ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 7, Issue, 12, pp.24701-24706, December, 2015

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

DESIGN AND FABRICATION OF TRIANGLE AIR COMPRESSOR WITH COMMON COMPRESSION CHAMBER

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ARTICLE INFO

Article History:
Received 27th September, 2015
Received in revised form
05th October, 2015
Accepted 17th November, 2015
Published online 30th December, 2015

Key words:

Air compressor,
Tri cylinder air compressor,
Tri angular compressor.

ABSTRACT

The compressor is mechanical equipment which is used to increase the pressure with the help of the piston. Need to improve the performance of compressor by several methods. The main aim of the project is to make tri-cylinder air compressor to generate large amount of air with less power and low vibration. In tri cylinder air compressor the three cylinders are kept at 120 degree to each other. The three cylinders are placed radically and equally apart such that the cylinder opening tends to meet on a common triangular compression chamber. The three pistons are made to compress air simultaneously on to common tri angular chamber over shorter stroke and the isothermal efficiency will be better than single cylinder with one piston. The motor is connected to the chain drive to drive the three crank shaft which is used to move the piston. If space is smaller the pressure will be more and bigger the lower. If compressor is made to work at 1400 rpm air taken will be147.18 × 1400 = 206052 litters at 7 atmospheres pressure .The advantage with triangular compressor will be low vibration, smaller unit giving more output and so cheaper to make, ideal for air compressor is Air conditioning and Refrigeration, Vacuum pumps and general purpose usage.

Citation*: Vasiga, D., MuthuKrishnan, P. and Prabhu, C. 2015.* "Design and fabrication of triangle air compressor with common compression chamber", *International Journal of Current Research,* 7, (12), 24701-24706.

INTRODUCTION

The compressor is mechanical equipment which is used to increase the pressure with the help of the piston.

Types of air compressor

According to the design and principle of operation

1. Reciprocating compressor
2. Rotary screw compressor
3. Turbo compressor

Positive displacement

Positive-displacement air compressors are the type of compressor executed by forcing air into a chamber whose volume is decreased to compress the air. Piston-type air compressors use this principle by pumping air into an air chamber through the use of the same motion of pistons. This type of compressor uses one-way valves to guide air into a chamber, where the air is compressed. Rotary screw compressors also utilizespositive-displacement compression by matching two helical screws that, when turned, guide air into a chamber, whose volume is increased as the screws turn.

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Vane compressors use a slotted rotor with varied blade placement to guide air into a chamber and compress the volume. This type of Compressor delivers a fixed volume of air at high pressures. The types of positive displacement compressors include piston compressors and rotary screw compressors.

Negative displacement

Negative-displacement air compressors consist of the centrifugal compressors. This type of compressor use centrifugal force generated by a spinning impeller to accelerate and then decelerate captured air, which pressurizes the air.

Cooling

The result of adiabatic heating, air compressors require some type of disposing of waste heat for the better performance. Generally the cooling is some form of air- or water-cooling, although some (particularly rotary type) compressors may be cooled by oil (that is then in turn air- or water-cooled) and the atmospheric changes also included during cooling of compressors.

Tri-cylinder air compressor

We need to improve the performance of compressor by several methods. Such as designs shape and construction are known

and screw type compressor is the latest design as on date. The power required to compressor air to a known pressure is given in the attached tables. One cubic root of air equals approximately 28 litters its volume we brought of a novel idea to design the triangular compressor as per the attached sketches or diagrams with this. It is three cylinder compressors placed radially and equally apart such that the cylinder openings tend to meet on a common triangular compression chamber that has one inlet and outlet value to a tank for receiving air in the compressed state. As an example let us take a 100cc displacement single cylinder compressor, e.g. that will have a bore of 50 mm and stroke 50mm.Now all 3 pistons are made to compress air simultaneously on to common triangular chamber over shorter stroke and so the isothermal efficiency will be better than the single cylinder one of 50cc pton also there will be no vibration due to triangle force acting towards the middle at the same time. Adiabatically also this will be advantages since 3 cylinders displacement is pushed at the same velocity and force on the common chamber because the three piston move at equal velocity driven by one chain to achieve this 3 compressors cranks sprockets as teeth. For every rotations of crank each pistons will move once from TDC to BDC and BDC to TDC two strokes. Therefore theoretically 147.18cc of air will be taken in and compressed to the volume of smaller space is the common compression chamber. If space is smaller the pressure will be more and bigger the lower. If compressor is made to work at 1400 rpm air taken will be147.18 × 1400 = 206052 litters at 7 atmospheres pressure the advantage with triangular compressor will be low vibration, smaller unit giving more output and so cheaper to make, ideal for air compressor is Air conditioning and Refrigeration, Vacuum pumps and general purpose usage.

