Pneumatic Door Operation System in Trains with Cogeneration

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Abstract— Global demand for transportation has exceeded the available capacity. In today's context of climate and pollution concerns, it is no longer possible to meet demands by increasing the physical capacity of transportation networks. Instead, we need more innovative solutions and this can be enabled by technology. The railway industry has embraced technology at a slower pace than other modes of transportation. Across most of the Americas, Europe, and Asia, planning and operating trains is still a human-intensive process. So the question is: can advanced control and automation deliver substantial benefits to railway operators? Historically, many transportation systems have been human intensive, but are benefitting from an amazing level of automation today. About 100 years ago, cars were steered using a tiller, and speed controlled by a hand-held throttle. The starter, carburettor, choke valve, were all manually operated. Today, most of these functions have been automated. With autonomous cars, almost incredibly, driving itself has been automated. As these cars become main stream, they will free up the chauffeur space (that is an increase in throughput) and also open our minds to the amazing possibilities of automation. As we understand the cause-effect relationship between the parts of a complex system, we can automate their operation. Railways are ready for such an evolution. Increasing railway infrastructure capacity is an expensive proposition, and doesn't guarantee proportional increases in efficiency. Despite a 75 billion dollar investment in railways in the US between 2009 and 2013, the American Institute of Civil Engineers assessed railway infrastructure and graded it C+. A much cheaper alternative is to supplement existing infrastructure with advanced sense-analyse-control. In India, we know that the current dispatching methods draw upon over 100 years of organizational experience, and are as efficient as humanly possible – but the key word here is 'humanly'. The beauty of automation lies in always finding that last drop of performance that may be missed by an inexperienced, distracted, or tired human dispatcher. Our calculations show that extracting just 5-7% additional throughput from Indian Railways may be worth as much as 10,000 crore rupees in additional revenue.

Key words: Pneumatic, Cogeneration, Compressor, Double Acting Cylinder, 5/2 Valve, Non Return Valve (NRV) Pressure Release Valve (PRV)

I. INTRODUCTION

The first commercial train journey in India between Bombay and Thane on 16 April 1853 in a 14 carriage long train drawn by 3 locomotives named Sultan, Sindh and Sahib. It was around 21 miles in length and took approximately 45 minutes.

From then till now we have moved a lot. A long distinct journey and as we step in the 21st century with industrialization we see more and more dependency towards railways. Railways have also changed a lot from plain and simple coal trains to high speed bullet train.

The first electric train ran between Bombay (Victoria Terminus) and Kurla, a distance of 16 kms, on February 3, 1925 along the city's harbour route.

Following independence in 1947, India inherited a decrepit rail network. About 40 per cent of the railway lines were in the newly created Pakistan. Many lines had to be rerouted through Indian Territory and new lines had to be constructed to connect important cities such as Jammu. A total of 42 separate railway systems, including 32 lines owned by the former Indian princely states existed at the time of independence spanning a total of 55,000 km. These were amalgamated into the Indian Railways.

In 1952, it was decided to replace the existing rail networks by zones. A total of six zones came into being in 1952. As India developed its economy, almost all railway production units started to be built indigenously. The Railways began to electrify its lines to AC. On 6 September 2003 six further zones were made from existing zones for administration purpose and one more zone added in 2006. The Indian Railways has now seventeen zones including Kolkata Metro.

With new technologies coming ahead we stand to make something useful that will help develop Indian Railways to greater heights. In the world of automation where people are more reliable on machines. Hence looking forward to this automation we decided to develop a system which will help opening and closing of doors in trains automatically. With the number of accidents and problems with the signalling system we don't think railway has any budget to imply this method into the system but probably in the near future we can see trains with automated doors and other system in place.

Hence keeping in mind the near future we plan to design our project to help Indian railways to take a step towards automation with the help of cogeneration.

Today energy conservation is the need of every industry, transportation field. So we have taken challenge to make project in this Train field to support energy conservation system.

II. DESIGN & CONSTRUCTION

Energy conservation will always stay on high priority so we will be using the pneumatic system for application in the train wheel operated door operating system.

The design and construction of train wheel operated compressor is very simple & compact. Basically it is assembly of Base frame Wheel, Piston-Cylinder, and Air reservoir.

