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Performance Analysis of Single-Stage Reciprocating Air Compressor with Passive Cooling System–Review

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ABSTRACT

Reducing the work requirement in any device is incredibly challenging today. Optimized work input without appreciable loss in output is somewhat challenging.A Passive cooling method is committed no additional power is required for cooling the substances which adds a bonus to be employed in the work reduction process. Reducing the temperature of inlet air in an air compressor will reduce the work required by the compressor. A replacement passive cooling device has been designed and fabricated for temperature reduction of inlet air in an exceedingly reciprocating air compressor that is not affecting outlet pressure. To design and fabricate a passive cooling device for work done reduction in reciprocating air compressor without affecting outlet pressure and to minimize the work done required by air compressor, without any additional power input. The overall efficiency of the system increases from 60 to 85% while the work done is reduced gradually on the other hand.

KEYWORDS: Air Compressor, Ethylene Glycol, Heat transfer, Thermosyphon Loop,
Passive Cooling System and Copper Tubes

I. AIR COMPRESSOR

Conventional heat transfer fluids such as water, ethylene glycol, and thermal fluids, are widely used in various industrial applications including refrigeration and air-conditioning, transportation, solar thermal, and microelectronics. However, the limitations in the performance of these heat transfer fluids necessitate new methods for further enhancing the thermal transport properties to improve the system's energy efficiency. It is known that the suspension of micro solid particles in the base fluid gives great potential for enhanced heat transfer. Thus, the size of the particles in the suspension leads to precipitation, abrasion, and clogging in the flow path of the fluid. The fascinating advancement in nanotechnology has introduced an innovative kind of heat transfer fluid called a nanofluid with suspended particles of less than 100nm.

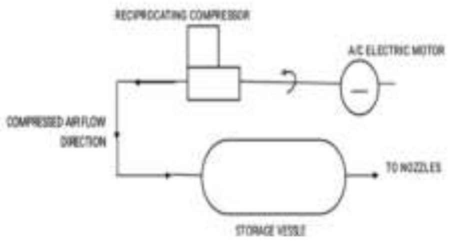

Figure 1.1 Working principle of the reciprocating compressor (Block Diagram)

Nanoparticles can be either Nanopowders, such as Al, Cu, Sic, and CuO, or carbon nanotubes. In the production of electricity in thermal power stations, steam turbines with operating temperatures of up to 600℃ and gas turbines with operating temperatures of up to 1500℃ are used. These prototypes of high-temperature steam turbines with working steam temperatures of 800-900C appeared not long ago.

Effective thermal management has become more and more important. This is because nowadays the electrical energy consumption of data centers represents 1.1~1.5% of the world's total electricity consumption. Besides, traditional cooling systems of the data center consume nearly 50% of the total energy. Moreover, according to industry predictions, the data center's annual power demand can reach up to 20%. In this regard, recent research focused on implementing new efficient cooling techniques that might help minimize electrical power usage and minimize the costs spent on thermal energy management. A reciprocating compressor is a positive-displacement air compressor that converts power into potential energy stored as compressed air using electric motors, diesel, or gasoline engines, among others as its prime-mover. It uses a piston driven by a crankshaft to deliver fluid (gases or air) at high pressure. The intake atmospheric air enters through the suction valve, then flows into the compression chamber where it is compressed by a piston driven in a reciprocating motion using a crankshaft. The compressed air is then held in the tank until it is required.

During the delivery process, the compressed air that was held in the tank is then discharged at high pressure through a discharge valve, therefore depressurizing the tank. It is essential to emphasize that the main function of a compressor is to take a definite quantity of fluid (typically gas, and most often air) and deliver it at a required pressure Salem (2005) and Rajput (2015).

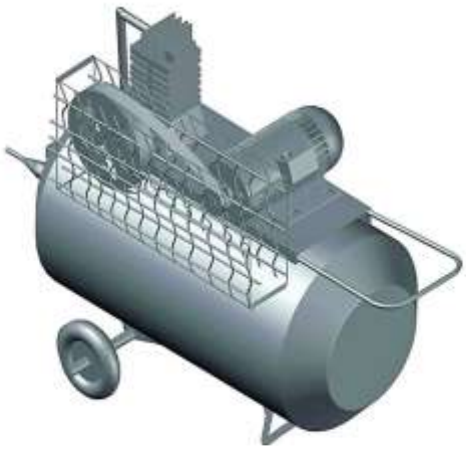

Figure 1.2 3D Model of the single-acting reciprocating compressor

The compressed air contains energy that can be employed for a variety of applications such as operating tools in factories, operating drills and hammers in road building, excavating, inflating tires, drying, and spray painting among others by utilizing the kinetic energy of the air as it is released, and the tank depressurizes. Reciprocating air compressors can be classified into single-acting and double-acting reciprocating air compressors. This paper focuses on the single-acting reciprocating compressor where the air that is compressed in the cylinder is on one side of the piston only. Figure 1.2 shows the AutoCAD 3D Model of the single-acting reciprocating compressor with a handle and belt guard used in this study.

COMPONENTS OF AIR COMPRESSOR

AIR FILTER

Air intake filters are installed in an air compressor to remove any dust or debris the compress may suck in. Dust will cause wear to the compressor element,
valves, filters, compressor oil, and any moving parts. Air compressor filters, also called airline filters, are used in condensed airlines to stop liquids and solid contaminants from entering air compressors. They stop these contaminants from entering the equipment and causing damage.

A cubic foot of compressed air may harbor millions of dirt particles, in addition to significant amounts of oil and water. Depending on the application, the compressed air might even contain lead, mercury, or other heavy metals. An air filter is usually made of a spun fiberglass material or from pleated paper or cloth enclosed in a cardboard frame. Its basic function is to clean the air that circulates through your heating and cooling system. Filters trap and hold many types of particulates and contaminants that could affect your health and comfort, including:

1. Dust and dirt
2. Pollen
3. Mould and mold spores
4. Fibres and lint
5. Metal, plaster, or wood particles
6. Hair and animal fur
7. Bacteria and microorganisms

Inlet pipe

1. The air compressor intake or inlet is where air enters the filter. There is an internal cap that forces air down into a spiral.
2. It’s important to get the right size inlet rather than using a filter smaller than the line.

