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# Design and Development of Water Ejector Refrigeration System

***Dr. Pradip Patil[1], Mr. Chetan Rane[2], Mr. Prathmesh Khairnar[3], Mr.Kunal Fuse[4], Mr.Prasad Baviskar[5]***

Jaywantrao Sawant College Of Engineering, Pune University,Mechanicalengineeringdepartment
Handewadiroad,Hadapsar,Pune,India-411028
papatil73@gmail.com[1], chetanrane1011@gmail.com[2], prathameshkhairnar2611@gmail.com[3]
kunalfuse2424@gmail.com[4],psbaviskar05@gmail.com[5]

**ABSTRACT–**

Conventional Vapor Compression refrigeration system uses compressor for its operation,which requires high grade energy and thus it consumes lot of power. In this project we aregoing to review Ejector based Water Refrigeration System, which helps to reduce energyconsumptionin this study, the compressor is replaced by pump, a constant-area mixingejector. The ejector creates vacuum in the chamber with the help of high velocity stream ofwater jet. Due to vacuum water evaporates and taking latent heat from water itself, resultingdecreasing temperature of water. Present work is to design and develop water ejector system and investigate the performance ofeffect of various operating conditions on energy consumption. The system performance will betested for five different water pressures, and to investigate the effect on cooling capacity,entrainment ratio and COP. This report presents a comprehensive literature review on ejector refrigeration systems and working fluids. It analyses different ejector technologies refrigerant properties and their influence over ejector performance.

Keywords ─ Ejector refrigeration, Theoretical model, Real gas property, subcritical mode, Refrigerants.

## Introduction–

Over the past few years, the concerning on energy saving and environment protecting has become an increasingly predominant. developments of industries and increase in population have caused a great demand of cooling and refrigeration application which use the mechanical vapor compression systems. These systems are generally powered by electricity generated by burning fossil fuels. The fossil fuel consumption can contribute to the global warming – the “greenhouse effect”. This compels more and more researchers turn to make use of low-grade thermal energy. The ejector refrigeration system provides a promising way of producing a cooling effect by utilizing waste heat from industrial process or using renewable energy, such as solar power and geothermal energy. With the development of technology, these systems can operate using low-temperature heat Source below 100 °C and even less. Ejectors are not new technology and have been already used in the industrial fields for more than 100 years. As the core part of the ejector refrigeration system, the information about the ejector design and performance is of great importance. Although the experimental method is considered as the best way to obtain data, it’s not economical because it will cost so much labour power and material resources. Therefore, the theoretical method is usually the priority selection for the ejector performance evaluation and parameter optimization based on its advantages, such as simplicity and accuracy. Various parameters such as COP and the effect of refrigerant have been studied.

The water ejector system work on the principle of boiling of liquid at lower temperature by reducing pressure on its surface. The ejector is a flow device that allows a high-pressure fluid, termed as primary fluid, to entrain a low-pressure fluid (the secondary fluid) into the flow path, and discharge the mixed flow at an intermediate pressure that is higher than the secondary flow pressure. Thus, the ejector acts like a compressor or a pump, but without any moving parts, lubricants and maintenance. The ejector is evaluated by the entrainment ratio, which is defined as the ratio of the mass flow rates between the secondary flow and the primary flow, and the pressure lift ratio, which is the ratio of the ejector outlet pressure to the secondary flow pressure at the ejector inlet.

## LiteratureReview-

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- Chen J, Havtun H, Palm B. Conventional and advanced exergy analysis of anejector refrigeration system. Appl Energy 2015; 144:139–51.

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## ExperimentalSetup-

Descriptionofthetest apparatus

The water ejector system work on the principle of boiling of liquid at lower temperature by reducing pressure on its surface.Thissystem consists of differentapparatustoperformdifferentfunctions.

**Reciprocating pump:**A reciprocating pump is a class of positive-displacement pumps that includes the piston pump, plunger pump, and diaphragm pump.A hollow cylinder made of steel alloy or castiron. Arrangement of piston and piston rod is inside this cylinder.