A. Base Frame

Base frame is made of Fabrication angle. Supported angles are joint under base frame, where the motor & valve is

located. Then piston supporter is mounted. Use: The use of the base frame is to give Support & Stability to all project components.

B. Wheel

By gas cutting a round shape locomotive wheel is made. Then rolling shaft is attached at the centre line of wheel & connecting rod is fixed at the periphery of wheel. Use: To give power and Rotary motion to Connection rod.

C. Air Tank

Air tank is made of Mild steel. A hole is drilled at the upper side & threading is done to keep the pressure gauge and then fix two ends using welding & make an input & output air connection. All pressurize air come in tank from various cylinders through the pipe connection. Use: To store pressurize compressed air & supply this pressurize air for various use when required.

D. Air Piston Utilizer

Air Piston utilizer is fitted on frame by using the nut & bolts, at the backside of door. This air piston utilizer is run by pressurize air that come from lever control valve, which is used to control air, come from Air tank. Use: To operate door, windows.

E. Door

The door is opened & closed on the base frame at the centre. A piston connection is given at the backside of the door due to which the door moves in both directions. Use: For comfort entry & exit to public.

F. Double acting cylinder:

In a double acting cylinder, air pressure is applied alternately to the relative surface of the piston, producing a propelling force and a retracting force.

III. WORKING

The train wheel operated compressor for various systems is work on law of energy conservation. The law states that " energy neither can be created nor destroy but it may transform from one form of energy to another, so sum of energy in its various forms remains constant in the universe." As the train starts moving, the wheel starts rotating. The connecting rod that is fixed on the periphery of the wheel also starts to rotate with wheel. This rotary motion is further converted in to reciprocating motion with the help of piston cylinder arrangement that is connected at the other end of the connecting rod. When piston start reciprocating in the cylinder t creates suction as it moves towards (B.D.C.) Bottom dead centre, air enter in the cylinder from one hole which is provided with a N.R.V. & when the piston moves towards (T.D.C.), it compresses the air and this operation is continuous and discharge is obtained in air reservoir tank. When we operate lever control valve, air come from air reservoir tank to Air piston utilize. This Pressurize air pushes & Pull to the piston in reciprocating motion causes the opening & closing of the Door.

Why We Used Compressed Air Pneumatic System?

We used pneumatic system, as it has some advantages over the hydraulic system. There is no need for fluid replenishment. Light tubing/piping is sufficient. There is no fire hazard. But in our pneumatic system, we have used air as a working fluid. Because air has the some advantages over the other gases. Properties of air are very suitable for pneumatic system.

IV. PROPERTIES OF AIR

Air is a mixture of 78% nitrogen, 21% oxygen and 1% other inert gases with moisture by volume. Air exerts pressure at sea level of about 1.013 bar (14.7 psi) called atmospheric pressure. It is equivalent to 760 mm of Hg or 10.3 m of water pressure as measured by U-tube manometer. Other physical properties of air are:

1) Molecular mass, M = 28.96 kg/kg mol.
2) Boiling point at 1 bar = -191º C to -194º C.
3) Freezing point at 1 bar = -212º C to -216 ºC.
4) Characteristic gas constant, R = 287 Nm/kg K.

A. Advantages of Compressed Air Pneumatic Systems:

1) Freely available from the atmosphere.
2) Explosive proof. No protection against explosion required.
3) Easily transportable in the vessels and pipes.
4) No return lines are required.
5) Clean system. It has self-cleaning properties.
6) Simple construction and ease of handling.
7) Unduplicated exhaust clear air which escapes through leaking pipe or components don't cause contamination.
8) The pressure, speed and forces required can be controlled easily.
9) Overload safety- Pneumatic tools and operating components can be loaded to the point of stopping and are therefore overload safe
10) Air enables high working speed to be obtained
11) Low cost of maintenance.

B. Disadvantages of Compressed Air System:

1) It is inaccurate in operation.
2) High forces cannot be transmitted.
3) It provides non-uniform speeds.
4) Creates noise pollution.
5) Expensive.
6) Conditioning of air is needed.