Filter cap

1. This component directs airflow through the filter.
2. You can tell the direction of the air by the arrow on the outside of the filter, which also prevents you from installing it backward.

Airpath

1. This is the air actual path as it spins like a cyclone and passes through the air filter itself.

Filter discharge

1. This orifice allows air to leave the filter, and it should match the inlet size.
2. If the filter discharge is too small, it will restrict the flow of air.

Filter element

1. The filter itself is what takes contaminants out of the air, catching particulates over time.

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Eventually, filters become clogged and must be cleaned or replaced.

Filter bowl

1. The bowl is the biggest part of the filter that you can see.
2. It is connected to the cap and is threaded or twisted and locked into place.

Filter quiet zone

1. The contaminants, water, and oil collected by the filter all end up in the quiet zone at the bottom of the filter.
2. You will usually find a barrier hanging from the filter bottom, preventing debris from being reintroduced into the air.

Drain

1. Collected contaminants and debris must be drained.
2. Many filters must be drained manually, but others have float-operated or electric auto drains.

EXPERIMENTAL SETUP AND PROCEDURE

Copper Tube

Copper tubing is most often used for heating systems and as a refrigerant line in HVACs systems. Copper tubing is slowly being replaced by tubing in hot and cold-water applications. There are two basic types of copper tubing, soft copper, and rigid copper. Copper tubing is joined using flare connection, compression connection, pressed connection, or solder.

Copper offers a high level of corrosion resistance but is becoming very costly. Copper tube is one of the components that are needed in air conditioning and refrigerant system. The tube is used as a path for the refrigerant to flow between system components and to contain it from escaping into the atmosphere. Sizing, installation layout, and fittings must be done properly to efficiently run the system. During installation, it is of utmost importance that moisture, dirt, and other contaminants are prevented from entering the system. These foreign particles will affect the performance of the system and may even cause damage to some of the components.

Types of Copper Tubes

1. Soft copper
2. Rigid copper

SOFT COPPER

Soft (or ductile) copper tubing can be bent easily to travel around obstacles in the path of the tubing. While the work hardening of the drawing process used to size the tubing makes the copper hard or rigid, it is carefully annealed to make it soft again; it is, therefore, more expensive to produce than non-annealed, rigid copper tubing. It can be joined by any of the three methods used for rigid copper, and it is the only type of copper tubing suitable for flare connections. Soft copper is the most popular choice for refrigerant lines in split-system air conditioners and heat pumps.

RIGID COPPER

Rigid copper is a popular choice for water lines. Rigid or "Hard" copper tubing is generally referred to as "pipe". Copper "piping" is referred to by nominal pipe size or the inner diameter.

It is joined using a solder/sweat, roll grooved, compression or crimped/pressed connection. Rigid copper, rigid due to the work hardening of the drawing process, cannot be bent and must use elbow fittings to go around corners or obstacles. If heated and allowed to cool in a process called annealing, rigid copper will become soft and can be bent/formed without cracking. Figure 3.8 illustrates the copper tube studied in this work. As can be seen, the length of the hot air section is Lh=¼ 4D, the length of the cold air section is Lc= ¼ 0.5D, and the diameter D was set at 24 mm.The investigation included three types of nozzles, in which the cold section diameter, dc/D, and z, which represent the groove depth for the different nozzle sizes, were varied. The design of the vortex tube is aimed at the reduction of the temperature at the compressor’s air inlet by operating in combination with the evaporator, as seen in Fig. 3.8, in which the exchange of the temperature of the air in the compressor with the cold air being released by the Vortex tube occurs.

Figure 3.5 Copper Tubes

The evaporator was constructed with 36 runs of 8-mm diameter coiled aluminium tubes having 128 fins. As a result, this research includes three sections: optimization of the cold-mass fraction for the various nozzle sizes, identification of the temperature changes caused by the vortex tube, and calculation of the system’s energy-based gains.

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DIFFERENCE BETWEEN RIGID AND SOFT COPPER

Soft copper It can be joined by any of the three methods used for rigid copper, and it is the only type of copper tubing suitable for flare connections. Soft copper is the most popular choice for refrigerant lines in split-system air conditioners and heat pumps.

Subsequently, question is, what are the different grades of copper pipe? CopperPipe Types Manufacturers provide copper pipe in four standardized types: K, L, M and DWV. The letters indicate, in part, the relative thickness of the pipe wall from thickest to thinnest. The actual wall thickness depends on the size of the pipe.

When to use Type L and Type M copper pipe sizes but for normal "in the wall" household plumbing, Type M copper pipe is just fine. The difference is the wall thickness of the copper pipe sizes and therefore the pressure it can handle. The exterior dimensions are identical, meaning you use the same copper fittings. Soldering and brazing, used in combination with capillary fittings, is the most common method of joining hard copper. Welding is also used, though it is far less common. "Soft" copper can also be joined by soldering or brazing and is also connected using flare-type or compression fittings.

Copper tubing also comes in three principal commercial wall thickness types, K, L and M, going from thicker, to medium to thinnest walls. More on this below. Copper has a characteristic known as "work-hardening". Forming, hammering, or working in any form tends to change the structure to a more rigid form. Copper is softened or "annealed" to its soft form by heating it above a critical temperature and allowing it to cool to ambient temperature more slowly. Copper tubing is formed by a form if extrusion dies, and it starts out as soft-temper copper. The process produces a tubing that will maintain rigidity and span greater distances than soft temper. Bending in its rigid form without kinking, takes special tools such as a pipe bender or a proprietary bend maker such as a Curve tool system.

