Pneumatic Sand Core Compression Testing Machine

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Abstract

All the successful achievements in science and technology in this world are due to human endeavor and curiosity for new inventions and developments. In this search there has been a considerable achievement in the pneumatic revolution. Nowadays, Pneumatics is widely adopted in various industries because it is light in weight, cheap, easy to handle and unlike hydraulic it is free from fire hazards. Hence, in this project pneumatics is being incorporated. The objective of the project is to incorporate Pneumatics into the manually Sand Core Compression Testing Machine, which has several advantages over the manually operated testing machine like it gives accurate readings, operation is quick, lighter, fluid medium used is safe, readily available, eco-friendly and the equipment is easy to handle.

Keywords: Pneumatic, compression, sand core, Air cylinder, Machine

I. INTRODUCTION

A core is essentially a body of material which forms a component of mould. It possesses sufficient strength to be handled as an independent unit. Core is an obstruction which when positioned in the mould, naturally doesn’t permit the molten poured metal to fill up the space occupied by the core. In this a core produces a hollow casting. Cores are required to create the recesses, under cuts and interior cavities that are an often a part of a casting. Cores are employed as inserts in the moulds to form design features that are extremely difficult to produce by simple moulding. A core may be defined as a sand shape which makes the contour of the casting for which no provision has been made in the pattern for moulding. Core as sand shape generally produced separate from the sand mould and is then baked (hardened) to facilitate handling and setting into the mould. Cores may be made up of sand, metal, plaster or ceramics. Cores are used to (a) Form the air space between cooling fins of an air cooled engine cylinder (b) Make the water cooling chamber in internal combustion engine.

A. Sand

1) Types of Sand
   - Green sand.
   - Dry sand.
   - Loam sand.
   - Synthetic sand.
   - Core sand
   - Parting sand.
   - Facing sand.
   - Baking sand.
   - Sharp sand.
   - Oil and molasses sand.
   - System sand.
   - Heap sand.

B. Core Sand

A core may be defined as any projection into the mould and made up of core sand. A core forms the internal or external surfaces of a casting. Core sand is a suitable sand mixture employed for making cores. Cores are made separately, are baked and are suitably placed and positioned in the mould cavity.

C. Core Sand Properties
   - Adequate Green strength to retain its shape before baking
   - High dry strength and core hardness after baking.
- Adequate permeability for letting go the gases generated during pouring.
- High refractoriness to withstand the effects of high temperature molten metals.
- High collapsibility so that the core gives way easily as the casting cools and shrinks. High collapsibility avoids the introduction of hot tears and cracks in the cast metals.
- Core sand should be able to impart good smoothness and finish to core surfaces.
- Core sand should be such that it generates minimum amount of gases during the pouring of casting.
- Core sand should be able to retain its properties during storage (bench life).
- Core sand should be able to resist the effects of molten metal like erosion, thermal shocks etc...

### Core Sand Ingredients (Core Materials)
- Granular refractories.
- Core binders (self-made and patented)
- Water
- Special additives

### Granular Refractories
- Clean, pure and dry silica sand.
- Zircon.
- Olivin.
- Carbon.
- Chamotte.

1. A few properties of above listed materials
   1) Because of their melting points and vibrated bulk density, zircon and olivine in certain cases are preferred over silica sand for making cores. However, silica is the most widely used core based sand.
   2) Coarse white silica sand of high refractoriness is employed for making core in steel foundries.
   3) Finer bank and lake sands are preferred for making cores in cast iron and non-ferrous foundries.
   4) Coarser and finer sands may sometimes be mixed for making cores. This mixing increases size distribution and strength, but permeability gets reduced.

### II. Selection of Core Material

The selection of a core sand mixture for a definite application depends upon:
1) Type and size of core.
2) Nature of metal/alloy to be cast.
3) Core properties desired.
4) Problems associated with core making and baking.
5) Degree of core surface finish desired.
6) Cost of binders and other additives used.

