EVALUATION OF THE TWO STAGES RECIPROCATING AIR COMPRESSOR'S PERFORMANCE

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***Abstract*—The performance of a double acting reciprocating air compressor in a laboratory setup is summarised in the current article. Performance testing's objective is to compare theoretical calculations to actual performance. To ascertain the functioning condition and analyse the delivery and suction pressure, which is crucial for maintaining proper pressure heads in the receiver, a performance test of the double acting reciprocating compressor is utilised. The effectiveness and operation of the double acting reciprocating air compressors are improved using traditional performance testing techniques. To measure things like power consumption, suction and delivery pressure, and air flow rate, several measurement tools are utilised. Although reciprocating air compressors are frequently employed in applications requiring high delivery pressures and continuous air flow, they are more susceptible to failure when the pressure is manually adjusted. The results collected demonstrate the impact of numerous parameters on the performance of a reciprocating air compressor, including speed, flow rate, pressure, etc.**

***Key words*—Delivery pressure, Performance testing, reciprocating air compressor, Suction pressure**

I. INTRODUCTION

y lowering a specified volume of the fluid as it passes through the compressor, a compressor is a device used to raise the pressure of a compressible fluid, either gas or vapour. Air compressors are devices that are used to compress air. For every application that calls for pressured air, a compressor is employed. Compressing the fluid and then delivering it to a pressure higher than its initial pressure is one of the fundamental purposes of using a compressor. Depending on the necessary process requirements, the inlet and output pressure levels can range from a complete vacuum to a high positive pressure. According to the type of compressor and its arrangement, this inlet and outlet pressure is compared. Reciprocating compressors generally have piston-cylinder arrangement where displacement of piston in cylinder causes rise in pressure. Reciprocating compressors are capable to give large pressure ratios but the mass handling capacity is limited or small. Reciprocating compressors may also be single acting compressor or double acting compressor. Single acting compressor has one delivery stroke per revolution while in double acting there are two delivery strokes per revolution ofcrank shaft.

Grolier suggests a technique for determining the reciprocating compressor tanks' cooling capacity.By estimating the suction gas temperature in the suction plenum of the cylinder-head of the compressor,

[1] carried out a performance analysis of compressors. The determination of the thermodynamic properties taken into account was necessary for the computation. The suction gas density and the enthalpy difference between the superheated and subcooled locations make up this thermodynamic property. The provided paper suggests a technique for rating the effectiveness of reciprocating compressors. One can get a decent understanding of the compressor performance by simulating the capacity and compression operations under various operating situations.

Hou et al. [2] investigated energy efficiency and power factor were most essential performances for compressor unit driven by inverter-fed motors. The performances are simulated utilizing a parametric linear model under variable frequency and variable conditions. The results shows that, at given rated frequency, both the performances would fall down with lighter load, if frequency was reduced from rated, energy efficiency would fall even lower, though powerfactor rise up slightly.

A numerical and experimental investigation was proposed by Burgstaller et al. [3] to quantify the influence of main parameters of the suction valve on the overall performance of the compressor. The thermodynamic cycle calculation is performed by using software AVL BOOST & CFD. The calculation model shows the whole compressor domain between shell inlet and outlet.

According to Grisbrook [4] gap is provided between the recess and the space above the piston and cylinder head, increasing the initial pressure above the piston and causing greater pressure to be developed during the compression stroke. The result is an increase in the volumetric efficiency of the compressor.

According to Tsuji et al. [5] Calculations of the mechanical efficiency of a large reciprocating compressor are developed. The optimal combination parameters yielding the maximum mechanical efficiency could be determined, and then compared with the empirical combination used in the Mayekawamake compressor.

According to Zhang at al. [6] the mechanical efficiency was calculated for various combinations of piston diameter and stroke at operating speeds of 800, 1000 (rated) and 1200 rpm. The optimal combinationsof the piston diameter and stroke were determined.

According to Wadbudhe et al. [7] the simulation model of variable speed air compressor provides a satisfactory performance study. The model can predict volumetric efficiency, free air delivered, indicated power, shaft power, cylinder air pressure, cylinder air temperature, resultant torque and mass of air drawn in or discharged out per cycle, by varying any operating parameters like, speed, discharge pressure, etc., and physical parameters like, clearance volume, crank radius, connecting rod length and cylinder diameter. The given study introduced the use of side inlet ports was proposed by Parker and Cawley [8] to improve volumetric efficiency. The author unexplored third use of the side inlet ports can be used for compressors in the high compression ratio range where additional lubrication of the piston ring as well as the suction anddischarge valve is needed.

