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Design of Universal Test Bench for The Pneumatic System

D. Balaji[*1], M.Logesh [#2], K. Prakash[#2], M. Kumaran[#2]
[*1]Assistant professor, Department of Mechanical Engineering
[#2]UG Student, Department of Mechanical Engineering
Ponnaiyah Ramajayam Institute of Science and Technology (PRIST), Tamil Nadu, India
Email: balajibala81@gmail.com

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ABSTRACT

This paper is about designing, manufacturing, and building the universal test bench for checking various pneumatic components. This test bench is used to check the functionality of the pneumatic component after they have been repaired. The design part focused more on the mechanical structure and pneumatic system. The whole design process was carried out with safety and design for assembly in mind. The mechanical structure consisted of key parts namely air compressor, FRL unit, reservoir, pneumatic lines, PLC unit & universal test bench. The universal test bench consists of three main portions namely test rig for pneumatic valves, test rig for pneumatic cylinders & test rig for air compressor. For each part the concepts were generated, evaluated and selected to obtain the most promising concept for further development. The methodologies applied in the design included; identification of need, concept generation and concept selection. Development of concepts involved CAD modeling calculations and selection of appropriate materials.

Keywords: Universal Test Bench, PLC Unit, Pneumatic Valves, Pneumatic Cylinders, Air Compressor, Pressure Transducer, Press Regulator & Test Rig.

I. INTRODUCTION

The pneumatic system consists of various pneumatic components like directional control value (DCV), safety valve, non-return valves, minimum pressure valve, pressure regulators, cylinder, reservoir and air compressor. All the pneumatic components required periodic maintenance (preventive maintenance) to

improve the availability of the system. After the maintenance activities (Service/Overhauling) of the pneumatic components are completed, it is not advisable to install pneumatic components in the pneumatic system or the machine assembly. Before the installation, it is recommended to check the functionality of the pneumatic components and ensure the operation. In view of the above, a universal pneumatic test bench is designed to check the functionality and hassle-free operation of various pneumatic components.

At the core of pneumatic testing is the use of air or another inert gas medium like nitrogen or helium to pressurize a piping system. The air or nitrogen is confined throughout the piping system to mimic a high-pressure environment at 110% of the system's design. Air and nitrogen are the most used mediums since they are affordable. Helium is more expensive but can be used as the most accurate tracer gas if deemed necessary. Depending on the material and type of piping products used, this high-pressure environment is held for certain time. A mass spec is used to measure the mass-to-charge ratio of molecules. In more simple terms, it measures the mass within the piping system at the beginning and end of the test. For a normal and safe piping system, there should be no discrepancy in mass. Any discrepancies in mass would mean that there are internal problems that need to be addressed.

II. RELATED WORKS

M. Carello, A. Ivanov and L. Mazza have given test methodology to determine the flow parameters, such as pressure drop and flowrate, for straight pipes. The experimental tests were carried out using a properly instrumented test bench and the curves pressure drop vs. flowrate, varying the upstream pressure, was obtained. The tests were made on pipes with different internal diameters, corresponding to common industrial size.

The system designed by Mujie You, Junzhizhang, Dongsheng sun, Jinfung Gou., to control and diagnose air brake systems in order to both sustain and improve their performance. A system developed is a hybrid model for predicting the response of the relay valve used in pneumatic systems.

The practical situation of high-pressure pneumatic control valve performance test process is discussed by Xudongpana, Guanglinwang, Guoyu Shen, RuiqiSong, automatically testing has been achieved through the development of dedicated test software. The precision and operational performance of this system is verified through experiment.

S.V. Natarajan, S.C. Subramanian1, S. Darbha, K.R. Rajagopal discussed the feasibility of pneumatic proportional valve as pressure regulator element. A nonlinear mathematical model was built and verified through experiment, the effect of main physical and geometrical parameters on characteristic of valve were analyzed based on model and suggestion of valve design are given.

In this paper design and development of Universal Test Bench for testing pneumatic system is explained. Linköping University among other divisions has a division of Fluids and Mechatronic Systems which has a view to develop more researches in pneumatics. Within the division a fluid laboratory has had several tests stands for projects and teaching in hydraulics and pneumatics.