### A. Preparing Core Mixture

Muller type mixers, because of their efficient mixing action, are usually employed for preparing core mix. Other mixing equipments are paddle mixers or kneading type mixers. Sand is weighed and put into the muller. Dry binders are also transferred to the muller in weighed quantities. Muller starts working and the dry ingredients are mixed for a little time. Water is measured by the meters fitted on the muller and added to the mixed ingredients. After a little while the water has taken to mix itself core oil binders in measured quantities are transferred to the muller. The total mixing time may of the order 3 to 6 minutes in normal muller. Centrifugal muller may take 60 to 90 seconds to mix the core ingredients properly.

### B. Different Functions of Cores
1) For hollow castings, cores provide the means of forming main internal cavities.
2) Cores may form a part of green sand mould.
3) Cores may provide external undercut features.
4) Cores may be employed to improve mould surface.
5) Cores may be inserted to achieve deep recesses in the casting.
6) Cores may be used to strengthen the moulds.
7) Sometimes the mould may be completed simply by assembling the core pieces or cores.
8) Cores may be used to form the gating system of large size moulds.
C. **Essential Characteristics of Dry Sand Cores**

1) Cores must possess:
2) Sufficient strength to support itself and to get handle without breaking.
3) High permeability let the mould gases escape through the mould walls.
4) Smooth surface to ensure a smooth casting.
5) High refractoriness to withstand the action of hot molten metal.
6) High collapsibility in order to assist the action of hot molten metal.
7) Those ingredients which do not generate mould gases.

1) **Core Making Procedure**
   1) Core sand preparation.
   2) Making the cores.
   3) Baking the cores.
   4) Finishing of cores.
   5) Setting the cores.

2) **Making the Cores**
   1) Small cores can be made manually in the hand rammer core boxes.
   2) Cores on mass scale are rapidly produced on a variety of core machines like:
      - Jolt machine.
      - Core roll-over machine
      - Sand slinger.
      - Core extrusion machine.
      - Core blower.
      - Shell Core machine.

3) **Steps Involved in Making Cores:**
   1) Core box is usually placed on work bench, it is filled with already mixed and prepared core sand, is rammed by hand and the extra sand is removed from core box.
   2) Weak cores may be reinforced with steel wires to strengthen them.
   3) Core box is inverted over core plate and this transfers the core from the core box to core plate, which(i.e., core).
   4) Larger cores can also be made manually, but on the floor. It needs more than one man to work and the cranes may also be used, if necessary.

D. **Core Applications**

1) Cores and core forms greatly increase the versatility of moulding and casting operations.
2) Besides being used for forming recesses and holes in the castings, cores are also employed;
   - As strainer, gates and pouring cups.
   - As riser cores.
   - For making moulds.
   - As core mould in centrifugal casting process.
   - As slab core for increasing castings' output from one mould.
   - For increasing production from match plate moulding.

E. **Sand Testing**

1) **Sand Control Tests**
   The need for systematic evaluation of the working qualities of moulding sands has led to the development of a wide range of sand control tests.
   - A moulding sand is supposed to possess many properties for its efficient functioning. These properties depend upon grain shape, size, distribution and the content and types of binders, additives and moisture.
   - Sand tests indicate the moulding sand performance and help the foundry men in controlling the properties of moulding sands.
   - Sand testing controls the moulding sand properties through the control of its composition,
   - Production of sound castings largely depends upon uniform and good quality of molding sands.
   - Sand control tests are performed on the sand which has been prepared and is ready to be transferred to the moulding section.

Various sand control tests are:
   a) Tests on moulding sands:
      - Moisture content test.
      - Clay content test.
      - Grain fineness test.
      - Permeability test.
      - Strength tests.
Green and dry compression.
Green tensile test.
Green and dry shear.
Transverse(bending)
- Hot strength test.
- Refractoriness test.
- Mold hardness test.

b) Test on core sands:
- Green strength test.
- Permeability test.
- Baked strength test.
- Hot strength test.
- Retained strength test.
- Core hardness test
- Moisture content test.

F. Pneumatics

Pneumatic components use pressurized gases to transmit and control power. As the name implies pneumatic systems typically use air (rather some other gas) as the fluid medium, because air is safe, low cost, and readily available fluid. It is particularly safe in environments where an electric spark could ignite leaks from system components.

