacity	1634	1006	1007	1006	J / kg.K
6	Thermal conductivity of medium	0.137	0.05	0.05	0.05	W / m2 K
7	Thermal conductivity of fin material	192	192	192	192	W / m2 K
8	Inlet temperature of fluid	100	45	100	45	°C

Heat Exchanger Design Analysis: The heat exchanger design to be analyzed using ANSYS Fluent software.3D model for air cooler and Oil cooler are created using SOLID WORKS software for both Rectangular and offset fin configuration.

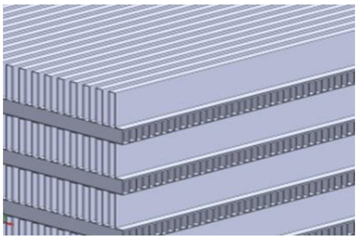

Figure.3. Rectangular Fin Design

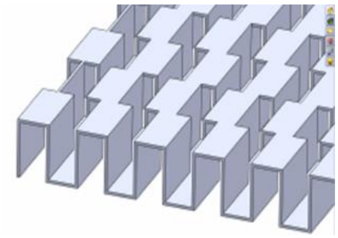

Figure.4. Offset Fin Design

4. CONCLUSION

To conclude on this study, performance analysis of a compressor cooling system has been carried out at different ambient temperatures with different shape, size and parameters. This paper has established that new approaches for material selection, at the foundation of a new concept, can be accomplished with minimal expertise. This approach can lead the engineer through the viability of innovating on the choice of new material for compressor. The heat exchanger design to be analyzed using ANSYS Fluent software 3D model for air cooler and Oil cooler are created using Solid works software for both Rectangular and offset fin configuration also done for compressor.

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