Continuous Air Supply From A Reciprocating Compressor by Using PCS (Piston, Cylinder, Spring) System

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Abstract – PCS (piston, cylinder, spring) arrangement is a small device which will make a continuous air supply from a reciprocating compressor which supplies discontinuous air. When the compressed air from the compressor enters the PCS system, it pushes the piston, which in turn rotates the spring and the spring stores energy. At the same time the exhaust valve is partially opened, so when the piston moves away from the head, partial compressed air exits from exhaust valve. In the second stroke, the spring releases its energy and rotates in opposite direction pushing the piston towards head. When the piston returns towards the head, it removes the remaining compressed air from the exhaust valve. Hence, we can obtain the compressed air in both the strokes.

Keywords – PCS system – It is a system which consists of a piston, a cylinder and two torsional springs coupled in parallel.

1. INTRODUCTION

A conventional reciprocating compressor supplies discontinuous compressed air. The reason being, it consists of 2 strokes namely suction and discharge. In the suction stroke, the piston moves downwards creating a vacuum, hence the air gets trapped inside the cylinder. In the discharge stroke, the piston moves upwards compressing the air and releasing outside the air at higher pressure. Thus, it can be inferred that the discharge takes place once in two strokes giving discontinuous flow.

To overcome this problem, a storage cylinder is attached with the compressor unit. The high pressure air from exhaust of compressor enters the storage cylinder. Thus, a continuous air supply is achieved.

But there are 2 huge disadvantages of using a storage cylinder:-

1. It has large weight:
   a. Due to large weight, it is not portable.
   b. Cannot be carried with running vehicle.
   c. Cannot be taken to high altitudes.
2. If the volume of air inside the storage cylinder is less than the volume of storage cylinder, the air expands in the free space resulting in the reduced pressure than that of the pressure from the exhaust of compressor.
3. It cannot be frequently started and stopped. So supply is possible only after fully filled tank.

So, to replace this storage cylinder, a PCS (Piston Cylinder Spring) system is used.

It consists of a piston cylinder arrangement. A Torsion spring (constant force) is attached to the piston via a rod and a wire. The rod is attached to the piston by the help of a Gudgeon pin. Two springs are coupled in parallel to increase the overall stiffness.

Advantages of using a PCS system:-

1. Less space occupied.
2. Frequent start and stop is possible.
3. Better control over pressure.
4. Since, the PCS system is an integral part of compressor so the output supply from a reciprocating compressor remains continuous.
5. Makes the whole unit portable.
6. Light weight.
7. Cheaper than the storage cylinder used in conventional compressor
8. Pressure of compressed air reduces lesser than that in storage cylinder.

Disadvantages of using a PCS system

1. Less volume flow rate
2. There is no storage tank so the air cannot be supplied when compressor is not operating.

2. SYSTEM MODEL

When the compressed air from the compressor enters the cylinder, it pushes the piston away from the head and the spring stores energy. At the same time the exhaust valve is partly opened. So when the piston moves away, partial compressed air exits from exhaust valve and at the same time the strain energy is stored in the torsional spring. In the second stroke, the spring releases its stored energy and rotates in opposite direction pushing the piston towards the head. When the piston returns, it removes the remaining compressed air from the exhaust valve. Hence we can obtain the compressed air in both the strokes.

Reason of using torsional spring is that it can store energy and can supply it at constant force which helps us to maintain constant force. If we use helical spring then it causes variation in force with linear displacement of piston which causes variation in pressure.

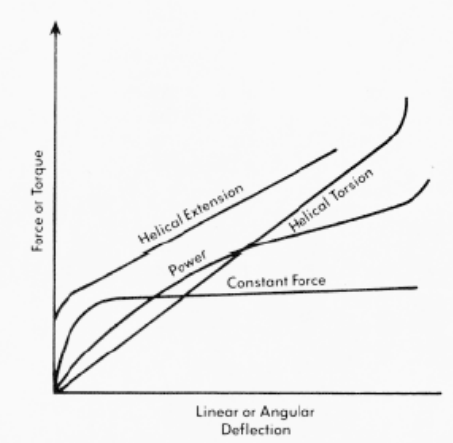


Figure 1- force and deflection relation of spring

3. PREVIOUS WORK

This is a new concept so there is no previous work found.

4. PROPOSED METHODOLOGY

PCS system stands for piston, cylinder and spring system. It consists of a piston which reciprocates inside a cylinder. The volume of the cylinder is 125cc. The gudgeon pin connects the piston with an aluminum rod. A small hole is drilled inside the other end of rod which used to tie a thin circular wire with torsional springs (constant force). Two torsional springs are coupled in parallel to double the stiffness of the spring. The top end of cylinder is enclosed by a hemispherical top which is welded by a plate. The plate is bolted with the cylinder. Two holes are drilled on the hemisphere. Inlet valve is attached on one hole and exhaust valve on other hole. The exhaust valve is attached with a T-section which is on the inner side. A pressure gauge is attached on the T-section as well. The pressure gauge is used to measure the pressure at the output of the PCS system. The whole PCS system is fixed on a wooden base. The compressed air from the reciprocating compressor is input at the PCS system from the inlet valve.