There are several reasons for considering the use of pneumatic systems instead of hydraulic systems. Liquids exhibit inertia than do gases. Therefore, in hydraulic systems the weight of oil is a potential problem when accelerating and decelerating actuators and when suddenly opening and closing valves. Liquids also exhibit greater viscosity than do gases. This results in larger frictional pressure and power losses. Also, since hydraulic systems use a fluid foreign to the atmosphere, they require special reservoirs and no leak system designs. Pneumatic systems use air that is exhausted directly back into the surrounding environment. Generally speaking, pneumatic systems are less expensive than hydraulic systems.

G. Components Used in a Pneumatic System:

1) Fluid Conditioners
1) Air filters.
2) Air pressure regulators.
3) Air lubricators.
4) Pneumatic pressure indicators.
5) Pneumatic silencers(muffler)
6) After coolers.
7) Air dryers.

2) Air Control Valves
1) Pressure regulators.
2) Check valves.
3) Shuttle valves.
4) Directional control two way valves.
5) Three way and four way directional control valves.
6) Flow control valves.

3) Pneumatic Actuators
1) Pneumatic cylinders.
   - Single acting cylinder.
   - Double acting cylinder.
2) Pneumatic rotary actuators.
3) Rotary air motors.

Listed are below some of the basic components required for pneumatic system:
1) An air tank to store a given volume of compressed air.
2) A compressor to compress the air that comes directly from the atmosphere.
3) An electric motor or other prime mover to drive the compressor.
4) Valves to control the direction, pressure and flow rate.
5) Actuators which are similar in operation to hydraulic actuators.
6) Piping to carry the pressurized air from one location to another.

H. Characteristics of Compressed Air

1) Air is available in abundance at all locations.
2) Air can be transported from the source to the point of utilization very conveniently through piping layout, and there is no limitation on the distance.
3) Compressed air can be stored conveniently in a reservoir and used whenever required.
4) Compressed air is free from explosion and electrical hazard problems.
5) Air is clean and has no leakage/messy problems like hydraulic fluids.
6) Generally, temperature variations do not affect the performance of air systems, as long as good air treatment systems (like filters, waters, separator, and lubricator) are maintained.
7) Most components of air system are simple and compact in design.

I. Choice of Working Medium
The choice of a system (between hydraulic and pneumatic); hence the choice of working medium (i.e., oil or air) depends basically on the type of application. Some of the general, broad rules followed in the selection of working medium are:
- When the system need high speed, medium pressure and less accuracy a pneumatic system is good. If the system requires high pressure and accuracy, a fluid system with oil is good.
- When the power requirements are very high, like in power press, oil hydraulics is the option, where air systems are insufficient.
- Location of system also plays a role in the choice of working medium. For locations with severe temperature variations, oil hydraulic system will do better, where an air system may lead to severe condensation problems.
- Another issue related to the selection of working medium is that of fire/electric hazards. Air being non-explosive in nature, it is preferred where fire/electric hazards are expected. Oil systems are more prone to fire and electrical hazards and are not recommended in such areas.

II. Pneumatic Filters
A pneumatic filter is a device which removes contaminants from compressed air stream. This can be done using a number of different techniques from using a media type that traps particulates, but allows air to pass through a venture, to a membrane that only allows air to pass through.
1) Primary Filters
Typical commercial pneumatic filters will remove particles as small as 5µm from the air. The filters protect pneumatic devices from damage that would be caused by theses contaminants. These contaminants include lubricant particles ejected by the compressor, dirt particles and small water droplets.
2) Secondary Filters
Secondary filters are used for a variety of applications and can remove particles as small as 50nm in size. These secondary filters can remove fumes, odors, vapor, mist, moisture, oil and tiny particles from the air stream. In addition, special point of use air drying devices called membrane air dryers may be used to depress the pressure dew point by selectively condensing water vapor from compressed air in order to deliver a cleaner and drier air supply before entering the equipment. Membrane air dryers, however, may be easily damaged through any contact with liquid droplets (water or oil) so they should be protected with a high efficiency nano air filter, positioned either immediately upstream or integrated with the membrane drier housing. Membrane driers are mostly used with equipment which is especially sensitive to water vapor such as paint booths, part mixing equipment (polyurethane sealants), polyurea dispensers, PUR applicators (edge banding equipment), laser cutting machinery, CMMs, industrial inkjet printers or even for laboratory use.

