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Design of a Universal Disc Brake Caliper Compressor

Charles Bentum Vroom, Isaac Edunyah, David Eshun

Abstract - When brake pads wear, they cause the piston in the caliper to move further out of its bore inorder to compensate for the lining wear. The Disc Brake Caliper piston (DBCP) compressor is used in servicing brakes. When the lining wear out, the brake pads are replaced by manually turning a simple handle on the DBCP to push the spreader plate to press the brake caliper piston inwards after which a new set of brake pads are fixed .

The design theories were based on the force transmissions and screw thread stress calculations to guarantee efficient compression of the piston caliper. Appropriate materials were selected based on these calculations to suit the design and functional requirements of the project.

Keywords – Disc, Brake Servicing, Compressor, Technicians

1.0 INTRODUCTION

The traditional way of compressing calipers with single or double piston by using different tools as a universal caliper piston compressor requires much strength by the user. Since the tools used are not the prescribed ones, much time is spent when carrying out brake servicing. Moreover, the usage of those tools as universal caliper piston compressor could result in improper seating of pistons in their bores.

The use of materials, tools, techniques, and sources of power to make life easier or more pleasant and work more productively can be termed as technology [3]. Technology has changed how work is done since the time of the invention of automobile vehicles; automobile mechanics have had their own means of compressing caliper piston into its bore. Brake caliper piston compressor is a manually operated tool used for compressing disc brake calipers with single or double pistons. Brake service is leading automobile repair activity with multiple brake service occasions during the vehicle life. [2]

Disc brake caliper piston compressor is designed to compress caliper pistons back into the bore to provide clearance for new pads and prevent damage to the piston. It is constructed of high carbon steel for durability. Caliper compressor can be used on most types of disc brake calipers. The tool consists of a spreader or pusher plate which forces the pistons inside the caliper, a backing plate that holds the threaded rod, handle to turn the threaded rod and a threaded rod which causes the rotary motion of the handle to linear motion to push the caliper piston inward.

There are three basic types of disc brakes caliper piston compressor as noted by [1]. These are the single, the double and the universal type. The single type is used to compress calipers with one piston which has a round spreader plate that pushes the piston inside the caliper. It is basically used on floating type caliper which has one piston at one side. The single type is the simplest in design and easy to use [4]. It has an advantage of being less expensive, simple in construction and is easy to use by the technician; [5] noted that the main advantage of this type of device is that it is not strong to withstand the residual pressure inside the piston. The double caliper piston compressor is also available for mechanics and technicians to use, its advantage is that it is strong and it can be able to speed up work therefore increasing productivity. Its main disadvantage is that it is expensive and complicated in design.

This design seeks to eliminate the problems that the single and double caliper piston compressor tools give and also to make work easier and faster during brake servicing.

2.0 METHODOLOGY

The design requirements were numerated together with its functional requirement. Based on the requirements, a design was arrived at. An orthographic view of the device was made. The design theories and calculations of the universal caliper piston compressor were arrived at.

2.1 Design Requirements

- The rotary speed of the spindle/handle is taken as 25rpm
- The average input power of the operator to manually turn the spindle is 70W
- The device should have a minimum efficiency of about 90%
- The rough treaded rod has 3mm pitch and 24mm diameter

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- The device would be manufactured from locally available raw materials

2.2 Functional Requirements

- The device is designed to compress disc brake caliper pistons on light duty vehicles.