Belt drive

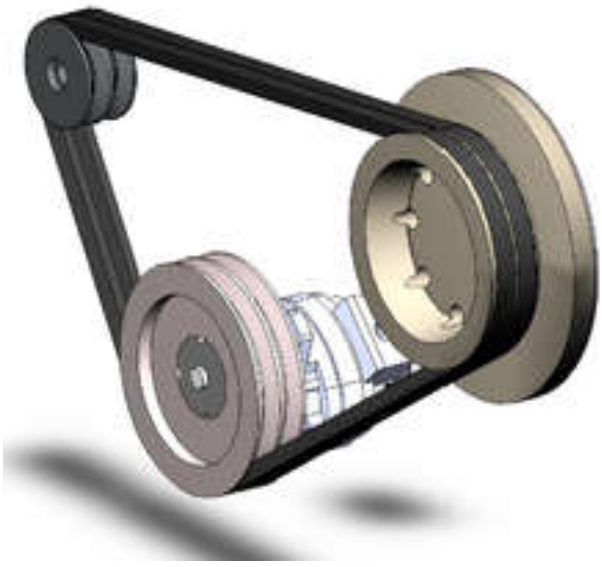

Figure 1. Belt drive

A belt is a closed loop of flexible material used to mechanically link two or more rotating shafts, most often parallel. Belts may be used as a source of motion, to transmit power efficiently, or to track relative movement. Belts are looped over pulleys and may have a twist between the pulleys, and the shafts need not be parallel. In a two pulley system, the belt can either drive the pulleys normally in one direction (the same if on parallel shafts), or the belt may be crossed, so that the direction of the driven shaft is reversed (the opposite direction to the driver if on parallel shafts). As a source of motion, a conveyor belt is one application where the belt is adapted to continuously carry a load between two points.

MATERIALS SELECTION

Compressor head

The material chosen for the body of the compressor head is high grade aluminum alloy IS4250. The head is of triangular shape with an angle of 60º to each side. First an Aluminum rod of 80mm diameter and length of is taken and it is turned and faced in Lathe as a triangular shape of required dimension. Then groove is taken on the three sides in order to fix the cylinder block to it. Then Central drill of diameter of 12.7mm is done in its length and the 3 drills of 15mm diameter are done from exactly centre of the side to the central drill.

Cast iron cylinder heads

Used for both racing and passenger vehicles, cast iron cylinder heads are generally considered more durable and believed to make more power due to the fact that the chamber holds in heat. As one would guess from the material used in manufacturing, cast iron cylinder heads are heavier than their aluminum counterparts which usually weigh at least 50% less than the cast iron cylinder heads. Cast iron cylinder heads are often preferred by day-to-day drivers who find them to be cheaper and less expensive to maintain as they tend to have fewer cracks and blown gaskets. On the down side, when cast iron cylinder heads do require attention it can be not only time consuming but expensive to repair. Despite being preferred by day-to-day drivers looking for an inexpensive and durable cylinder head, cast iron cylinder heads are also used in racing vehicles. In fact, certain race tracks are mandated as “iron only”.

Aluminum cylinder heads

Aluminum cylinder heads are popular among much of the racing set as they are lightweight, and produce more torque than cast iron cylinder heads. Despite the issue of dissipating heat, aluminum cylinder heads are usually easier (less expensive) to repair than cast iron cylinder heads. Close attention must be paid to certain areas such as fastener tightening procedures and issues with valve lash that result from the expansion of aluminum under normal operating temperatures. In general both types of cylinder heads can be beneficial depending on what type of performance you are expecting from your vehicle. Understanding how each work and the benefits and drawbacks will help you better determines which type of cylinder head will best suit your needs.

Cylinder block

The material for cylinder block is Cast Iron. The Cylinder Block is first cast and then machined and also required surface

are finished with suitable methods like boring and honing. The outer diameter was turned. and facing of the top and bottom surfaces are done in a lathe.When boring is done in boring machine, care should be taken to machine it with accurate dimension.