The present investigation has been carried out to study an approach for performance testing of double acting reciprocating air compressors by integrating sensors for measuring pressure variations and energy supply for running the compressors and analysis of the output. The present approach can be used for testing the reciprocating air compressors at industries or even at households and also similar equipment or product by determining the parameters and their values that affect the performance of the equipment. Reciprocating air compressors are widely used due to their ease of use and simple arrangement. In case of this double acting reciprocating air compressor, flow is constant but also varies with variation in pressure. Output flow will be decreased when system pressure will be increased.

II. EXPERIMENTAL SETUP

The apparatus consists of a double acting reciprocating air compressor is operated on closed circuit basis. An AC motor with 3 speeds is provided to regulate the rpm of the compressor. Suction and delivery pressure can be varied by the valves provided and Pressure & Vacuum Gauges can measure it. Flow of air is measured by using measuring tank and stopwatch as shown in Fig. 1.

Fig. 1. Experimental set-up of reciprocating aircompressor

The following are the steps for the performance testingof a double acting reciprocating air compressor:

1- Clean the apparatus and make tank free from dustand foreign particles.
2- Close the drain valve provided below the receivertank.
3- Open the suction valve provided in main suction line.
4- Ensure that power switch given on panel should be on.
5- Set the speed of compressor with control knob provided in electric panel board in front section of apparatus.
6- Operate the flow control valve to regulate the flow of air in the receiver by the compressor.
7- Record discharge pressure by means of pressure gauge, provided on discharge line.
8- Operate the control valve to regulate the suction of compressor.
9- Record the suction pressure by means of vacuumgauge, provided at suction line of the pump.
10- Also note energy input for this time from energy meter.
11- Note down the rpm of the compressor inrevolution counter provided in the panel board.
12- Measure the flow of suction air by the compressor, using the stopwatch and measuring tank.
13- Repeat the same procedure for different pressure head.
14- Repeat the same procedure for the different rpm with help of rheostat provided in the panel board.
15- When the experimental measurements are over, properly open the control valve provided on discharge line.
16- Switch off the compressor first.
17- Switch of the main power line supply to panel board.

The following are the precautions taken while carrying out experiments on double acting reciprocating compressor.

- Ensure all the connections of the thermocouples are proper and electrical wiring is in safe condition, since the system is working at high voltage.
- Never fully close, the delivery line and by pass

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blade type of pulley. The compressor is driven by a 3
H.P. motor connected to compressor via the belt. Air receiver tank of approximately capacity of 500 liters made up of mild steel 5 mm thick sheet. Working pressure is 10 kg/cm^2 approximately. Discharge capacity of compressor is 15 CFM. The control panel consists of digital temperature indicator with selector switch, energy meter, U-tube manometer connected to the orifice, pressure gauges for measuring suction and delivery pressure (after every stage) on/off starter and indicator lamp for the compressor. The air flow to the compressor is measured with help of an orifice meter of 10 mm internal diameter (as per IS) and U-tube manometer. Dampening of the air is achieved with help of air dampening tank. The receiver tank is hydraulically tested for leakage at the operating pressure and shall be provided with all accessories like as safety valve, pressure switch, pressure gauge, drain valve and wire breaded tubing network. Total 5 nos. of thermocouples are also provided to measure temperature of air into first stage, air out of the first stage, air in to the second stage, air out of the second stage and air to the air receiving tank respective.

III. DATA REDUCTIONThe theoretical required per unit time W$P2$

line valves simultaneously.

- To prevent the clogging of moving parts, run

$= Pi * V1 \ln (\frac{P2}{Pi}) (1)$

compressor at least once in fortnight.

- Always use clean air.
- If the apparatus will now use for more than month,drain the apparatus completely.
- Always keep apparatus free from dust.
- If air suction is not carried out, the revolution of the AC motor may be reverse. Change the electric connection of motor to change the revolutions.
- If the panel is not showing input, check the fuse and main supply electricity.
- Do not run the compressor at fully speed for the longer period to avoid leakages of compressed air in discharge lines.

The following are the specifications of the doubleacting reciprocating air compressor:
The unit consists of a two stage reciprocating air compressor with second stage connected via a finned type air cooled intercooler to the first stage as well as after cooler has been made effective by providing a fan
The air flow rate at suction in m^3/s

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$V1 = Cd * Ao * \rho_{air}\sqrt{2} * g * h * (\rho_{air} - \rho_w)/\rho_w$ (2)

Volumetric efficiency is given by

$\eta = 1 - \zeta\ [(\frac{P2}{Pi}^{1/exp}) - 1] * 100$ (3)

IV. RESULTS AND DISCUSSIONS

The following are the observations obtained for the motor speed 2680 rpm in Table 1. It is seen that a high delivery air temperature increases oil carryover and thereby further increase in the delivery air temperature due to the formation of carbon deposits on the piston and the cylinder head. Carbon deposits on the cylinder head reduce the heat dissipation capacity of the fins on the inner cavity of the cylinder head. Cylinder head design has a vital influence on the delivery air temperature.