WORK DONE BY AIR COMPRESSOR

Workdone(w)=$\boldsymbol{\frac{n}{n-1} mRT_1 \left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right]}$

…eqn.1 (1.1)

- P_1-Inlet air pressure(N/m^2)
- P_2-Outlet air pressure(N/m^2)
- m-mass of air compared (kg)
- R-Gas constant (J/kg. K)
- T_1-Inlet air temperature(K)
- n-Polytrophic index

Inlet temperature directly affects the work done by the compressor. It is directly proportional to work done, which means reducing the inlet temperature will reduce the work required by the compressor theoretically.

CALCULATION FOR COMPRESSION INPUT PARAMETERS

Inlet temperature T_1 = 30℃
Mass of air (m) = 1 kg
Polytrophic index (n) = 1.2
Inlet air pressure (p_1) = 1×10^5 (N/m^2)
Outlet air pressure (p_2) = 5×10^5(N/m^2)
Gas constant (R) = 287 J/Kg. K

FORMULAE

Workdone(W)=$\frac{n}{n-1} mRT_1 \left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right]$

…eqn. (1.2)

SOLUTION

1. Inlet temperature of air T_1=29℃

W=$\frac{1.25}{1.25-1} 1 \times 287 \times 302 \left[\left(\frac{5}{1}\right)^{\frac{1.25-1}{1.25}} - 1\right]$

…eqn. (1.3)

W = 164.56×10^3 J

2. Inlet temperature of air T_1=28℃

W=$\frac{1.25}{1.25-1} 1 \times 287 \times 303 \left[\left(\frac{5}{1}\right)^{\frac{1.25-1}{1.25}} - 1\right]$

…eqn. (1.4)

W = 164×10^3 J

ADVANTAGES

- The experimental results indicate that energy-saving increases with the rise of the filling ratio.
- At a low filling ratio like 10%, the evaporator starves for refrigerant, and a very uneven air temperature distribution occurs at the exit of the data rack
- A lower overall thermal resistance occurs at high filling ratios and a higher ambient temperature.

DISADVANTAGES

- The appreciable increase in overall thermal resistance is encountered at low filling ratios due to the starvation of working fluid.
- The effect of ambient temperature on the overall thermal resistance is negligible at high filling ratios

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EXPERIMENTAL SETUP

Figure 3.7 Experimental Setup

POLYTROPIC WORK DONE (UNDER ROOM TEMPERATURE)

1. Inlet temperature of air T_1=29°C

$$W = \frac{1.25}{1.25-1} 1 \times 287 \times 302 \left[\left(\frac{5}{1}\right)^{\frac{1.25-1}{1.25}} - 1\right] \quad \text{...eqn. (3.1)}$$

W = 164.56×10³ J

2. Inlet temperature of air T_1=28°C

$$W= \frac{1.25}{1.25-1} 1 \times 287 \times 303 \left[\left(\frac{5}{1}\right)^{\frac{1.25-1}{1.25}} - 1\right] \quad \text{...eqn. (3.2)}$$

W = 164×10³ J

3. Inlet temperature of air T_1=27°C

$$W= \frac{1.25}{1.25-1} 1 \times 287 \times 304 \left[\left(\frac{5}{1}\right)^{\frac{1.25-1}{1.25}} - 1\right] \quad \text{...eqn. (3.3)}$$

W = 163.639×10³ J

4. Inlet temperature of air T_1=26°C

$$W= \frac{1.25}{1.25-1} 1 \times 287 \times 305 \left[\left(\frac{5}{1}\right)^{\frac{1.25-1}{1.25}} - 1\right] \quad \text{...eqn. (3.4)}$$

W = 161.555×10³ J

5. Inlet temperature of air T_1=25°C

$$W= \frac{1.25}{1.25-1} 1 \times 287 \times 306 \left[\left(\frac{5}{1}\right)^{\frac{1.25-1}{1.25}} - 1\right] \quad \text{...eqn. (3.5)}$$

W = 160×10³ J

Table 3.1 Tabulation of Polytropic Work done

S.NO	m	R	T_2	P_1	P_2	n	n/n-1(mRT_2)	n-1/n	$P_2/P_1^{(n-1/n)-1}$	Polytropic Work done
1	0.0042	0.287	303	100	500	1.2	2.18	0.166666667	0.307660486	0.670686546
2	0.0042	0.287	301	100	500	1.2	2.17	0.166666667	0.307660486	0.666259572
3	0.0042	0.287	299	100	500	1.2	2.15	0.166666667	0.307660486	0.661832598
4	0.0042	0.287	297	100	500	1.2	2.14	0.166666667	0.307660486	0.657405624
5	0.0042	0.287	295	100	500	1.2	2.12	0.166666667	0.307660486	0.65297865
6	0.0042	0.287	293	100	500	1.2	2.11	0.166666667	0.307660486	0.648551676
7	0.0042	0.287	291	100	500	1.2	2.09	0.166666667	0.307660486	0.644124702
8	0.0042	0.287	289	100	500	1.2	2.08	0.166666667	0.307660486	0.639697728

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9	0.0042	0.287	287	100	500	1.2	2.06	0.166666667	0.307660486	0.635270754
10	0.0042	0.287	285	100	500	1.2	2.05	0.166666667	0.307660486	0.630843781
11	0.0042	0.287	283	100	500	1.2	2.04	0.166666667	0.307660486	0.626416807
12	0.0042	0.287	281	100	500	1.2	2.02	0.166666667	0.307660486	0.621989833
13	0.0042	0.287	279	100	500	1.2	2.01	0.166666667	0.307660486	0.617562859
14	0.0042	0.287	277	100	500	1.2	1.99	0.166666667	0.307660486	0.613135885
15	0.0042	0.287	275	100	500	1.2	1.98	0.166666667	0.307660486	0.608708911

ISOTROPIC WORK DONE (UNDER ROOM TEMPERATURE)

1. Inlet temperature of air, T_1=29°C

W= $mRT_1 \ ln\left[\left(\frac{P_2}{P_1}\right)\right]$

W = $1 \times 287 \times 302 \times ln\left[\left(\frac{5}{1}\right)\right]$ **…eqn. (3.8)**