V. APPLICATIONS

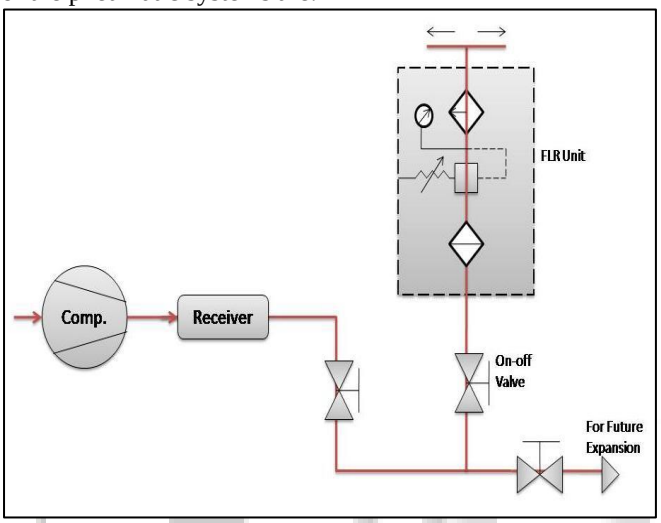
Usually air at low pressures in the range of 5 to 7 bar is used in pneumatic systems. Compressed air systems are used for many industrial applications. Some of its applications are:

1) To operate pneumatic tools
2) Spray Painting
3) Refrigeration and air conditioning systems
4) Gas turbine power plants
5) Supercharging of I.C Engines
6) Conveying materials like sand and concrete, coal mixtures etc. in pipe line
7) Pumping of Water
8) Driving the mining machinery
9) In Blast furnaces
10) In Robotics

VI. BASIC PRINCIPLE OF PNEUMATIC SYSTEM:

A. Basic Pneumatic System

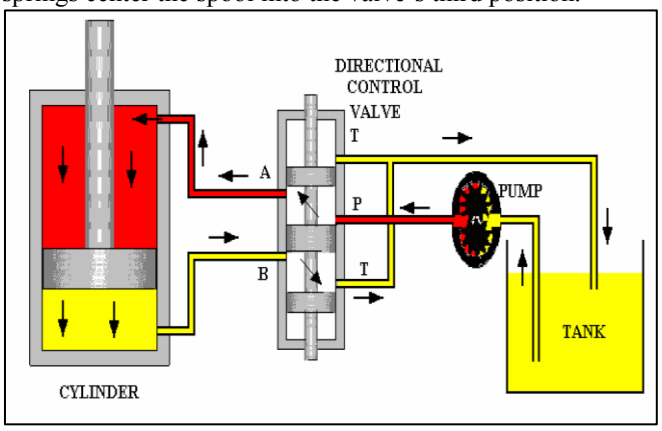
The basic layout of a pneumatic system is shown in fig.. it could be observed that the basic components involved are similar to a hydraulic system. The basic differences between hydraulic and pneumatic systems are that in hydraulic system the input mechanical energy is imparted to the oil is by pump, whereas, in pneumatic systems the working fluid being air, the mechanical energy is imparted to air by a compressor. Further, a hydraulic system usually operates at very high pressures to transmit the large force and power while a pneumatic system operates at low pressures of about 5 – 7 bar for industrial applications. The major components of the pneumatic systems are:



1) A compressor of appropriate capacity to meet the compressed air requirements.
2) A receiver to store the compressed air.
3) Air distribution lines to distribute the air to various components of the system.
4) Filter lubricator regulator (FLR) unit for conditioning of air and regulation of pressure.
5) Pneumatic control valves to regulate control & monitor the air energy.
6) Pneumatic actuators.
7) Air driers.

B. Working of 5/3 valve:

The directional control valve must direst the flow from the compressor either to port A or port B. The fluid exhausted by the cylinder must be directed from the other port to back to tank. The valve shown has 5 ports and 3 Position so called as 5/3V. Valves are necessary to control the pressure, flow rate and direction of the fluid. Pneumatic systems are low pressure systems. Pneumatic valves are made from cheaper materials (e.g. aluminium and polymer) and are cheaper to manufacture. The directional control valve must direct the flow from the compressor either to port A or port B. The fluid being exhausted by the cylinder must be directed from the other port back to tank. The number of ports (External connections) and the number of positions describe such valves. The valve we used and shown above has 5 ports and 3 positions so it is designated as a 5/3 directional Control Valve. It is noted that the third position in a 5/3 valve is a center position. The air control mechanism inside 5/3 valve (usually a spool of some sort) is shifted into the center position inside the valve by one of two internal spring valve actuators. There is a spring located inside the valve at each end of the internal spool. When no external valve actuator is being exerted on the valve these springs center the spool into the valve's third position.