The effort was needed to do more extension within the field of pneumatics. One of the existing pneumatic test stands was rod less cylinder for horizontal application. In this thesis a completely new test stand for vertical application of rod less cylinder had to be designed, manufactured, built and tested. All concepts were new and had to be generated from non-existing

ideas, except that the concept of disturbance mechanism was revised and improved from the horizontal test stand. The slot type roadless cylinder and some pneumatic and electronic components had to be obtained from market. The test stand was going to facilitate research projects and teaching at Linköping University.

III. PROPOSED METHODOLOGY

The main objective of this paper is to improve the reliability of the pneumatic system by checking the functionality of various pneumatic components using a universal test bench. Utilizing the universal test bench, the maintenance operator can easily check the functionality of various pneumatic components at a single place after completing periodic or preventive maintenance activity on the component.

As the pneumatic components are used in various critical and complicated machine assemblies, it takes a lot of time to assemble the component in the machine & check the functionality of the same. Sometimes, a faulty component assembled in a machine may lead to major accidents. Hence, this test bench could be valuable as it checks the functionality of various pneumatic components before getting installed in the actual machine. This saves a lot of time, reduces the operator fatigue & also improves operator safety.

3.1 Universal Test Bench

The universal test bench is used to check the functionality of valves, cylinders & air compressor. One end of the test bench is connected to the Air compressor via FRL unit & on the other end three header lines are mounted.

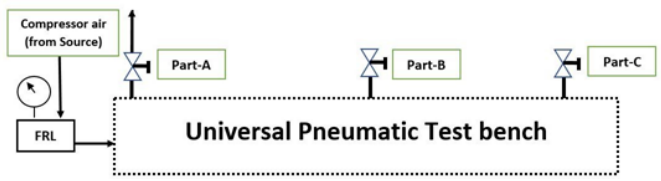

Figure 1: Universal Test Bench

3.2 CONSTRUCTION OF UNIVERSAL TEST BENCH

The compressor output is directly is connected to FRL (Filter, Regulator and Lubricator) unit by pipelines and then it passes through the isolation valve, after that it is connected to the air reservoir. This line is called"**Main pneumatic line**".

From the reservoir, inside the test bench three tapping are taken and air supply is given to each part of the test bench through "**Header line**".

Each header lines represent each part of the test bench (Header line-A, B & C). The construction diagram is shown below.

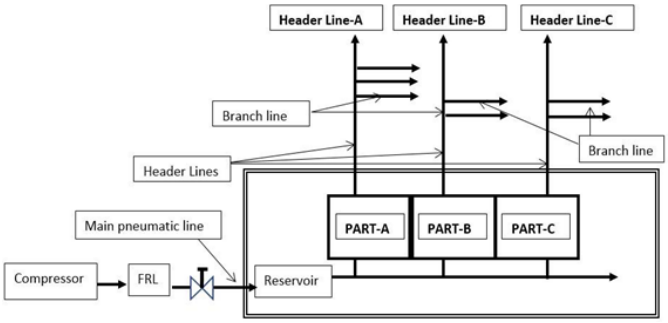

Figure 2: Construction of Test Bench

IV. WORKING PRINCIPLE OF UNIVERSAL TEST BENCH

The compressed air is used as a working medium for the universal test bench. The output pressure shall not be less than 10 bar. Based on the operational requirement the pressure will be reduced in each line.

The compressed air is then treated through FRL (Filter, Regulator and Lubricator) unit and fills the air reservoir. From the air reservoir it distributes the air to all the three parts of the test bench and reaches the branch line.

The functionality of each valve is different and the procedure to check the functions of each valve is also different. Hence separate airline is routed to check the functionality of all the valves.

In a designated airline, the valve and cylinder need to be fixed and then the air supply to be given and the valve operation and functionality can be monitored with the help of pressure transducers & PLC unit. The separate program can be selected using the PLC unit depending upon type of valves & cylinders tested.