**Ejector**:The ejector is a flow device that allows a high pressure fluid, termed as primary fluid, to entrain a low pressure fluid (the secondary fluid) into the flow path, and discharge the mixed flow at an intermediate pressure that is higher than the secondary flow pressure. Thus the ejector acts like a compressor or a pump.

**Evaporator:** - Another important component of the system is evaporator also called as flash chamber. This is the place where we get refrigerating effect. It is located at the outlet of the ejector, it is properly insulated to avoid any atmospheric contact. Materials used for evaporator can be steel, glass, aluminium etc.

**Pressure valve**: - Flow control valves come in all shapes, sizes, and designs. Their basic function, is the scontrol flow of air. Flow control valves for hydraulic systems (liquids under pressureare of the same basic design.

## Data Reduction–

For mass of water evaporated in evaporator

Evaporator is in cylindrical shape,

Volume of water evaporated,

V = πr2h

ρw =mw / vw

mw =ρw * vw

Heat Extracted in Evaporator,

QL = mv∗LH/ Time

Work input,

Wi =Final energy reading – Initial energy reading

4.COP,

QL / Wi

Analysis of System Using Single Piston Reciprocating Pump With U-Tube Manometer

| **SinglePistonReciprocatingPumpandU-TubeManometer(Evaporator)** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Pressure(bar)** | InitialWaterLevel (m) | FinalWaterLevel (m) | **Drop inWater Level (m)** | Time(sec) | Dia.of U-Tube(m) | Massofwater evaporated(Kg) | **Heat Extracted(KW)** | Work Input(KW) | **COP** |
| **2** | 0.3 | 0.056 | **0.244** | 1800 | 0.005 | 0.0047909 | **0.0058597** | 0.2 | **0.029299** |
| **3** | 0.3 | 0.07 | **0.23** | 1800 | 0.005 | 0.0045161 | **0.0054273** | 0.2 | **0.027137** |
| **4** | 0.3 | 0.086 | **0.214** | 1800 | 0.005 | 0.0042019 | **0.0049791** | 0.3 | **0.016597** |