W = 139.496×10^3 J

2. Inlet temperature of air, T_1=28°C

W = $mRT_1 \ ln\left[\left(\frac{P_2}{P_1}\right)\right]$

W= $1 \times 287 \times 303\left[\left(\frac{5}{1}\right)\right]$ **…eqn. (3.7)**

W = 138.882×10^3 J

3. Inlet temperature of air, T_1=27°C

W= $mRT_1 \ ln\left[\left(\frac{P_2}{P_1}\right)\right]$

W= $1 \times 287 \times 304\left[\left(\frac{5}{1}\right)\right]$ **…eqn. (3.8)**

W = 136.432×10^3 J

4. Inlet temperature of air, T_1=26°C

W= $mRT_1 \ ln\left[\left(\frac{P_2}{P_1}\right)\right]$

W= $1 \times 287 \times 305\left[\left(\frac{5}{1}\right)\right]$ **…eqn. (3.9)**

W = 135.1×10^3 J

5. Inlet temperature of air, T_1=25°C

W= $1 \times 287 \times 306\left[\left(\frac{5}{1}\right)\right]$ **…eqn. (3.10)**

W = 133.333×10^3 J

Table 3.2 Tabulation of Isotropic Work done

S.NO	m	R	T_2	P_1	P_2	mRT_2	P_2/P_1	$\ln(P_2/P_1)$	Isothermal Work done
1	0.0042	0.287	303	100	500	0.3633	5	1.6094	0.58475083
2	0.0042	0.287	301	100	500	0.3609	5	1.6094	0.58089109
3	0.0042	0.287	299	100	500	0.3585	5	1.6094	0.57703135
4	0.0042	0.287	297	100	500	0.3561	5	1.6094	0.57317161
5	0.0042	0.287	295	100	500	0.3537	5	1.6094	0.56931187
6	0.0042	0.287	293	100	500	0.3513	5	1.6094	0.56545213
7	0.0042	0.287	291	100	500	0.3489	5	1.6094	0.56159238
8	0.0042	0.287	289	100	500	0.3465	5	1.6094	0.55773264
9	0.0042	0.287	287	100	500	0.3441	5	1.6094	0.5538729
10	0.0042	0.287	285	100	500	0.3417	5	1.6094	0.55001316
11	0.0042	0.287	283	100	500	0.3393	5	1.6094	0.54615342
12	0.0042	0.287	281	100	500	0.3369	5	1.6094	0.54229368
13	0.0042	0.287	279	100	500	0.3345	5	1.6094	0.53843394
14	0.0042	0.287	277	100	500	0.3321	5	1.6094	0.53457419
15	0.0042	0.287	275	100	500	0.3298	5	1.6094	0.53071445

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ADIABATIC WORK DONE (UNDER ROOM TEMPERATURE)

1. Inlet temperature of air, T_1=29°C

$$W=\frac{\gamma}{\gamma-1}mRT_1\left[\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}-1\right]$$

$$W=3.5\times1\times287\times302\left[\left(\frac{5}{1}\right)^{3.5}-1\right] \quad \text{...eqn. (3.11)}$$

$\mathbf{W = 81.838\times10^3 J}$

2. Inlet temperature of air, T_1=28°C

$$W=\frac{\gamma}{\gamma-1}mRT_1\left[\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}-1\right] \quad \text{...eqn. (3.12)}$$

$$W=1\times287\times303\left[\left(\frac{5}{1}\right)\right]$$

$\mathbf{W = 80.109\times10^3 J}$

3. Inlet temperature of air, T_1=27°C

$$W=\frac{\gamma}{\gamma-1}mRT_1\left[\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}-1\right] \quad \text{...eqn. (3.13)}$$

$$W=1\times287\times304\left[\left(\frac{5}{1}\right)\right]$$

$\mathbf{W = 78.978\times10^3}$

4. Inlet temperature of air, T_1=26°C

$$W=1\times287\times305\left[\left(\frac{5}{1}\right)\right] \quad \text{...eqn. (3.14)}$$

$\mathbf{W = 75.872\times10^3}$

5. Inlet temperature of air, T_1=25°C

$$W=1\times287\times306\left[\left(\frac{5}{1}\right)\right] \quad \text{...eqn. (3.15)}$$

$\mathbf{W = 72.918\times10^3}$

Table 3.3 Tabulation of Adiabatic Work done

S.NO	m	R	T_2	P_1	P_2	P_2/P_1	mRT_2	3.5*(mrt$_2$)	$\{(P_2/P_1)^{3.5-1}\}$	Adiabatic Work done
1	0.0042	0.287	303	100	500	5	0.3633	1.27164	0.58454808	0.7433356
2	0.0042	0.287	301	100	500	5	0.3609	1.26325	0.58454808	0.738429
3	0.0042	0.287	299	100	500	5	0.3585	1.25485	0.58454808	0.7335225
4	0.0042	0.287	297	100	500	5	0.3561	1.24646	0.58454808	0.728616
5	0.0042	0.287	295	100	500	5	0.3537	1.23807	0.58454808	0.7237095
6	0.0042	0.287	293	100	500	5	0.3513	1.22967	0.58454808	0.718803
7	0.0042	0.287	291	100	500	5	0.3489	1.22128	0.58454808	0.7138965
8	0.0042	0.287	289	100	500	5	0.3465	1.21289	0.58454808	0.70899
9	0.0042	0.287	287	100	500	5	0.3441	1.20449	0.58454808	0.7040835
10	0.0042	0.287	285	100	500	5	0.3417	1.1961	0.58454808	0.699177
11	0.0042	0.287	283	100	500	5	0.3393	1.1877	0.58454808	0.6942705
12	0.0042	0.287	281	100	500	5	0.3369	1.17931	0.58454808	0.689364
13	0.0042	0.287	279	100	500	5	0.3345	1.17092	0.58454808	0.6844575
14	0.0042	0.287	277	100	500	5	0.3321	1.16252	0.58454808	0.679551
15	0.0042	0.287	275	100	500	5	0.3298	1.15413	0.58454808	0.6746445