After the valve or cylinder testing is completed the compressed air should be drained from the all the branch lines.

TEST RIG FOR PNEUMATIC VALVES (PART – A)

OVERVIEW

This test rig is used to check the functionality of Directional Control Valve (DCV), Non-Return Valve (NRV), Pressure Regulator, Safety Valve and Minimum Pressure Valve (MPV).

SCHEMATIC DIAGRAM

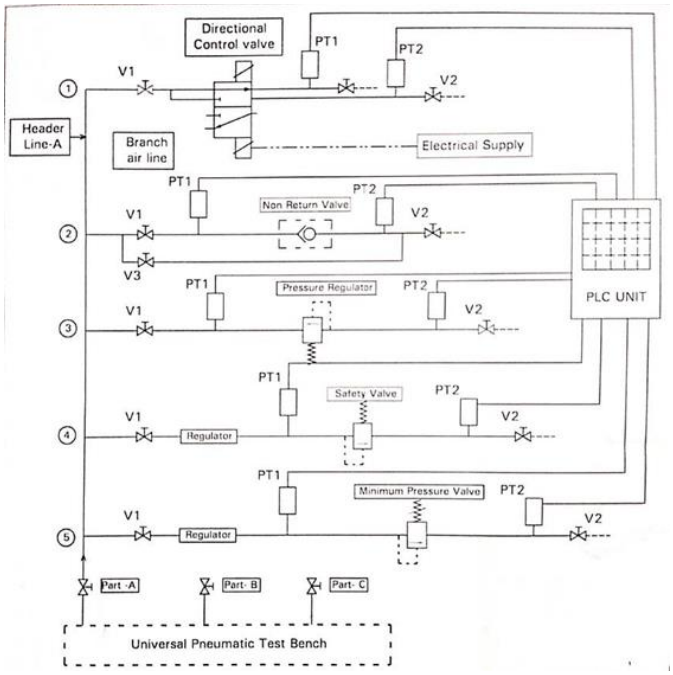

Figure 3: Test Rig for Pneumatic Valves

TEST RIG FOR PNEUMATIC CYLINDER (PART – B)

OVERVIEW

This test rig is used to check the functionality of pneumatic cylinder. It checks the forward and reverse movement of cylinder. And it is also used to calculate the force applied by cylinder.

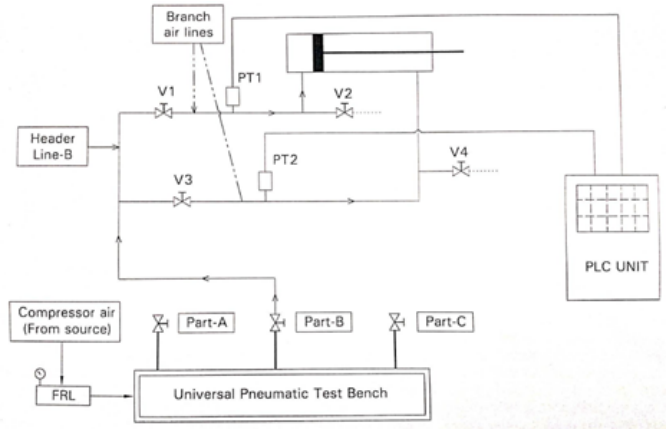

Figure 4: Test Rig for Pneumatic Cylinder

CYLINDER FORCE CALCULATION

The cylinder force can be calculated with help of following formula.

$$Force = Area \; x \; Pressure \qquad (1)$$

PRESSURE

This is the pressure used to move the piston upward or downward. From the test rig, the pressure can be measured with the help of pressure transducers PT1 & PT2.

The following are the unit of pressure,

One Bar
1.01 kg/cm²
760 mm of Hg.
0.1 N/mm²
14.6 psi
The above values are equal to atmospheric pressure.