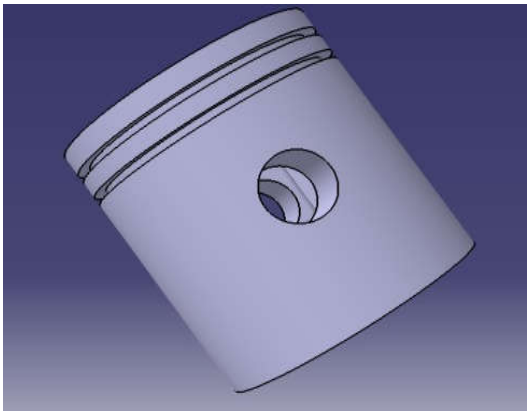

Figure 2. Piston Diagram

Connecting rod

The material chosen for connecting rod is mild steel. It is hardened to withstand the pressure of 7 bar. First the template is made with the actual dimension and then gas cutting is done on the mild steel plate for the template dimension and then machined.

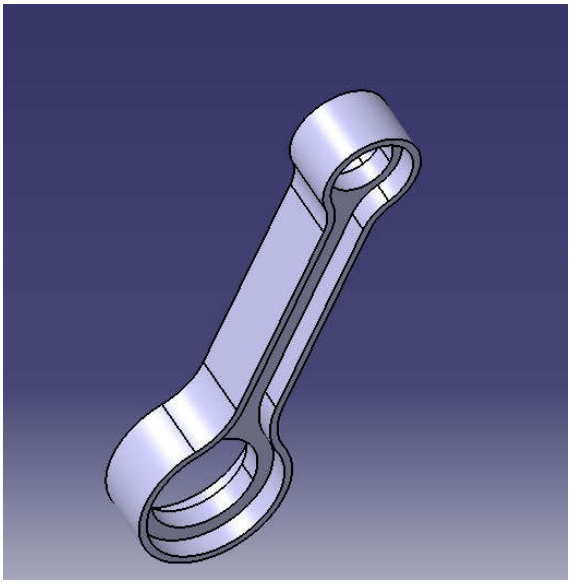

Figure 3. Connecting rod

Crankshaft assembly

The Crankshaft is of solid type made of cast iron to withstand the pressure developed by the bearing and the compressor components. The Crank shaft is turned, hardened, grand and the ends are tapered. All the made tapers are checked using ring gauge. Up to 30º taper angle is provided.

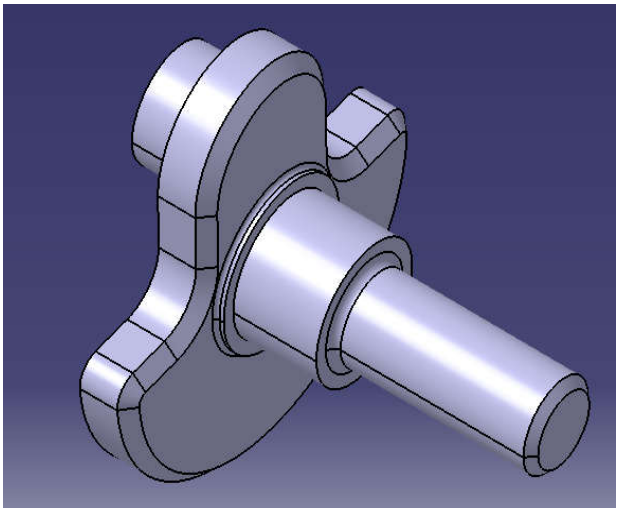

Figure 4. Crank shaft

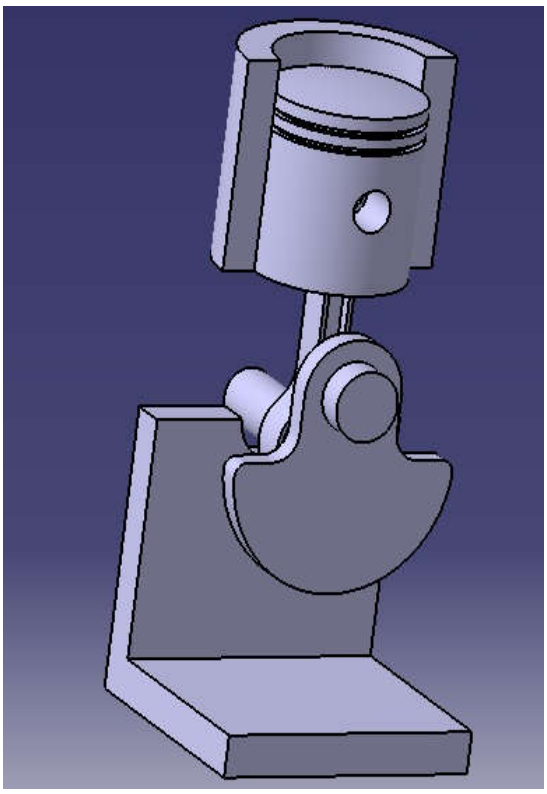

Figure 5. Piston assembly

The web is separately machine and welded. The end bearings are restricted between the web and end cover. The main connecting rod with its centre bearing is fitted with interference fit to the eccentric crank shaft assembly. The Crankshaft has its centre of gravity off set from the axis of rotation of the Crankshaft. Hence it acts as balancing weight.