WORKDONE AT HIGH TEMPERATURE RATE

WORKDONE AT LOW TEMPERATURE RATE

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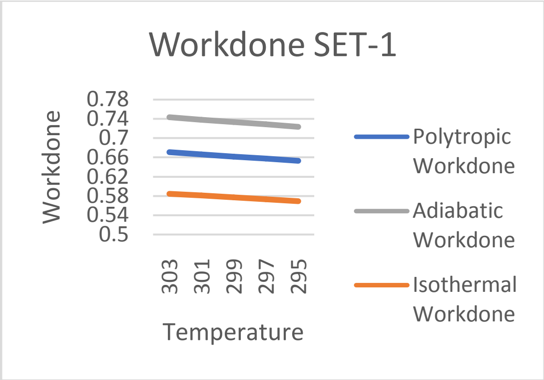
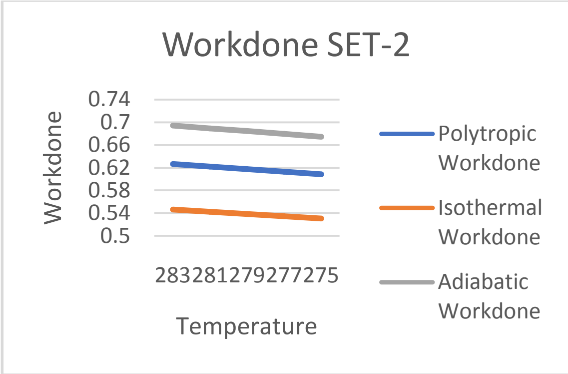
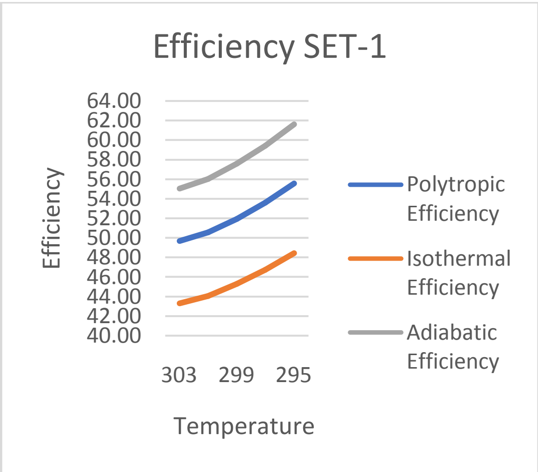
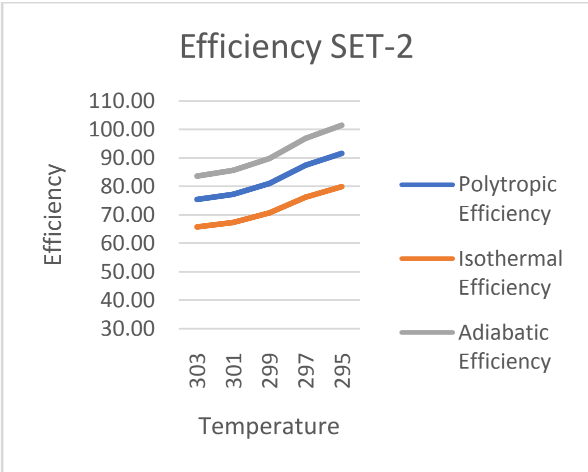




EFFICIENCY AT HIGH TEMPERATURE RATE (WITHOUT ETHYLENE GLYCOL)

EFFICIENCY AT LOW TEMPERATURE RATE (WITHOUT ETHYLENE GLYCOL)





POLYTROPIC EFFICIENCY(WITH ETHYLENE GLYCOL)

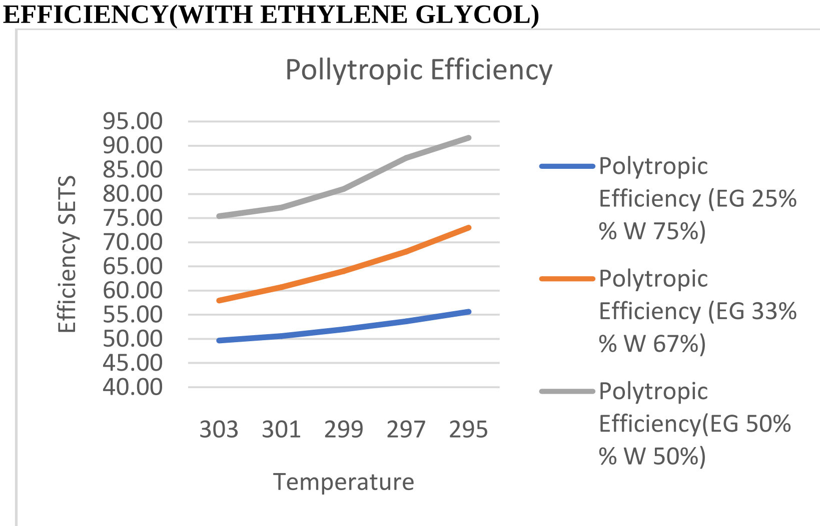


Figure 4.7 Polytropic Efficiency graph (with EG)

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ADIABATIC EFFICIENCY (WITH ETHYLENE GLYCOL)

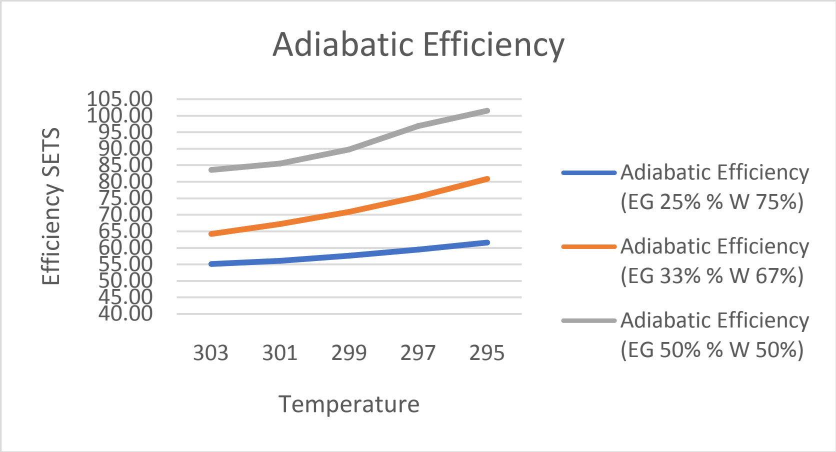

Figure 4.8 Adiabatic Efficiency graph (with EG)