AREA:

Assume that the cylinder is having circular cross section. We can measure the diameter of the piston inside the cylinder and the area can easily calculated. The unit of area should be in mm²

CALCULATIONS

In the test rig, pressure applied is 5 bar. We can the convert the pressure unit from Bar to N/mm². That means the pressure is 0.5 N/mm². Diameter of the Piston is 100 mm. Area of the Piston is 7853.9 mm².

$$Force = Area\ x\ Pressure$$

$$= 7853.9\ x\ 0.5$$

$$\boldsymbol{Force = 3926.9\ N\ or\ 3.9\ KN}$$

TEST RIG FOR AIR COMPRESSOR (PART – C)

OVERVIEW

This test rig is used to check the performance of air compressor. It is alsoused to check the pneumatic tightness of the air reservoir.

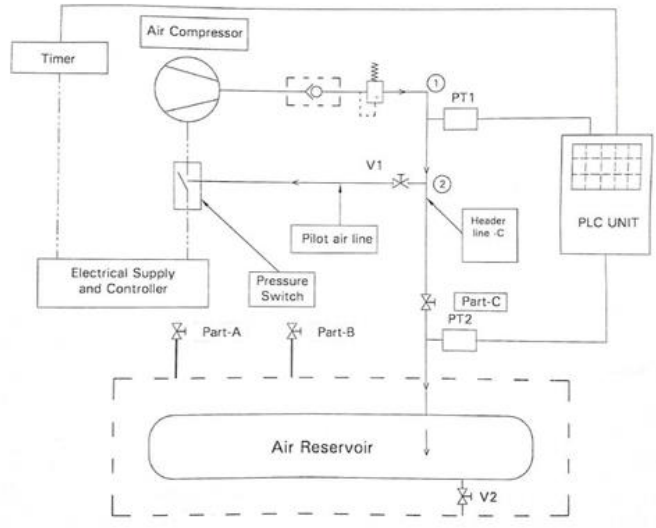

Figure 5: Test Rig for Air Compressor

TEST RIG FOR AIR RESERVOIR

OVERVIEW

This test rig is used to check the pneumatic tightness and air leak in the reservoir. If there is any air leak in the reservoir, it will affect the performance and efficiency of the pneumatic system.

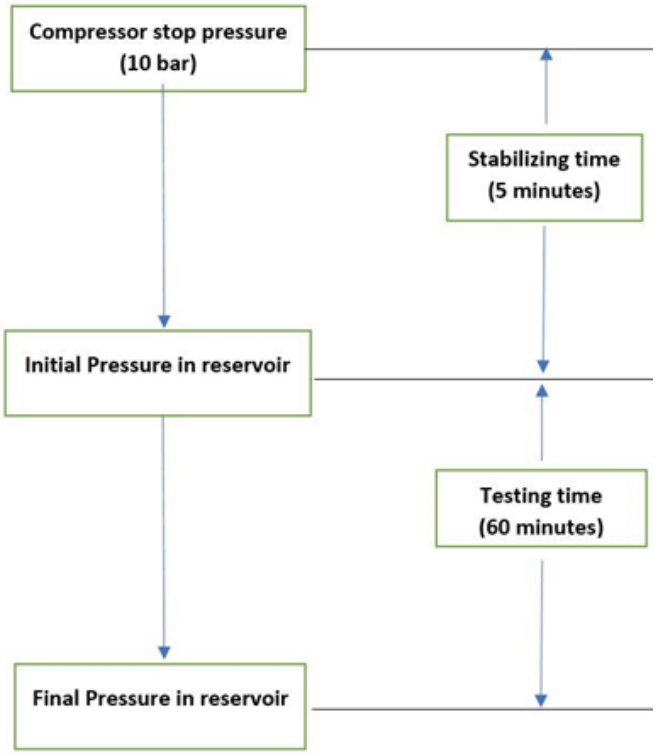

Figure 6: Flow Chart

V. DISCUSSION

Nowadays automatic machines with sensitive controls are replacing the manual and semi-automatic machines. It is more important that in automatic machines each system and their components must work efficiently for better performance.

We decided to improve the reliability of one of the mechanical systems involved in modern machines. Pneumatic system has components like critical valves, cylinders, air compressors etc. The role and significance of these components are to be considered in high priority. Also these components are

frequently undergone for maintenance activities like overhaul and repair.