2.3 The Design

Based on the above requirements the design below was arrived at

2.3.1 Isometric View

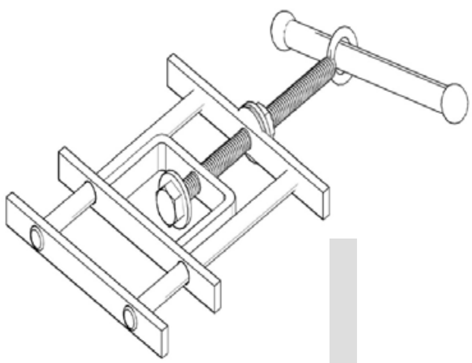

Fig. 1 shows the isometric view of the universal caliper piston compressor

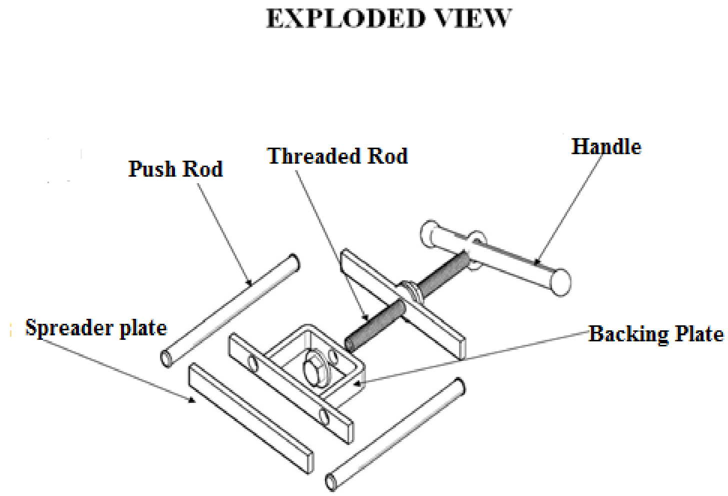

Fig. 2 shows the exploded view of the universal caliper piston compressor

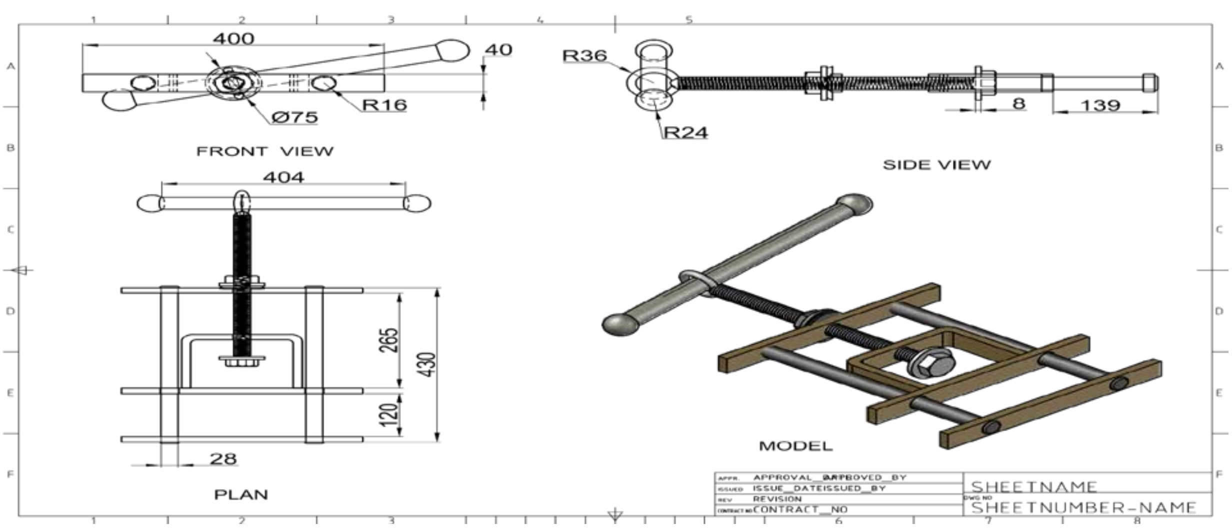

Fig. 3 shows the orthographic views of the universal caliper piston compressor

2.4 The Design Theory And Its Operation

The master cylinder converts the pedal force into pressure in a fluid system. When the brake pedal is depressed, the push rod forces the piston in the master cylinder along the cylinder, pushing the main cup in front of it and compressing the spring. When the main cup shuts off the by-pass port, the fluid is completely enclosed and continuous piston movement builds up the pressure in the forward end of the cylinder. The action of the check valve, maintains a standing pressure of (about 55KN/m^2) when the pedal is released [4].

When the brake pads are worn, the standing pressure pushes the piston forward out of the caliper bore. To be able to replace the worn out pads, the device is positioned is such a way that the caliper piston is between the backing plates and the spreader plate. Torque generated from the anti-clockwise rotation action of the spindle is directed by an externally threaded screw thread through an internally threaded sleeve joined to the backing plate.