End bearings

The thrust ball bearings are provided on the cover plate to safe guard the Crankshaft. The bearing takes up the variable loads at the reasonable speeds. Care should be taken while placing the bearing in the cover in the centre portion of the body thickness plate.

Stand

The stand for the Compressor is made in mild steel to withstand all the loads of the Compressor and motor assembly.

Compressor cooling

When a gas is compressed adiabatically pressure P_1 to P_2 the temperature of gas raised from T_1 to T_2. The increase in temperature occurs accordingly to the following relation

$$\left(\frac{P_2}{P1} = \frac{T_2}{T_1}\right)^{\frac{n-1}{n}}$$

Therefore when the stage pressure ratio is high the effect of the raise temp is prominent therefore cooling of the gas is essential. The general types of cooling arrangements available are

a) Water jacket cooling
b) Air cooling
c) Inter Cooling and after cooling

Plan of experiments

Electrical connection

The electrical power supply must be connected to the motor through starter. Start the unit momentarily and observe the direction of rotating the rotor. The direction should be clockwise. If the direction of rotation is not correct change the direction by interchanging the two places in the starter.

Adjusting belt tension

The chain tension between the motor and Crankshaft flywheel must be correctly adjusted with proper tension. Otherwise the Compressor will not run of the required speed.

Starting procedure

The following are to be checked before starting the unit.

- Check the oil level in the oil indicator if the level is the oil level indicator if the level is below the minimum mark, add fresh oil to the correct grade.
- Check the chain tension
- Check the suction pipe air filler
- Check that the unit rotates freely by hard and that there is no mechanical obstructions
- Start the unit and allow it to run for a few minutes

Checks during operation

- Check whether the running sound is normal
- Check the pressure developed by opening manometer safety device

If all the above preliminary checks are found satisfactory then the unit may be put to regular use.