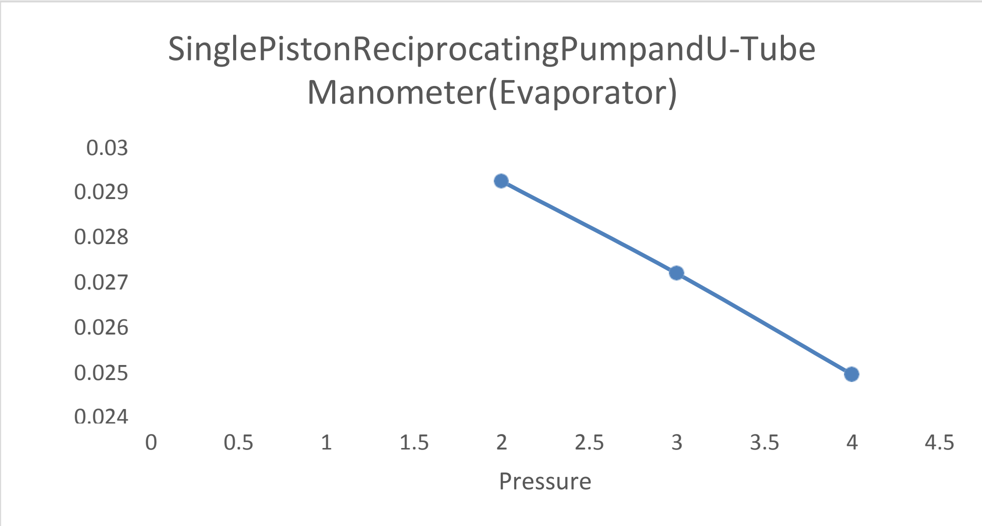



Fig., PRESSURE VS COP CHART

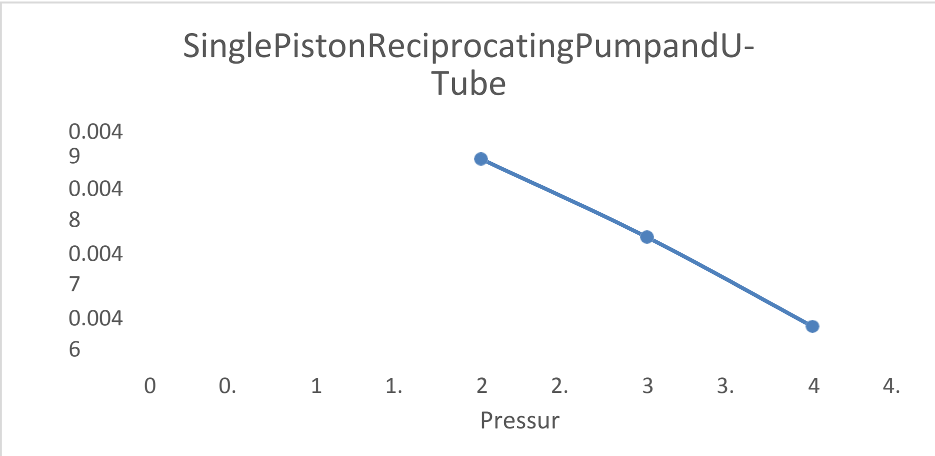



Fig., PressurevsHeatExtractionchart

- COP decreases with increase in system pressure due to back pressure developed inSystemduetoexperimentalerror(randomerror).
- Heat Extraction decreases with increase in system pressure due to back pressuredeveloped inSystemduetoexperimentalerror(randomerror).

ANALYSISOF SYSTEMUSINGSINGLEPISTONRECIPROCATINGPUMPWITHCYLINDRICALTESTTUBE

| **SinglePistonReciprocatingPumpandCylindricalTestTube(Evaporator)** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pressure(bar)** | InitialWaterTemp. (°C) | FinalWaterTemp. (°C) | **DropinWaterTemp. (°C)** | Time.(sec) | Dia. ofTestTube (m) | HeightofWaterColumn (m) | Mass ofWater (Kg) | **HeatExtracted (KW)** | WorkInput (KW) | **COP** |
| **2** | 27.6 | 19.1 | **8.5** | 1800 | 0.015 | 0.025 | 0.0044178 | **0.0054034** | 0.3 | **0.018011** |
| **3** | 27.9 | 21.8 | **6.1** | 1800 | 0.015 | 0.025 | 0.0044178 | **0.0053093** | 0.35 | **0.015169** |
| **4** | 29.1 | 23.2 | **5.9** | 1800 | 0.015 | 0.025 | 0.0044178 | **0.0052349** | 0.35 | **0.014957** |