III. Pneumatic Cylinders
Pneumatic cylinders (sometimes known as air cylinders) are mechanical devices which produce force, often in combination in movement, and are powered by compressed gas (typically air). To perform their function, pneumatic cylinders impart a force by converting the potential energy of compressed gas into kinetic energy. This is achieved by the compressed gas able to expand, without external energy input, which itself occurs due to pressure gradient established by the compressed gas being at a greater pressure than the atmospheric pressure. This air expansion forces to move the piston in the desired direction.
1) Composition and structure
Apart from the cylinder barrel (which is the body of the cylinder itself), a typical cylinder will include a piston and piston rod.
2) Operation
Once actuated, compressed air enters into the tube at one end of the piston and, hence, imparts force on the piston. Consequently, the piston becomes displaced (moved) by the compressed air expanding in an attempt to reach the atmospheric pressure.
3) Types
Although, pneumatic cylinders vary in appearance, size and function, they generally fall into one of the specific categories below. However, there are also numerous other types of pneumatic cylinders available, many of which are designed to fulfill specific and specialized functions.
4) Single acting cylinders
Single acting cylinders (SAC) use the force imparted by the air to move in one direction (usually out), and a spring to return to the home position.
5) **Double acting cylinders**

Double acting cylinders (DAC) use the force of air to move in both extend and retract strokes. They have two ports to allow air in, one for outstroke and one for in stroke.

6) **Other types**

Although SACs and DACs are the most common types of pneumatic cylinders the following types are not particularly rare:

- Rotary air cylinders: Actuators that use air to impart a rotary motion.
- Rod less air cylinders: Actuators that use a mechanical or magnetic coupling to impart force, typically to a table or other body that moves along the length cylinder body, but does not extend beyond it.

7) **Sizes**

Air cylinders are available in a variety of sizes and can typically range from a small 2.5 mm air cylinder, which might be used for picking up a small transistor or other electronic component, to 400 mm diameter air cylinders which would impart enough force to lift a car. Some pneumatic cylinders reach 1000mm in diameter, and are used in place of hydraulic cylinders for special circumstances where leaking hydraulic oil could impose an extreme hazard.

**K. Pressure Vessel**

A pressure vessel is a closed, rigid container designed to hold gases or liquids at a pressure different from the ambient pressure. The end caps fitted to the cylindrical body are called heads. In addition to industrial compressed air receivers and domestic hot water storage tanks, other examples of pressure vessels are: diving cylinders, recompression chamber, distillation towers and many other vessels in oil refineries and petrochemical plants, nuclear reactor vessel, habitat of a space ship, habitat of a submarine, pneumatic reservoir, hydraulic reservoir under pressure, rail vehicle air brake reservoir, road vehicle air brake reservoir and storage vessels for liquefied gases such as ammonia, chlorine, propane, butane and LPG.

**L. Muffler**

A muffler (or silencer) is a device for reducing the amount of noise emitted by a machine. On internal combustion engines, the engine exhaust blows out through the muffler. The internal combustion engine muffler was developed in parallel with the firearm suppressor by Hiram Percy Maxim.

Mufflers are typically installed along the exhaust pipe as part of the exhaust system of the engine. The muffler accomplishes this with a resonating chamber, which is specifically designed such that opposite sound waves are likely to collide, canceling each other out. They are a common piece of equipment on automobiles, usually slung under the rear of a car, but many diesel-powered semi trucks have large mufflers mounted vertically behind the cab.

1) **Advantages**

Mufflers that reduce backpressure were invented in the late 20th century, and resulted in increased engine efficiency, performance, power output, and simultaneously decreased overall wear and tear on the engines’ components, as well as sound to levels in compliance with the law.