Figures and equations

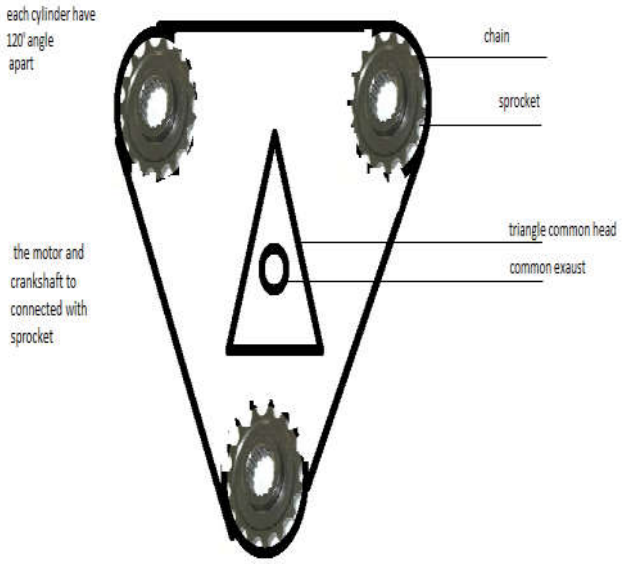

Figure 6. Chain drive

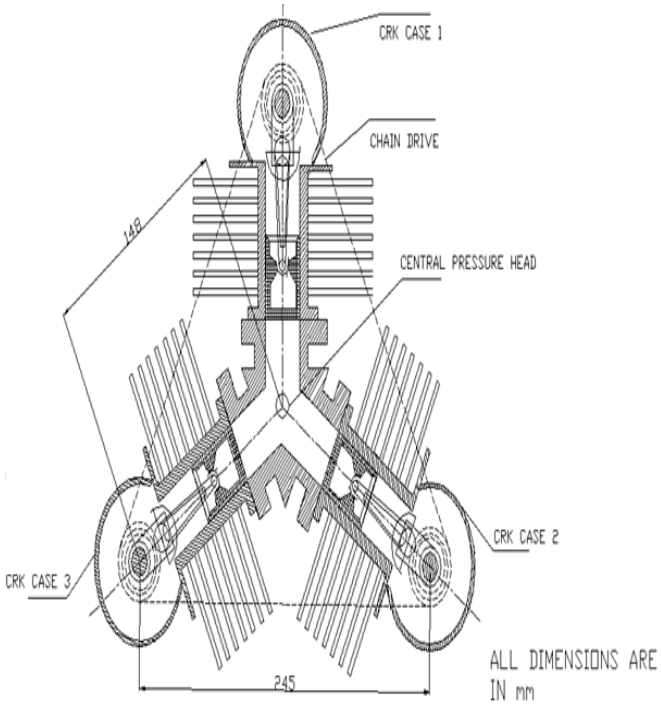

Figure 7. Design Diagram

Working principle

This triangular air compressor with common compression chamber consists of three cylinders placed at 120 to each other cylinder. The main aim if this compressor is to generate large amount of air compared with existing compressor with less power input and with low vibration. For this compressor contain three cylinders having their own piston, connecting rod, crank shaft and their drive. Chain drive was preferred to overcome slipping.

When the motor drives the crank shaft all the three piston will move in phase from BDC to TDC**,** when the piston reaching TDC compression takes place and discharge is done and when reaches the BDC suction condition are obtained and suction takes place.

Comparison of conventional one with ours

We know of several types of compressors made in many renowned factories at Coimbatore for various applications piston type, screwed type value type etc., but three pistons compressing air into a common compression chamber is not known to be a existing and so we decide to make this novel design to prove its superiority to others in cost and performance. Any new product must be novel and useful it must be superior is performance, reliable and dependable compared to known models. The cost of making must be comparatively low and in the market it should be capable of competition similar products, is every way, color appearance, value etc. Range must be based on from perspective users and customers. However first working model is only to prove superiority as per maker's claims. When it is compared with the existing ones it has very lesser vibration and lesser oil consumption and it is more reliable than the connectional ones because of having less vibration and also it is a Novel-idea.

Calculation

For 100cc engine

Bore diameter d = 50mm
Stroke length l = 50mm

For replacing engine,

Bore diameter d = 50mm
Stroke length l = 50mm

Whereas three engines are involved

Area of 100cc engine = $\pi/4 \times d^2$
A= 1962.5 mm²

Area of replacing engine = $\pi/4 \times d^2$
A = 1962.5 mm²

The volume displaced is V= $\pi/4 \times d^2 \times l$
= $\pi \times 5^2 \times 5$
= 98.125cc
≈ 100cc.

For replacing engine,

The volume displaced is V= $\pi/4 \times 5^2 \times 5 \times 1.5$
Three Cylinders of 50cc each = 147.18cc

For three replaced engines,

Compress area A= 3x1962.5 mm2
= 5887.5 mm².
When comparing the areas of the engines, the replaced engine has high compressing area than 100cc engine

Difference in area= (5887.5 -1962.5)
= 3925 mm².

Therefore theoretically 49.06cc of air will be taken in and compressed to the volume of smaller space in the common compression chamber which we have made as to 1.5cm bore×7cm long = 12.37cc or 7times the total 98cc volume = 7 atmospheric pressure.

RESULTS AND DISCUSSION

The performance of the compressor was found to be satisfactory and the output of the compressor is continuous it is up to the level expected. Further improvements can be done on the radial compressor.

Advantages

1. Best suitable for low pressure application.
2. Less weight compared to other compressor.
3. Production cost is low.
4. Higher efficiency because of less power required.
5. High Durability.
6. Compactness of the compressor saves utilization space.
7. Easy to use and portable.

Applications

1. Used in laboratories and pharmaceuticals.
2. Used for fabrication of plastic structure with hot gas.
3. Used for best control fumigation service.
4. Used for air agitation of photo film processing tanks, electroplating bath and in chemical plants.
5. Used for cooling electronic circuits.
6. Used for inflating tyres and air mattresses.
7. Used for light duty spray painting.
8. Used to operate air driven hand tools such s Die-Polishers, Die-Grinders etc.,
9. Used in bore wells to deliver water from the well

Conclusion

The design and fabrication of triangular air compressor in the common compression chamber have been successfully completed and over all assembly of the compressor is drawn in this report. The performance of the compressor was found to be satisfactory and the output of the compressor is continuous it is up to the level expected. Further improvements can be done on the radial compressor as dealt in the previous chapter.

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