The backing plate slides along the axis of the push rod during compression thus, the push rod helps to direct the force.

To be able to push the piston back, a greater pressure from the device is needed to overcome the standing pressure in the pipe lines which is (about 55kN/m^2).

2.5 Design Theories Of The Universal Brake Caliper Compressor

Pitch of thread = 0.003m

Length **of spindle = 0.28m**

Average power to rotate the spindle = 70 watts

Therefore one revolution of the spindle will move the thread downwards by 0.003m

Assumed force to compress = 40N

Assumed average speed = 25rev/min

Power = torque × angular velocity

Torque = $\frac{power}{angular\ vector}$

Angular velocity, $\omega = \frac{2\pi N}{60} = \frac{2 \times 3.142 \times 25}{60} = 2.618$ **rad/s**

Torque, T = $\frac{70}{2.618} = 26.738$ **Nm**

Therefore force, F = $\frac{torque}{length\ of\ spindle}$

F = $\frac{26.738}{0.28}$

F = 95.49N

To find the shear stress due to the force transmitted,

Shear stress, $\tau = \frac{shear\ force}{area\ of\ shear}$

Area of shear = $\pi \times n \times l_e \times D_s min\ [(\frac{1}{2n}) + 0.57735\ (D_s min - E_n max)]$

Where = $D_s min$ **= min diameter of external threads**

$E_n max$ **= maximum pitch diameter of external threads**

N = threads per inch

L_e **= length of thread engagement**

Area = $\pi \times 10 \times 0.945\ [\frac{1}{2 \times 10} + 0.57735\ (0.945 - 0.82677)]$

Area = 3.511in² = 0.0023m²

Therefore, Shear stress, $\tau = \frac{95.49}{0.0023}$

τ **= 41.5kN/m²**

The shear stress due to the force transmitted is 41.5kN/m²

For the compression to be possible, the pressure coming down from the screw threads should exceed that of the standing pressure which is (about 55kN/m^2 according to S.C. Mudd, 1972) in the pipe lines and wheel cylinders.

To find the pressure coming down,

Pressure $= \frac{force}{area}$, force = 95.49N.

Therefore, Area of cross section of screw thread, $A = \frac{\pi d^2}{4}$

$A = \frac{\pi \times 0.024^2}{4}$

$A = 0.00045239 m^2$

Therefore pressure, $p = \frac{95.49}{0.00045239}$

Pressure = 211.1kN/m²

Comparing 211.1kN/m² as downward pressure from screw thread and 55kN/ m² as standing pressure in the pipe lines, it can be concluded that, compression is possible even if there is slight difference in diameter of the pipelines.

2.6 Material Selection

Various materials were selected for the construction of this hand tool, the handle was made from carbon steel because it is strong and has a higher compressive strength. It is also easy to mold into different shapes and available in the market.

The spreader plate was made for gray cast iron because of its higher compressive strength and has good resistance to wear. The threaded rod was made from high strength low – alloy steel because it has a good machine-ability and ductility and easy to produce complicated parts. The push rod was made from high strength low-alloy steel because it can withstand high strength and good resistance to wear.

3.0 Conclusion

The universal disc brake caliper piston compressor is a very simple tool which is purposely made for Auto workshops to help technicians carry out brake services to reduce operator fatigue. Having conducted the research and given the necessary literature review on the subject matter, it can be concluded that this portable hand tool can replace the use of G-Clamp in removing disc brake caliper piston. A detailed analysis of the research from the researched areas and a carefully undertaken engineering procedures and principles are to ensure that the universal brake caliper piston compressor works effectively.

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Authors:

1. Charles Bentum Vroom, Lecturer, Takoradi Polytechnic, Mechanical Engineering Department, Charles.vroom@tpoly.edu.gh
2. Isaac Edunyah , Lecturer, Takoradi Polytechnic, Mechanical Engineering Department, Isaac.edunyah@tpoly.edu.gh
3. David Eshun , Lecturer, Takoradi Polytechnic, Mechanical Engineering Department, david.eshun@tpoly.edu.gh