**M. FRL Unit**

The air that is sucked by the air reservoir is evidently not clean because of the presence of various types of contaminants in the atmosphere. Moreover, the air that is supplied to the system from the reservoir is further contaminated by virtue of generation of contaminants downstream. It is also a fact that the pressure of air does seldom remain stable due to the possibility of line fluctuations. Hence to enable supply clean, pure and contamination free compressed air, the air requires to be filtered. The system performance and accuracy depend much on the pressure-stability of the air supply. An air filter and a pressure regulator therefore, find an important place in pneumatic system along with a third component – an airline lubricator. The main function of the lubricator is to provide the air with a lubricating film of oil. These three units together are called service unit or FRL unit. Hence the three main elements of an FRL unit are:

- Air filter.
- Pressure regulator.
- Lubricator.

**N. Direction Control Valves**

Direction control valves are used mainly to direct the flow of the pressure fluid in the desired directions. The main functions of these valves are to start, stop, regulate the direction of air flow and help distribution of air in the desired line. They can be actuated to assume different positions by various actuating mediums, viz. electrical, mechanical and pneumatic or other modes of control. This results in corresponding connection or disruption of flow between various port openings. A direction control valve has generally two, three, four or five port openings. The openings are termed ways or ports. The ways are designated by letters or alphabets such as:

- P = compressor line port
- R = exhaust port
- A&B = workingports to cylinders or motors.
Directional control valves are classified functionally as
- 2/2 direction control valve.
- 3/2 direction control valve.
- 4/2 direction control valve.
- 5/2 direction control valve.
- 4/3 direction control valve.
- 5/3 direction control valve. Etc

**O. Pipeline**

The following factors are taken into account while selecting pneumatic pipes and other airline installations.
1) Pressure of compressed air in the line.
2) Total flow rate per unit time through the line.
3) Permissible pressure drop in the line.
4) Type of tube material and type of line fittings.
5) Length and diameter of the tube or other pipelines.
6) Working environment, etc.,

**P. Pipe Materials**

If the system pressure is quite high, materials of pipes and their physical and metallurgical properties become an important parameter for their correct selection. But as the pneumatic system usually works at much lower pressure in comparison to hydraulic system, one may not need super high strength material for pneumatic pipelines and fittings. Materials which are mostly used for pneumatic pipes and tubes are listed below:
1) Galvanized iron pipes (G.I. pipes)
2) Cast iron pipes.
3) Copper tubes.
4) Aluminum tubes.
5) Rubber tubes.
6) Plastic and nylon hose.
7) High strength steel pipe.
8) Brass tubes.
9) Reinforced rubber or plastic hose, etc.,

**Q. Pressure Gauge**

A pressure gauge normally forms the part of the service unit measuring the pressure above the atmospheric pressure of air which goes out to the downstream system and components after regulation. This gauge is sometimes known as ‘Bourdon Pressure Tube’. It is a phosphor-bronze tube oval in section and circular in form. When pressure is applied to the tube, it needs to straighten and this movement of the tube is transferred to a needle or pointer through a link, sector arm and a pinion assembly. The pressure can be read out from the pointer scanning a graduated dial. Nowadays digital pressure gauges are being used. The accuracy of the pressure gauge should be within ±1-2% of the read value. The gauges are calibrated by a master gauge dead weight tester which accuracy should be at least within ±0.25% of the indicated value.

The mechanical type Bourdon’s tube pressure gauges are widely used in industry. To maintain the accuracy of the pointer movement and to avoid damage to the link mechanism, the entire internal of the gauge is filled with transparent liquid like glycerin. This will suppress any vibration and thus will ensure accuracy of pressure reading.