When the compressor undergoes the discharge stroke, the compressed air from the reciprocating compressor flows inside the PCS system. The exhaust valve is partially opened. When the air enters the PCS system, it pushes the piston away from the head while partial air exits from the exhaust valve. When the piston moves away, the torsional spring (because relation between force and displacement of spring always remains constant) rotates and stores energy. When the compressor undergoes the suction stroke, the load from the piston is removed. The spring releases its stored energy, rotating in opposite direction and pushes the piston towards the head. When the piston moves towards it removes the remaining air from the PCS system. So, when the compressor undergoes the suction stroke, the PCS system supplies the air. Hence, we are receiving continuous air even when the compressor undergoes the suction stroke. The exhaust valve is partially closed to control the air supply and maintain the continuous flow. It is observed that volume flow rate reduces by closing the exhaust valve partially but the mass flow rate remains constant. This is because the density of air increases inside the PCS system but the volume from outlet reduces. Hence, the product of density and volume remains almost constant. The pressure gauge attached at the T-section determines the pressure.

Since the aluminum rod is significantly long, it may result in bending from the far end. To prevent this bending, a bearing is used to kee++p the rod parallel to the base. The marketing strategies have changes a lot in recent years. The customer is attracted to a cheaper product than to an expensive one. So rather than fixing a ball bearing which may cost up to 500 INR, we have used a plastic roller which has smaller diameter at the center. This roller is placed freely on a steel plate which is bolted with the wooden base. When the rod reciprocates, the roller rolls with it on the steel plate. Because of the smaller diameter at the center of roller, the roller cannot move in any other direction, i.e. its motion is constrained.

We have used an exhaust valve to control the flow rate obtained from the reciprocating compressor.

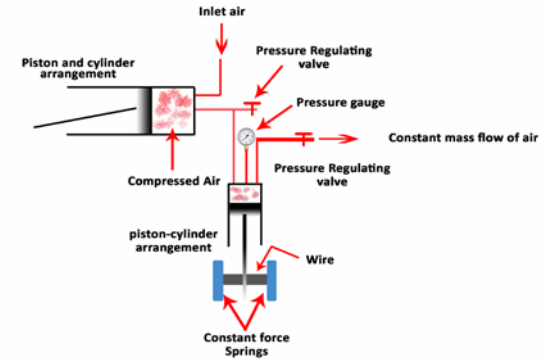


Figure 2 : Block diagram of the PCS system along with the compressor

Figure 3 : Actual model of a PCS system

Compressor specifications-

Speed - 300 rpm

Time per stroke - 1/5 second

Output reading-

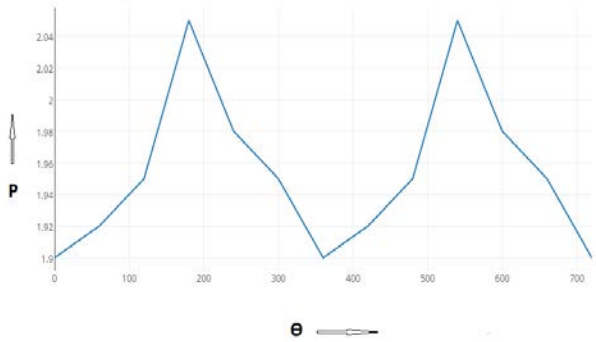
Took 60 photos with 60 fps mode by a Nikon camera and noted reading of pressure gauge.

5. SIMULATION/EXPERIMENTAL RESULTS

Table-1: Variation in final Pressure

Time(second)	Crank angle of main compressor (Ɵ in degrees)	Final Pressure from PCS (P in bar)
0	0	1.9
1/30	60	1.92
2/30	120	1.95
3/30	180	2.05
4/30	240	1.98
1/5	300	1.95
6/30	360	1.9
7/30	420	1.92
8/30	480	1.95
9/30	540	2.05
10/30	600	1.98
11/30	660	1.95
2/5	720	1.9

The graph is plotted below as per the table shown above.



Ɵ = Crank Angle at X-axis

P = Pressure from PCS system at Y-axis

6. CONCLUSION

Continuous mass flow rate can be achieved from a reciprocating compressor by using a PCS (piston, cylinder, spring) system which can work as a rotary air compressor but PCS system also works at higher pressure which is not possible in rotary compressor.

7. FUTURE SCOPE

PCS system shall be used where continuous air supply is required at high pressure. Because of this, a cheaper device which occupies less space and frequent start and stop is possible. Also it is light weighted with better control over pressure. It can replace the heavy storage cylinder from the conventional reciprocating compressor. It can have vast applications in Pneumatic tools.

REFERENCES

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[2] https://plot.ly/create/

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