ISOTHERMALEFFICIENCY (WITH ETHYLENE GLYCOL)

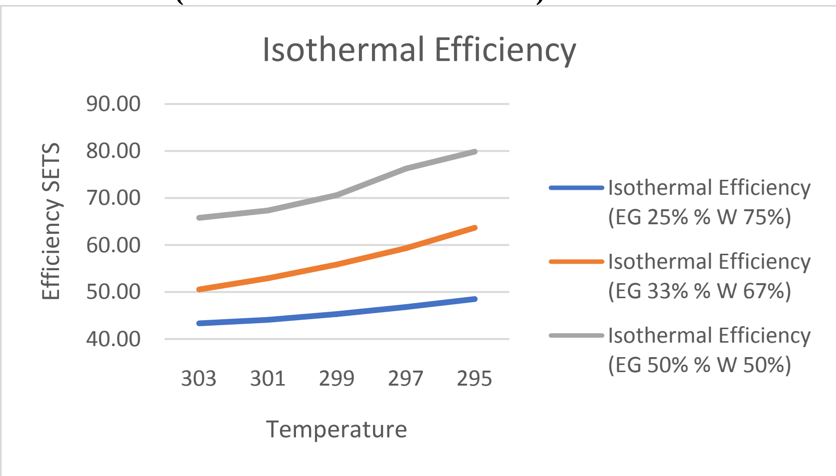

Figure 4.9 Isothermal Efficiency graph (with EG)

II. FINDINGS FROM PREVIOUS WORK

Ganta Vanya. et.al (2020) [1], Analyse the Reciprocating compressor is also known as positive displacement compressor and is used to deliver high pressure. Air enters from intake manifold and enters the cylinder, and it gets compressed by reciprocating motion of the piston then high-pressure air delivers from exhaust manifold.

Ekong Godwin I. et.al (2020) [2], Presents the application of thermodynamic concepts in the analysis of the performance of a Single acting Reciprocating Compressor. Reciprocating Compressor is a positive-displacement compressor with applications in automotive industries, gas pipeline processes, oil refinery industries, chemical and gas processing plants among others, hence it is essential to apply the thermodynamics concepts in the study of the specific physical quantities of temperature, energy, work, power, and heat transferred, for the overall improvement of the efficiencies of the system.

Ganta Vanya Sree. et.al (2020) [3], shows that the Reciprocating compressor is also known as positive displacement compressor and is used to deliver high pressure. Air enters from intake manifold and enters the cylinder, and it gets compressed by reciprocating motion of the piston then high-pressure air delivers from exhaust manifold. These are used for various manufacturing industries such as chemical plants, refrigeration plants.

V. Kumaresan et al. (2019) [4], aimed to measure and analyze the thermo-physical properties of water–ethylene glycol mixture-based CNT nanofluids experimentally at various temperatures. The measured density data show observable deviation from the predictions of the

Pak and Cho correlation, due to the spontaneous filling of water inside the carbon nanotubes in a confined way.

Alexander R et.al (2019) [5], Designs the scheme of closed two-phase thermosyphon was suggested that can pro5vide standard thermal operation of blades of a high-temperature steam turbine. The method for thermosyphon calculation is developed. The example of thermal calculation was implemented, it showed that to cool the steam turbine blades at their heating by high-temperature steam, the heat can be removed in the rear part of the blades by air with a temperature of about 440 deg C.

Karla Goncalves. et.al (2019) [6], Analyse the radiative cooling system applied to a typical Portuguese building was studied to minimize the electric consumption of a heat pump. The cooling system consists of an inertia tank which absorbs excess heat from the building and dissipates it using a thermal photovoltaic panel. This is a 24h working system, during the day absorbs the excess heat, at night-time the system forces the heat water to pass through the photovoltaic panel to cool down, using the radiative and convective natural effect.

Huseyin Kurtet.al (2018) [7], Developed an artificial neural network (ANN) model to predict the thermal conductivity of ethylene glycol–water solutions based on experimentally measured variables. The thermal conductivity of solutions at different concentrations and various temperatures was measured using the cylindrical cell method that physical properties of the solution are being determined fills the annular space between two concentric cylinders.

Shashank Gurnule. et.al (2018) [8], show the important the intercooling of air compressor is necessary for an efficient process. Basically, the meaning of air compression is to reduce a specified volume, resulting in an increase in pressure. For improving efficiency of the system, compression is done in more than one stage and intercooler is provided between each stage.

Aliakhnovich V.A et.al (2018) [9], showsthe simplest solutions to ensure the thermal control of a hermetic reciprocated refrigeration, or heat pumping compressor is related to the loop thermosyphon application. This paper presents experimental data obtained on two innovative loop thermosyphons - one with capillary structures and the second without them. These thermosyphons are prime candidates for small hermetic compressor cooling solutions to replace typical oil-cooled and air-cooled systems, where commercially available heat exchangers cannot be used due to the high power and transport length limitations.

Hafiz M. Daraghmeh et.al (2018) [10], Investigate the feasibility of using R-134a filled separated two-phase thermosyphon loop (STPTL) as a free cooling technique in datacenters. Two data center racks one of them attached with a fin and tube thermosyphon were cooled by the CRAC unit (computer room air conditioning unit) individually. Thermosyphon can help partially eliminate the compressor loading of the CRAC; thus, the energy-saving potential of the thermosyphon loop was investigated. The condenser is a water-cooled design and perfluoroalkoxy pipes were used as adiabatic riser/downcomer for easier installation and mobile capability. Tests were conducted with a filling ratio ranging from 0 to 90%.