VII. TRANSMISSION SYSTEM

The mechanical power produced by prime over I used to drive various machines in the workshop and factories. A transmission system is the mechanism. The rotary motion of the motor is transmitted to the operative element to provide an operative working or auxiliary motion. When the required motion is rotary; the transmission takes place through mechanisms that transfer Rotary motion from one shaft to another. Transmission of the motion from the external source to the operative element can take place through Mechanical elements such as belts, Gears, chains etc. Mechanical Transmission and its elements: -

1) Belt Transmission
2) Gear Transmission
3) Chain Transmission

A. Belt Transmission

Belt drive is one of the most common effective devices transmitting motion and power from one shaft to the other by means of thin inextensible belt over running over to pulleys. This largely used for general purpose on mills and factories especially when the distance between the Shafts is not very great. When the center distance between the two shafts is large than the tight side of the belt should be the lower one the pulley called driver is mounted on the driving shaft while the shaft while the other, which is mounted on the shaft to which power is to be transmitted is called the driven pulley or follower. When the belt moves over the pulleys there is always the possibility of slipping between the belt and pulley and hens the Character of the motion transmitted is not positive when positive action is required. Gears and chain must be used.

B. Gear Transmission

Efficiency of power transmission in belt and rope drives is less. The power may be transmitted from one shaft another by means of mating gears with high transmission Efficiency and a gear drive is also provide when the between driver and follower is very small.

C. Chain Transmission

Chains are used for high transmission number. They are mostly used when distance between center is short but the

center distance is as much as 8m. They are now generally used for transmission of power in cycle, motor vehicle, and agriculture machinery in workshops. It is general requirement for any machines that they should provision for regulating speed of travel the regulation may be available in discrete steps or it may be steeples i.e. continuous. The format are known as stepped drives Ex. Lathe machine, milling machine, printing machine etc.

The pneumatic power is converted to straight line reciprocating motions by pneumatic cylinders. According to the operating principle, air cylinders can be sub-divided as

1) Single acting
2) Double acting cylinders

1) Single acting cylinder

In a single acting cylinder, the compressed air is fed only in one direction. Hence this cylinder can produce work in only one direction. The return movement of the piston is effected by a built-in spring or by application of an external force.

2) Double acting cylinder:

Here we have used double acting cylinder. It is the pneumatic actuator, which is actuated using compressed air. The Force exerted by the compressed air moves the piston in two directions in a double acting cylinder. In principle, the stroke length is unlimited, although buckling and bending must be considered before we select a particular size of piston diameter, rod length and stroke length. The double acting cylinder consists of 1) Cylinder tube, 2) Piston unit, 3) Double cup packing on piston, rod packing of "O" rings, 4) Bronze rod guide, Piston rod, 6) End covers (flanges) 7) Port connection, 8) Cushion assembly. The cylinder is manufactured from aluminium solid bar with central bore on lathe machine. It is then made smooth internally using method of honing and lapping. It contains piston and piston rod, which reciprocates to and fro with the application of high pressure air. The piston is fitted with the piston ring which is made of Teflon rubber to make perfect compression of the air. The material used for various parts differs for different types of cylinders depending upon applications

3) 5/2 Direction control foot operated valve:

Its basic symbol is as shown the control of the to and fro motion of a pneumatic cylinder, the air energy has to be regulated, controlled, and reversed with a predetermined sequence in a pneumatic system. Similarly one has to control the quantity of pressure and flow rate to generate desired level of force and speed of actuation. To achieve these functions, valves are used to- (i) Start and stop pneumatic energy, (ii) Control the direction of flow of compressed air, (iii) Control the flow rate of the compressed air and (iv) Control the pressure rating of the compressed air. A direction control valve has two or three working positions generally. They are: 1) Neutral or zero position 2) Working position the positions are mostly numbered as 0, 1, 2. Direction control valves are designated to indicate both the number of ways as well as the number of working positions such as 4/2, 3/2, 5/2 means 5 ways / 2positions. Here we have used 5/2 direction control valve. In this design of direction control valve, 5 openings are provided. This ensures easy exhausting of the valve along with the two positions i.e. ON and OFF. Here the spool slides inside the main bore and according that the spool position is made ON or OFF due to the fact that the spool gets connected to the open side or the closed side of the air opening.