### III. EXPERIMENTAL SETUP

(Pneumatic Sand Core Compression Testing Machine)
A. Basic Components of Test-Rig

1) Core 7) Foot mountings.
2) Movable bracket 8) Pressure gauge
3) Frame 9) Direction control valve
4) Air reservoir 10) Control panel
5) Foot pump 11) FRL unit
6) Air Cylinder 12) Jaws

B. Double Acting Pneumatic Cylinder

Fig. 1: Schematic Diagram of Sand Core Compression Test Rig

Fig. 2: Double Acting Pneumatic Cylinder

The double acting pneumatic cylinder made of aluminum barrel, chrome, steel piston rod and cast iron piston of bore diameter 50mm and stroke length of 100mm is used as linear actuator to move the movable jaw of the test rig. The pressurized air when supplied to the rear port of the cylinder, the piston extracts and does the mechanical work and when the pressurized air is supplied to the front port of the cylinder the piston retracts.
C. Air Reservoir (Tank)

Fig. 3: Air Reservoir (Tank)

It is made up of mild steel plate of 5mm thickness with top and bottom cover plate welded circumferentially to the cylindrical part. The cylindrical part is welded longitudinally. The reservoir is of 200mm diameter and 400mm height.

D. FRL Unit

Fig. 4: FRL Unit

It is an essential component of the system. A filter removes dust particles from the air and also moisture present in the air and thus gives out the clean dust free air. Regulator is used to control the air pressure to the required level before supplying it to the air cylinder. A lubricator provides the thin oil mist which mixes with the incoming air this permits the smooth operation of valve spool of direction control valve and piston inside the air cylinder.

E. 5/3 Direction Control Valve

In certain designs of direction control valves 5 openings are preferred instead of 4 openings. This ensures easy exhausting of the valve. Below figure shows a 5/3 direction control valve-spool type design. The spool here slides inside the main bore and according to spool position it gets connected or disconnected.

Fig. 5: 5/3 Direction Control Valve
The working principle is as follows:

1) Position 1: When the spool is actuated towards outer direction, port ‘P’ gets connected to ‘B’ and ‘S’ remains closed while ‘A’ gets connected to ‘R’.
2) Position 2: When the spool is pushed in the inner direction, port ‘P’ and ‘A’ get connected to each other and ‘B’ to ‘S’, while port ‘R’ remains closed.
3) Position 3: When the spool is in center position all the ports will be blocked and no actuation of the piston rod is possible.

1) **Foot Pump:**

   Leg pump is used instead of the compressor, in order to make the system more compact and portable. It supplies the compressed air into the air reservoir, which is then used for further process.

2) **Pressure Gauge:**

   A pressure gauge of Bourdon type with a range of 0-0.98 N/mm² is connected to the extension stroke line of the air cylinder to measure the pressure acting upon the core during testing.

3) **Polyurethane Pipes:**

   The polyurethane pipes are used in the system to supply the pressurized air from the air reservoir to all other components connected in the system to perform the required operation during the testing of core.

4) **Circular Jaws:**

   The jaws are used to hold the testing specimen in between two grips. There are two types of jaws; one is the fixed jaw which will be fixed to movable bracket held in the slots provided on the frame. And the other is a movable jaw which is fixed to the end of the piston rod of the air cylinder.

5) **Brackets:**

   Brackets also known as foot mountings are used to hold the cylinder in position and fixed the frame.

6) **Frame:**

   Frame is the member which forms the base for the test rig on which all the components such as air cylinder, brackets, fixed jaw with movable bracket, are mounted.

7) **Control Panel:**

   Control panel consists of FRL unit, Direction control valve, and the pressure gauge mounted on it. And is used to control the test rig.

![Pneumatic Circuit Diagram](image)

**Fig. 6: Pneumatic Circuit Diagram:**

**F. Working of the Test Rig:**

Using a leg pump air is filled through inlet valve into the air tank up to a required pressure based on the type of core tested. Then by opening the shut off valve air is allowed to pass through the FRL unit. While passing air through the FRL dust particles and excess moisture is removed in the filter. Pressure of air can be regulated to require value by using a pressure regulator. A lubricator mixes an oil mist with air. Air that comes out of FRL unit will be clean, dry and lubricated which then enters the 5/3 D.C. valve which is normally closed type.