Anan Tempiam et.al (2018) [11], Investigate to lower the temperature of the inlet air of a 7.5 kW piston air compressor was designed and tested. The vortex tube reduces the air temperature by acting as a cold air generator that exchanges the temperature within the evaporator. The first step of the research method started with the design of nozzles of three sizes to be used for the vortex tubes to identify the most effective nozzle size, followed by the conducting of experiments to determine the energy-saving procedures that can be applied to and affect the compressed air.

Marco Carrilho Diniz. et.al (2016) [12], representthe performance of reciprocating compressors is usually evaluated under steady-state operating conditions defined in standards. However, the compressor is submitted to quite different conditions in actual refrigeration systems, such as transients associated with the on/off cycling operation.

Luca Porreca et.al (2016) [13], Analyze air separation units (ASU) applications have suction at ambient conditions and deliver air to a pressure range between 5.6 ~ 6.5 bar. Therefore, the performance of the compressor is greatly affected by the seasonal variation of ambient conditions (winter/summer conditions). Since the compressor must be sized for the maximum volume flow i.e. in the “summer” conditions, it results that when the seasonal difference is significant (i.e. >15°C) casing, stages, as well as the cooler design, must be oversized.

Krishna Kumar Gupta et.al (2016) [14], representthe absence of refrigeration leads to an increase in temperature within the system which may lead to spoilage of products stored inside. Phase change materials may pose as a promising solution as they absorb the latent heat of the system at the expense of the phase change absorbing, latent heat. Due to its high latent heat content and negligible hazards, ethylene glycol is selected as the phase change material.

Thiago Antonini Alves et.al (2015) [15], Heat pipe and thermosyphon are passive heat transfer devices with phase change, which can be applied for thermal management of thermoelectric cooling, such as the TEC hot side. The heat pipes consist of a metal tube sealed with a capillary structure internally that is embedded with a working fluid. This capillary structure can be made of screen meshes, grooves, or sintered media.

Goehl Ketan Kumar Nathalie et.al (2014) [16], Analyze that there are many types of compressors with different working principles and working conditions. The function of all is to draw air from the atmosphere and produce higher pressure air for different applications.

Robert Fulton Dye et.al (2014) [17], shows theEthylene glycol (EG) or mono ethylene glycol (MEG), the addict of ethylene oxide (EO) and water, is the simplest glycol. It is the first of a homologous series of three dihydroxy alcohols discussed in this article. The other two are diethylene and trim ethylene glycols (DEG, TEG). These glycols are composed solely of carbon, hydrogen, and oxygen. Although they have similar chemical properties, their applications vary mainly with physical properties such as viscosity, hygroscopicity, and boiling point.

Tang Bin. et.al (2013) [18], showsthe basic principle of stepless capacity control system for large reciprocating compressor, the thermal cycle was analysed. The equations for the process of suction, reverse flow, compression, discharge, and expansion of clearance gas were established.

V. Kumaresan et.al (2011) [19], aimed to measure and analyze the thermo-physical properties of water–ethylene glycol mixture-based CNT nanofluids experimentally at various temperatures. The measured density data show observable deviation from the predictions of the Pak and Cho correlation, due to the spontaneous filling of water inside the carbon nanotubes in a confined way.

Qiusheng Liu et.al (2011) [20], Analyze aclosed loop thermosyphon (CLT) has advantages of simple structure and reliability for transporting heat over long distances with a small decrease in temperature. It is considered a promising cooling device for power electronics onboard ships. In this research, CLT for cooling power electronics onboard the ship was developed, and the performance was experimentally examined using a CLT apparatus.

Walid Aniss Aissa. et.al (2010) [21], Tells us the Hydraulic Air Compressor (HAC) is a device which converts hydraulic energy to energy of compressed air. A better exploitation of this hydraulic resource is currently investigated. The aim of the current work is to analyse a low head open type HAC in terms of compression ratio and HAC efficiency. The results are both presented and discussed. Variation of the mean diameter of air bubbles in the downward flow in the downcomer is both determined and investigated. The losses in the whole system are classified, investigated and its impact on HAC is discussed.

Jiwon Yeo et.al (1999) [22], showswiththerapid development of semiconductor technology, more efficient cooling systems for electronic devices are needed. In this situation, in the present study, a loop thermosyphon type cooling system, which is composed mainly of a heating block, an evaporator, and an air-cooled condenser, is investigated experimentally to evaluate the cooling performance. According to these equations, p–V diagrams at various situations were simulated.

T. Hirai. et.al (1986) [23], representthe performance analysis and the internal pressure measurement of the oil injection free single screw compressor. The geometric shape of the single screw compressor and its theoretical performance with the slide valve have been analyzed. The internal pressure has been measured with piezo type pressure sensors, and the pressure-volume diagram has been obtained. The experimental results agree well with the theoretical predictions, and the volumetric and adiabatic efficiency can be estimated by this analysis.

M. Fujiwara. et.al. (1984) [24], Executes a computer model for calculating screw compressor performance is presented. Geometrical characteristics such as volume curve, sealing line length, discharge port area, etc. are studied. The volume curve is obtained from the sealing line shape, using the principle of virtual work. This procedure has the advantage of simplifying the numerical calculation of the volume curve. An analytical model of an oil-injected screw compressor is developed, based on the laws of thermodynamics for perfect gases.

Prakash Pandeya. el.at (1978) [25], shows the term "performance of a compressor" means different things to different people in the compressor industry in general. For instance, isothermal efficiency, adiabatic efficiency, mechanical efficiency, clearance volumetric efficiency, overall volumetric efficiency is some of the terms most used in the air and gas compressor industry [1]. In the refrigeration and air conditioning industry, some of the most common terms used to indicate the compressor performance are coefficient of performance (COP), energy efficiency ratio (EER), performance factor, and relative efficiency, besides other less common terms such as compression efficiency, volumetric efficiency, and mechanical efficiency, etc. [2,3].

