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DESIGN, FABRICATION AND TESTING OF AN IMPROVED AIR COMPRESSOR

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ABSTRACT

Air compressors are used as versatile tool throughout the industries for a variety of purposes. They are used for various applications in manufacturing plants such as driving pneumatic tools, air operated controlling equipment's, conveying of fly ash. Air compressors are one of the major sources of energy consumption in industries. In the present scenario, the importance of energy conservation is increasing day by day. For a manufacturing plant, improving energy efficiency or replacement of less energy efficient equipment with energy efficient ones can earn significant savings. In the manufacturing plant, it was found that compressors which are running were installed in the earlier stages. The existing hand air pressure pump and air compressors in the market have not fully exhausted this problem. The hand air pressure pump usually has a problem inflating tubes due to more work done pushing piston up and down to pressurize air into tubes. In addition the pumps are small in size i.e. they pump in small volume of air thus take longer time to refill especially during repair and after. With air compressors, they are expensive for most upcoming young entrepreneurs in this field to acquire, also some rural areas lack reliable power supply like electricity to run the compressors and also expensive. This project of a modified air compressor is based on mechanical operation which reduces time required to inflate tyre tubes and the force required in a single operation. The project has been tested in cycle garages in some rural areas and the results were impressive and met our objective. The results have far reaching economic implications on upcoming entrepreneur's growth.

Keywords: Design, fabricate, Performance, sizing,, air compressor.

I. INTRODUCTION

1.1 Background of the problem

Compressor is a mechanical device to compress and pump the refrigerant vapour from a low-pressure region to a high-pressure region. Refrigerating compressor is a heart of refrigeration system. It also provides the primary force to circulate the refrigerant through the cycle [1].

Rotary compressor is a machine which compresses the gas as a result of the angular movement of the vane or roller. Rotary compressors have certain advantages such as continuously flow process, high speed of rotation and the design can be scaled down to vary small dimension. The design of this compressor does not require suction valve and installation of discharge valve is optional [4]. The rotary compressors are divided into four types; rotary sliding vane compressor, scroll compressors, screw compressor and rolling piston rotary compressor [2].

Reciprocating compressors are used widely in industry. They could deliver high pressure compressed gas. The modifications of design parameters of such compressors lead to more efficient use of the machines. By modeling of these compressors, it is possible to study effects of various parameters on their performance and to identify the optimum design parameters. The modeling and simulation could also enable us to diagnosis possible fault which degrade compressor performance. The reciprocating compressors have been modeled with various methods. These methods could be generally classified into global models and differential models where the variable depends on crank angle [3, 4, 6]

In Kenya, motorcycles is a major mode of transport which hand air compressors are used to inflate the tubes. Due to the cost of electric air compressor and low electricity or alternative connections in most rural parts of country, it has been a problem for many garages to own electric air compressors for their work. The repairers use small hand air compressors which take longer time and energy during the process of inflating the tubes, hence there is need to develop a pumps are ideal for small jobs.

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II. METHODOLOGY

2.1 Material selection

Materials used in the design fall into two groups.

a. Metals
b. Hard Plastic and rubber

The choice of material involved a consideration of factors which can be grouped under the following heading.

- Service requirement: Ability of the material to withstand service condition
- Manufacturing requirement and cost
- Cost of materials.

2.2 Factor considered in material selection

2.2.1 Service requirement

Service requirement fall under the following classifications

a. Physical properties
b. Mechanical properties

2.3 Material selected

2.3.1 Rubber

(a) Tuflon:

It was used to manufacture the pistons.

Properties:

- Good temperature resistance.
- It has good stiffness.
- It is cheap.
- It resists shock

2.3.2 Rubber

It was used to manufacture piston rings.

2.3.2 Steel

Other components of the air compressor i.e. frame, sprockets, shafts, connecting rods, arms are made of bright drawn mild steel due to good mechanical properties.

Properties – EN8 (080M40)

- ✓ Tensile strength 430 N/mm^2
- ✓ Yield strength 215 N/mm^2
- ✓ Hardness 201 – 255 (Brinell)
- ✓ Elongation 21%
- ✓ 0.2 proof stress – 450N/mm^2
- ✓ Good weldability thus suitable for fabrication
- ✓ Can be case hardened
- ✓ Low stress thus used in most engineering application
- ✓ Readily available in different shapes

(a) Connecting rod

This connects the piston to crankshaft in such away that it changes the rotation motion of shaft to a reciprocating motion of the piston (up and down motion). It is incorporated with bearing to make change of motion possible. It is made of steel.