We concluded that these components must check for its performance before introduction into the main system whether it is new or repaired. Hence we planned to design a test bench for testing all these pneumatic components at one place.

This test bench also helps to reduce the maintenance time by avoiding frequent removal for frequent failures. Prior checking helps prevention of failures which leads to better performance of whole system.

A better performing and fail safe machine will increase productivity as well as quality. Finally we concluded for designing a test bench for checking all these pneumatic components.

VI. CONCLUSION

This project experience has provided us a great opportunity and experience in putting our limited understanding to use. We gained a lot of knowledge about working of pneumatic components as well as role and significance of each components performance in the Pneumatic System.

The project's goal of developing a Universal Test Bench for Pneumatic system has been successfully established. In short, test bench for checking pneumatic components has been successfully designed.

This test bench works well in checking the pneumatic components before their introduction to the system. In this project, for testing we designed separate branches based on type of pneumatic components.

Based on similarity of components we have designed separate branch for Pneumatic Valves, Pneumatic Cylinders and Air Compressors. Also, we incorporated PLC to select the type of test and to monitor during the test of each component. Here we programmed the PLC to show the test results based on feedback from sensors in each circuit and to record those results.

This test bench helps to check performance of pneumatic components and to eliminate failures after introduction of these components in the system. Because of prior checking using this test bench, may greatly reduce the maintainer fatigue due to avoidance of frequent removal of components for failures.

Finally, this Universal Test Bench for Pneumatic System will help for hassle free operation and save lots of time in maintenance activities which helps for better productivity.

VII. REFERENCES

[1]. Mikhail A. Ermilov, Maxim V. Balyaba (12-16 July 2015.Test Bench for vibroacoustic research of the pneumatic system units and pipe fittings. ICSV22, Florence (Italy)

[2]. Xudongpana, Guanglinwang, Guoyu Shen, RuiqiSong.High pressure pneumatic control valve performance test system. Key Engineering Materials Vols 579-580 (2014) pp 295-299;2014.

[3]. Peter Beater, Pneumatic Drives: System Design, Modelling and Control

[4]. Karl-Erik Rydberg, Basic Theory for Pneumatic System Design

[5]. Karl T. Ulrich and Steven D. Eppinger. Product Design and Development. McGraw-Hill Irwin, fourth edition, 2008.

[6]. NSI/ISA-75.02-1996, "Control Valve Capacity Test Procedures". Approved 1 October of 1996, ISA.

[7]. Fleischer H., Forster K. y Franson D., "Clearing the air on pneumatic valve ratings", Machine Design., pp. 97-100 (2000).

[8]. Balla R., 1991. Electro - Pneumatics, Mannesman Rexroth Pneumatik GmbH, Hannover.

[9]. Belforte G., Manuello Bertetto A., Mazza L., 2003. Pneumatics, Tecniche Nuove, Milan. (in italian).

[10]. Fleischer H., 1995. Manual of Pneumatic Systems Optimization, McGraw Hill, New York.

[11]. Hasebrink B.J., 1991. Basic Pneumatics, Mannesman Rexroth Pneumatik GmbH, Hannover.

[12]. Sorli M., Figliolini G., Pastorelli S., "Dynamic model and experimental investigation of a pneumatic proportional pressure valve", IEEE/ASME Transactions on Mechatronics, 2004, 9 (1), pp.78-86.

[13]. Sorli M., Figliolini G., Pastorelli S., "Modeling and experimental validation of a two-way pneumatic digital valve", Bath Workshop on

[14]. Power Transmission & Motion Control, Eds. C.R. Barrows and K.A. Edge, Professional Engineering Publishing, London, 2003, pp.291-305.

[15]. ISO 6358, Pneumatic Fluid Power Components Using Compressible Fluids, Determination of Flow-rate Characteristics, 1992.

[16]. Robert L. Norton, Machine Design, an integrated approach.

[17]. Bernard J.Hamrok Steven R. Schmid, Bo Jacobson, Fundamentals of Machine Elements, second edition

[18]. Karl T. U, Steven D. Eppinger, Product Design and Development, fifth edition.

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