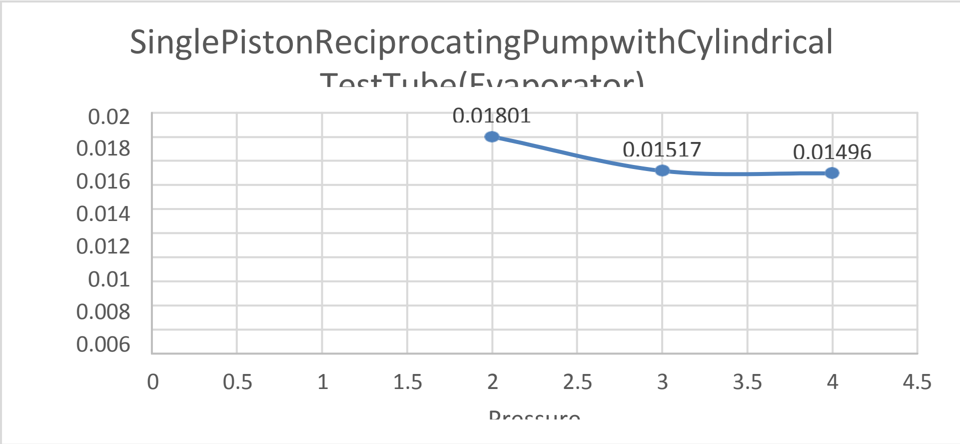



Fig12.PressurevsCOPchart

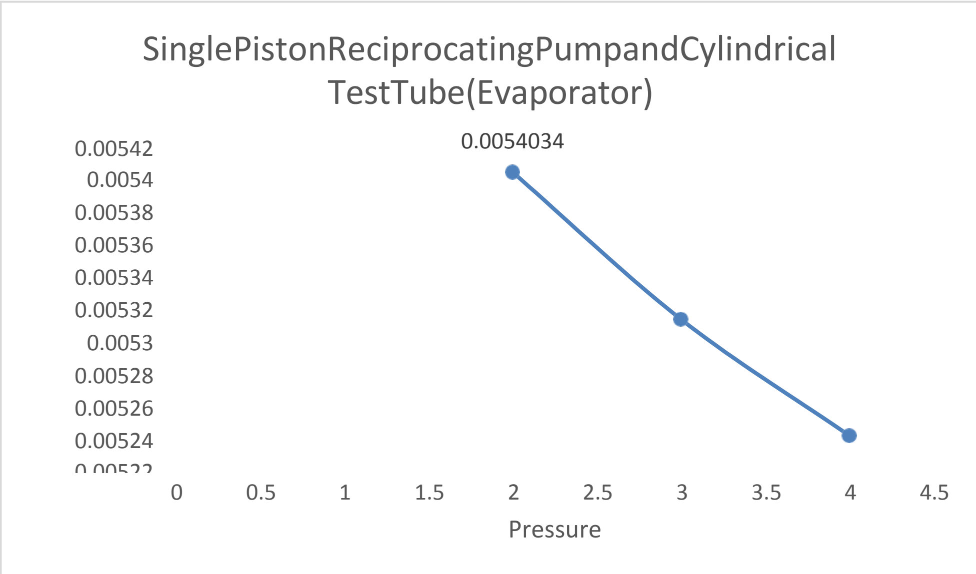
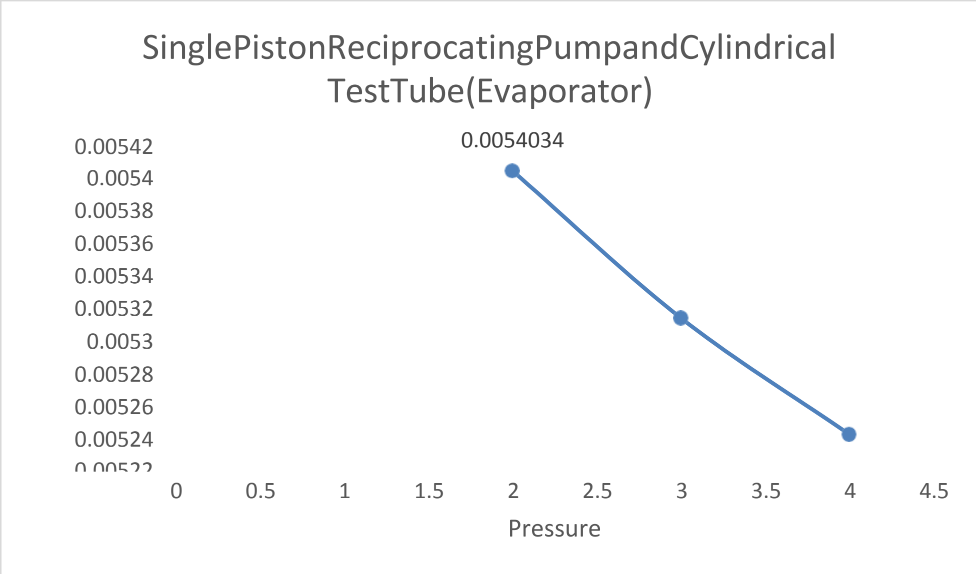