Table -1. Observation table.

Temperature (°C)		Pressure (bar)		Time(Sec)
Tin let	Tout let	Pinlet	Pout let	t
26	39	1.013	4	6.68
26	43	1.013	6	5.88
26	51	1.013	8	5.60
26	55	1.013	10	5.35

The obtained results show that the isothermal efficiency of the compressors decreases with increase in the discharge pressure. As the discharge pressure increases the pressure ration goes on increasing whichultimately results decrease in Isothermal efficiency asshown in Fig. 2 and Fig. 3.

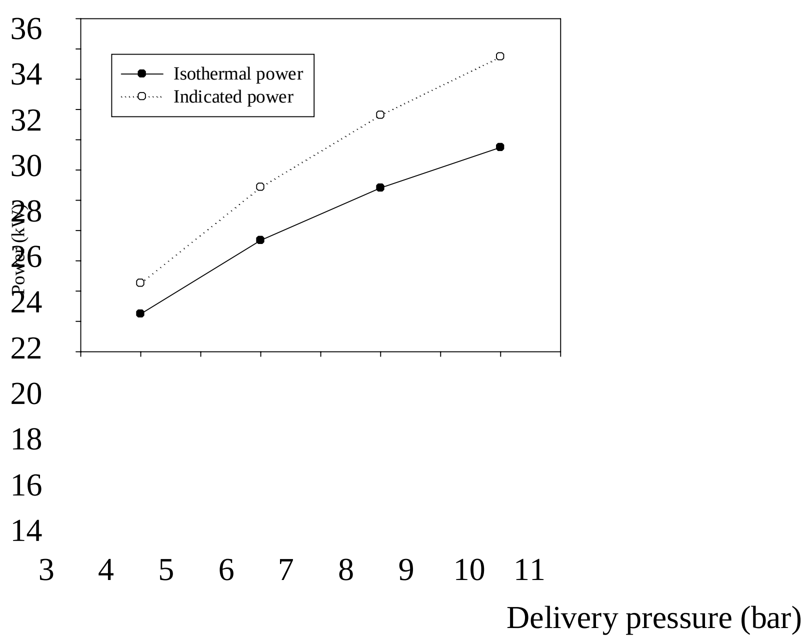

Fig. 2. Effect of variation in delivery pressure onisothermal and indicated power.

The calculation of isothermal power does not include power needed to overcome friction and generally gives an efficiency that is lower than adiabatic efficiency. The reported value of efficiency is normally the isothermal efficiency. This is an important consideration when selecting compressors based on reported values of efficiency.

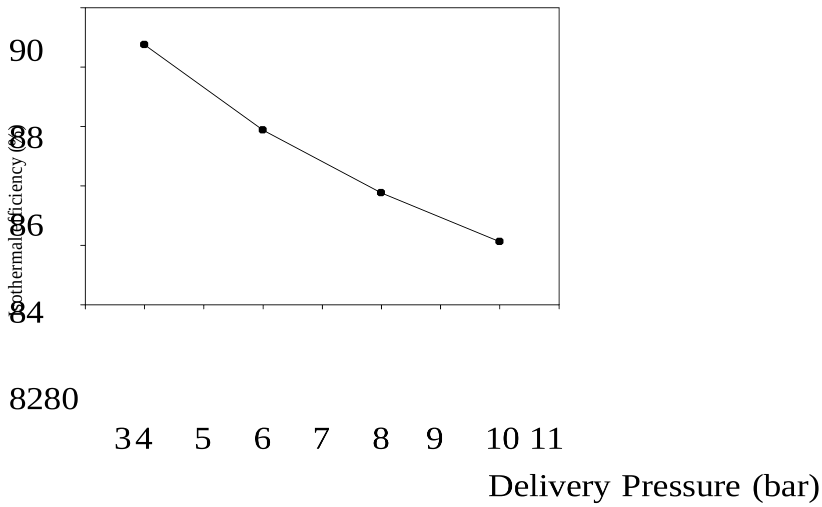

Fig. 3. Effect of variation in delivery pressure over isothermal efficiency.

I. CONCLUSIONS

By monitoring the operational parameters while it is operating, the performance of the double acting reciprocating compressor has been determined. The reciprocating compressor generates compressed air at a fixed discharge volume and high compression pressure. Energy consumption and compressor efficiency are directly correlated. The twin acting reciprocating air compressor's volumetric efficiency is found to be 86%. This reciprocating compressor has a wide pressure range and can deliver compressed air at steady flow rates. It is anticipated that the double acting reciprocating compressor will find commercial use due to its advantages, efficiency, and ease. Due of its energy efficiency, the application is probably going to grow significantly.

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