Before operating the valve the core specimen is held between the jaws firmly. When the lever is pushed to left air from the valve port ‘P’ enter port ‘A’ of cylinder and performs the extension stroke. During this stroke it compresses the specimen in its line if stroke. Pressure at which the specimen fails can be read directly from the pressure gauge mounted on the control panel inline with extension stroke.

When the valve lever is pushed to the right air from the valve port ‘T’ enters the port ‘B’ of cylinder and thus the piston rod retracts. By using this valve air supply the any of the two ports can be shut off, which is possible only in the neutral position of the valve.
Advantages:
1) Since, this test rig operates on compressed air, which is easily available in nature.
2) Since, air is used as a working medium wear and tear of machine parts and mechanism is minimum.
3) Pneumatic devices offer durability coupled with easy and cheap maintenance.
4) Pneumatic devices will not create fire hazards in explosive atmosphere.
5) It is a portable machine.
6) Since operating pressure are less pneumatic system holds good.

Disadvantages:
1) Since air acts in spring manner, the output speed and position cannot be controlled accurately in pneumatic system.
2) Air used in pneumatic system being compressible in nature, the force transverse behaves like through a spring that means the output motion does not go directly with the input motion.

G. Design:

1) Air Cylinder Design:
Material: Aluminium
Safe permissible stress, \( f = 49 \text{ N/mm}^2 \) [machine design data hand book] Young’s modulus, \( E = 0.7 \times 10^5 \text{ N/mm}^2 \)
Poisson’s ratio, \( \mu = 0.3 \)
Pressure inside the air cylinder, \( P = 0.98 \text{ N/mm}^2 \)
Bore diameter, \( D_i = 50 \text{mm} \)
Outside diameter, \( D_o = 54 \text{mm} \)
Thickness of cylinder barrel, \( t = 2 \text{mm} \)
a) For thickness from relation
\[
t = R_i \times [( f_t + p/(f-t) )^{1/2} - 1]
\]
\[
= 25 \times [(0.98/49 + 0.98/49 - 0.98)^{1/2} - 1]
\]
\(= 0.5 \text{mm} \) since \( t = 0.5 < 2 \text{mm} \) design is safe
b) Circumferential stress, \( f_1 = PD/2t \)
\(= 0.98 \times 50/2 \times 2 \)
\(= 12.25 \text{ N/mm}^2 \)
c) Longitudinal Stress, \( f_2 = PD / 4t \)
\(= 0.98 \times 50 / 4 \times 2 \)
\(= 6.125 \text{ N/mm}^2 \)
d) Maximum intensity of shear stress, \( Q_{max} = (f_1 - f_2) / 2 \)
\(= (12.25 - 6.125) / 2 \)
\(= 3.0625 \text{ N/mm}^2 \)
Since the circumferential stress \( f_1 = 12.25 < 49 \text{ N/mm}^2 \)
Longitudinal stress \( f_2 = 6.125 < 49 \text{ N/mm}^2 \)
Maximum shear stress \( Q_{max} = 3.0625 < 24.5 \text{ N/mm}^2 \)
The design is safe for the air cylinder.

H. Pressure Drop in the Pipeline
The pressure drop in the pipeline is neglected because the length of the connections used for the system is small.

IV. Conclusions

Compared to hydraulic system pneumatic system has better operational advantages such as explosion proof characteristics, high degree of controllability of pressure speed and force and it can also be operated remotely.

Since, pneumatic systems are widely used in various industrial applications such as assembly, foundry machineries, packaging industries, press tools, processing, wood working and material handling.

This test rig can also be used for conducting other tests such as shear test and tensile test on sand cores requiring modifications only in the jaws design.

Provisions have been made to include other pneumatic components such as flow control valves, digital pressure indicator, flow meter, etc. This test rig can also be modified easily to perform meter-in, meter-out operations etc.

By this we can conclude scope for pneumatic operated machines are wide and never ending, it will continue to move the industries of today and tomorrow.

REFERENCES

[1] Pneumatics Basic Level Tp 101, By Peter Croser and Frank Ebel, Festo Didactic Publication – 1999
[10] www.flowserve.com