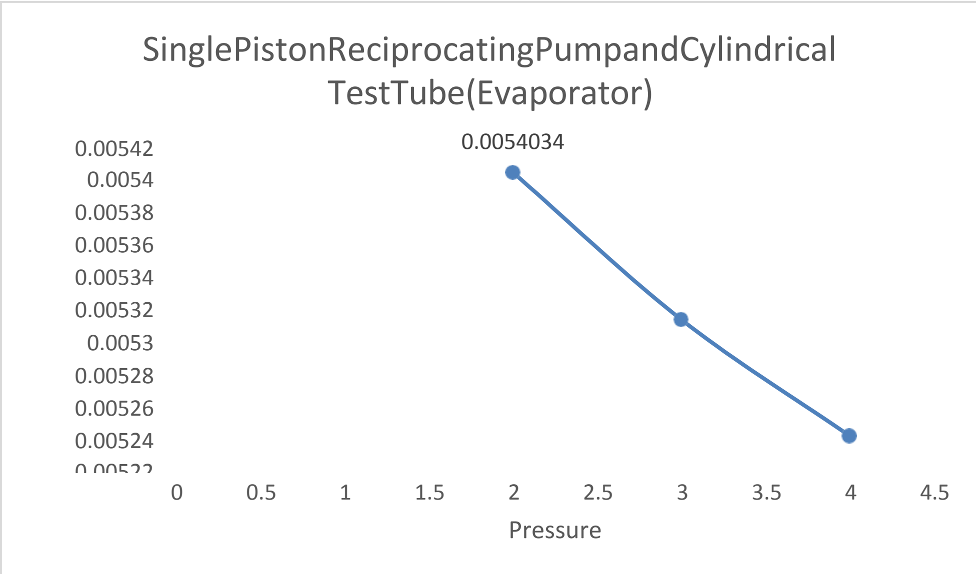

Fig.Pressure vs heat extraction

- COP decreases with increase in system pressure due to back pressure developed inSystemduetoexperimentalerror(randomerror).
- Heat Extraction decreases with increase in system pressure due to back pressuredeveloped inSystemduetoexperimentalerror(randomerror).

ANALYSISOF SYSTEMUSING SINGLEPISTONRECIPROCATINGPUMP WITHCYLINDRICALGLASSBOTTLE:

| **SinglePistonReciprocatingPumpandCylindricalGlassBottle(Evaporator)** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Pressure(bar)** | InitialWaterTemp(°C) | FinalWaterTemp (°C) | **DropinWaterTemp(°C)** | Time(sec) | Dia. ofTestTube(m) | HeightofWaterColumn(m) | Mass ofWater(Kg) | **HeatExtracted(KW)** | WorkInput(KW) | **COP** |
| **2** | 31.2 | 26 | **5.2** | 2700 | 0.05 | 0.05 | 0.09817 | **0.08** | 0.3 | **0.266667** |
| **3** | 32.6 | 27.1 | **5.5** | 2700 | 0.05 | 0.05 | 0.09817 | **0.0786** | 0.35 | **0.224571** |
| **4** | 33.1 | 28.2 | **4.9** | 2700 | 0.05 | 0.05 | 0.09817 | **0.0775** | 0.37 | **0.209459** |


SinglePistonReciprocatingPumpandCylindrical TestTube(Evaporator)
0.0054034
0.00542
0.0054
0.00538
0.00536
0.00534
0.00532
0.0053
0.00528
0.00526
0.00524
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5
Pressure


SinglePistonReciprocatingPumpandCylindrical TestTube(Evaporator)
0.0054034
0.00542
0.0054
0.00538
0.00536
0.00534
0.00532
0.0053
0.00528
0.00526
0.00524
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5
Pressure