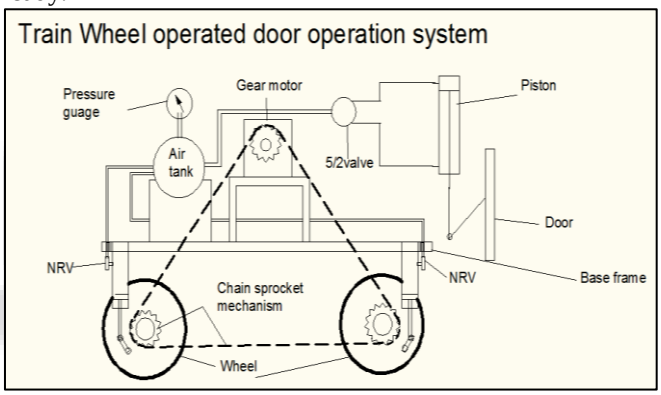
4) Air circulating devices:

The compressed air is stored in an air receiver from which air is drawn out in to the consumer point by means of pipe line. While laying out the pipe line for the system, one should take sufficient care and pay attention to see that the pressure drop from the generating point to the point of consumption remains as low as possible. For economical reason, it is always better if the total drop of pressure is kept limited to a maximum value of 0.1 bar or even less. The following factors are taken into account while selecting pneumatic pipeline and other air- line installations:-

1) Pressure of compressed air in the lines.
2) Total flow rate per unit time through the line.
3) Permissible pressure drops in the line.
4) Types of tube material and types of line fitting.
5) Length and diameter of tube or other pipelines.
6) Working environment.

Considered the above factors we have selected the flexible hose tubes of 1/8"diameter.

Hence by assembling all these components together in proper manner the miniature working model would be ready.



As different test were conducted on the working model to check whether our proposed design actually works. A detailed report of all the material used with specification will accompany the model.

VIII. ADVANTAGE & DISADVANTAGE

A. Advantages

1) Air is available free of cost.
2) No external supply is required.
3) Low Cost
4) No pollution & less noisy system.
5) Efficiency is high.
6) No supervision is required.
7) High portability.
8) No high leakage & reliable.
9) Easy construction & Very compact.
10) Low maintenances.
11) It can be used with any rotating systems.
12) Easily & immediately get results.
13) It can work for long time continuously.
14) Required less power to work the system.
15) A higher average of productive hours per day, because it do not required frequent stop for fuel, and other servicing.

B. Disadvantage

1) Leakage problems.
2) Clogging may occurs.
3) System may affect by thermal stresses.
4) Due to working burring of material occurs.

IX. APPLICATION

Compressed air is utilizing for opening & closing the Door-Windows of the train. It can be also used for AC system & refrigeration system by using pulse tube mechanism to store the food like fish, vegetable etc. Compressed air is used for Supporting Breaking system in emergency, by arranging many piston & cylinder in large capacity. It can also use to clean the train, cooling the radiator of engine. It is used for generation of electricity with the help of turbine mechanism to operate lighting, horn, etc.

X. FURTHER MODIFICATION

1) We can drive more than one piston & cylinder on one shaft by using crank.
2) We can use screw compressor instead of piston & cylinder arrangement.
3) By using plus tube mechanism air can be used for Refrigeration & AC system.
4) By using Crankshaft on wheel shaft, we can compress the air instead of mounting wheel.
5) More capacity tanks mounted to store large amount of air.
6) Safety valve can be used for safety of air tank.
7) We can use IR sensors instead of 5/2 direction control valve.

XI. CONCLUSION

It has been a great experience while designing the project we come across lot many practical knowledge as well as experience. While designing Train wheel operated compressor it was kept in mind that this machine is being manufactured only once. Therefore the design must be as perfect as possible and special attention is given during each manufacturing activity. We paid special attention during each & every manufacturing process that was carried out. In the manufacturing we come to know how theoretical aspects are implemented in actual practice, we got to learn about different manufacturing processes, welding, gear, cutting etc. We are really pleased to see our pneumatic door operating system at work for various system working successfully.

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