III. CONCLUSIONS

1. Experimental results obtained from this work show the appreciable work reduction in a reciprocating air compressor.
2. For the Ethylene glycol water mixture, the inlet air temperature is reduced appreciably.
3. Work required by the compressor is reduced with a high percentage of Ethylene glycol water mixture.
4. Passive cooling method used in this work reduced the compressor work appreciably.

REFERENCES

[1]. Ganta Vanya Sree, “Performance Analysis of Two stage reciprocating Air compressor”, International journal of Engineering and Technology (IRJET), Volume: - 07 Issue 03, March 2020.

[2]. Ekong Godwin I, “Performance Analysis of a Sinlge Acting Reciprocating Compressor using Thermodynamic Concept”, International Journal of Engineering Science Inoovation Conference, May 2020

[3]. Ganta Vanya Sree, “Performance Analysis of Single stage reciprocating Air compressor”, International journal of Engineering and Technology (IRJET), Volume: - 07 Issue 04, March 2020.

[4]. V. Kumaresan and R. Velraj, “Experimental Investigation of the Thermo- Physical Properties of Water- Ethylene Glycol Mixture Based CNT Nanofluid”, International Journal of Research of Thermo Chemical 545(2012)180-186 Issue 12, July 2019.

[5]. Alexander.R and Bogomolov, “Thermosyphon Method for Cooling the Rotor Blades of High-Temperature Steam Turbine”, EPJ Web of Conferences, March 2019.

[6]. Karla Goncalves, “Energy Performance Analysis on a Radiative Cooling Storage System”, central European Symposium on Thermophysics (ICEST), July,2019.

[7]. Huseyin kurtet, Muhammet kayoes, “Predication of Thermal Conductivity of Ethylene Glycol –Water Solution by Artificial Neural Networks”, International Journal Of Research of Applied Energy, 15-06-2018.

[8]. Shashank Granule, “Design, Modification and Analysis of Industrial air compressor”, Seventh Sense Research Group Conference, Dec,2018.

[9]. Aliakhnovich V.A. Kireichikd.G, Vasillievl. L. Konev.S, “Cooling System for Hermetic Compressor Based on The Loop Thermosyphon”, VIII Minsk International Seminar “Heat Pipes, Heat Pumps, Refrigerators, Power Sources”, Minsk, Belarus, September 12–15, 2018.

[10]. Hafiz M. Daraghmeh, Mohammedw .Sulaiman, Kai-Shing Yang, Chi-Chuwan wang, “Investigation Of Separated Two-Phase Thermosyphon Loop For Relieving The Air-Conditioning Loading in the data center”, International Journal Of Research In Thermosyphon 29 December 2018.

[11]. Anan Tempian, Pongsakormkachapong Kum, and PhandumgsakRattanadecha, RatthasakPrommas, “Experimental Investigation of Vortex for Reduction Air Inlet of a Reciprocating Air Compressor”, International Journal of Research In case of Studies in Thermosyphon 19(2020)100617, 11-08-2018.

[12]. Marco Carrilho Diniz, “Performance Analysis of a Reciprocating Compressor under Typical Transients of Refrigeration system”, International Compressor Engineering Conference, 2016.

[13]. Luca porreca. Wentaozhu, “Effect of Inlet Cooling on The Performance of Isothermal Air Compressor Used for ASU applications”, International Journal of Research in Effect of Inlet Cooling in Air Compressor 25 February 2016.

[14]. Krishnakumar Gupta, M. Ramachandran, “Effect of Ethylene Glycol as Phase Change Material in a Cold Storage Unit of Retention of Cooling”, International Journal of Research in Material Science of Engineering 377(2018)012190, 2016-08-2016.

[15]. Thiago Antonini Alves, Larissa Krambeck and Paulo H. Dias Dos Santos, “Heat Pipes and Thermosyphon for Thermal Management of Thermoelectric Cooling”, International Journal of Research in Heat Pipes Thermosyhon2015.

[16]. Gohel Ketan Kumar national, “A Review of Study of Air Compressor”,

International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 12 Dec. 2022, pp: 129-141 www.ijaem.net ISSN: 2395-5252

International Journal of Research in Air Compressor Volume 5, Issue 4, (ISSN-2349-5126), April 2014.

[17]. Robert Fultondye "Ethylene Glycol Technology", International Journal of Research in Mono Ethylene Glycol 18(5) 571-579(2014).

[18]. Tang Bin "Thermosyphon Method of Cooling of High-Temperature Steam Turbines", EPJ Web of Conferences 110, 01009, March 2011.

[19]. V.Kumaresan, R. Velraj, "Experimental Investigational of the Thermo-Syphon Properties Glycol Mixture Based Cnt nanofluid", International Journal of Research in Thermochemical 545 (2012) 1800-186, 2011.

[20]. Qiuheng Liu, Katsuya Fukud and PurwonoSutopo, "Experimental Study on Thermosyphon For Shipboard High – Power Electronics cooling system", International Journal of Research in Heat Transfer Engineering 35(11-12):1077-1083,2011.

[21]. Walid Aniss Aissa, "Performance Analysis of Low Head Hydraulic Air Compressor",Smart Grid and Renewable Conference,May 14th, 2010.

[22]. Jiwon yeo and SeiyayamashitaMizukihayashidaShigerukoyama, "A Loop Thermosyphon Type Cooling System for High Heat Flux", Journal of Electronics Cooling and Thermal Control, 128-137, July 1999.

[23]. Hirai, "Performance Analysis of Single screw Compressor", International Compressor Engineering Conference (paper 520), 1986.

[24]. Fajiwara, "Computer Modeling for Performance analysis of Rotary screw compressor", international compressor Engineering Conference, 1984.

[25]. Prakash Pandeva, "A Generalized Approach Towards Compressor Performance Analysis", International Compressor Engineering Conference, 1978.