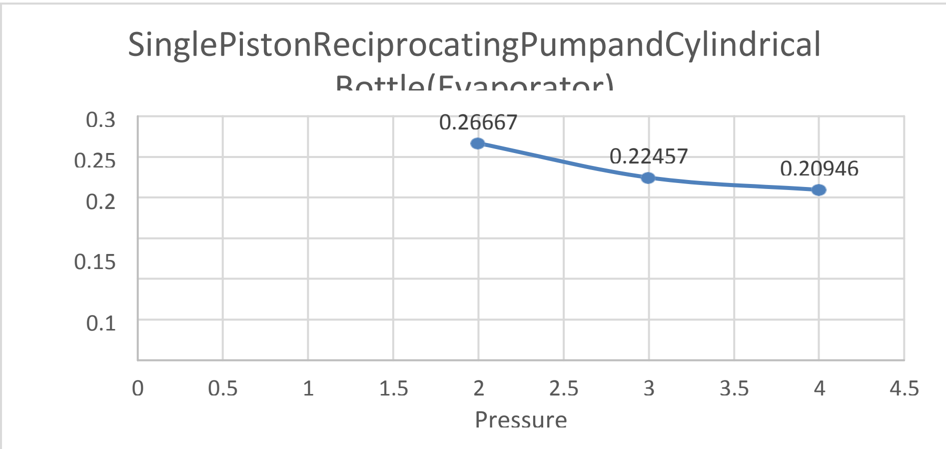

SinglePistonReciprocatingPumpandCylindrical
0.26667
0.22457
0.20946
0.3
0.25
0.2
0.15
0.1
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5
Pressure

Fig.,pressure vs COP

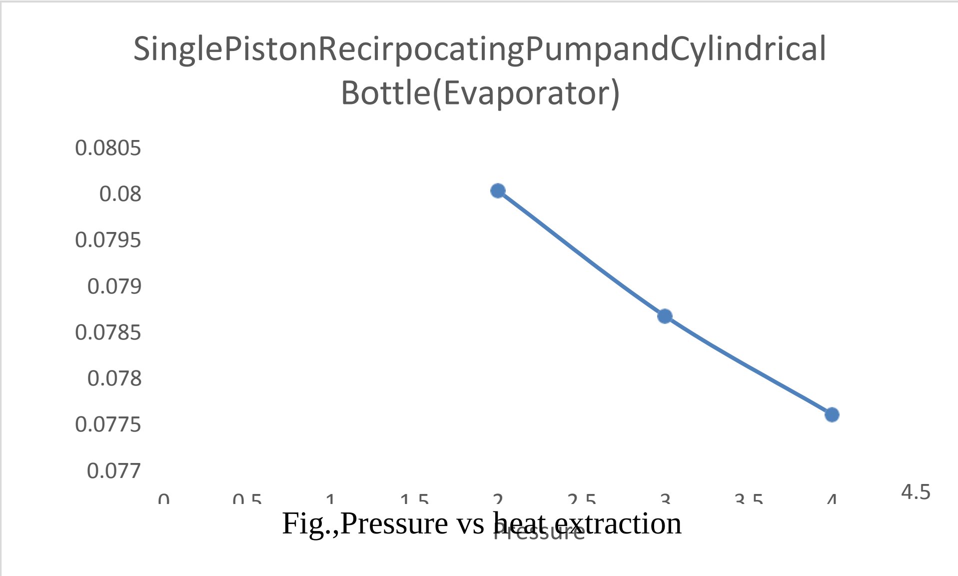



Fig.,Pressure vs heat extraction

- COP decreases with increase in system pressure due to back pressure developed in
- Systemduetoexperimentalerror(randomerror)

- Heat Extraction decreases with increase in system pressure due to back pressuredeveloped inSystemduetoexperimentalerror(randomerror).

## Nomenclature:

$\rho_w$ =Density of water

$m_w$= Mass of water

$v_w$ = Volume of water

$Q_{L}$ = Total heat extracted

Fig. SinglePistonReciprocatingpumpandU-TubeManometer (Evaporator)

Fig. SinglePistonReciprocatingpumpand CylindricalTest-Tube(Evaporator)

Fig. SinglePistonReciprocatingpumpand Cylindrical Glass Bottle (Evaporator)