(b) Piston

This part is connected to the driven shaft through the gudgeon pin and connecting rod. It creates a vacuum on either side by its reciprocating motion hence compressing air through outlet valve of the compressor to tyre. The piston is made of tuflon and rubber seal.

2.5 Cylinders

The modified air compressor contains two cylinders to increase the volume of air output. These are parts of the compressor that determines amount of air compressed to the tyre tube. It is chamber that houses the piston. The cylinder has a hole that allows the delivery of compressed air by piston to the tubes through the flexible pipes. The cylinder is made of steel pipe.

2.6 Driven & driver shafts assembly

Shafts are two, one for driving and other driven sprocket. The shafts assembly consists of the shaft itself, driven and driver sprockets and are welded to the shafts. They are made of steel material.

2.7 Driver & driven sprockets

There are two sprockets, both of them fitted to the shafts. The driven sprocket (Free wheel) is small in size than the driver sprocket. Motion is transmitted from driver sprocket to driven sprocket through the chain that connects the two sprockets which are apart. Driving sprocket has 32 teeth and driven 18 teeth. The driven sprocket is a free wheeler and the ratio of gears is,

$$\text{Sprocket ratio} = \frac{Driver}{Driven} = \frac{32}{18} = 1:1.8$$

2.8 Chain

This transmits rotation motion and torque from driver gear to driven gear.

2.9. Air pressure gauge.

This indicates the amount of compressed air in the tyre. Helps to minimize risk of under charging or over charging which can cause bursting of tyre.

2.10 Frame

This is the part that all parts are mounted and joined as one component or unit it is made of steel frame.

2.11 Bearings

They are on connecting rod as an assembly to allow smooth motion of the shafts. They are of different sizes and are made of steel.

2.12 Flexible pipes

They are one in which compressed air is delivered to the tyre tube.

2.13 System operation

When the cycling pedals are operated to rotate the bigger gear (driver gear), this motion is transferred to the driven gear through the chain. The driven gear is attached to the two connecting rods by connecting arms. As the driven gear rotates it forces the connecting rods which are connected to the two pistons in the cylinders to move up and down in motion. As the pistons moves down it compresses air in the cylinder to the tyre tube through the valves then the air gauge. The air gauge will indicate the amount of air in the tyre tube. The pistons are arranged in such away that when one piston is in exhaust the other one starts to compress. The higher the speed cycling pedal rotates the more compression the cylinders make thus the faster to fill the air into the tyre tubes.

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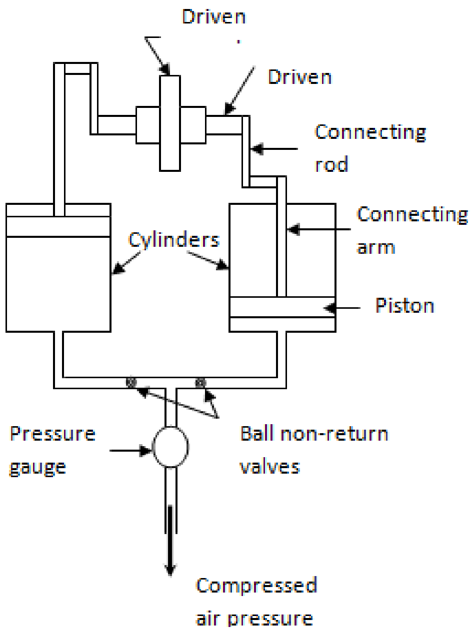

Fig.-1: Operation diagram

III. THE PROJECT DESIGN ANALYSIS

3.1 Air compressor design

The compressor employed is a positive displacement as it sucks and raise air by actually displacing it with a piston that execute a vertical motion in a closely fitted cylinder.

If D = Diameter of the cylinder

A = Cross -section area of the piston

$$CSA=\frac{\pi D^2}{4}$$

VC = Speed of the piston

L = Length of the stroke

Volume of air sucked in during suction stroke

= A x L

Discharge of air delivered

Q = A x L………… eq. (i)

DIMENSIONS:

- ✓ Length of cylinder = 115 mm
- ✓ Cylinder thickness = 20 mm
- ✓ Diameter of cylinder = 54 mm
- ✓ Diameter of piston = 50 mm

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- ✓ Stroke of the comp. = 48 mm
- ✓ Piston thickness = 25 mm
- ✓ Clearance = 4 mm

The compressor capacity = Area of piston x stroke

= π x 50^2 x 48

= $94248 mm^3$

Compressor ratio = $9.4248X10^{-5}M^3$

Work by piston when temperature is constant

WD = $p_1 v_1 \log \frac{p_2}{p_1}$ ………………eq. (ii)

W.D - work done by the piston to the air

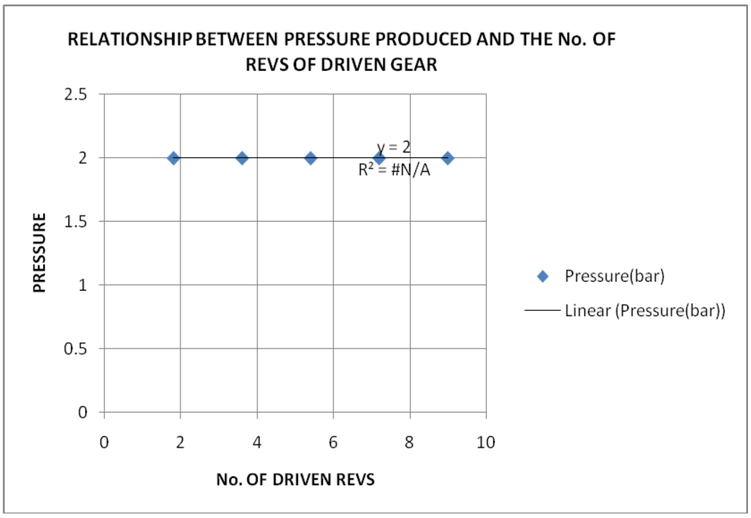
P_i = Atmospheric pressure =1.013 bar

V_i = L x area = $94248 mm^3$

P_2= average pressure produced

Table-1: Pressure produced at different revolution

No of trials	Driver Revolution	Driven Revolution	Pressure(bar)
1	1	1.8	2
2	2	3.6	2
3	3	5.4	2
4	4	7.2	2
5	5	9	2
Average pressure			2



W= $1.013X10^5 \times 0.00942 \times \log \frac{2}{1.013} = 281.9\,J$

3.2 Cylinder design

(a) Longitudinal stress in cylinders

The cylinder is subjected to same internal pressure which tend to split the cylinder into two

Therefore Longitudinal stress, σ_L given by:

$$\sigma_L = \frac{Total\ pressure}{resisting\ section} = \frac{pd}{4t} \text{ ....eq. (iii)}$$

$$\sigma_L = \frac{pd}{4t} = \frac{2 \times 5.4}{4 \times 0.2} \times 10^5 = 1350\, KN/M^2$$

(b) Circumferential stress in the cylinder

The cylinder is subjected to internal pressure that will tend to split the cylinder into two troughs.

Therefore circumferential stress, Gc is given by:

$$\sigma_C = \frac{Total\ pressure}{resisting\ section} = \frac{pd}{2t} \text{ ....eq (iv)}$$

$$\sigma_C = \frac{pd}{2t} = \frac{2 \times 5.4}{2 \times 0.2} \times 10^5 = 2700\, KN/M^2$$

The maximum allowable stress its 2700KN/M^2

3.3 Analysis discussion

We expected the amount of air sucked in to the cylinder per stroke to be 168.9cm^3 instead of 94.2 cm^3 this reduction happened due to the stroke being shortened by the modified connecting rod. This caused lot of space lost on the upper side of piston. The pressure produced is minimum as this was a result of small cylinder we incorporated. This was due to the available size of cylinders on market. The pressure produced is constant because it's a positive displacement air compressor

IV. CONCLUSION

In a domestic air conditioner, compressor is the most important part to produce power.. Some assumption of compression process is made isentropic expansion. Actually in the practical work isentropic process cannot be done. Compressor heat is assumed to be zero. But, actually compressor heat cannot be zero due to the compressor losses. This paper can support to increase the compressor power. And it can provide the flow in the compression chamber of rotary compressor

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